KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

Effects of Green Design Sustainability on Environmental Performance: Mediating Role of Green Innovation

By

AGBAVOR FAITH

(MSc. Logistics and Supply Chain Management)

A Thesis submitted to the Department of Supply Chain and Information Systems, KNUST School of Business in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN LOGISTICS AND SUPPLY CHAIN MANAGEMENT

NOVEMBER, 2023

DECLARATION

I hereby declare that this submission is my work towards the Master of Science in Logistics and Supply Chain Management and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgment has been made in the text.

AGBAVOR FAITH …..... ….....

(PG 9250521) Signature Date

Certified by:

Prof. Kwame Owusu Kwarteng ....

(Supervisor) Signature Date

Prof. David Asamoah ....

(Head of Department, SCIS) Signature Date

DEDICATION

I dedicate this thesis wholeheartedly to my friend Mr. Arnold Awudza who has been my source of inspiration and whose words of encouragement and push for tenacity ring in my ears. I also dedicate this dissertation and give special thanks to my lovely foster parents Mr. and Mrs. Brooks whose support and for being there for me throughout the entire master's program. Both of you have been my best cheerleaders. Most importantly, I dedicate this work to Almighty God for his guidance, strength, power of mind, protection and for giving me healthy life to complete this program.

ACKNOWLEDGMENT

My utmost gratitude is to the Almighty God for the gift of wisdom and knowledge and for giving me the courage to accomplish this task. In addition, I am grateful to my supervisor, Professor Kwame Owusu Kwarteng for bringing the weight of his considerable experience and knowledge to this project. His high standards have made me better at what I do.

I am also indebted to my lecturers and my course mates for letting my study be an enjoyable moment, and for their intelligent comments and suggestions, thanks to you all.

Furthermore, my appreciation goes to my best friend Mr. Arnold Awudza whose words of encouragement and direction helped me attain this goal.

Finally, to my caring and supportive Guardian, Mr. and Mrs. Brooks, my deepest gratitude. Your encouragement when the times got rough is much appreciated and noted. It was a great comfort and relief to know that you were willing to provide and support this program financially while I completed this work. My heartfelt thanks to you.

ABSTRACT

The main aim of the study is to examine the effects of green design sustainability on environmental performance and the mediation role of green innovation in mining firms in the Western Region of Ghana. The study employed an explanatory research design. This survey was conducted using a quantitative approach. Purposive sampling techniques were used to choose 332 participants. A prepared questionnaire was the main tool used for data collection. Both SPSS v26 and SmartPls v4 were used for the statistical analysis. Both descriptive and inferential approaches were used to analyze the data. The result revealed that green design sustainability does not have a direct effect on environmental performance but a direct effect on green innovation. The result showed that green innovation had a significant direct influence on environmental performance. The results also revealed that green innovation positively and fully mediates interactions between green design sustainability and environmental performance. Therefore, the study recommended that firms should design eco-friendly products, eliminates hazardous waste and materials in their production operations, and employs products that save coal, oil, power, and water in order to enhance firms try to work with customers on eco-design to reduce the environmental effect, develop products and packaging that may be reused, mended, or recycled, surpasses legal environmental laws, uses alternative energy, reduces water use, and frequently examines the environment.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Although there are differences between the meanings implied by each, the terms "green" and "sustainable" design are frequently used synonymously. Green building practices can minimize ongoing maintenance costs for buildings, including costs for salaries and suppliers, as well as reduce building running expenses through lower utility and waste disposal costs. Efficiency is the main focus. Sustainable development is to maintain the level of life while preventing irreparable harm to the resources that our species depends on to survive (Arora et al., 2018).

The goal of green design is to create products and processes that are less harmful to the environment. Utilizing green design requires a specific framework for thinking about environmental issues, the use of pertinent analysis and synthesis techniques, and a challenge to conventional design and manufacturing processes (Hendrickson, 2022). The "green approach" to architecture is not a recent development; it has been around for quite some time. What is novel is the understanding that a green approach to the built environment necessitates a holistic approach to building design; if sustainable architecture is to be produced, all resources that go into a building, be they materials, fuels, or the contribution of the users, need to be taken into consideration (Jacomossi et al., 2021). Reducing the number of raw materials used during the product's life cycle is a key component of green design, also known as eco-design. In this way, green design directly applies the 3Rs of reduce, reuse, and recycle to emphasize sustainability throughout the product lifecycle (Zu and Cong, 2022).

It is estimated that by 2050, approximately 70% of the world's population, up from more than half today, would reside in cities (Tripathi et al., 2019). Cities will soon account for 90% of the increase in world population, as well as around 75% of carbon dioxide emissions and 75% of energy use (Griffiths and Sovacool, 2020; Zhou et al., 2019). However, urbanization will continue because cities are where 80% of the world's wealth is produced and where people may find jobs and social opportunities (Beissinger, 2022). Likewise, due to its benefits to resource conservation, environmental preservation, and improved financial performance, green innovation has garnered more attention in recent years (Chouaibi et al., 2021). One of the most proactive methods to reap the rewards of environmental growth is through green innovation (GI). Innovative green businesses are changing the market more frequently (Yousaf, 2021). Innovation, according to MacMillan (2020), goes beyond technology; green innovation includes technological advancements that reduce energy use, lessen pollution, or permit waste recycling, as well as green product design. Environmental issues have so grown in importance along with the economy's fast development. Environmental deterioration and pollution are becoming major world issues. The total performance of a firm is favorably correlated with GI (Kraus et al., 2020; Mahto et al., 2020). Organizations can utilize it to increase efficiency and offset growing raw material costs (Rehman et al., 2021). Exploitative GI, which concentrates on making existing products and processes more environmentally friendly without fundamentally altering them, and exploratory GI, which concentrates on introducing new products and processes, are two types of GI. Due to GI, new products and processes may fundamentally alter current operational procedures, drastically lowering their adverse effects on the

environment. Additionally, exploratory GI may result in the development of new goods and procedures that aid in the sanitization, recuperation, and restoration of the environment. According to research, a company's environmental strategy and certain proactive tactics aimed at creating eco-friendly technologies might boost its financial results (Walker et al., 2014; Fousteris et al., 2018). On the other hand, an ineffective managerial culture can cause an environmental strategy to be reactive rather than proactive, potentially raising the risk of possible disasters and resulting in irreparable reputational damage (Mojtahedi and Oo, 2017). Numerous studies on green practices have been done, showing that green practices can give an organization a competitive advantage. These studies include Muisyo et al. (2021) research on green human resources practices, Khan et al. (2022) research on environmental capabilities, Tuni et al. (2018) research on green supply chains; Chang and Chen (2012) research on green intellectual capital; Davey (2018) research on ecological learning; Muisyo et al. (2018) research on the green; and innovative performance and green products, strategies for green innovation, green value chains, green human resources management, and green information system infrastructure (Dao et al., 2011; Yang et al., 2018). This shows that an increase in green practices awareness among firms and corporations has been noted.

Considering previous studies, green design as well as green innovation play a significant role in environmental performance. However, most of these studies solely focused on either green design or green innovation, without assessing the significant relationship between these variables on environmental performance. Thus, this study seeks to investigate the mediating role of green innovation in the relationship between green design sustainability and environmental performance.

1.2 Problem Statement

Environmental issues have gotten worse due to an expanding population, an ever-present technology, a global economy, and the overuse of natural resources. Resources and environmental issues have emerged as the primary roadblocks to sustainable economic growth, raising concerns among society (Holmberg and Sandbrook, 2019). For many years, it has been thought that economic expansion is incompatible with environmentally responsible behavior. However, this is a persistent issue that forces businesses to operate sustainably in terms of commerce, industry, and service delivery.

The conventional approach to environmental protection places a strong emphasis on the trade-off between spending money on effective and ineffective anti-pollution machinery (Chuang and Huang, 2018). According to earlier research, adopting conventional methods to comply with environmental requirements does not improve competitiveness (Christainsen and Haveman, 1981; Reinhardt, 1998). Additionally, previous research indicates that there is little connection between environmental sustainability and company performance (Li et al., 2017). According to conventional wisdom, environmentally responsible businesses efficiently minimize waste and use less energy, which enables them to reduce costs and improve performance. Although following environmental standards increases expenses, doing so also makes it less likely that more expenditures may arise in the future (Chuang and Huang, 2018; Sánchez-Medina et al., 2015; Saxena and Khandelwal, 2012).

Although there is a wealth of research showing a positive relationship between green supply chain management (GSCM) strategies and firm performance, little is known about the potential confounding variables that could affect the nature and strength of the

association between green design sustainability and firm performance (Dubey et al., 2015; Li et al., 2017). Even though a few recent research in the operations management and SCM sectors have attempted to analyze performance using institutional theory's lenses, these studies are insufficient to draw conclusions about and make generalizations about the use of institutional theory in the GSCM environment. For instance, Dubey et al. (2015) looked into how a firm's environmental performance is impacted by its green operations and green innovation. The mainstream GSCM research, however, does not offer any precise information about how green innovation affects the relationship between green design sustainability and environmental performance. Additionally, the majority of prior studies (Chuang and Huang 2018; Saeed et al. 2018) focused on the direct impact of GSCM practices on firm performance, which restricts our understanding of how GSCM practices like green design affect environmental performance because such research models do not test the underlying mechanisms (Chan et al., 2016). According to the aforementioned, most of the earlier studies neglected the relationship between green design sustainability and environmental performance.

In addition, green innovation is seen as a strong predictor of organizations' performance (Qiu et al., 2020). In addition, the literature confirms that green innovation is crucial to ensuring sustainable performance (Chen, 2008). The researchers gave green innovation little consideration when measuring environmental performance. The purpose of this study is to determine the environmental performance of green innovation. Industrial practitioners and academics have emphasized environmental strategy (Zhou et al., 2019). Environmental strategy (such as creative preventive procedures and eco-efficient practices) is favorably connected with financial performance, according to Fousteris et al. Walker et al. (2014)

stated that proactive green innovation is a crucial component when evaluating the performance of businesses. Despite this, researchers have given green innovation and environmental performance little consideration. This study is motivated by the fact that scholars have given less attention to green design to assess environmental performance in rising economies like Ghana, where green innovation plays a mediating role. Thus, this study tries to fill this gap by examining the mediating role of green innovation in explaining the relationship between green design sustainability and environmental performance in mining firms in Ghana.

1.3 Objectives of the study

The main aim of the study is to examine the effects of green design sustainability on environmental performance and the mediation role of green innovation in mining firms in the Western Region of Ghana. The specific objectives will include:

i. To examine the effect of green design sustainability on environmental performance.
ii. To ascertain the relationship between green design and green innovation.
iii. To establish the effect of green innovation on environmental performance.
iv. To assess mediating role of green innovation on the link between green design sustainability and environmental performance.

1.4 Research Questions

To verify this study, the following questions were answered:

i. What is the effect of green design sustainability on environmental performance?
ii. What is the relationship between green design and green innovation?
iii. What is the effect of green innovation on environmental performance?

iv. What is the mediating role of green innovation on the link between green design sustainability and environmental performance?

1.5 Significance of the Study

To provide a thorough knowledge of the function of green design sustainability and green innovation in connection to environmental performance, this study first operationalizes green design as GSCM practices and aims to establish the correlations at the dimension level. Thus, this study emphasizes the need for a GSCM framework to meet businesses' sustainability issues.

Second, this study suggests that green innovation acts as a mediating mechanism to explain how GSCM activities enhance an organization's environmental performance. Although a few recent studies have looked into the relationship between GSCM and environmental performance and found positive linkages (Chuang and Huang, 2018; Saeed et al., 2018), we think that innovation is linked to the improved operational efficiency of firms and will therefore likely explain the gap between green design sustainability and environmental performance.

The adoption of ecologically friendly procedures in the mining industry is further expanded upon by this study. Because academics have conducted numerous research studies on sectors including automotive, chemicals, electronics, and oil and gas, it makes sense to analyze the proposed framework in the context of the mining industry. To the best of the authors' knowledge, however, very few such studies have been carried out from the perspective of the mining industry and have been restricted to specific aspects of it, although it is one of the main industrial sectors and one of the major sources of pollutant emissions.

1.6 Research Methodology

This study employed a cross-sectional survey design. The study performed a quantitative analysis in order to examine how green design sustainability as GSCM practice influences environmental performance. The study's target population comprised selected mining companies in Ghana. Convenience and purposive samples are combined and used to sample mining companies. In all, 120 respondents were sampled from mining firms including Procurement, storage, accounts, estates, maintenance, and other divisions. A questionnaire was used to gather primary data for testing the model proposed in the study. The results of both descriptive and inferential statistics were employed to analyze the data gathered. The use of SPSS and Smart PLS-SEM was employed. Results were presented using tables and graphs and conclusions were discussed in line with the literature.

1.7 Scope of the study

The theoretical focus of the study will be on green design sustainability, green innovation, and environmental performance. This proposed study aims to ascertain the degree to which green innovation mediates the relationship between green design sustainability and environmental performance using the underlying triple-bottom-line (3PL) theory. To measure the important variables for testing the research model, the study will use the key respondents to express their opinions through the questionnaires that were provided to them. The study's geographic focus is on mining companies in Ghana.

1.8 Limitation of the study

Like any other research, this study is without exception as far as limitations are concerned. One such limitation was the risk of geographical bias because the sample size of the population of mining businesses is only limited to the Western Region of Ghana. Therefore,

the generalizability of the results across the whole country might be limited. However, despite this bias, the study's outcome should be credible.

1.9 Organization of the study

There are five (5) chapters in the study. Chapter One, which is the introduction to the problem, covered the study's background, statement of the problem, research objectives (general/specific), research questions, the purpose of the study, the scope of the study, an overview of the research methodology, limitations, and study organization. A review of relevant literature is provided in Chapter Two. This will comprise a study of concepts that flow throughout the research to get a comprehensive understanding of the topic under inquiry. This chapter also contains the conceptual framework and development of the hypothesis.

The method used in data collection and analysis is the focus of Chapter Three. It will also cover the subtopics that will be used, such as population, sample size, and sampling techniques. This chapter further discusses sampling techniques and the organizational profile. The study's findings are given in Chapter Four, along with a discussion of the research findings, which will help in evaluating if any of the findings agree or disagree with prior findings in the literature. This chapter will also enable the study to contribute to knowledge by bringing new findings to light. Chapter 5 presents an overview of the research, summarizes the study, and makes recommendations depending on the study's findings and conclusion.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Chapter two of this research is organised into five main sub-headings. The first sub-heading talks about the conceptual review which provides definitions, operationalisations and how the constructs have been used in the study. The next sub-heading talks about the theoretical review which also provides the theoretical underpinnings of the study. The third sub-heading also talks about the empirical review which present a related article based on the study. Conceptual framework and hypotheses development were discussed in following sub-headings. The chapter ends with a summary which highlight the gap explored in the study.

2.2 Conceptual Review

The conceptual review section contains the definitions, operationalization and how the variables have been used in this study. Under this section, there are three main variables (green design for sustainability, green innovation and environmental performance) to be operationalized.

2.2.1 Green Design for Sustainability

Green Design protects natural materials in the environment (He et al., 2018). Sustaining green design will go a long way to conserve nature. Green Design for Sustainability (GDS) is defined as product designs, product materials and equipment, product methods and delivery techniques that enables the conservation of natural resources to reduce the impact on the activities of human, protect the environment (Al-Sheyadi et al., 2019) and maintain

an eco-friendly environment. Awan et al. (2021) also defined GDS as the degree to which a firm will go to develop and maintain processes and product that have minimal effect on natural environment. GDS is a strategy employed by firms to maintain and prevent long term pollution by creating products for use that can be recycled (Ikram, 2022). GDS is maintaining procedures, practices and techniques that utilize little materials and energy, minimize potential harm and waste through recycle and reuse to prevent pollution (Singh et al., 2021). This study will define GDS by (Awan et al., 2021) as maintaining processes and product that have minimal effect on natural environment.

2.2.2 Green Innovation

Green Innovation (GI) focuses on improving environmental friendly businesses. Chin (2022) defined GI as a key strategy to attain sustainable development including innovations in technology involved in preventing pollution, waste recycling and energy saving. GI is the ability of a firm to push towards identifying activities that form economic value whilst ensuring eco-friendly environment for business practices (Olawoyin, 2021). Green innovation refers to innovations that reduce of adverse impacts on the environment to provide a great opportunity for companies to attain the environmental performance benefits and targets (Lin et al., 2014). GI is also defined as exploitative and explorative means to ensure environmental friendly business practices. Exploitative GI maximizes the transformation of existing processes, products and goods that are made environmentally friendly and explorative GI is the creation of novel processes, goods and product (Rehman et al., 2021). Rehman et al. (2021) also emphasized that due to GI, novel processes, goods and products many be transformed radically using existing methods and procedures to reduce negative impact on the environment. GI is also defined as the creation of products

and processes which improves environmental cleanliness (Ullah et al., 2022). Cao and Chen (2018) stated that GI is a strategy firms adopt to minimize environmental effect on business activities. GI is also described by Amores-Salvadó et al. (2014) as green firms' ability to produce new products that are green enough to ensure environmental benefits. GI refers to creating environmentally friendly processes and products (Albort-Morant et al., 2016) by adopting organizational practices (greener raw materials, use of fewer materials) during the development of products using eco-model principles which is aimed at reducing the consumption of water, electricity and minimizing emissions (Singh et al., 2020). This study will define GI as the push towards identifying activities that form economic value whilst ensuring eco-friendly environment for new products in business practices (Olawoyin, 2021).

2.2.3 Environmental Performance

Environmental Performance (EP) is meeting and exceeding social expectations in the natural environment to go above compliance with regulations (Chen et al., 2015). EP is defined as when a firm is able to produce processes, goods, products, materials and resource consumption in a way that ensures legal environmental requirements are meet (Dubey et al., 2015). EP is referred to as the increase in quality of eco-friendly products, green processes and resources to foster business product (Chen et al., 2015; Dubey et al., 2015). Rawashdeh (2018) also says that EP is the results of using initiatives that positively influence the environment. EP is described as the overall activities of a firm to boost efficiency and effectiveness in delivering environmental friendly products (Al-Ghwayeen et al., 2018). Al-Sheyadi et al. (2019) stated that there are two parts of EP and they are environmental impact and environmental cost savings. Environmental impact is the

potential negative effect that a company may have on the environment by using and releasing substances into the environment and environmental cost savings can be defined in two forms; the internal cost saving and the external cost savings (Al-Sheyadi et al., 2019). Al-Sheyadi et al. explained internal cost savings as the direct effect on the income of a firm and the external cost savings are costs imposed on the society but not brought on by the firm that created the cost at first. This study will define EP by (Al-Ghwayeen et al., 2018) as the overall activities of a firm to boost efficiency and effectiveness in delivering environmental friendly products.

2.3 Theoretical Review

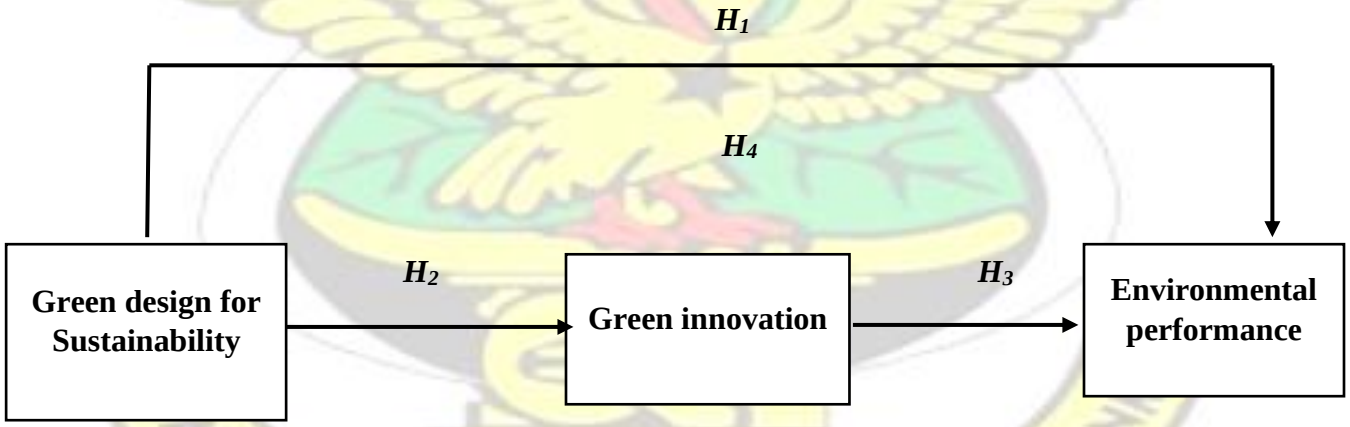
2.3.1 Natural Resource-Based Theory

The natural resource-based theory states that a firms' competitive advantage is dependent on its connection with the natural environment (Hart, 1995). The GI is an important prerequisite for the firm to select a green strategy for EP (Martensson and Westerberg, 2016). However, GI is easier to be backed when innovation materials are in abundance. Many studies argue that GI is tacit resource that improves the GDS in firms. Thus GI improves GDS and improves the overall EP, maintaining a competitive advantage (Ullah et al., 2022). Through exploitative GI, existing products and technologies are improved to reduce negative impacts on the environment (Rehman et al., 2021). The exploratory GI will create novel products and technologies to reverse the environmental damage done in the past days (Rehman et al., 2021). From this view, GI materials allow firms to have higher autonomy in the selection of green designs and projects, avoid resource competition and focus on the environmental effects to increase EP (Leonidou et al., 2017). Some studies have assessed GI as an index and that social, economic performance and EP is significantly

related to it (Yusliza et al., 2020). Strengthening the effect of GI on GDS, and ultimately on their EP may achieve an advantage that competitors will not be able to replicate (Chang, 2011). Furthermore, firms can continually increase their competitive advantage by absorbing the knowledge gained via GI into their GDS while applying GI to promote EP.

2.4 Conceptual Framework

This study is motivated by the fact that scholars have given less attention to green design to assess environmental performance in rising economies like Ghana, where green innovation plays a mediating role. Thus, this study tries to fill this gap by examining the mediating role of green innovation in explaining the relationship between green design sustainability and environmental performance in mining firms in Ghana. Figure 2.1 depicts the proposed model (conceptual framework) showing the various relationships proposed in the study.



` Figure 2.1: Conceptual framework of the study

2.5 Empirical Review

2.5.1 Impact of Green Design for Sustainability on Environmental Performance

Rawashdeh (2018) carried out a study to examine the relation linking green human resource management practices including green selection and recruitment, green training and

development, and green rewards, and EP. Quantitative research design was adopted by the researcher to carry out the study. Data was gathered from participants who work in the hospital. Questionnaires were sent through email to study participants to gather the data. The researcher found that green human resource management practices is associated with EP. The researcher recommended that future studies should use a large sample size to carry out the study.

Anwar et al. (2020) carried out a cross-sectional survey in Malaysia. The purpose of the survey was to examine the mediating effect of organizational citizenship behaviour towards the environment between green human resource management and EP. The researchers used convenience sampling procedure to select the sample from the academic staff of University of Technology, Malaysia. Structured questionnaires were distributed to survey participants to gather responses. The researchers found that green human resource management practices of the school is influenced positively by EP of the university campus. The researchers recommended that future studies should carry out a longitudinal study because their research only collected data at one point in time.

Al-Sheyadi et al. (2019) also carried out a survey on green supply chain management practices and the impact on EP. The aim of the survey was to evaluate the collective effect of external and internal green supply chain management practices on EP. The survey population was large and medium manufacturing companies in Oman who had more than 20 employees. Data was gathered using questionnaires from December 2021 and ended in March 2013. The researchers found that green supply chain management practices impact EP achieved in manufacturing companies. They recommended that future research should

conduct studies by using dyadic buyer-supplier network as a unit of analysis for in-depth understanding.

Hameed et al. (2020) carried out a study on green human resource management practices and environmental performance. The purpose of the study was to investigate an integrative framework including the direct impact of green human resource management practices on organizational citizenship behaviour of employee toward environment through green employee empowerment. The researchers used quantitative method to sampled study participants from manufacturing companies. Data was collected from study participants by distributing the data collection instrument through email. The findings revealed that green human resource management practices have indirect effect on green employee empowerment. The researchers recommended that future studies should examine the impact of green human resource management on employees' non-green outcomes in terms of behaviour and attitude.

Inman and Green (2018) carried out a study to examine the relationship between green and lean practices and evaluate the combined effect of green and lean practices on operational performance and EP. Data was gathered from 182 manufacturing plant managers from the United States. The findings revealed that green supply chain management practices are positively influence EP. They recommended that future studies should conduct research focusing on benefits of combining lean and green and a more complete set of wastes.

2.5.2 Impact of Green Design for Sustainability on Green Innovation

Zhang et al. (2020) conducted a study to assess environmental regulations and its impact on urban GI. The researchers adopted explanatory research design to conduct the study. They collected data from participants Xi'an city in China. After data collection, they

analysed and found that there is a relationship between environmental regulations and green innovation efficiency. The researchers recommend that future studies should focus on more environmental variables to increase reliability and accuracy of the model.

Lisi et al. (2020) conducted a cross-sectional study to look into the influence of green supply chain learning (green supplier and customer learning) on green innovation (green product and green process innovation) and the moderating role of green technology turbulence. The study was conducted in China. The sample size for the study was 249 firms. The findings show that green supply chain learning positively affect GI. The researchers recommend that future studies should conducted the study using longitudinal research design and multi-source data.

Huang et al. (2018) conducted a study to evaluate the relation connecting green innovation performance, environmental innovation strategy and resource alignment. They sampled 120 information technology firms in Taiwan. Questionnaires were used to collect data from study participants. The findings reveal that environmental innovation strategy and resource alignment between partners are associated with green innovation performance. They recommended that future studies should use longitudinal research approach to carry out the study.

2.5.3 Impact of Green Innovation on Environmental Performance

Rehman et al. (2021) conducted a study to reevaluate the complex relation connecting green intellectual capital, green human resource management and GI, environmental strategies, and EP. The researchers used quantitative research approach to conduct the study. The study population were manufacturing firms in Malaysia. They developed questionnaires to collect data from the sampled managers. Analysis was run on 244

questionnaires and the results show that environmental strategy positively influence EP while mediating the relation connecting GI and EP. The researchers recommend that future studies should conduct studies to differentiate between the different kinds of GI.

Cao and Chen (2018) conducted a study on EP. The goal of the study was to examine how external and internal environmental forces make companies pick GI: moderating role of top management's environmental awareness. They utilized quantitative research approach to carry out the study. Data was collected using questionnaires. Cao and Chen found that there is strong relation of GI strategy and the coercive policy when there is higher top management's environmental awareness. They recommend that future studies should collect data from a large sample to enhance research findings generalization.

Singh et al. (2020) conducted a survey to examine how green human resource management influence the relationship between green transformational leadership, GI and EP. Data was collected from 309 manufacturing companies in United Arab Emirates. Questionnaires were used to collect data from the survey participants. The researchers after analysing the data gather from the survey participants, they found that GI influences EP. They recommended that future studies should conduct the study in non-manufacturing companies in United Arab Emirates.

Soewarno et al. (2019) carried out a study to find out whether environmental organizational legitimacy and green organizational identity mediate the relation between GI and green innovation strategy. The researchers carried out the study by utilizing quantitative research methods. They sampled a cross-section of companies in Indonesia. After analysis the research found that green innovation strategy positively impacts GI. The researchers recommended that future studies should use secondary data.

2.5.4 The Mediating Role of Green Innovation on Green Design for Sustainability and Environmental Performance

El-Kassar and Singh (2019) conducted a study to design a holistic model bringing together views of stakeholders on green product, and demand for green products and corporate environmental ethics, as driving factor of green innovation to attain competitive advantage and sustainable performance. The researchers used quantitative research design to carry out the study. They sampled 215 participants who are managers and employees in both middle and senior level. They found that GI has a positive effect on EP. Future studies should use mixed methods research design to further examine the proposed model.

Ullah et al. (2022) also conducted a study on GI. The aim of the study was to evaluate the complex relations between green human resource management, green intellectual capital and GI for enhancement in the EP of a company. The researchers used manufacturing firms in Punjab in Pakistan. The sample size for the study was 620 food manufacturing companies. Questionnaires were used to gather data. Responses were analysed and they found that GI mediates EP of the companies, and that GI and green intellectual capital have a positive impact on EP.

Tariq et al. (2019) carried out a study to examine the effect of green product innovation performance on the financial performance of a firm. Data was gathered from manufacturing firms in Thai. The researchers used purposive sampling technique to select the sample for the study. A sample size of 425 firms were used and 202 responses were utilized. The results show that green product innovation performance influence financial performance of firms. Tarig et al. recommend that future studies should focus on carrying this study in other geographic locations.

Kraus et al. (2020) carried out a study on green innovation, EP and corporate social responsibility to assess the effect corporate social responsibility on environmental performance. The researchers adopted quantitative research design to carry out the study. They sampled manufacturing companies in Malaysia. They found corporate social responsibility has no direct impact on EP but has a positive relationship with environmental strategy and GI. The researchers recommend that future research should focus on using green capability and green transformational leadership as mediators between corporate social responsibility and EP.

2.6 Research Gap

The chapter empirically reviewed the literature on the relationships among green design, green innovation, and environmental performance. The results of the literature review revealed that the relationships had been examined extensively in literature in different industries such as the manufacturing, educational, health sector, and public sector, and the context of these studies have been mainly limited to Asia, South America, and some developed countries such as America, Spain and Lithuania with little consideration to Africa and more importantly Ghana. The literature review indicates that the results of the literature review revealed that the relationship had been examined extensively in literature in different industries such as the manufacturing, educational, health sector, and public sector, the context of these studies has primarily been limited to Asia, South America, and some developed countries such as America, Spain and Lithuania with little consideration to Africa and more specifically Ghana. More importantly, none of these studies looked at the relationships in the context of the mining firms, which serves as a significant gap in this study.

Table 2.1: Summary of Literature Review

Author (Year)	Country	Purpose	Theory	Method	Findings	Future Studies
Rehman et al. (2021)	Malaysia	To reevaluate the complex relation connecting green intellectual capital, green human resource management and GI, environmental strategies, and EP.	Natural-Resource-Based Theory	Quantitative	Environmental strategy positively influence EP while mediating the relation connecting GI and EP.	Future studies should conduct studies to differentiate between the different kinds of GI.
El-Kassar and Singh (2019)	Middle East and North Africa Region	To design a holistic model bringing together views of stakeholders on green product, and demand for green products and corporate environmental ethics, as driving factor of green innovation to attain competitive advantage and sustainable performance.	Resource-Based View Theory	Quantitative	GI has a positive effect on EP.	Future studies should use qualitative and quantitative research design to further examine the proposed model.

Ullah et al. (2022)	Pakistan	To evaluate the complex relations between green human resource management, green intellectual capital and GI for enhancement in the EP of a company.	Natural-Resource-Based Theory	Quantitative	GI mediates EP of the companies, and that GI and green intellectual capital have a positive impact on EP.	The researchers did not give clear directions for future studies.
Cao and Chen (2018)	China	To examine how external and internal environmental forces make companies pick GI: moderating role of top management's environmental awareness.	Resource Based Theory		They found that there is strong relation of GI strategy and the coercive policy when there is higher top management's environmental awareness.	Future studies should collect data from a large sample to enhance research findings generalization.
Tariq et al. (2019)	Thailand	To examine the effect of green product innovation performance on the financial	Resource-Based View Theory and Contingency Theory	Quantitative	Green product innovation performance influence financial performance of firms.	Future studies should focus on carrying this study in other geographic locations.

		performance of a firm.				
Singh et al. (2020)	United Arab Emirates	To examine how green human resource management influence the relationship between green transformational leadership, GI and EP.	Ability-Motivation-Opportunity Theory and Resource-Based View	Quantitative	The researchers found that GI influences EP.	Future studies should conduct the study in non-manufacturing companies in United Arab Emirates.
Rawashdeh (2018)	Jordan	To examine the relation linking green human resource management practices including green selection and recruitment, green training and development, and green rewards, and EP.	Resource Based Theory	Quantitative	The researcher found that green human resource management practices is associated with EP.	Future research should use large sample size.
Anwar et al. (2020)	Malaysia	To examine the mediating effect of organizational citizenship behaviour towards the environment between green	Ability-Motivation-Opportunity Theory	Quantitative	Green human resource management practices of the school is influenced positively by EP of the university campus.	Future studies should adopt a longitudinal research design.

		human resource management and EP.				
Al-Sheyadi et al. (2019)	Oman	To evaluate the collective effect of external and internal green supply chain management practices on EP.	Complementarity Theory	Quantitative	Green supply chain management practices impact EP achieved in manufacturing companies.	Future research should conduct studies by using dyadic buyer-supplier network as a unit of analysis for in-depth understanding.
Hameed et al. (2020)	Pakistan	To investigate an integrative framework including the direct impact of green human resource management practices on organizational citizenship behaviour of employee toward environment through green employee empowerment.	Sport Value Framework and Ability-Motivation-Opportunity Theory	Quantitative	The findings revealed that green human resource management practices have indirect effect on green employee empowerment.	Future studies should examine the impact of green human resource management on employees' non-green outcomes in terms of behaviour and attitude.

Inman and Green (2018)	United States	To examine the relationship between green and lean practices and evaluate the combined effect of green and lean practices on operational performance and EP.	Complementarity Theory	Quantitative	The findings revealed that green supply chain management practices are positively influence EP.	Future studies should conduct research focusing on benefits of combining lean and green and a more complete set of wastes.
Zhang et al. (2020)	China	To assess environmental regulations and its impact on urban GI.	No Theory	Explanatory Case Study	They found that there is a relationship between environmental regulations and green innovation efficiency	Future studies should focus on more environmental variables to increase reliability and accuracy of the model.
Lisi et al. (2020)	China	To look into the influence of green supply chain learning (green supplier and customer learning) on green innovation (green product and green process innovation) and the moderating role of green technology turbulence	No Theory	Quantitative	The findings show that green supply chain learning positively affect GI.	Future studies should conducted the study using longitudinal research design and multi-source data.

Soewarno et al. (2019)	Indonesia	To find out whether environmental organizational legitimacy and green organizational identity mediate the relation between GI and green innovation strategy.	Organizational Identity Theory and Organizational Legitimacy Theory.	Quantitative	Green innovation strategy positively impacts GI.	The researchers recommended that future studies should use secondary data.
Kraus et al. (2020)	Malaysia	To assess the effect corporate social responsibility on environmental performance.	Natural Resource-Based view Theory	Quantitative	They found corporate social responsibility has no direct impact on EP but has a positive relationship with environmental strategy and GI.	Future research should focus on using green capability and green transformational leadership as mediators between corporate social responsibility and EP.
Huang et al. (2018)	China	To evaluate the relation connecting green innovation performance, environmental innovation strategy and resource alignment.	Ecological Modernization Theory and Resource-Based Theory	Quantitative	The findings reveal that environmental innovation strategy and resource alignment between partners are associated with green innovation performance.	Future studies should use longitudinal research approach to carry out the study.

CHAPTER THREE

RESEARCH METHODOLOGY AND ORGANIZATIONAL PROFILE

3.1 Introduction

This chapter presents the methodological approaches that were used in conducting the study. The researcher begins with a discussion on the research paradigm employed. The chapter further discusses research approaches and justifies the choices of research approach. The chapter also makes a case for the design for this study, the sampling procedures and sample sizes for the study. The data collection and analysis techniques are also discussed in this chapter. The chapter concludes with a summary.

3.2 Research Design

For this study, the use of the positivist paradigm was relevant because there is an assumption that a good green design, green innovation would create a very supportive working environment that improves environmental performance in mining firms in Ghana. This is an observable reality. Therefore, based on this paradigm, the researcher sought to test the hypothesis that originated from the theory by objective data of facts gathered through sensual observation in which the researcher was independent of the phenomenon being studied and therefore administered questionnaires to employees of mining firms and without influencing their opinions on the subject of study.

In light of what was discussed above, the paradigm viewpoint informed the decision to use an explanatory research design rather than a descriptive or exploratory one for this investigation. This is because the quantitative method was used in this study. Furthermore, the study was cross-

sectional rather than longitudinal, using terminology from Okesina (2020), as data were collected over the course of three months. Therefore, this research design supports this study.

3.3 Population of the Study

Population is the set of individual persons or objects in which an investigator is primarily interested during a research inquiry (Igwenagu, 2016). It describes the total number of people or items that one wishes to understand. In this study the population describes all the permanent staff or employees of the selected mining companies in the Western Region of Ghana. A preliminary field survey revealed that the number of employees for the targeted mining firms was 3902.

3.4 Sample Size and Sampling Technique

A sample size represents the population the researcher utilized, and from whom inferences are made (Babbie, 2020). In determining the sample size for a small population, Wagner and Stehman (2015) argue that the sample size should be approximately 30% of the population. The author further indicated that the sample size should be around 10% in the case of a large population. According to Ary, Jacob, Sorensen, and Walker (2018), a significant factor in sample size determination is retrospectivity, and not necessarily its size. It can therefore be argued that the determination of sample size is very much of an 'educated' personal choice. Yamane (1967:886) provides a simplified formula to calculate sample sizes. This formula was used to calculate the sample size.

The formula is given as;

$$n=\frac{N}{1:+N(e^2)}$$

Where n is the sample size, N is the population size, and e is the level of precision. When this formula is applied to the above example, we get

$$n=\frac{3902}{1:+3902(0.05^2)}$$

n=332 firms

This study purposively used senior executives, operational managers, supply chain managers, warehouse and store managers and other middle or functional managers who have experience and knowledge in the area of the study to provide in-depth information for analytical purposes.

3.5 Data Collection

The two key sources of data for most research is primary and secondary. While primary data consists of first-hand materials that the researcher has gathered himself or herself mainly using questionnaires (Dubey et al., 2016), secondary data in contrast is the information that has been collected by other individual (s) for other purposes (Bryman and Bell, 2007). In this study the main source of data collection is primary. To support or reject the findings from this study, data from secondary sources were reviewed. The primary source of data includes information gathered through questionnaires that were administered to the respondents sampled from pharmaceutical firms in Ghana. In gathering the primary data required in this study, a cross-sectional survey design is utilized. A structured questionnaire with a mainly close-ended format was self-administered to the respondents. A team comprising the researcher and research assistants will visit the metropolitan and municipalities to administer the questionnaires in addition to the online survey. Before the questionnaires are administered, an introductory letter was obtained from Kwame Nkrumah University of Science and Technology, Department of Supply Chain and Information Systems, and presented to the selected establishment Human Resources Managers (HR)/ Chief Executive Officer (CEO). The CEO or HR manager after being satisfied with the demands of the research then issued a letter introducing the team to the

workers. After obtaining the approval, the researcher will seek the consent of the respondents before administering the questionnaire. To achieve this purpose the researcher will explain in detail the aim and importance of the study to the respondents before they decided to participate in the study. Also, part of the questionnaire preamble will reiterate the promise of confidentiality of the data. The team will distribute three hundred (300) questionnaires to compensate for non-response. For each randomly selected organization, we identified a key informant, who typically had a title such as supply chain managers who were in charge of the company's internal and external processes. The study targeted these executives and other top and middle-level managers as they are most knowledgeable about organizational issues and their application in other business functions. The questionnaire was the main instrument used to collect primary data. A well-structured questionnaire containing measurement items validated in previous studies will be employed in the study. Each of the variables was measured based on a five (5) point Likert which ranged from 1 (strongly disagree) to 5 (strongly agree). The questionnaire will be structured to reflect the relevant objectives of the research. The questionnaire helped to solicit responses to test all the key variables in the conceptual framework of the study. Using a Five-point Likert scale point (1= "Strongly Disagree" to 5= "Strongly Agree"), each item was measured. The preliminary part consisted of demographic measures which included gender, educational background, work experience, and position within the firm of the participants, of the categorization questions included in the survey, captured the kind of company. The constructs and their respective measures are shown in the appendix.

3.6 Data Processing and Analysis

Data analysis is the process of employing a systematic technique to derive conclusions from field-collected data, as well as taking into account the numerous procedures that can be employed

to examine the data (Churchill and Iacobucci, 2009). The researchers also propose that the research design, the type of data and the assumptions used in the research, as well as the issues associated with the study, will impact the applicability of a specific technique. In examining the vast quantity of data collected in the field, data analysis may follow quantitative or qualitative processes. In a quantitative environment, the procedure entails the application of statistical methods to describe and analyze variation in the quantitative measures. To comprehend and establish links between conceptions, the quantitative method stresses the use of either inferential or descriptive statistics (statistical methods).

Statistical Package for the Social Sciences (SPSS) version 23 and SmartPLS 3 will be used to conduct descriptive and inferential statistics, respectively, in this study. The acquired information will be encoded, cleansed, and readied for analysis. Initially, the data would be coded in Microsoft Excel. Excel data will be extensively inspected to prevent data entering errors. After data cleansing, it will be exported to SPSS. SPSS's data checks include missing values, reliability, descriptive statistics, and multivariate analysis assumption testing. Subsequently, Smart-PLS version 3 (Ringle et al., 2015) will be utilized to analyze multivariate data using inferential statistics.

3.7 Reliability and Validity

In quantitative research, evaluating the measurement model is crucial since it ensures the validity and results. Nonetheless, researchers must concentrate on enhancing the quality of their work (Heale and Twycross, 2015). Again, there are two crucial aspects to consider when evaluating the measurement model: the reliability and validity of the intended study instrument (Saunders, Lewis, and Thornhill, 2016). Khalid et al. (2012) defined dependability measurement as the degree to which a measurement is free of random error by consistently producing the same

outcome. Simultaneously, it is referred to as internal consistency of measurement, which reflects the same fundamental construct (Cooper and Schindler, 2003). Hair et al. (2012) devised two tests of reliability to determine the dependability of an instrument: internal consistency and indicator of reliability. Cronbach Alpha was utilized for internal consistent reliability. According to Hair, Sarstedt, Ringle, and Mena (2012), indicator reliability is used to quantify the indicator's variance in order to explain the latent construct, where each indicator's absolute standardized loading must be more than 0.70. (Hair, Ringle, and Sarstedt, 2011). The researchers argue that indicator loadings between 0.4 and 0.7 should be removed from the scale if removing the indication increases the composite reliability above the approved level. However, if the indicator loading is less than or equal to 0.70, it must always be deleted from the reflective scale. Zikmund (2000) defined validity as the precision of the measuring instrument and the capacity of a scale to measure what is intended to be measured. For quantitative research, the researcher must guarantee that the three classic kinds of validity, namely face validity, content validity, and construct validity, exist in the measurement instrument (Heale and Twycross, 2015).

3.8 Ethical Considerations/Issues

Ethics are the moral standards a person must adhere to regardless of place or time (Akaranga and Makau, 2016). Research ethics center on the moral ideals that researchers in their particular fields of study must uphold (Fouka and Mantzorou, 2011). A permission form was provided to the authorities of all selected companies in order to advise them of the potential benefits and dangers of participation and to seek their approval for inclusion in the study. Select businesses were permitted to decline participation in the study. On the consent form, the researcher indicated that all types of anonymity and confidentiality would be observed. Also observed was the right of businesses to determine the time, scope, and conditions of information exchange. In their

interactions with subjects, the researcher refrained from engaging in any deceptive practices. In addition, the researcher avoided all sorts of plagiarism and data manipulation.

3.9 Profile of Organization

The mining industry in Ghana predates the colonial era. Ghana was once known as the Gold Coast, and Ghanaians searched for gold using pickaxes, shovels, and pans. Along riverbanks, they washed or "panning" for gold or dug holes to find deposits of gold dust and nuggets. Prior to 1983, the majority of Ghana's mining production was held by the state. Since the Economic Recovery Program, however, Ghana has welcomed international investment and pursued privatization and state divestment. The sector is now dominated by foreign ownership, but the Ghanaian government retains a minority (10%) carrying interest in the majority of operational large-scale mining. The industry of small-scale mining is designated for Ghanaians.

The mining sector of Ghana produces 5% of the country's gross domestic product, minerals account for 37% of overall exports, and gold contributes more than 90% of the total mineral exports. Ghana is Africa's leading gold exporter in 2019, surpassing South Africa's output of 4.8 million ounces. Gold is the nation's leading foreign exchange earner, and its revenues are a significant contributor to government budget allocations. Manganese, bauxite, and diamonds are other commercially mined minerals in Ghana. Ghana has also discovered commercial quantities of lithium and hopes to recruit investors in order to mine and develop lithium processing. Small-scale miners, many of whom operate illegally, extract a significant portion of Ghana's resources. The majority of Ghana's mining industry consists of legally sanctioned mining by multinational corporations. From Canada to Australia, more than 20 large mining corporations operate in Ghana. In addition to abundant untapped iron ore, limestone, columbite-tantalite, feldspar, quartz, and salt deposits, there are also modest concentrations of ilmenite, magnetite, and rutile.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND DISCUSSION OF RESULT

4.1 Introduction

Chapter four presents a statistical analysis of chapter three's contents. This chapter has four sections. First, data analysis is presented, followed by demographic profiles. This component included descriptive and correlational study variable analyses. Last part discusses model fit index and confirmatory factor analysis. Using the structural model, the investigation's hypotheses are tested. The conclusion discusses the key results.

4.2 Exploratory Factor Analysis

Initially, the study performed an exploratory study of the data. As a first step in determining the reliability of the data, an exploratory factor analysis was performed. In this case, SPSS was used. Response rate, non-response bias, and common method bias or variance are all discussed here. The tests and interpretation that went into this preliminary analysis of data quality are outlined in sub-sections.

4.2.1 Response Rate

The percentage of those who answered the survey is often reported. The percentage is calculated by dividing the total number of surveys sent out by the total number of answers. It is unusual for surveys to get a response rate of 50% or higher. Information was gathered from November 4, 2022, through December 22, 2022. Study participants were limited to 332, although 350 surveys were sent out to ensure a response. Previous studies (Sun et al., 2022; López, 2022; Lavidas, et al., 2022) indicate that a response rate of 100.0% is satisfactory for analysis from a total of 332 questionnaires that were deemed relevant after review.

Table 4.1: Responses Rate

Distributed	Collected	Percentage of Usable
Response	332	100.0%
Non-Response	0	0.0%
Total	**332**	**100%**

4.2.2 Test for Common Method Bias and Sampling Adequacy

Survey studies must test for CMB since reliance on a single respondent might alter the connection between predictors and dependent variables (Podsakoff and Organ, 1986; Bahrami et al., 2022). Thus, incorrect judgments. Podsakoff et al. (2003) found CMB in consistency or social desirability. Several methods may reduce data output from CMB. The Exploratory Factor analysis confirmed Harman's single component method by showing that a single factor could explain less than 50% of the variation. The principal component analysis explained a 46.6% variance.

Table 4.2: Common Method Bias

Component	Initial Eigenvalues			Extraction Sum of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.851	46.582	46.582	8.851	46.582	46.582
2	2.118	11.147	57.729	2.118	11.147	57.729
3	1.602	8.432	66.161	1.602	8.432	66.161
4	0.955	5.025	71.186			
5	0.834	4.391	75.577			
6	0.581	3.059	78.636			
7	0.508	2.676	81.311			
8	0.495	2.604	83.915			
9	0.446	2.349	86.264			
10	0.393	2.069	88.333			

11	0.349	1.836	90.169			
12	0.326	1.717	91.886			
13	0.309	1.625	93.512			
14	0.252	1.329	94.84			
15	0.239	1.257	96.097			
16	0.222	1.169	97.266			
17	0.193	1.017	98.284			
18	0.172	0.903	99.187			
19	0.155	0.813	100			
Extraction Method: Principal Component Analysis.						

The sphericity of the samples was determined using the Bartlett test and the Kaiser-Meyer-Olkin (KMO) test. Table 4.3 shows that the level of Kaiser-Meyer-Olkin sampling accuracy is 91.9% and that the results of Bartlett's test imply statistical significance (Approx. Chi-Square = 8181.298, df: 190, Sig. = 0.000). The results prove that the samples were collected correctly.

Table 4.3: Bartlett's Test of Sphericity and KMO test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.919
Bartlett's Test of Sphericity	Approx. Chi-Square	8181.298
	df	190
	Sig.	0.000

4.2.2 Non-response Bias

Non-response bias was investigated. Non-response bias results from fewer survey responders than population members. If survey response rates are poor, non-response bias may affect sample validity and generalizability. Early and late replies were compared to reduce non-response bias. Oppenheim (2001) required that "early responders" and "late responders" have identical input variables to use the same model. This shows the sample was representative of the population.

Both early and late responses scored 166. T-tests assessed non-response bias. Inconclusive t-test findings (see Table 4.4). First- and last-month construct data were identical.

Table 4.4: Results of Independent-Samples t-Test for Non-Response Bias

			Levene's Test for Equality of Variances		
Variables	**Group**	**Mean**	**F**	**Sig.**	**T**
Green Design Sustainability	1	14.53	0.042	0.838	-0.144
	2	14.61			-0.144
Green Innovation	1	26.93	0.004	0.95	-0.038
	2	26.96			-0.038
Environmental Performance	1	34.52	0.138	0.71	-0.276
	2	34.79			-0.276

4.3 Demographic Information

In order to provide context for the study, this section presents demographic data about the persons and organisations that were surveyed. Key information collected from respondents includes: gender, age, educational level, position, and firm age. The 332 responses were 44.3% female and 55.7% male. Males dominated the study. 10.8% were over 50, 25.0% were 18–30, 46.7% were 31–40, and 17.5% were 41–50. Participants were mostly 31–40. Table 4.5 shows that 56.0% had a bachelor's degree, 11.1% had a diploma, and 32.8% had graduate degrees (Master's or Ph.D.). The majority held bachelor's degrees. 29.8% were business owners, 47.3% were business owners and managers, 18.7% were managers, and 4.2% were production managers. Most participants were business owners and managers, according to the results. 12.0% of the 332 companies have been in existence for 1–5 years, 31.6% for 11–15 years, 6.3 percent for more than 16 years, and 50.0 percent for 6–10 years. Most businesses are 6–10 years old, according to research.

Table 4.5: Demographic Information

Variables	Items	Frequency	Percentage
Gender	Female	147	44.3
	Male	185	55.7
Age	18-30 years	83	25.0
	31-40 years	155	46.7
	41-50 years	58	17.5
	Above 50 years	36	10.8
Level of Education	Bachelor Degree	186	56.0
	Diploma	37	11.1
	Graduate Studies (Master / Ph.D.)	109	32.8
Your Position in the Firm	Business Owner	99	29.8
	Business Owner and Manager	157	47.3
Position in the firm	Manager	62	18.7
	Production Manager	14	4.2
How many years have your firm been in operation?	1 - 5 years	40	12.0
	11 – 15 years	105	31.6
Years of firm operation	16 years and above	21	6.3
	6 - 10 years	166	50.0
	Total	**332**	**100.0**
Gender	Female	147	44.3
Number of employees	Male	185	55.7
Age	18-30 years	83	25.0
	31-40 years	155	46.7
Firm ownership	41-50 years	58	17.5
	Above 50 years	36	10.8
Level of Education	Bachelor Degree	186	56.0

Source: Field Data, 2023

4.4 Correlation Analysis

The correlation coefficients between EP and GDS ($r = 0.216$, $P < 0.05$), EP and GI ($r = 0.265$, $P < 0.05$), and GDS and GI ($r = 0.861$, $P < 0.05$) are all very high in Table 4.6. A correlation value

of 0–0.30 indicates a weak link, 0.30–0.70 is a moderate correlation, and 0.70–1.0 is a strong correlation. The variables are strongly correlated.

Table 4.6: Correlation Analysis

Variable	1	2	3
Environmental Performance	1.000		
Green Design Sustainability	0.216	1.000	
Green Innovation	0.265	0.861	1.000

Source: Field survey (2023); **. Correlation is significant at the 0.01 level (2-tailed).

4.4 Measurement Model Assessment

Validity assessment of research models is crucial. The study's authors utilised Cronbach's alpha and the Composite reliability test to evaluate the model's consistency. To test the reliability of the model, we employed AVE and indication loadings. Cronbach's alpha was calculated to be 0.7, and a composite reliability score was utilised to examine the degree to which the various constructs in this research were consistent with one another. Table 4.7 shows that both Cronbach's alpha and the composite reliability index are higher than .80 (Hair, et al., 2016). The properties of the measurement model are supported by these results. There was no sign with a loading below 0.7. Convergent validity may be established. For AVE values over 0.5, convergent validity was established (see Table 4.6.) Table 4.7 shows that the T test found all of the variables to be statistically significant at the 1.96-percentile level and Sig. < 0.05. Check out Table 4.7 for more descriptive statistics. Calculated as: (Mean and Standard Deviation). The average in the table ranges from 3.512 to 4.016. The range of standard deviations was 1.066-1.389.

Table 4.7: Reliability and Validity

Scale	Code	Outer Loadings	T statistics (|O/STDEV|)	P values	Mean	Std. Dev	Skewness
Environmental Performance (CA = 0.962; CR = 0.964; AVE = 0.768)	EP1	0.846	55.510	0.000	4.016	1.095	-0.916
	EP2	0.885	84.900	0.000	3.949	1.066	-0.84
	EP3	0.853	57.240	0.000	3.91	1.15	-0.878
	EP4	0.877	71.388	0.000	3.823	1.21	-0.771
	EP5	0.918	111.642	0.000	3.797	1.291	-0.76
	EP6	0.830	42.483	0.000	3.768	1.282	-0.717
	EP7	0.931	176.074	0.000	4.006	1.088	-0.779
	EP8	0.836	49.431	0.000	3.923	1.088	-0.882
	EP9	0.906	101.227	0.000	3.958	1.12	-0.852
Green Design Sustainability (CA = 0.941; CR = 0.948; AVE = 0.850)	GDS1	0.921	80.382	0.000	3.482	1.389	-0.318
	GDS2	0.941	193.492	0.000	3.512	1.363	-0.366
	GDS3	0.956	201.053	0.000	3.548	1.365	-0.473
	GDS4	0.866	62.112	0.000	3.994	1.275	-1.258
Green Innovation (CA = 0.957; CR = 0.960; AVE = 0.796)	GI1	0.873	51.474	0.000	3.828	1.181	-0.776
	GI2	0.921	132.671	0.000	3.75	1.232	-0.484
	GI3	0.929	148.840	0.000	3.901	1.111	-0.544
	GI4	0.912	99.147	0.000	3.771	1.206	-0.598
	GI5	0.890	69.114	0.000	3.94	1.131	-0.822
	GI6	0.876	64.081	0.000	3.886	1.092	-0.79
	GI7	0.842	40.311	0.000	3.828	1.191	-0.813

The study also examined the differences between constructs (Hair et al., 2010; Henseler et al., 2016b). When assessing discriminant validity, each latent variable's square root of the AVE (diagonal value) must be bigger than the construct's maximum correlation. Table 4.8 shows discriminant validity. Again, multicollinearity is not present (Byrne, 2013). Table 4.8 reveals that Environmental performance is 0.876 with itself, 0.216 with Green design sustainability, and

0.265 with Green innovation. Green design sustainability was 0.922 with itself and 0.861 with Green innovation. Green innovation correlated with 0.892.

Table 4.8: Fornell-Larcker test

Constructs	1	2	3
Environmental Performance	0.859		
Green Design Sustainability	0.307	0.804	
Green Innovation	0.398	0.640	0.770

A more rigorous measurement of discriminant validity, the heterotrait-monotrait (HTMT) ratio of correlations, has been developed as a reaction to criticisms leveled against the Fornell-Larcker criteria (Hair et al., 2019; Henseler et al., 2015; Voorhees et al., 2016). According to studies, it's best to use HTMT scores below 0.90, which would be characterized as the geometric mean of the average correlations for scales to measure the very same variable divided by the average value of the items' correlations across constructs (Henseler et al., 2015). According to Table 4.89 the model is valid up to an HTMT of 0.723

Table 4.9: HTMT Test results

Constructs	1	2	3
Environmental Performance			
Green Design Sustainability	0.685		
Green Innovation	0.778	0.695	

4.5 Model Fit Indices

The values for the Extracted-Index Fitness, SRMR, Root Mean Square of Approximation, and Chi-Square are all appropriate (Table 4.10). Both the rare and extracted indices are much lower than 0.9, the threshold for acceptability. Considering that the square of the residual is not close

to zero, the root demonstrates that the residual is unsatisfactory. The Root Mean Square Approximation and the Total Residual Value are both unacceptable. These numbers are much larger than 0.1 and 3. This suggests that all relevant factors need to be taken into account in future research. An SRMR of 0.045 was found in Table 4.9, which is within the range of values considered acceptable in this research. Chi-square = 3363.489, and the normed fit index was 0.858.

Table 4.10: Model Fit Indices

Model fitness indices	Estimated model
SRMR	0.045
d_ULS	0.423
d_G	0.646
Chi-square	3363.489
NFI	0.858

As shown by coefficient of determination analyses, the independent factors do account for part of the variance in the dependent variable (R2). Calculating R2 indicates how well the result was predicted by the independent variables. Predictive significance was defined as an R2 of 0.10 or above by Falk and Miller (1992). Table 4.11 shows that both Environmental performance and Green innovation have high levels of predictive accuracy (adjusted R2).

Table 4.11: Coefficients of Determination (R2) and R2Adjusted

Construct	R-square	R-square adjusted
Environmental Performance	0.071	0.069
Green Innovation	0.740	0.740

A second method for validating PLS models is using Q2 (Hair et al., 2020). This statistic is generated by randomly removing a data point, replacing it with an appropriate value, then computing the model's phase (Zhang, 2022). Model explanatory power and sample data

predictions are used in Q2 (Hair et al., 2020). This approximate value aids the blind method in making sense of output data. When Q2 outcomes are better than expected and estimates are near to baseline, accuracy increases (Zhang, 2022). For endogenous estimations to be valid, Q2 must be greater than zero. Q2 greater than 0, 0.25, and 0.50 generates low, medium, and low predictions from the PLS path model, respectively. (Zhang, 2022). In the second quarter, the study received scores of 0.041 and 0.737, respectively, for environmental performance and green innovation (Table 4.12). All Q-square values over 0.5 indicate a highly predictive model fit.

Table 4.12: The Predictive Power of the PLs Model

Construct	**Q^2predict**
Environmental Performance	0.041
Green Innovation	0.737

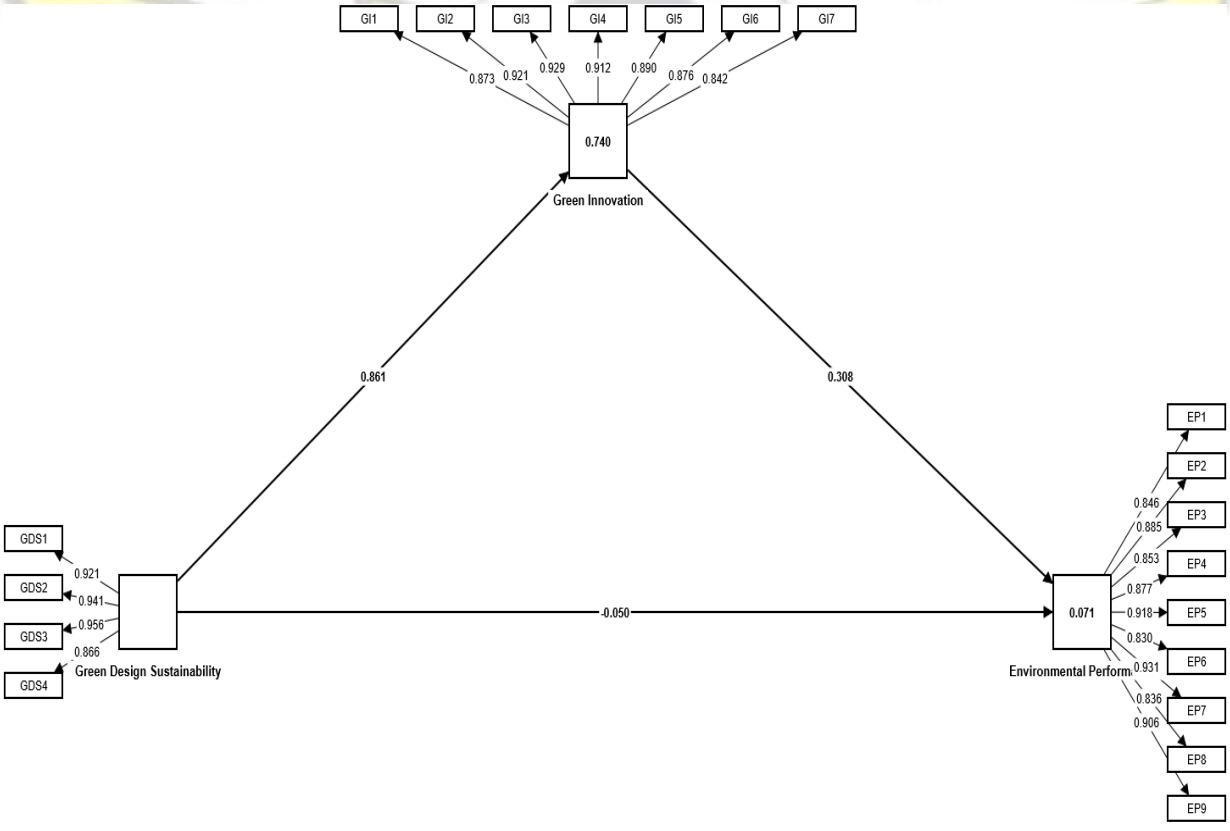


Figure 4.1: Measurement Model Assessment

4.6 Hypotheses for Direct Relationship

The research hypotheses are investigated using SmartPLS 4. Table 4.12 displays the findings. Bootstrapping is then used to examine the mediation and moderation models in this study 5,000 times, with replacement, and the standard error will be computed in accordance with the confidence level of the evaluative model (Hair, Sarstedt, Hopkins and Kuppelwieser, 2014). This study analyses the impact of green design sustainability on environmental performance through the mediation effect of green innovation.

Table 4.13: Hypotheses for Direct and Indirect Relationship

Path	Path Coefficient	T statistics (|O/STDEV|)	P values	Hypothesis Validation
Green Design Sustainability -> Environmental Performance	-0.050	0.638	0.523	Not Accepted
Green Design Sustainability -> Green Innovation	0.861	62.881	0.000	Accepted
Green Innovation -> Environmental Performance	0.308	3.669	0.000	Accepted
Green Design Sustainability -> Green Innovation -> Environmental Performance	0.265	3.650	0.000	Accepted

Table 4.12 shows that the relationship between green design sustainability and environmental performance is not significant (B = -0.050, t = 0.638, P = 0.523, and Sig > 0.05). Given that the p-value for H1 was more than 0.05 and the path coefficient was negative, it can be concluded that green design sustainability does not have a direct effect on environmental performance. This suggests that when the sustainability of green design declines, environmental performance also declines. Sustainability in green design reduces environmental performance by 5%.

Green design sustainability directly affects green innovation (B = 0.861; t = 62.881; P = 0.000; Sig < 0.05). The path coefficient was positive and the p-value for H2 was less than 0.05,

indicating a significant positive direct influence on green design sustainability to green innovation. Green design sustainability enhances green innovation because the path coefficient is positive. Green design sustainability accounts for 86.1% of green innovation.

Green innovation directly affected environmental performance (B = 0.308; t = 3.669; P = 0.000; Sig < 0.05). Since the p-value was less than 0.05 and the path coefficient was positive, green innovation had a significant direct influence on environmental performance, validating the third hypothesis (H3). The positive path coefficient indicates that environmental performance will improve with green innovation. Green innovation boosts environmental performance by 30.8%.

Green innovation indirectly affected green design sustainability and environmental performance (B = 0.265; t = 3.650; P = 0.000; Sig < 0.05). Green innovation mediates green design sustainability and environmental performance positively since the p value for H4 was less than 0.05 and the path coefficient was positive. The positive path coefficient indicates that green innovation positively and fully mediates interactions between green design sustainability and environmental performance. This also means that green innovation mediates 26.5% of the GDS-EP connection.

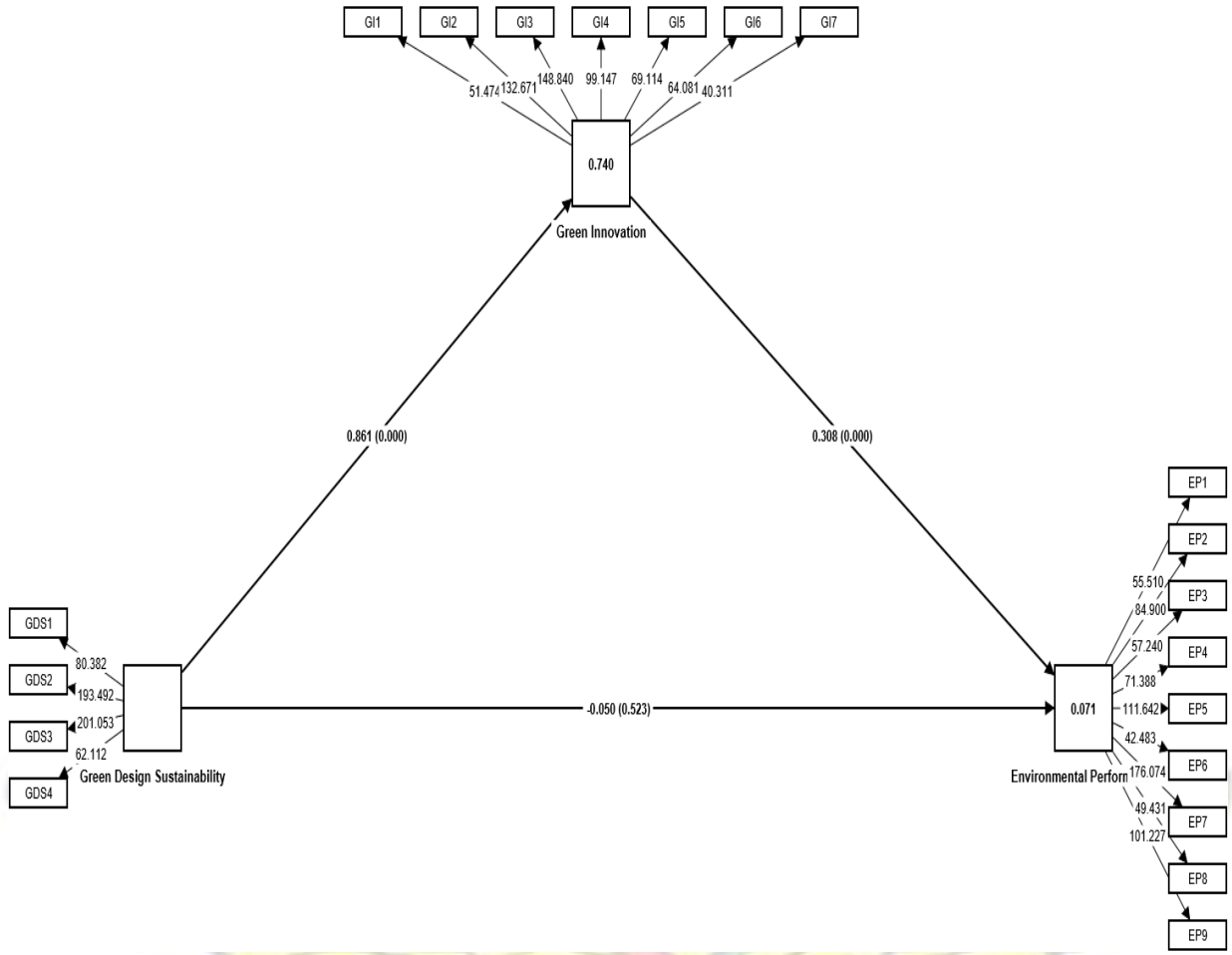


Figure 4.2 Structure Model Evaluation

4.7 Discussion of Findings

The results of the study are discussed in light of the previous research in this section. In particular, it discusses how the relationship between green design sustainability and environmental performance may be explained by the mediating function of green innovation. Objectives on the relationship between the variables are then investigated further.

4.6.1 Effect of Green Design Sustainability on Environmental Performance

The initial objective examines the effect of green design sustainability on environmental performance. The result reveals that green design sustainability does not have a direct effect on environmental performance. This suggests that when the sustainability of green design declines, the environmental performance also declines. Sustainability in green design reduces environmental performance by 5%. This means that firms should try to work with customers on eco-design to reduce the environmental effect, develop products and packaging that may be reused, mended, or recycled, surpasses legal environmental laws, uses alternative energy, reduces water use, and frequently examines the environment. The prior study's results are in line with the current finding. The research of Wakulele et al. (2017) demonstrates that eco-design techniques positively affect the performance of organizations, most notably in the areas of decreased environmental impact and increased financial performance. Eco-design may improve environmental performance by reducing emissions and waste and raising awareness and concern. Kour et al. (2020) demonstrate that top firms may pursue ecologically advanced low-emission solutions that simultaneously provide other sustainable competitive advantages (Fernando, 2017). Companies that make things with the fewest emissions have a first-mover advantage (García-Sánchez et al., 2021). If a company claims its products are ecologically friendly yet produces a lot of waste and emissions in production, its reputation and image are at risk (Kour et al., 2020). Wagner (2016) illustrates that an organization's environmental management technology only performs well when it prevents pollution. Thus, it may improve product quality, efficiency, productivity, and cost. Preventing pollution may improve the company's energy, water, and resource efficiency by reducing the input needed to produce a given output (Wagner, 2016). Dost et al. (2019) found that pollution-prevention devices boost company production. Improved environmental performance may higher assets by opening new markets, differentiating

products, and controlling pollutants. Risk management, stakeholder relations, raw material, utility, labor, and capital costs may all decrease (Ambec and Lanoie, 2008). The Eco-design team gets management assistance by analyzing the technical capability and commercial potential of a modified product.

4.6.2 Effect of Green Design Sustainability on Green Innovation

The next objective of this study ascertains the relationship between green design and green innovation. The result indicates a significant positive direct influence on green design sustainability to green innovation. Green design sustainability enhances green innovation because the path coefficient is positive. Green design sustainability accounts for 86.1% of green innovation. This means that firms should work with customers on eco-design to design eco-friendly products, eliminates hazardous waste and materials in their production operations, and employs products that save coal, oil, power, and water. Ecodesign devises aid businesses in determining their negative environmental effect and developing more sustainable goods, procedures, structures, and advertising strategies (Baumann, Boons, and Bragd, 2002; Rousseaux et al., 2017). Types of ecodesign tools have been developed by scholars to aid businesses in selecting the most suitable ecodesign tool for their needs (Brink, Destandau, and Hamlett, 2009; Faludi, 2017; Rousseaux et al., 2017; Bovea and Pérez-Belis, 2012).

4.6.3 Effect of Green Innovation on Environmental Performance

The following objective establishes the effect of green innovation on environmental performance. The result shows that green innovation had a significant direct influence on environmental performance. The positive path coefficient indicates that environmental performance will improve with green innovation. Green innovation boosts environmental performance by 30.8%. This means that firms should design eco-friendly products, eliminates

hazardous waste and materials in their production operations, employs products that save coal, oil, power, and water to reduce the environmental effect, develop products and packaging that may be reused, mended, or recycled, surpasses legal environmental laws, uses alternative energy, reduces water use, and frequently examines the environment. Green innovation is connected to an organization's environmental management strategy and improves environmental performance, as shown by some research (Adegbile et al., 2017; Kammerer, 2009; Chen et al., 2006). Furthermore, a company's financial and social performance may benefit from the green product and process innovation by cutting down on waste and expenses (Weng et al., 2015). Green innovation is best understood not as a firm's reactive measures towards stakeholder pressures, but rather as a proactive organizational intention and practice to improve environmental performance for the sake of competitive advantage (Kratzer et al., 2017; Lin, Tang, and Geng, 2013; de BurgosJiménez et al., 2013). Evidence from several sources, including Oliva et al. (2019), Chen et al. (2015), Dubey et al. (2015), and Darnall et al. (2008), supports the idea that businesses may enhance their environmental performance by integrating sustainability issues into their operations and product development.

4.6.4 Mediating Effect of Green Innovation

The final objective of this study assesses the mediating role of green innovation on the link between green design sustainability and environmental performance. The result also shows that green innovation mediates green design sustainability and environmental performance positively. The positive path coefficient indicates that green innovation positively and fully mediates interactions between green design sustainability and environmental performance. This also means that green innovation mediates 26.5% of the GDS-EP connection. This means that firms should design eco-friendly products, eliminates hazardous waste and materials in their

production operations, and employs products that save coal, oil, power, and water in order to enhance firms' work with customers on eco-design to reduce the environmental effect, develop products and packaging that may be reused, mended, or recycled, surpasses legal environmental laws, uses alternative energy, reduces water use, and frequently examines the environment. Prior studies finding were in line with the current study's findings. The research of Ullah et al. (2022) demonstrated that green innovation mediates the link between green intellectual capital and environmental performance. However, there is strong empirical data that suggests an innovative culture may boost productivity (Padilha and Gomes, 2016). Thus, green innovation serves as a bridge between ecological sustainability and the provision of economic benefits (Chang, 2011). In other words, green innovation will likely be both a deciding factor and a mediating construct when the green design of the firm serves as its fundamental axis to improve environmental outcomes. It is not only prescriptive policy that should be considered whether green innovation inside a firm is positively correlated with organizational success; rather, there must be additional forces driving the organization from within. This is because its design is founded on principles that promote long-term economic stability (Aguilera-Caracuel and Ortiz-de-Mandojana, 2013). The environmental performance of a business may be measured by how well it fosters green innovation inside the organization (Chen, Chang, and Lin, 2014). In addition, a firm's environmental performance will improve when green standards of practice are integrated into corporate strategy and embraced by staff as part of their environmental vision (Chen, Tang, Jin, Li, and Paillé, 2015).

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS FOR FUTURE RESEARCH

5.1 Introduction

The main aim of the study is to examine the effects of green design sustainability on environmental performance and the mediation role of green innovation in mining firms in the Western Region of Ghana. The first part of the chapter provides a quick overview of the study's findings and its conclusion. Recommendations for further research are included at the end of the chapter.

5.2 Summary of Findings

5.1.1 Effect of Green Design Sustainability on Environmental Performance

The initial objective examines the effect of green design sustainability on environmental performance. The result reveals that green design sustainability does not have a direct effect on environmental performance. This suggests that when the sustainability of green design declines, the environmental performance also declines. This means that firms should try to work with customers on eco-design to reduce the environmental effect, develop products and packaging that may be reused, mended, or recycled, surpasses legal environmental laws, uses alternative energy, reduces water use, and frequently examines the environment.

5.1.2 Effect of Green Design Sustainability on Green Innovation

The next objective of this study ascertains the relationship between green design and green innovation. The result indicates a significant positive direct influence on green design sustainability to green innovation. This means that firms should work with customers on eco-

design to design eco-friendly products, eliminates hazardous waste and materials in their production operations, and employs products that save coal, oil, power, and water.

5.1.3 Effect of Green Innovation on Environmental Performance

The following objective establishes the effect of green innovation on environmental performance. The result shows that green innovation had a significant direct influence on environmental performance. This means that firms should design eco-friendly products, eliminates hazardous waste and materials in their production operations, employs products that save coal, oil, power, and water to reduce the environmental effect, develop products and packaging that may be reused, mended, or recycled, surpasses legal environmental laws, uses alternative energy, reduces water use, and frequently examines the environment.

5.1.4 Mediating Effect of Green Innovation

The final objective of this study assesses the mediating role of green innovation on the link between green design sustainability and environmental performance. The result also shows that green innovation mediates green design sustainability and environmental performance positively. This implies that green innovation positively and fully mediates interactions between green design sustainability and environmental performance. This means that firms should design eco-friendly products, eliminates hazardous waste and materials in their production operations, and employs products that save coal, oil, power, and water in order to enhance firms' work with customers on eco-design to reduce the environmental effect, develop products and packaging that may be reused, mended, or recycled, surpasses legal environmental laws, uses alternative energy, reduces water use, and frequently examines the environment.

5.3 Conclusion

The main aim of the study is to examine the effects of green design sustainability on environmental performance and the mediation role of green innovation in mining firms in the Western Region of Ghana. The study employed an explanatory research design. This survey was conducted using a quantitative approach. Purposive sampling techniques were used to choose 332 participants. A prepared questionnaire was the main tool used for data collection. Both SPSS v26 and SmartPls v4 were used for the statistical analysis. Both descriptive and inferential approaches were used to analyze the data. The result revealed that green design sustainability does not have a direct effect on environmental performance but a direct effect on green innovation. The result showed that green innovation had a significant direct influence on environmental performance. The results also revealed that green innovation positively and fully mediates interactions between green design sustainability and environmental performance. Therefore, the study recommended that firms should design eco-friendly products, eliminates hazardous waste and materials in their production operations, and employs products that save coal, oil, power, and water in order to enhance firms try to work with customers on eco-design to reduce the environmental effect, develop products and packaging that may be reused, mended, or recycled, surpasses legal environmental laws, uses alternative energy, reduces water use, and frequently examines the environment.

5.4 Recommendation

This section provides recommendations based on the findings of the research for various stakeholders. These ideas should be taken into consideration by management and academics.

1. The results revealed that green design sustainability does not have a direct effect on environmental performance. The study, therefore, recommended that firms should try to

work with customers on eco-design to reduce the environmental effect, develop products and packaging that may be reused, mended, or recycled, surpasses legal environmental laws, uses alternative energy, reduces water use, and frequently examines the environment.

2. The results indicated a significant positive direct influence on green design sustainability to green innovation. The study recommended that firms should work with customers on eco-design to design eco-friendly products, eliminates hazardous waste and materials in their production operations, and employs products that save coal, oil, power, and water.
3. The results showed that green innovation had a significant direct influence on environmental performance. The study suggested that firms should design eco-friendly products, eliminates hazardous waste and materials in their production operations, employs products that save coal, oil, power, and water to reduce the environmental effect, develop products and packaging that may be reused, mended, or recycled, surpasses legal environmental laws, uses alternative energy, reduces water use, and frequently examines the environment.
4. Finally, the study found that green innovation positively and fully mediates interactions between green design sustainability and environmental performance. Therefore, the study recommended that firms should design eco-friendly products, eliminates hazardous waste and materials in their production operations, and employs products that save coal, oil, power, and water in order to enhance firms try to work with customers on eco-design to reduce the environmental effect, develop products and packaging that may be reused, mended, or recycled, surpasses legal environmental laws, uses alternative energy, reduces water use, and frequently examines the environment.

5.5 Limitations and Future Research Directions

Numerous possible avenues for further research are obstructed by the constraints of this study. First, only managers from the analyzed firm were included in the study sample. Therefore, a similar study on employees may provide more generalizable results. Causation is difficult to prove using explanatory research design. Future research may use longitudinal and cross-sectional data to empirically determine causality. The quantitative analysis examined green design sustainability, green innovation, and environmental performance. Qualitative research methods may be needed for future comparative studies. This study suggests that future research may benefit from using other statistical analysis methods. Future research may replicate this study in other countries to verify similar results.

REFERENCES

Farrukh, A., Mathrani, S. and Sajjad, A., 2022. A natural resource and institutional theory-based Adegbile, A., Sarpong, D. and Meissner, D., 2017. Strategic foresight for innovation management: A review and research agenda. *International Journal of Innovation and Technology Management*, *14*(04), p.1750019.

Aguilera-Caracuel, J. and Ortiz-de-Mandojana, N., 2013. Green innovation and financial performance: An institutional approach. *Organization and Environment*, *26*(4), pp.365-385.

Albort-Morant, G., Leal-Millán, A. and Cepeda-Carrión, G., 2016. The antecedents of green innovation performance: A model of learning and capabilities. *Journal of Business Research*, *69*(11), pp.4912-4917.

Al-Ghwayeen, W.S. and Abdallah, A.B., 2018. Green supply chain management and export performance: The mediating role of environmental performance. *Journal of Manufacturing Technology Management*.

Al-Sheyadi, A., Muyldermans, L. and Kauppi, K., 2019. The complementarity of green supply chain management practices and the impact on environmental performance. *Journal of environmental management*, *242*, pp.186-198.

Ambec, S. and Lanoie, P., 2008. Does it pay to be green? A systematic overview. *The Academy of Management Perspectives*, pp.45-62.

Anwar, N., Mahmood, N.H.N., Yusliza, M.Y., Ramayah, T., Faezah, J.N. and Khalid, W., 2020. Green Human Resource Management for organisational citizenship behaviour towards the environment and environmental performance on a university campus. *Journal of Cleaner Production*, *256*, p.120401.

Arora, N. K., Fatima, T., Mishra, I., Verma, M., Mishra, J., and Mishra, V., 2018. Environmental sustainability: challenges and viable solutions. *Environmental Sustainability*, *1*(4), 309-340.

Awan, U., Arnold, M.G. and Gölgeci, I., 2021. Enhancing green product and process innovation: Towards an integrative framework of knowledge acquisition and environmental investment. *Business Strategy and the Environment*, *30*(2), pp.1283-1295.

Baumann, H., Boons, F. and Bragd, A., 2002. Mapping the green product development field: engineering, policy and business perspectives. *Journal of cleaner production*, *10*(5), pp.409-425.

Beissinger, M. R., 2022. *The Revolutionary City: Urbanization and the Global Transformation of Rebellion*. Princeton University Press.

Bovea, M.D. and Pérez-Belis, V., 2012. A taxonomy of ecodesign tools for integrating environmental requirements into the product design process. *Journal of Cleaner Production*, *20*(1), pp.61-71.

Brink, G., Destandau, N. and Hamlett, P., 2009. The Living Principles for Design.

Byrne, B.M., 2013. Structural equation modeling with AMOS: Basic concepts, applications, and programming . Hoboken.

Cao, H. and Chen, Z., 2018. The driving effect of internal and external environment on green innovation strategy-The moderating role of top management's environmental awareness. *Nankai Business Review International*, *10*(3), pp.342-361.

Chan, H. K., Yee, R. W., Dai, J., and Lim, M. K., 2016. The moderating effect of environmental dynamism on green product innovation and performance. *International Journal of Production Economics*, *181*, 384-391.

Chang, C. H., and Chen, Y. S., 2012. The determinants of green intellectual capital. *Management decision*.

Chang, C.H., 2011. The influence of corporate environmental ethics on competitive advantage: The mediation role of green innovation. *Journal of business ethics*, *104*(3), pp.361-370.

Chen, Y., Tang, G., Jin, J., Li, J. and Paillé, P., 2015. Linking market orientation and environmental performance: The influence of environmental strategy, employee's environmental involvement, and environmental product quality. *Journal of Business Ethics*, *127*(2), pp.479-500.

Chen, Y.S., Chang, C.H. and Lin, Y.H., 2014. The determinants of green radical and incremental innovation performance: Green shared vision, green absorptive capacity, and green organizational ambidexterity. *Sustainability*, *6*(11), pp.7787-7806.

Chen, Y.S., Lai, S.B. and Wen, C.T., 2006. The influence of green innovation performance on corporate advantage in Taiwan. *Journal of business ethics*, *67*(4), pp.331-339.

Chin, T., Shi, Y., Singh, S.K., Agbanyo, G.K. and Ferraris, A., 2022. Leveraging blockchain technology for green innovation in ecosystem-based business models: A dynamic capability of values appropriation. *Technological Forecasting and Social Change*, *183*, p.121908.

Chouaibi, S., Chouaibi, J., and Rossi, M., 2021. ESG and corporate financial performance: the mediating role of green innovation: UK common law versus Germany civil law. *EuroMed Journal of Business*.

Christainsen, G. B., and Haveman, R. H., 1981. The contribution of environmental regulations to the slowdown in productivity growth. *Journal of environmental economics and management*, *8*(4), 381-390.

Chuang, S. P., and Huang, S. J., 2018. The effect of environmental corporate social responsibility on environmental performance and business competitiveness: The mediation of green information technology capital. *Journal of business ethics*, *150*(4), 991-1009.

Dao, V., Langella, I., and Carbo, J., 2011. From green to sustainability: Information Technology and an integrated sustainability framework. *The Journal of Strategic Information Systems*, *20*(1), 63-79.

Darnall, N., Jolley, G.J. and Handfield, R., 2008. Environmental management systems and green supply chain management: complements for sustainability?. *Business strategy and the environment*, *17*(1), pp.30-45.

Davey, G., 2018. *Ecological learning theory*. Routledge.

de Burgos-Jiménez, J., Vázquez-Brust, D., Plaza-Úbeda, J.A. and Dijkshoorn, J., 2013. Environmental protection and financial performance: An empirical analysis in Wales. *International Journal of Operations and Production Management*.

Dost, M., Pahi, M.H., Magsi, H.B. and Umrani, W.A., 2019. Influence of the best practices of environmental management on green product development. *Journal of environmental management*, *241*, pp.219-225.

Dubey, R., Gunasekaran, A. and Ali, S.S., 2015. Exploring the relationship between leadership, operational practices, institutional pressures and environmental performance: A framework for green supply chain. *International Journal of Production Economics*, *160*, pp.120-132.

El-Kassar, A.N. and Singh, S.K., 2019. Green innovation and organizational performance: The influence of big data and the moderating role of management commitment and HR practices. *Technological forecasting and social change*, *144*, pp.483-498.

Falk, R.F. and Miller, N.B., 1992. *A primer for soft modeling*. University of Akron Press.

Faludi, J., 2017. *Golden Tools in Green Design: What drives sustainability, innovation, and value in green design methods?*. University of California, Berkeley.

Farrell, A.M., 2010. Insufficient discriminant validity: A comment on Bove, Pervan, Beatty, and Shiu (2009). *Journal of business research*, *63*(3), pp.324-327.

Fernando, Y., 2017. An empirical analysis of eco-design of electronic products on operational performance: does environmental performance play role as a mediator?. *International Journal of Business Innovation and Research*, *14*(2), pp.188-205.

Fornell, C. and Larcker, D.F., 1981. Structural equation models with unobservable variables and measurement error: Algebra and statistics.

Fousteris, A. E., Didaskalou, E. A., Tsogas, M. M. H., and Georgakellos, D. A., 2018. The environmental strategy of businesses as an option under recession in Greece. *Sustainability*, *10*(12), 4399.

García-Sánchez, I.M., Gallego-Álvarez, I. and Zafra-Gómez, J.L., 2021. Do independent, female and specialist directors promote eco-innovation and eco-design in agri-food firms?. *Business Strategy and the Environment*, *30*(2), pp.1136-1152.

Griffiths, S., and Sovacool, B. K., 2020. Rethinking the future low-carbon city: Carbon neutrality, green design, and sustainability tensions in the making of Masdar City. *Energy Research and Social Science*, *62*, 101368.

Hair Jr, J.F., Howard, M.C. and Nitzl, C., 2020. Assessing measurement model quality in PLS-SEM using confirmatory composite analysis. *Journal of Business Research*, *109*, pp.101-110.

Hair Jr, J.F., Sarstedt, M., Hopkins, L. and Kuppelwieser, V.G., 2014. Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. *European business review*.

Hair, J. F., Hult, G. T. M., Ringle, C., and Sarstedt, M., 2016. A primer on partial least squares structural equation modeling (PLS-SEM) (2nd ed.). Sage Publications.

Hair, J.F., Black, W.C., Babin, B.J. and Anderson, R.E., 2010. Canonical correlation: A supplement to multivariate data analysis. *Multivariate Data Analysis: A Global Perspective, 7th ed.; Pearson Prentice Hall Publishing: Upper Saddle River, NJ, USA*.

Hameed, Z., Khan, I.U., Islam, T., Sheikh, Z. and Naeem, R.M., 2020. Do green HRM practices influence employees' environmental performance?. *International Journal of Manpower*.

Hart, S.L., 1995. A natural-resource-based view of the firm. *Academy of management review*, *20*(4), pp.986-1014.

He, Y., Kvan, T., Liu, M. and Li, B., 2018. How green building rating systems affect designing green. *Building and Environment*, *133*, pp.19-31.

Hendrickson, C., 2022. Introduction to Green Design By Chris Hendrickson, Noellette Conway-Schempf, Lester Lave and Francis McMichael Green Design Initiative, Carnegie Mellon University, Pittsburgh PA.

Henseler, J., Ringle, C.M. and Sarstedt, M., 2015. A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the academy of marketing science*, *43*(1), pp.115-135.

Henseler, J., Ringle, C.M. and Sarstedt, M., 2016b. Testing measurement invariance of composites using partial least squares. *International marketing review*.

Holmberg, J., and Sandbrook, R. , 2019. Sustainable development: what is to be done?. In *Policies for a small planet* (pp. 19-38). Routledge.

Huang, J.W. and Li, Y.H., 2018. How resource alignment moderates the relationship between environmental innovation strategy and green innovation performance. *Journal of Business and Industrial Marketing*.

Ikram, M., 2022. Transition toward green economy: Technological Innovation's role in the fashion industry. *Current Opinion in Green and Sustainable Chemistry*, p.100657.

Inman, R.A. and Green, K.W., 2018. Lean and green combine to impact environmental and operational performance. *International Journal of Production Research*, *56*(14), pp.4802-4818.

Jacomossi, R. R., Feldmann, P. R., Barrichello, A., and Morano, R. S., 2021. Does ecological sustainability really matter? Evaluation of its mediating role in the relationship between innovation and competitiveness. *BAR-Brazilian Administration Review*, *18*.

Kammerer, D., 2009. The effects of customer benefit and regulation on environmental product innovation.: Empirical evidence from appliance manufacturers in Germany. *Ecological Economics*, *68*(8-9), pp.2285-2295.

Khan, S. A. R., Yu, Z., Umar, M., and Tanveer, M., 2022. Green capabilities and green purchasing practices: A strategy striving towards sustainable operations. *Business Strategy and the Environment*.

Kock, N., 2015. Common method bias in PLS-SEM: A full collinearity assessment approach. *International Journal of e-Collaboration (ijec)*, *11*(4), pp.1-10.

Kour, M., Kaur, R., Bhullar, A. and Chaudhary, R., 2020. Impact of Green Practices on the Financial Performance: A Study of Indian Automobile Companies. *International Journal of Economics and Financial Issues*, *10*(5), p.220.

Kratzer, J., Meissner, D. and Roud, V., 2017. Open innovation and company culture: Internal openness makes the difference. *Technological Forecasting and Social Change*, *119*, pp.128-138.

Kraus, S., Rehman, S.U. and García, F.J.S., 2020. Corporate social responsibility and environmental performance: The mediating role of environmental strategy and green innovation. *Technological Forecasting and Social Change*, *160*, p.120262.

Lavidas, K., Petropoulou, A., Papadakis, S., Apostolou, Z., Komis, V., Jimoyiannis, A. and Gialamas, V., 2022. Factors affecting response rates of the Web survey with teachers. *Computers*, *11*(9), p.127.

Leonidou, L.C., Christodoulides, P., Kyrgidou, L.P. and Palihawadana, D., 2017. Internal drivers and performance consequences of small firm green business strategy: The moderating role of external forces. *Journal of business ethics*, *140*(3), pp.585-606.

Li, D., Zhao, Y., Sun, Y., and Yin, D., 2017. Corporate environmental performance, environmental information disclosure, and financial performance: Evidence from China. *Human and Ecological Risk Assessment: An International Journal*, *23*(2), 323-339.

Lin, R.J., Chen, R.H. and Huang, F.H., 2014. Green innovation in the automobile industry. *Industrial Management and Data Systems*.

Lin, R.J., Tan, K.H. and Geng, Y., 2013. Market demand, green product innovation, and firm performance: evidence from Vietnam motorcycle industry. *Journal of Cleaner Production*, *40*, pp.101-107.

Lisi, W., Zhu, R. and Yuan, C., 2020. Embracing green innovation via green supply chain learning: The moderating role of green technology turbulence. *Sustainable Development*, *28*(1), pp.155-168.

López, M., 2022. The effect of sampling mode on response rate and bias in elite surveys. *Quality and Quantity*, pp.1-17.

MacMillan, C., 2020. Sustainable business model innovation: A means to societal and economic good for Canadian businesses. *International Management Review*, *16*(1), 32-41.

Mahto, R. V., Belousova, O., and Ahluwalia, S., 2020. Abundance–A new window on how disruptive innovation occurs. *Technological Forecasting and Social Change*, *155*, 119064.

Mårtensson, K. and Westerberg, K., 2016. Corporate environmental strategies towards sustainable development. *Business Strategy and the Environment*, *25*(1), pp.1-9.

Mojtahedi, M., and Oo, B. L., 2017. Critical attributes for proactive engagement of stakeholders in disaster risk management. *International journal of disaster risk reduction*, *21*, 35-43.

Muisyo, P., Su, Q., Ho, T. H., Julius, M. M., and Usmani, M. S., 2021. Implications of green HRM on the firm's green competitive advantage: the mediating role of enablers of green culture. *Journal of Manufacturing Technology Management*.

Olawoyin, F.S., 2021. *Impact of Green Innovation on the Performance of Selected Carbonated Drink Manufacturing Companies in Nigeria* (Doctoral dissertation, Kwara State University, Malete).

Oliva, F.L., Semensato, B.I., Prioste, D.B., Winandy, E.J.L., Bution, J.L., Couto, M.H.G., Bottacin, M.A., Mac Lennan, M.L.F., Teberga, P.M.F., Santos, R.F. and Singh, S.K., 2018. Innovation in the main Brazilian business sectors: characteristics, types and comparison of innovation. *Journal of Knowledge Management*.

Padilha, C.K. and Gomes, G., 2016. Innovation culture and performance in innovation of products and processes: a study in companies of textile industry. *RAI Revista de Administração e Inovação*, *13*(4), pp.285-294.

Podsakoff, P.M. and Organ, D.W., 1986. Self-reports in organizational research: Problems and prospects. *Journal of management*, *12*(4), pp.531-544.

Podsakoff, P.M., MacKenzie, S.B., Lee, J.Y. and Podsakoff, N.P., 2003. Common method biases in behavioral research: a critical review of the literature and recommended remedies. *Journal of applied psychology*, *88*(5), p.879.

Rawashdeh, A., 2018. The impact of green human resource management on organizational environmental performance in Jordanian health service organizations. *Management Science Letters*, *8*(10), pp.1049-1058.

Rehman, S.U., Kraus, S., Shah, S.A., Khanin, D. and Mahto, R.V., 2021. Analyzing the relationship between green innovation and environmental performance in large manufacturing firms. *Technological Forecasting and Social Change*, *163*, p.120481.

Reinhardt, F. L., 1998. Environmental product differentiation: Implications for corporate strategy. *California management review*, *40*(4), 43-73.

Rousseaux, P., Gremy-Gros, C., Bonnin, M., Henriel-Ricordel, C., Bernard, P., Floury, L., Staigre, G. and Vincent, P., 2017. "Eco-tool-seeker": A new and unique business guide for choosing ecodesign tools. *Journal of Cleaner Production*, *151*, pp.546-577.

Saeed, A., Jun, Y., Nubuor, S. A., Priyankara, H. P. R., and Jayasuriya, M. P. F., 2018. Institutional pressures, green supply chain management practices on environmental and economic performance: A two theory view. *Sustainability*, *10*(5), 1517.

Sánchez-Medina, P. S., Díaz-Pichardo, R., Bautista-Cruz, A., and Toledo-López, A., 2015. Environmental compliance and economic and environmental performance: Evidence from handicrafts small businesses in Mexico. *Journal of Business Ethics*, *126*(3), 381-393.

Saxena, R. P., and Khandelwal, P. K., 2012. Greening of industries for sustainable growth: An exploratory study on durable, non-durable and services industries. *International Journal of Social Economics*.

Singh, C., Singh, D. and Khamba, J.S., 2021. In quest of green practices in manufacturing industries through literature review. *World Journal of Entrepreneurship, Management and Sustainable Development*.

Singh, S.K., Del Giudice, M., Chierici, R. and Graziano, D., 2020. Green innovation and environmental performance: The role of green transformational leadership and green human resource management. *Technological Forecasting and Social Change*, *150*, p.119762.

Soewarno, N., Tjahjadi, B. and Fithrianti, F., 2019. Green innovation strategy and green innovation: The roles of green organizational identity and environmental organizational legitimacy. *Management Decision*, *57*(11), pp.3061-3078.

Sun, Z., Wu, L.Z., Ye, Y. and Kwan, H.K., 2022. The impact of exploitative leadership on hospitality employees' proactive customer service performance: A self-determination perspective. *International Journal of Contemporary Hospitality Management*, (ahead-of-print).

Tariq, A., Badir, Y. and Chonglerttham, S., 2019. Green innovation and performance: moderation analyses from Thailand. *European Journal of Innovation Management*.

Tripathi, A. D., Mishra, R., Maurya, K. K., Singh, R. B., and Wilson, D. W., 2019. Estimates for world population and global food availability for global health. In *The role of functional food security in global health* (pp. 3-24). Academic Press.

Tuni, A., Rentizelas, A., and Duffy, A., 2018. Environmental performance measurement for green supply chains: A systematic analysis and review of quantitative methods. *International Journal of Physical Distribution and Logistics Management*.

Ullah, S., Mehmood, T. and Ahmad, T., 2022. Green intellectual capital and green HRM enabling organizations go green: mediating role of green innovation. *International Journal of Innovation Science*, (ahead-of-print).

Wagner, A., 2016. Mycelium Biking: Eco-design at its best.

Wakulele, S.R., Odock, S., Chepkulei, B. and Kiswili, N.E., 2016. Effect of eco-design practices on the performance of manufacturing firms in Mombasa County, Kenya. *International Journal of Business and Social Science*, *7*(8), pp.108-132.

Walker, H., Seuring, S., Sarkis, J., and Klassen, R., 2014. Sustainable operations management: recent trends and future directions. *International Journal of Operations and Production Management*.

Weng, H.H., Chen, J.S. and Chen, P.C., 2015. Effects of green innovation on environmental and corporate performance: A stakeholder perspective. *Sustainability*, *7*(5), pp.4997-5026.

Yang, Z., Sun, J., Zhang, Y., and Wang, Y., 2018. Peas and carrots just because they are green? Operational fit between green supply chain management and green information system. *Information Systems Frontiers*, *20*(3), 627-645.

Yousaf, Z., 2021. Go for green: green innovation through green dynamic capabilities: accessing the mediating role of green practices and green value co-creation. *Environmental Science and Pollution Research*, *28*(39), 54863-54875.

Yusliza, M.Y., Yong, J.Y., Tanveer, M.I., Ramayah, T., Faezah, J.N. and Muhammad, Z., 2020. A structural model of the impact of green intellectual capital on sustainable performance. *Journal of Cleaner Production*, *249*, p.119334.

Zhang, J., Kang, L., Li, H., Ballesteros-Pérez, P., Skitmore, M. and Zuo, J., 2020. The impact of environmental regulations on urban Green innovation efficiency: The case of Xi'an. *Sustainable Cities and Society*, *57*, p.102123.

Zhou, N., Price, L., Yande, D., Creyts, J., Khanna, N., Fridley, D., ... and Franconi, E., 2019. A roadmap for China to peak carbon dioxide emissions and achieve a 20% share of non-fossil fuels in primary energy by 2030. *Applied Energy*, *239*, 793-819.

Zu, X., and Cong, Y., 2022. Green at source: an empirical examination of the effectiveness and sustainability of operational-level environmental management practices in US industry. *Total Quality Management and Business Excellence*, *33*(11-12), 1213-1232..

APPENDIX

SURVEY QUESTIONNAIRE

Dear Sir/ Madam,

My name is …….., a postgraduate student at the Kwame Nkrumah University of Science and Technology, Kumasi, Department of Supply Chain and Information Systems. This survey instrument has been designed to enable me carry out research on the topic: **"Effect of Green Design Sustainability on Environmental Performance: Mediating Role Of Green Innovation"**. Any information provided will be used for academic purposes ONLY. There are no risks associated with your participation, and your responses will remain confidential and anonymous.

SECTION A: RESPONDENT'S BIOGRAPHY AND COMPANY PROFILE

When completing this questionnaire, please tick **[√]** in the applicable box or provide an answer as applicable.

Please answer the following questions:

1. *Gender*: Male ☐ Female ☐
2. *Age*

   18-30 years ☐ 31-40 year's ☐ 41-50 years ☐ Above 50 years ☐
3. *Level of Education*

   Junior High School ☐ Senior High School ☐ Diploma ☐ Bachelor Degree ☐ Graduate Studies (Master / Ph.D.) ☐ Others ☐ For Others, Please specify:……
4. *Your Position in the Firm*

   Operations managers ☐ Supply Chain Warehouse Manager ☐ **HR** Manager ☐ Production Manager ☐ Others ☐……
5. *How many years have your firm been in operation?*

   1 - 5 years ☐ 6 - 10 years ☐ 11 – 15 years ☐ 16 years and above ☐

SECTION B: Green Design for Sustainability

Indicate the extent to which you agree or disagree with each statement by checking the appropriate number from 1 to 5, using the following scale:

1 = Strongly Disagree ***2 = Disagree*** ***3 = Somewhat Agree*** ***4 = Agree*** ***5 = Strongly Agree***								
Item	**Statement**	**1**	**2**	**3**	**4**	**5**		
Green Design (Zhu et al. (2008), Esfahbodi et al. (2016), Hamdy et al. (2018)								
GDS1	My company uses products designed to reduce consumption of material/energy							
GDS2	My company uses materials designed to reuse, recycle, recovery of material, component parts							
GDS3	My company uses materials designed to avoid or reduce use of hazardous products							
GDS4	My company ensure cooperation with customers for eco design							

SECTION C: Green Innovation

Indicate the extent to which you agree or disagree with each statement by checking the appropriate number from 1 to 5, using the following scale:

1 = Strongly Disagree ***2 = Disagree*** ***3 = Somewhat Agree*** ***4 = Agree*** ***5 = Strongly Agree***								
Item	**Statement**	**1**	**2**	**3**	**4**	**5**		
Green Innovation (Aboelmaged, 2018b; Kusi-Sarpong et al., 2015; Chang, 2011)								
GI1	My company uses materials that produce least pollution.							
GI2	My company uses materials that consumes less energy and resources.							
GI3	My company uses materials that design environment friendly product.							
GI4	My company uses materials that are easy to recycle, reuse, and decompose.							
GI5	The manufacturing processes of my company effectively reduces materials that less hazardous substance or waste.							
GI6	My company uses materials that reduce consumption of coal, oil, electricity or water							
GI7	My company uses materials that use of raw materials.							

SECTION D: ENVIRONMENTAL PERFORMANCE (P **Zhu, Q., Sarkis, J., and Geng, Y. (2005).**)

Indicate the extent to which you agree or disagree with each statement by checking the appropriate number from 1 to 5 using the following scale:

1 = Strongly Disagree ***2 = Disagree*** ***3 = Somewhat Agree*** ***4 = Agree*** ***5 = Strongly Agree***								
Item	**Statement**	**1**	**2**	**3**	**4**	**5**		
EP1:	My organization minimizes the environmental impact of its activities							
EP2:	My organization designs products and packaging that can be reused, repaired, or recycled							
EP3:	My organization voluntarily exceeds legal environmental regulations							
EP4:	My organization makes investments to save energy							
EP5:	My organization reuses and recycles materials							
EP6:	My organization adopts measures for ecological design in products/services							
EP7:	My organization implements programs to use alternative energy							
EP8	My organization implements programs to reduce water consumption							
EP9	My organization regularly conducts environmental audits							

Thank you for participating in the survey.