UNIVERSITY OF CAPE COAST

ASSESSING THE EFFECTS OF THE DIMENSIONS OF KNOWLEDGE ABSORPTION CAPACITY ON SUSTAINABLE INNOVATION OF FIRMS IN GHANA

BY

BRIGHT KOFI MOTTEY

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature …… Date ……

Name: Bright Kofi Mottey

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature……...Date ……..

Name: Dr. Benedict Afful Jr.

Co-Supervisor's Signature……...Date ……

Name: Dr. Eric Amoo Bondzie

ABSTRACT

The global and dynamic landscape of the business environment necessitates firms to effectively assimilate, transform, and exploit their newly acquired knowledge to ensure the ultimate innovative result. However, innovation is a creative-destruction, as it could yield both positive and negative rippling effects. It is thereby imperative for firms to ensure that the implementation of their innovative activities, facilitated by effective firm-level absorption capacity, transcends beyond the economic dimension of sustainability to incorporate ecological and social dimensions. The study investigated the influence of the dimensions of absorption capacity on sustainable innovation of firms. The study was limited to 549 firms with data sourced from the Ghana Enterprise Survey combined with the Ghana Innovation Follow-up Survey, conducted in 2013 and 2014 respectively. The study applied both the ordered-logit and the logistic regression models. The study found that the knowledge acquisition capacity of firms exerts a significantly positive effect on firms' likelihood to sustainably innovate. The capacity of firms to transform knowledge exerts significantly positive effect on firms' likelihood to sustainably innovate. Furthermore, knowledge exploitation capacity of firms was found to exert a positive and significant effect on firms' likelihood to introduce at least a form of sustainable innovation. The study recommended that the government of Ghana, through the Ministry of Trade and Industry, in collaboration with the Ministry of Finance, should support research and development of firms through granting of interest-free loans for research and development purposes. The study, further, recommended that firms should prioritize investment in state-of-the-art machinery, ultra-modern equipment, and cutting-edge software to facilitate seamless knowledge transformation within the organization.

KEY WORDS

Acquisition

Assimilation

Transformation

Exploitation

Sustainable

Innovation

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DEDICATION

To Mrs Mottey-Azumah Evelyn and Bright Edinam Mottey Junior.

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LIST OF ACRONYMS / ABBREVIATIONS

DCT	Dynamic Capabilities Theory
EcoAP	Eco-Innovation Action Plan
ECOPOL	Accelerating Eco-innovation Policies
ES	Enterprise Survey
ETAP	Environmental Technology Action Plan
EPA	Environmental Protection Agency (EPA),
GIFS	Ghana Innovation Follow-up Survey
GIRCC	Ghana Innovation and Research Commercialisation Centre
GNLCD	Ghana National Low Carbon Development
ICT	Information and Communication Technology
KBV	Knowledge Based View
MESTI	Ministry of Environment, Science, Technology and Innovation
NAMA	Nationally Appropriate Mitigation Actions
NCCP	National Climate Change Policy (NCCP)
OECD	Organisation for Economic Corporation and Development
REDD	Reducing Emissions from Deforestation and forest Degradation
R&D	Research and Development
RDT	Resource Dependency Theory
SGDs	Sustainable Development Goals
STEM	Science, Technology, Engineering and Mathematics
STI	Science Technology and Innovation
WCED	World Commission on Environment and Development

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CHAPTER ONE

INTRODUCTION

Background to the Study

The global and dynamic landscape of the business environment necessitates firms to effectively assimilate, transform, and exploit their newly acquired knowledge to ensure the ultimate innovative result (Albort-Morant & Henseler, 2018; Contreras et al., 2021; Sancho-Zamora et al., 2021). Innovation is an inevitable element in boosting firm-level competitiveness, survival, and overall performance (Zhang et al., 2018). However, innovation is a creative-destruction, as it could yield both positive and negative rippling effects. It is thereby imperative for firms to ensure that the implementation of their innovative activities, facilitated by effective firm-level absorption capacity, transcends beyond the economic dimension of sustainability to incorporate ecological and social dimensions (Albort-Morant & Henseler, 2018). Considering the need to ensure protection of the environment, it is important to find out how the various dimensions of knowledge absorption capacity of firms affect their level sustainable innovation.

Knowledge acquisition is defined as the technique of extracting knowledge, information, and organizing knowledge through diverse human credible sources (Baeshen et al., 2021). Acquiring knowledge is however just the first step towards its implementation as it needs favourable propelling firm level environment to warrant effectiveness. These flourishing conditions are captured as absorption capacity. The major dimensions of absorption capacity can be grouped into four; knowledge acquisition, assimilation capacity, knowledge transformation and exploitation (Müller et al., 2020). Firm-level newly acquired knowledge can be integrated to align with old knowledge structure for use known as knowledge assimilation, and or restructured to create new insights for internal use known as knowledge transformation capacity. The

last stage of the absorption is knowledge utilization or application known as knowledge exploitation capacity. These absorption capacities of firms' bridge the gap between the acquisition of new knowledge and the sustainable innovation processes, thereby facilitating the incorporation of environmentally conscious and socially responsible dimensions into their strategic initiatives (Albort-Morant & Henseler, 2018; Contreras et al., 2021).

Sustainable innovation refers to innovation on the basis that businesses undertake refers to innovation that account for economic, environmental and social impact of innovative activities (Zhang et al., 2018). It can be through organizational processes (process sustainable innovation) which can be aimed to maintain outcome (service or product produced) or result to a new one (product sustainable innovation).

Globally, adherence to the United Nations' Sustainable Development Goals (SDGs) emphasizes the need for worldwide institutionalization of industrial policies to ensure firms minimize environmental pollution through innovative activities (Anaafo, 2021). Equally, the impetus for eco-friendly practices is fortified by international agreements, exemplified by the Paris Agreement, particularly in Article 4.5, compelling countries and firms worldwide to enact policies for carbon emissions reduction. These commitments are evident in various countries, in China, the pivotal "Environmental Protection Law" mandates firms to proactively acquire knowledge for pollution prevention and control (Zhang et al., 2022). Moreover, Article 20 of the same Law emphasizes environmental impact assessments, compelling firms to assimilate critical knowledge before initiating new projects. China's commitment to green innovation is further evidenced by the "Green Development Guideline" and the "Circular Economy Promotion Law," both promoting the absorption and application of environmentally friendly knowledge within firms (Zhang et al., 2022). Similarly, Spain's dedicated "Law on Climate Change and Energy Transition," not only

establishes ambitious emission reduction targets but actively encourages firms to acquire, assimilate, transform and utilize knowledge on clean energy technologies and sustainable practices (Albort-Morant & Henseler, 2018).

In Ghana, evidence exist on the flourishing firm-level innovation landscape signalling a notable increase in innovation within the Ghanaian business community. For instance, the Ghana Investment Promotion Center's (GIPC's) fourth quarter review for 2022 report emphasized new innovative activities and registration of sixty-five wholly domestic innovative firm level projects, valued at US$335.59 million(GIPC, 2023). Notwithstanding the above, evidence strongly supports the existence of policies in Ghana that foster environmental protection through innovative activities within firms (Antwi-Agyei et al., 2017). These policies, namely the "Environmental Protection Agency Act" established in 1994, the "Renewable Energy Act" implemented in 2011, and the "National Climate Change Policy" put into effect in 2014, clearly emphasize the assimilation and transformation of new knowledge by firms while conscientiously considering their ecological impact (Yamoah et al., 2021). These legislative frameworks collectively underscore a commitment to sustainable practices and innovation, reflecting a concerted effort to integrate environmental considerations into the operations and strategies of businesses in Ghana (Yamoah et al., 2021). A question worth asking is whether the policies are implemented effectively through monitoring and supervision of firm-level knowledge absorption activities to ensure that firms' absorption of new knowledge in their innovative activities remains sustainable?

Statement of the Problem

The concept of environmental protection has received worldwide recognition in corporate or strategic agendas due to society's tremendous increase in environmental

consciousness in recent decades (Castaldi, 2021). A question worth asking is whether the nature and quest for innovation permit firms to consider the "sustainable" concept of it? However, the quest for sustainable innovation as a means to help protect the environment requires effective organizational knowledge acquisition and the existence of a well-planned existing corporate environment to facilitate the implementation of innovative ideas (Lis & Sudolska, 2015).

Knowledge acquired at the organizational level, however, needs a favourable propelling environment to warrant effectiveness, including making use of acquired knowledge through assimilation and exploitation (Zhang et al., 2018). It is of this that Sancho-Zamora et al. (2021) stated that a firm's ability to acquire new knowledge, combine, transform, or implement such knowledge in its operations is essential to champion its ability to innovate all-round sustainably and remain competitive. These flourishing conditions are captured in extant literature as absorption (Zhang et al., 2018).

A growing global awareness among policymakers centers on environmental pollution, specifically focusing on concerns such as greenhouse gas (GHG) emissions (UNEP & UNDP, 2019). Mandated by international agreements such as the United Nations' Framework Convention on Climate Change, governments all over the world are required to formulate and implement policies aimed at reducing environmental degradation while improving environmental sustainability on a global scale (UNEP & UNDP, 2019).

In Ghana, greenhouse gas (GHG) emissions at the firm level reached 39,070.29 in 2020, signifying a 8.32% rise compared to the figures in 2019 (UNDP, 2021) Coupled with the above, reports indicate delays in operationalizing core components of environmental policies designed for monitoring of implementation of firms level

green innovative initiatives through green absorption (UNEP & UNDP, 2019). Notwithstanding the above, the government of Ghana has declared unwavering commitment to implementing unconditional actions with the potential to reduce emissions by 39.4 MtCO2e by 2030, underscoring the imperative for effective implementation of green innovative initiatives by firms through effective green knowledge assimilation, transformation, and exploitation (Yamoah et al., 2021). This urgency extends beyond GHG emissions to address the broader spectrum of industrial pollution, emphasizing the need for robust firm-level green absorption capacities to foster a sustainable and environmentally conscious industrial landscape. It is thereby important to assess the effects of the implemented dimensions of knowledge absorption capacity on sustainable innovation of firms in Ghana so as to provide empirical evidence for policy purposes.

Coupled with the above, empirical studies on absorption capacity and firm-level innovation (example: Albort-morant & Henseler, 2018; Contreras et al., 2021; Sancho-Zamora et al., 2021; Zhang et al., 2018) focused on only one dimension of sustainable innovation (thus green innovation), ignoring the other two dimensions (economic and social or socio-economic dimensions of sustainable innovation). These empirical studies in question focused solely on general innovation without critically examining its sustainability dimension. Therefore, such studies lacks the comprehensive perspective necessary to be considered as encompassing sustainable innovation.

Equally, mixed findings exist from studies on the effects of absorption capacity on firm-level sustainable innovation. While some empirical findings concluded that absorption capacity positively affects sustainable innovation (example: Albort-morant & Henseler, 2018; Contreras et al., 2021; Sancho-Zamora et al., 2021; Zhang et al.,

2018), others (example: Tang et al., 2020), however, found that absorption capacity exerts no significant effect on sustainable innovation. Others (example: Mikhailov & Reichert, 2019) also found that some of the dimensions of absorption capacity exert negative effects on eco-friendly innovation while some exert significantly positive effects on the same construct.

Notwithstanding the above mixed findings, empirical studies on the absorption capacity and sustainable innovation remain country and industry-level specific. This makes findings thereof limited to the specific country or industry investigated, affecting the generalization of the outcome (Albort-Morant & Henseler, 2018).

In Ghana, there exists extant literature on determinants of firm innovation (example Afful & Owusu, 2019; Fiave, 2019; Oduro & Nyarku, 2018). However, limited studies exist on the extent to which the dimensions of knowledge absorption capacity exert influence on sustainable innovation. This recent study builds on the previous studies by focusing on the extent to which the dimensions of knowledge absorption capacity influence sustainable innovation of firms. The study further categorized sustainable innovation into two broad views as stated by Oslo's fourth manual and analyzed the extent to which knowledge absorption capacity influences each of them. The study included control variables such as the firm's age, the size of the firm, location, as well as the sector of the firm based on reviewed extant literature.

Purpose of the Study

The purpose of the study is to assess the effects of the dimensions of absorption capacity on sustainable innovation of firms in Ghana.

Objectives of the Study

To ensure holistic assessment and evaluation of the study's purpose, the study specifically seeks to:

1. assess the effects of knowledge acquisition capacity on sustainable innovation of Ghanaian firms;
2. examine the effects of knowledge assimilation capacity on sustainable innovation of Ghanaian firms;
3. determine the effects of knowledge transformation capacity on sustainable innovation of Ghanaian firms;
4. investigate the effects of knowledge exploitation capacity on sustainable innovation of Ghanaian firms.

Hypothesis Testing

In line with the specific objectives as stated above, the study tested the following null and alternative hypothesis:

1. H_0: Knowledge acquisition capacity does not exerts any significantly positive effect on sustainable innovation of Ghanaian firms.

   H_1: Knowledge acquisition capacity exerts significantly positive effect on sustainable innovation of Ghanaian firms.
2. H_0: Knowledge assimilation capacity does not exerts any significantly positive effects on sustainable innovation of Ghanaian firms.

   H_1: Knowledge assimilation capacity exerts significantly positive effect on sustainable innovation of Ghanaian firms.
3. H_0: Knowledge transformation capacity does not exerts any significantly positive effect on sustainable innovation of Ghanaian firms.

   H_1: Knowledge transformation capacity exerts significantly positive effect on sustainable innovation of Ghanaian firms.
4. H_0: Knowledge exploitation capacity does not exerts any significantly positive effect on sustainable innovation of Ghanaian firms.

H_1: Knowledge exploitation capacity exerts significantly positive effect on sustainable innovation of Ghanaian firms.

Significance of the Study

Examining the impact of the four main dimensions of knowledge absorption capacity on a firm's sustainable innovation provides valuable insights for firm managers in shaping effective policies. By assessing how effective knowledge acquisition, assimilation or integration, transformation or modification, and exploitation or utilization contribute to sustainable innovation, managers could gain a comprehensive understanding of the intricate role knowledge absorption capacity plays in organizational success. This knowledge equips them to formulate targeted policies that enhance knowledge absorption capacity, fostering a conducive environment for sustainable innovation within the firm. As a result, firm managers can make informed decisions and implement strategies that align with the unique dynamics of knowledge absorption, ultimately contributing to the organization's long-term innovation goals.

The study is of great importance to the government of Ghana, especially the Ministry of Trade and Industry, as it provides valuable insights to shape policy directions for promoting sustainable innovation among firms. The specific recommendations, such as supporting knowledge acquisition and offering nationwide assistance for its assimilation, transformation, and exploitation, will serve as a guide for the Ministry in crafting policies that foster the growth of businesses in Ghana. This strategic guidance ensures that government policies are in harmony with the intricacies of knowledge absorption dynamics, thereby creating a conducive environment for sustainable innovation throughout the business sector. The recommendations are equally valuable for the Ministry of Environment, Science, and

Innovation, enabling them to redirect their efforts toward ensuring sustainable innovation at the firm level. The suggested measures for sustainable innovation will play a crucial role in guiding the ministry's policy formulation and implementation, emphasizing the importance of environmentally friendly innovation practices at the firm level. This alignment with sustainable principles contributes to the overall policy framework, fostering a cleaner and more innovative approach within firms.

The study contributes to the existing body of literature on dimensions of absorption capacity and firms' sustainable innovation. Thus, specifically, the study methodology or approaches can be adopted by future researchers in studying similar subject areas. Findings from related future studies can also be compared and contrasted with the findings of this recent study. Limitations and suggestions for further studies could help position new researchers on the areas to explore.

Delimitations of the Study

The study operationalizes the dimensions of knowledge absorption to include knowledge acquisition capacity, knowledge assimilation capacity, knowledge transformation capacity, and knowledge exploitation capacity. This was done based on the existing extant literature.

Forms of sustainable innovation depend on the types of firm-level innovations that exist. Several studies grouped the types of innovation into four; product, process, marketing, and organizational innovation (Afful & Owusu, 2019). This recent study adopted the fourth Oslo's manual's categorization of innovation, which captures innovation into process and product, where the former encompasses both organizational and marketing innovations. This adoption limits the scope of sustainable innovation constructs used in the study, where only sustainable product and sustainable process innovations were looked at. However, the existing dataset

used (Ghana Enterprise Survey-2013 and Ghana Innovation Followed-Up Survey-2014) provided separate information on process innovation, marketing innovation, and organizational innovation, implying they were not merged together as a depiction variation from the Oslo's fourth manual classification.

The study is limited to firms in Ghana. It captured firms surveyed by the World Bank in its Ghana Enterprise Survey-2013 and Ghana Innovation Followed-Up Survey-2014.

Limitations of the Study

Innovation has four main dimensions or categories: process, product, organizational, and marketing innovations. It is because of this that studies on sustainable innovation should encompass the four dimensions. The study used a definition of sustainable innovation based on the 4th Oslo's manual to include only product and process innovations, as the other two (marketing and organizational) are incorporated into the process innovation. The data sets (ES and GIF data sets) used provided information on innovation on the 4 dimensions, implying the data categorized innovation into the four types. However, the sustainability of organizational and marketing innovations was non-existent in the data. This made it impossible to assess the influence of absorption capacity on the 4 dimensions of sustainable firm-level innovation.

The dynamic nature of businesses and the drive towards sustainability in Ghana over the past 6 years after the implementation of SDGs in 2015 could have exerted influence on the dynamic capabilities of firms towards sustainable innovation. However, the existing innovation data set in Ghana is the ES and GIF data sets of 2013 and 2014, respectively. This indicates that the study made findings and recommendations in retrospect and not contemporaneously.

The study used dummy variables for all the key independent variables and as such could smoothen the data for the issue of endogeneity. This was not explored in the study and hence remain a limitation.

Definition of Terms

1. *Sustainable Innovation:* It refers to implementing of innovative initiatives to accommodate social, economic and ecological concerns. This captures engaging in either sustainable process and or product innovation.
2. *Sustainable Product Innovation*: It refers to firms bringing/producing new products which are both socio-economic and green in nature.
3. *Sustainable Process Innovation*: It refers to introducing new production and distribution processes which are both socio-economic and green in nature.
4. *Knowledge Acquisition:* It refers to the process of obtaining new knowledge through external or internal research and development and or training.
5. *Knowledge Assimilation:* It refers to the routines and processes that indicates a firms commitment towards integrating of new knowledge to align with old knowledge structure for use. Thus, the capacity to integrate new equipment, machinery, or software to develop or produce innovative products, services, or processes, aligning with existing firm-level knowledge or integrate knowledge by purchasing or licensing any patented or non-patented inventions for the development of innovative products, services, or processes, aligning with existing firm-level knowledge.
6. *Knowledge Transformation:* It refers to the capacity of firms to recognize usefulness of external knowledge and restructure /modifies it to create new insights for internal us. It captures the adoption of internet for R&D to transform initial product ideas to meet market demands and or the adoption of new

approaches to online sales, marketing strategy and purchasing due to market or supplier demand.

7. *Knowledge Exploitation:* It refers to a firm's capability to competitively use/utilize new external knowledge to achieve its goals.

Organisation of the Study

The study is organized into five major chapters: Chapter One of the study provides an introduction to the study. The chapter discusses the background of the study, the statement of the problem, and the purpose of the study. Other important sections of the chapter are the objectives of the study, hypothesis, and significance of the study, delimitation and limitations of the study, definition of terms, and organization of the study. The second chapter provided a review of the dimensions of absorption capacity and sustainable innovation. Theoretical and empirical justifications were also provided. Chapter three provided discussion on the methodology employed in the study. It provides discussion on the study design and approach, types and sources of data used, econometric model used, as well as methods of data analysis. Results were presented in the fourth chapter of the study, and discussions followed thereafter. The last chapter, "Chapter Five," provided a summary of major findings, study conclusions, as well as recommendations for policy making and suggestions for future studies based on limitations identified.

CHAPTER TWO

LITERATURE REVIEW

Introduction

The chapter provided a review of related literature. Initial part of the Chapter provided discussion on the theories that relate to the study goals. The chapter also provided conceptual reviews of the main concepts of the study; the concept of sustainable innovation and the concept of absorption capacity. The chapter also provided a review of past related studies under the construct "empirical literature" and ended with a chapter summary.

Theoretical Literature

The Resource Based View and the dynamic capabilities theory were reviewed in attempt to link absorption capacity dimensions and sustainable innovation of Ghanaian firms.

The Resource-Based View

The theory was propounded by Penrose in 1959 (Xue et al., 2019). He viewed the enterprise as an administrative organization as well as a repository of production factors (both human and physical). The theory states that firms can take advantage of new opportunities by either making use of current resources or building new capabilities (Xue et al., 2019). The theory classified firms' resources into tangibles and non-tangibles. Physical assets such as land, buildings, equipment, machinery, and capital are examples of tangible assets. Intangible assets are things that do not exist physically, and they include trademarks, intellectual property, and brand image (Du & Wang, 2022).

The theory is built on two main essential tenets: heterogeneity and the immobility of resources. The first presumption is that businesses' skills, competences, and other

resources vary from one firm to the other (Du & Wang, 2022). The second premise of RBV is that, at least in the medium term, resources are immobile and cannot easily be transferred from one organization to another. Operations, knowledge, brand image, as well as intellectual property are examples of intangible assets that are typically immovable. As a result of their immobility, companies are unable to imitate rivals' resources and carry out their strategies (Du & Wang, 2022).

The resource-based view argues that for firms to acquire a long-lasting competitive advantage, it is important that they focus on their resource analysis, allocation, and cross-functional resource use (Xue et al., 2019). Similarly, a business can only develop more effectively and differentiate itself from competitors if it fully realizes the potential of its employees. The RBV argument stems from the fact that key capabilities like developing and leveraging the value of intangible assets are essential for enterprises (Du & Wang, 2022). The theory, thereby, captures knowledge as an essential resource of a company, and hence the ability to obtain new knowledge through research and development or build on existing knowledge remains key to a firm's competitive position (Xue et al., 2019). This idea captures the knowledge acquisition dimension of absorption capacity, which remains a key concept in this study.

Furthermore, the theory contends that effective implementation of new ideas depends on knowledge integration and the methods by which knowledge is coordinated (Xue et al., 2019). According to the resource-based view (RBV), the ability of firms to absorb knowledge is a distinctive organizational learning capability that aids businesses in gathering information from various sources and using internal information over time to establish a long-term competitive advantage (Xue et al., 2019). This view best explains the need for knowledge assimilation, its

transformation, and exploitation by the firm to ensure effectiveness of its innovative activities. Argued differently, scholars (such as Du & Wang, 2022) contended that the theory emphasizes the need for the development of essential functional capabilities and improved utilization of those capabilities as requirements for firms in securing successful innovation. Thus, the resource-based view (RBV) identifies absorptive capacity as organizational capabilities and resources for generating long-term competitive advantages through innovations.

The presented theory is relevant study's objectives, which aim to examine the effects of the 4 main dimensions of knowledge absorption capacity on sustainable innovation. The theory intricately aligns with these objectives by emphasizing the significance of a firm's capacity to enhance, organize, and utilize its resources, along with the ability to develop and employ value-adding strategies. Crucially, the theory explicitly links the dimensions of absorption capacity encompassing knowledge acquisition, assimilation, transformation, and exploitation to innovative activities, including both sustainable process and product innovation. This connection becomes pivotal as it highlights how the various facets of absorption capacity directly contribute to sustainable innovative endeavour, placing the firm in a more competitive position through the introduction of novel and valuable innovations. Essentially, the theory serves as a guiding framework to understand and explore how the different dimensions of absorption capacity influence sustainable innovation, aligning seamlessly with our study's overarching objectives.

Dynamic Capabilities Theory

In 1994, Teece and Pisano introduced dynamic capabilities theory, challenging static explanations within the resource-based view (RBV) and emphasizing adaptability in a continuously evolving competitive landscape (Amaranti et al., 2019;

Beuter et al., 2019).This theory focuses on a firm's response to dynamic market conditions, underlining the importance of enhancing its ability to integrate, develop, and restructure internal and external skills.

Central to dynamic capabilities is the assertion that knowledge assimilation, transformation, and utilization are crucial for effective knowledge application, treating firms as diverse resource bundles, including competences (Onamusi, 2020). Aligned with the RBV, this theory extends to the organization's capacity to mix, develop, and restructure skills for rapid adaptation (Bleady, Abbas et al., 2018). Bleady, Abbas et al., (2018), delve into various definitions related to dynamic capabilities theory, highlighting the pivotal role of knowledge acquisition. Arguments from Samsudin & Ismail, (2019) stress the importance of knowledge acquisition and advocate for a favourable absorption environment, including dimensions of transformation, assimilation, and exploitation. The dimensions of knowledge absorption capacity; acquisition, assimilation, transformation, and exploitation, stand out as crucial components within dynamic capabilities theory, emphasizing not just knowledge acquisition but also its integration, continuous renewal, and strategic utilization for sustained innovation.

In further contextualization, studies by Amaranti et al. (2019) and Beuter et al. (2019) leverage the dynamic capabilities theory to explore the impact of knowledge acquisition dynamics on sustainable innovation. These findings reinforce the idea that successful knowledge absorption, across all dimensions, plays a pivotal role in driving sustainable innovation within firms operating in dynamic environments.

The dynamic capabilities theory is inherently aligned with the objectives of the study, which seeks to examine the effects of the dimensions of knowledge absorption capacities on sustainable innovation. A firm's capacity to dynamically adjust to its

surroundings and its pursuit of sustainable innovation are directly linked, according to the notion. The dynamic capabilities theory fundamentally addresses the key components expressed in the objectives of the study by highlighting the necessity for businesses to improve, develop, and reorganize their internal and external capabilities. The theory's emphasis on how a company reacts to changing market conditions is directly relevant to the study's focus on knowledge acquisition capabilities. It emphasizes the significance of actively responding to the changing market by integrating and transforming knowledge, in addition to just receiving it. Additionally, the theory's focus on the strategic use of resources is in line with the objectives of the study as it highlights the role of knowledge absorption capabilities in fostering sustainable innovation.

Essentially, the theory of dynamic capabilities offers an all-encompassing structure for comprehending how an organization's capacities, including those associated with knowledge absorption capacities, directly influence its capacity for sustainable innovation. The idea aligns well with the study's many goals as it highlights how dynamically a company responds to its surroundings and emphasizes the necessity for a comprehensive strategy for knowledge management that goes beyond simple acquisition.

Concept of Sustainable Innovation

Providing a robust meaning of the concept of "sustainable innovation" demands decomposing it by providing separate definitions of the terms "sustainability and innovation" before combining them to explain the concept as a whole. Sustainability became a household name immediately after it was used by the "World Commission on Environment and Development (WCED)" when they published "Our Common Future," also known as the "Brundtland Report" (Lopes et al., 2022).

According to the report, many definitions of sustainability were discovered, reflecting the aspects that a researcher intends to investigate. Thus, the concept has multidisciplinary meaning as no unanimously approved definition exists.

Calik and Bardudeen, (2016) defined sustainability as “meeting the needs of the present without compromising the ability of future generations to meet their needs.” This definition emphasizes the need for prevention of activities that are detrimental to the ecology or environment or have the capability to reduce long-term threats linked to the degradation of natural resources or emissions. It was, however, criticised for its vagueness as it failed to specify the role of social dimensions in the entire process (Lozano, 2019).

Baeshen et al. (2021) defined the term by including the “Triple Bottom Line”; economic, social, and ecological dimensions. Sustainability concepts can be defined at the firm level (corporate sustainability), at the natural level (ecological sustainability), or as a social case. At the firm level, corporate sustainability, according to Ekman and Carlsson, (2019), firm-level sustainability, captures engaging in productive activities or processes aimed at achieving output growth, social as well as eco-friendly goals. Baeshen et al. (2021) echoed the above as they defined the term to encompass companies' processes and activities that solve environmental and social issues in a strategic way.

On the other hand, varied definitions exist for what the term innovation means. However, many writers coined the term to include doing something new (novelty or change from a previously existing process). The first Oslo’s manual characterizes innovation as the technical, scientific, corporate, and economic processes responsible for the effective production and commercialization of enhanced industrial goods, the commercial utilization of new and enhanced techniques, or the introduction of a novel

technique to a social service (OECD, 2018). This first edition was criticised for limiting the concept to including only manufacturing sector operations.

The second and third Oslo's manuals also provided refined definitions based on the loopholes identified in the first manual. For instance, the third manual defined innovation to capture innovation to include process, product, organizational, and marketing innovation. The fourth Oslo Manual defined the term as "a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)" (OECD, 2018). This new definition reframed process innovation to include both organizational and marketing innovation and thus shrank the dimensions to only two; product and process.

Lopes et al. (2022) defined firm level innovation as "the capacity that organizations have to implement new products or transform existing products through new combinations of materials used in production processes or add qualities to the product in order to meet the needs of the market in which it is located."

As reflected in the diverse definitions of the two terms (sustainability and innovation) separately, there is no universally accepted definition of the concept "sustainable innovation". The term is used synonymously with eco-friendly innovation, green innovation, and sustainable-oriented innovation at the firm level.

Kneipp et al. (2019) defined the term as an improvement that transcends into economic, social, and environmentally friendly goals. Hence, at the firm level, such improvements are innovations introduced by the firms. According to Hermundsdottir and Aspelund, (2021), "sustainably innovation" refers to the mechanism in which ecological, social, as well as economic sustainability factors are incorporated into an organization's processes through the acquisition of new knowledge. This "innovation

at the firm level" refers to innovation in relation to a firm's processes of production and marketing as well as its managerial operations. The sustainable factors employed are usually acquired through knowledge acquired externally.

Lopes et al. (2022) echoed the above definition as they defined the term as "a set of activities that modify product design (marketing innovation) and those that modify production, both with the aim of eliminating negative impacts on the environment and obtaining environmentalist value." Like the previous definitions, this definition captures sustainable innovation into conventional innovation (economic dimensions), eco-friendly (environmental or green innovation), and combines the two with social dimensions to define the term sustainable innovation.

Conceptualization of the definition of Sustainable Innovation

The study conceptualized the notion of sustainable innovation to refer to the implementation of product and/or process innovative initiatives to accommodate social, economic, and ecological concerns. As such, sustainable product innovation is conceptualized to capture firms bringing/producing new products that are both socio-economic and green in nature, while sustainable process innovation refers to introducing new production and distribution processes that are both socio-economic and green in nature.

Ghana's Sustainable/Green Innovation Policies

Several nationwide attempts have been made by various governments in Ghana towards ensuring sustainable innovation by creating an enabling environment and ensuring firms adhere to green innovative production processes. The discussion below provides a review of major policy developments.

Uzor and Nyambane, (2021) in their paper entitled "*Eco-innovation Policies for Sustainable Development in Africa*" argued that the National

Development Planning Commission's (NDPC's) Vision 2020 whitepaper, which is infused with green-innovation concepts promoting the ecological spheres, is Ghana's roadmap for sustainability. In recent decades, Ghana's plans, guidelines, and initiatives have taken into account green building, environmental conservation, green economy, and sustainable development strategies.

Ghana's 1992 Constitution establishes a broad legislative framework for environmental preservation in Ghana. The foundation of Ghana's environmental protection is found in Article 36(9) of its constitution (thus, the 1992). Specifically, the 1992 constitution, article 36 (9), stated that:

"*The State shall take appropriate measures needed to protect and safeguard the national environment for posterity; and shall seek cooperation with other states and bodies for the purposes of protecting the wider international environment for mankind" (Ghana's Constitution, 1992).*

The constitution establishes that each Ghanaian and the government have an obligation to keep and preserve the environment for future generations. It expressly demands that the government take appropriate measures to conserve and defend the natural environment. This is something that the state is supposed to accomplish in partnership with the right agencies (Uzor & Nyambane, 2021).

The Environmental Protection Agency (EPA), formed by EPA Act 490 (1994), is an institution under the Ministry of Environment, Science, Technology, and Innovation (MESTI) that supports the operation of nationwide green policies. It acts on ecological concerns in Ghana and guarantees that enterprises follow Ghanaian ecological and sustainability regulations when it comes to remaining environmentally friendly in corporate operations. Businesses that fail to comply with the environmental protection Acts face penalties and fines.

The Sustainable Development Goals (SDGs), commonly referred to as "the Global Goals", are a worldwide drive aimed towards eradicating poverty, safeguarding the environment, and promoting peace and prosperity for every individual by 2030. The SDGs were agreed upon by 193 nations, such as Ghana, and came into force in January 2016. They aim to promote economic expansion, inclusivity, and environmental protection. Specifically, SGD goal 9 emphasized the role of innovation in sustainable growth. As a result, it states:

"Sustained investment in infrastructure and innovation are key drivers of economic growth and development. Bridging the so-called digital divide is crucial to ensure equal access to information and knowledge and, as a consequence, to foster innovation and entrepreneurship. With this, failing to improve infrastructure and promote technological innovation could translate into poor health care, inadequate sanitation, and limited access to education."

The tailored innovative drive towards sustainability since the signing of the SDG in Ghana has led to efforts towards ensuring green innovation. In its 2019 Voluntary National Review Reportage, it was stated that the government is committed to ensuring investment innovation and ensuring environmental protective operations to safeguard the ecological environment for future generations (Voluntary National Review (VNR), 2019). Specifically, the report stated that:

"Government is focusing on the following priority actions: implementation of the National Climate Change Policy (NCCP); the GHG Inventory Initiative of the EPA; Reducing Emissions from Deforestation and Forest Degradation (REDD); Ghana National Low Carbon Development (GNLCD) Strategy; and promoting low carbon growth through Nationally Appropriate Mitigation Actions (NAMA). The Ghana National Cleaner Production Centre has been set up to implement projects

and activities that will promote resource efficiency and cleaner production in the areas of energy, waste management, water and material efficiency practices in industries, to reduce manufacturing costs, lower pollution and improve health and safety. In addition, the National Greenhouse Gas Inventory and the National Greenhouse Gas Inventory Manual of Procedures have been prepared, and a survey conducted to estimate GHG emissions from commercial generators" (Voluntary National Review (VNR), 2019).

On the issue of innovation, the Voluntary National Review (2019), stated the government's commitment towards establishing the "*Ghana Innovation and Research Commercialisation Centre (GIRCCentre), the National Entrepreneurship and Innovations Plan to aid the establishment of incubation centres with basic facilities required by Ghanaian innovators; revamping the Science, Technology, Engineering and Mathematics (STEM) programme; and enactment of a Science, Technology and Innovation (STI) law to facilitate the implementation of the STI Policy"* (Voluntary National Review (VNR), 2019).

The Sustainable Innovative Business Climate in Ghana

Ghana's deliberate incorporation of science, technology, and innovation (STI) into its corporate environment highlights the country's dedication to socioeconomic and green advancement (Fiave, 2019; UNDESA, 2022). In United Nations Economic and Social Affairs (UNEDESA's) 2022 reportage entitled "Ghana Innovation Ecosystem Insights, Challenges & Opportunities", it is argued that, Ghana strategically incorporates science, technology, and innovation (STI) into its developmental frameworks (UNDESA, 2022). This aligns its efforts with worldwide aims outlined in the 2030 Agenda and the Sustainable Development Goals (SDGs).

The focus on sustainable innovation permeates specific STI frameworks designed to meet SDGs in diverse commercial sectors.

Furthermore, the Ministry of Environment, Science, Technology, and Innovation is a frontrunner in promoting environmentally conscious behaviours and enabling the smooth assimilation of scientific and technological breakthroughs (UNDESA, 2022). Under MESTI, the Ghana Innovation & Research Commercialization Center turns scholarly discoveries into marketable products and services, therefore strategically advancing innovation and research (UNDESA, 2022).

Ghana prioritizes digital green or sustainable innovation in its national development policy framework (Yamoah et al., 2021). This was echoed in the UNEDSA's reportage in 2022 to be evident in the country's Coordinated Programme of Economic and Social Development Policies (2017–2024), (UNDESA, 2022). The framework focused on providing industrial assistance to entrepreneurs through the National Entrepreneurship and Innovation Programme. This thoughtful strategy highlights Ghana's steadfast dedication to fostering innovation, assisting in the acquisition of information, and encouraging sustainable growth within its economic environment. The effort is aimed to aggressively promotes a favourable business climate (UNDESA, 2022).

A dedication to cooperative and inclusive ecosystem development is demonstrated by ongoing programs like the Ghana Digital Innovation Week (GDIW), which aims to catalyze digital innovation. Additionally, the government's digitization strategy is heavily promoted by the Ministry of Communication and digitization (MoCD). Aiming to promote equitable involvement in the innovation ecosystem, special efforts such as the Miss Geek Ghana Competition actively encourage young women to pursue jobs in STEM fields (science, technology, engineering, and mathematics).In

light of inclusive innovation's revolutionary potential for building up the environment, the Coordinated Programme emphasizes the significance of advancing diversity, equity, and inclusion (UNDESA, 2022).

The Accra Digital Centre (ADC) helps startup businesses with their infrastructure needs by offering vital services including business assistance, incubation, acceleration, digital skills development, and research. These services drive technical advancements and promote faster growth. In its reportage, the UNDESA, (2022) also indicates that while Ghana has made strides in incorporating equity and inclusion into systemic norms and procedures, more work is clearly needed to take an equitable and inclusive approach to ecosystem strengthening through its innovative activities. In general, the strategic coordination of laws, government programs, and partnerships with foreign entities indicates a business-friendly atmosphere that supports innovation, learning, and sustainable growth in Ghana.

Concept of Knowledge Absorption Capacity (KAC)

Knowledge absorption capacity can be described as an entity's capacity to value, integrate, and utilize new information (Albort-Morant & Henseler, 2018). Xue et al. (2019) defined it as a company's ability to gain knowledge and apply insights and ideas or relevant data, internalize it, and utilize it. According to Sancho-Zamora et al. (2021), the term refers to “the ability of a firm to recognize the value of new external information, assimilate it, and apply it for business purposes.” It refers to a company's ability to find or acquire new knowledge (through research), integrate, and apply it.

Absorptive ability is a measure of how quickly an organization can acquire and implement new knowledge to help in its development (Agustí et al., 2021). In a nutshell, a company's absorptive capacity is defined as its ability to comprehend the significance of novel external knowledge, internalize, or utilize it. Thus, the concept

relates to access to knowledge (to identify and acquire new knowledge), anchoring it (transform and assimilate it), and disseminating it at organizational level (exploitation for development). It is a company's ability to identify hugely beneficial new knowledge from exploratory learning, internalize significantly new information using transformational learning, and put such knowledge to use.

External sources of knowledge acquisition and the ability to leverage such knowledge constitute an important step towards an organization's success. The transformation, monitoring, incorporation, and eventual use of this newly integrated knowledge are thus its core components. Sancho-Zamora et al.(2021) echoed the above as they stated that in the absence of absorptive capacity, knowledge transmission in a corporation will be significantly hindered, and hence they emphasized the relevance of absorptive capacity in organizations. This was supported by Agustí et al. (2021), as they stated that without the aid of absorptive capacity, knowledge acquired will yield no significant outcome.

Absorption capacity is noted to be a complementing component to external knowledge acquisition (Ferreras-Méndez et al., 2015). The variation of a firm's body of knowledge, previous learning experience, research and development activities, availability of cross-functional interconnections as well as its problem-solving capability necessitates absorption capacity to ensure effective exploitation of knowledge acquired (Sancho-Zamora et al., 2021).

Organizational learning theory stipulates the relevance of acquired knowledge to a firm. However, researchers such as Xue et al. (2019) stated that the ability to transform and use such knowledge is key, and hence such a dynamic capability explains the role of absorption capacity in the whole process. Agustí et al. (2021) noted that absorption capacity remains a unique dynamic for effective utilization of a

firm's acquired knowledge. Thus, "Absorptive capacity (ACAP) determines the potential usefulness of new knowledge to generate new products and new behaviour, or to enter into new markets" (Agustí et al., 2021).

Dimensions of Absorption Capacity

Various related terms are used in extant literature to explain the dimensions of knowledge absorption capacity; for example, dynamic absorption capacity, relative absorption capacity, conceptualized absorption capacity, and reconceptualized absorption capacity are a few examples. According to their proponents, all of these concepts have different dimensions. For instance, knowledge acquisition or identification, knowledge assimilation, knowledge transformation, and application are the dimensions of absorption capacity (example: Albort-morant & Henseler, 2018; Baeshen et al., 2021; Zahra & George, 2002).

Other researchers also included maintenance, reactivation, and transmutation in the dynamic absorption capacity, while others merged the assimilation and transformation capacity and hence had only three dimensions under the construct name "reconceptualized dimensions of knowledge absorption"(Todorova & Durisin, 2007). Below is a discussion on the 4 main dimensions of absorption capacity.

Knowledge Acquisition Capacity

It is the absorption capacity's initial dimension. The term is used synonymously with knowledge or information identification. It is the process of a corporation identifying and acquiring significant external knowledge. This is in line with the way the procedure of determining and evaluating external knowledge is viewed (Albort-Morant & Henseler, 2018). It encompasses the incentive to properly assess and obtain prior knowledge, propensity to recognize, digest, and process new knowledge (Sancho-Zamora et al., 2021).

Knowledge Assimilation Capacity

This term has evolved to relate to a company's routines, procedures, and practices, which influence the quality and efficiency of its evaluation, processing, as well as comprehension of external knowledge (Albort-Morant & Henseler, 2018). This capability is based on the firm's ability to comprehend and process knowledge. Knowledge assimilation is thus predicated on a company's ability to comprehend and generate understanding of newly acquired external knowledge (Albort-Morant & Henseler, 2018).

Assimilation of external knowledge, according to Sancho-Zamora et al. (2021), entails integrating it into systems and procedures for assessing, processing, evaluating, and comprehending external knowledge. Assimilation of knowledge is the process of incorporating it into organizational systems (Sancho-Zamora et al., 2021).

Knowledge Transformation Capacity

This concept incorporates elements of newly obtained external knowledge as well as relevant previous knowledge held by the organization (Albort-Morant & Henseler, 2018). This component "connotes a company's potential to establish and modify the procedures that permit integrating current and recently gained as well as absorbed knowledge. This stage is thought to be very relevant as it is accomplished by either introducing additional knowledge, deleting existing one, or simply contextualizing knowledge (Albort-Morant & Henseler, 2018).

The capability to integrate old as well as ingrained information with recently obtained information is referred to as transformation. This is accomplished by incorporating new knowledge while re-evaluating and updating the firm's existing knowledge (Sancho-Zamora et al., 2021). Given the foregoing, it could be argued that by creatively integrating old as well as current knowledge, increases the relationship

between such knowledge for better performance. This can open up new possibilities for improving present operations, which can lead to effective product innovation or entering new markets in a unique way (which can result in process or market innovation) (Sancho-Zamora et al., 2021).

Knowledge Exploitation Capacity

It is a routine-based organizational skill that allows companies to enhance, broaden, and exploit current competencies or develop new ones by infusing learned as well as transformed information into their operations (Albort-Morant & Henseler, 2018). The phrase "exploitation" refers to the economic implementation of additional external information. It denotes a company's ability to profitably utilize innovative external information (market or technological) to meet its objectives (commercialization) (Sancho-Zamora et al., 2021).

Albort-Morant and Henseler (2018) argued that it is a must that all the other dimensions result into exploitation which is a yardstick to measure their effectiveness. Sancho-Zamora et al. (2021) echoed the above by stating the commercialization of acquired knowledge is the ultimate goal of a firm's knowledge acquisition. Firms can use market knowledge to figure out how to monetize their expertise, while technological knowledge can help them create innovative manufacturing processes.

Despite the 4 dimensions identified and discussed above, some researchers re-grouped them into two main dimensions; where Potential Absorption Capacity (PACAP) measures knowledge acquisition and assimilation capacities while Realized Absorption Capacity (RACAP) measures the transformational and application capacities (Albort-Morant & Henseler, 2018; Müller et al., 2020).

Conceptualization of the Dimensions of Absorption Capacity

The study conceptualized knowledge acquisition capacity to encapsulate the process of obtaining new knowledge through external or internal research and development and or training. Knowledge assimilation capacity was conceptualized to refer to the routines and processes that indicates a firms' commitment towards integrating of new knowledge to align with old knowledge structure for use. Thus, the capacity to integrate new equipment, machinery, or software to develop or produce innovative products, services, or processes, aligning with existing firm-level knowledge or integrate knowledge by purchasing or licensing any patented or non-patented inventions for the development of innovative products, services, or processes, aligning with existing firm-level knowledge.

Furthermore, the study conceptualized knowledge transformation capacity to refer to the capacity of firms to recognize usefulness of external knowledge and restructure /modifies it to create new insights for internal us. It captures the adoption of internet for R&D to transform initial product ideas to meet market demands and or the adoption of new approaches to online sales, marketing strategy and purchasing due to market or supplier demand. Lastly, exploitation capacity was conceptualized to refer to a firm's capability to competitively use/utilize new external knowledge to achieve its goals.

Empirical Literature

Empirical studies on knowledge acquisition and its effects on sustainable innovation have consistently reported a unidirectional positive effect. For example, Zhang et al. (2018) utilized confirmatory factor analysis and structural equation modelling to investigate learning resources, innovation, and sustainable performance in 321 industrial sector firms in China. Their findings revealed a positive influence of

knowledge acquisition capacity on green product and process innovativeness. In the exploration of the interconnections among Research and Development (R&D), innovation, and productivity within micro-enterprises, Luong & Hewitt-Dundas, (2020) strategically applied the dynamic capabilities theory. Spanning regions including the United Kingdom, Ireland, and the United States, the study employed the probit model for data analysis. The pivotal revelations underscored the profound impact of R&D investments, demonstrating a compelling link between such investments and a firm's inclination toward engaging in innovative practices.

In the study investigating the repercussions of R&D on the innovation of products and processes within Latin countries, Esteban et al. (2023) grounded their research in the institutional theory. Drawing data from the World Bank's Enterprise Survey in 2010, the study incorporated a comprehensive array of variables, including R&D investment, expenditure, R&D development, utilization capacity, and firm size. The analytical framework adopted for this investigation was the Crepon Duguet Mairesse model. The outcomes of the study uncovered the positive cascading impacts stemming from R&D investments on the landscape of innovation. Furthermore, the research accentuated the affirmative role played by innovative development and expenditure as precursors to a firm's overall prowess in innovation.

Studies also exist on the effects of knowledge integration or assimilation on sustainable innovation. For instance, Mohan et al. (2020) examined the effects of knowledge integration on the green innovative performance of firms in China using the Partial Least Square Structural Equation Modelling. They concluded that the integration of acquired knowledge propels green process innovative performance. Shi and Yang (2022) examined the effects of the integration of knowledge acquired through multidimensional R&D on green innovation of firms in China using the

dynamic threshold effect estimation technique. Their findings suggest that the integration of knowledge acquired through multifaceted Research and Development (R&D) has a positive impact on the green innovation initiatives of companies in China.

Regarding the effects of knowledge transformation on sustainable innovation, Amaranti et al. (2019) studied green dynamic capabilities as precursors for green innovation in manufacturing sector firms in Indonesia. They found that firm-level innovation is directly linked with knowledge gathering (acquisition), its transformation, and utilization (exploitation) capacities. Singh and Del-Rio (2019) assessed the missing link between eco-innovation and its major drivers, utilizing the Partial Least Square Structural Equation Modeling. They concluded that modifying knowledge exerts positive effects on eco-innovation in firms. Du & Wang, (2022) investigated "Green Innovation Sustainability of firms in China and assessed the role of absorption capacity through transformation of knowledge." Primary data was used, and the study concluded that the sustainable green innovation initiatives of firms in China benefit significantly from the effective absorption capacity demonstrated through the transformation of acquired knowledge.

Some studies examined the ultimate effects of the absorption capacity (knowledge utilization) on sustainable innovation in firms. However, mixed findings exist. For instance, Xue et al. (2019), used hierarchical linear modeling to explore the moderating role of absorption capacity and managerial factors on the linkage between sustainable innovation and green performance. They concluded that commitment from management on environmental issues directs absorption capacity to activate green innovative practices. Song et al. (2021) assessed green innovation of firms considering potential and realized absorption capacity. They found that the discovery

of new ideas and their utilization positively affects green innovative performance, moderated by environmental turbulence. Baeshen et al., (2021) used structural equation modelling to determine the drivers of green innovation in firms, concluding that absorption capacity is a one-dimensional driver, intensified in medium-scale enterprises. Some studies also used moderators for instance, Yin et al., (2022) also investigated the moderating role of firm age on green entrepreneurship among SMEs. They sampled 1667 SMEs in China from the period of 2010 to 2019. Using regression analysis, they concluded that firm age exerts significantly positive effect on their propensity to green innovate as well as engage in utility model innovations.

Conceptual Framework

The framework for the study was adopted from the works of Cappellari et al. (2019) in their study entitled "Absorptive capacity: Components and organizational mechanisms for its development". Detailed discussion of the model is done beneath.

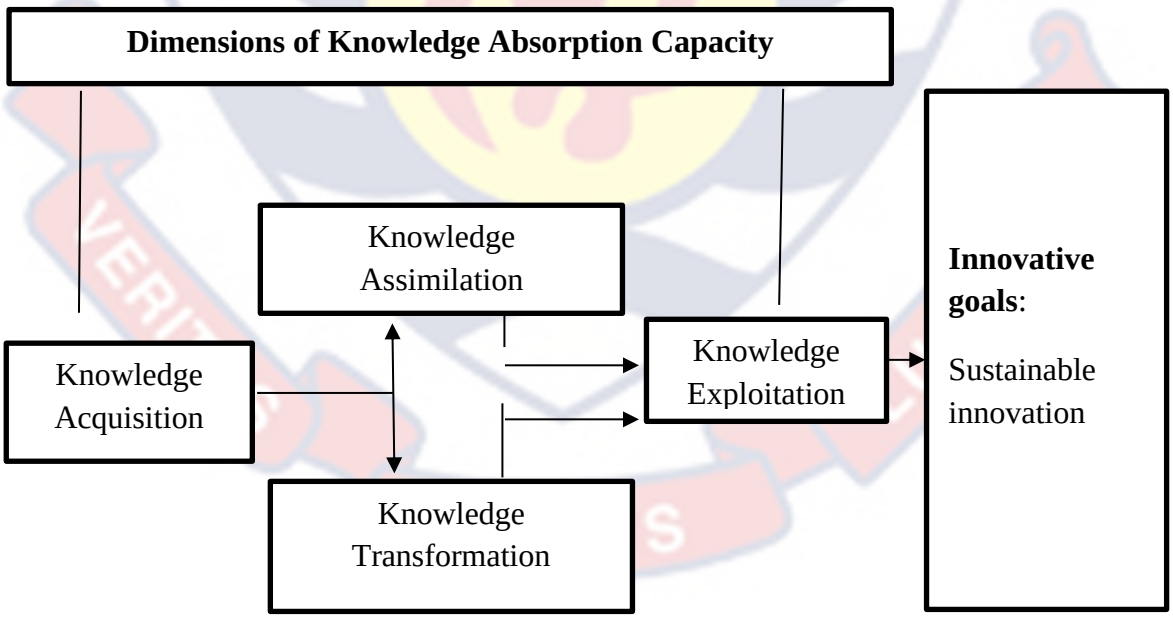

Figure 1: Linkage between the dimensions of Absorption Capacity on Sustainable Innovation.

Source: Adopted from Cappellari et al. (2019)

The model outlines the key dimensions of absorption capacity and their interconnections to generate innovative outcomes, particularly in the realm of sustainable innovation. It underscores that the initial step involves knowledge acquisition, achievable through methods such as internal or external research and development initiatives or training. The acquired knowledge may then undergo integration, aligning with existing knowledge before its utilization. Alternatively, in certain ground-breaking situations, firms have the capacity to autonomously transform acquired knowledge, leading to the generation of novel insights without strict adherence to pre-existing internal knowledge structures. These dual processes subsequently transition into effective utilization, wherein the firm applies the acquired knowledge in its production processes to develop novel or enhanced products or services. The ultimate result is the realization of innovative objectives, prominently featuring sustainable innovation.

Research Gap

The effect of absorption capacity dimensions on green innovation has received several empirical validations (example: Chen et al., 2015; Hashim et al., 2015). However, empirical findings on the effects of the dimensions of absorption capacity on the broader concept, thus, sustainable (green, social and economic) innovation remains inconclusive. Whiles some studies maintained the direct role of absorption capacity on green innovation (example: Amaranti et al., 2019; Baeshen et al., 2021), others (such as: Xue et al., 2019) maintained it as a moderator in explaining the role of innovation and green performance.

Other studies (example: Zhang et al., 2018) used absorptive capacity in conjunction with other constructs regarded as components of firm level dynamic

capabilities. It is however unclear if knowledge absorption capacity dimensions will exert significant effects on sustainable innovation.

Equally, extant literature on the two concepts remains limited in Sub-Saharan Africa. This is justified from the fact that most of the existing extant literature are geographically limited to developed countries (such as Xue et al., 2019; Song et al., 2021), making effective generalization to cover developing nations such as Ghana problematic.

This study aimed to fill the research gap identified by examining the extent to which the dimensions of knowledge absorption capacity influences sustainable innovation of firms in Ghana.

Chapter Summary

In a nutshell, the chapter provided contrasting viewpoints expressed on what constitutes sustainable innovation. Incorporating eco-friendly innovation combined with social dimensions and conventional innovation (economic) guarantees sustainable innovation. Discussion was also done on absorption capacity and its quadruple dimensions (knowledge acquisition, transformation, assimilation, and exploitation dimensions).

The chapter provided a theoretical review where the resource-based view was explained to link the main concepts of the study. The argument of the resource-based view (RBV) was that absorptive capacity remains a key organizational capability and resource for generating long-term competitive advantages through innovations.

Extant related literature was reviewed where limitations were juxtaposed in each case. However, the review shows minimal empirical literature exists on the extent to which the dimensions of knowledge absorption capacity influence the sustainable innovation of firms in Ghana.

CHAPTER THREE

RESEARCH METHODS

Introduction

The chapter provided the research methodology employed. The research design used was described and justified. The source of data used for the study as well as the type of data used was discussed in the chapter. Other significant sections of the chapter include; theoretical and empirical model specification, justification, measurement of variables and expected signs. The chapter also provided discussions on estimation methods used and the diagnostic test used to estimate the effects of the dimensions of absorption capacity on sustainable innovation of Ghanaian firms.

Research Design

The study is rooted in the positivist research philosophy. Positivism is a philosophy that is heavily reliant on empirical evidence, implying that science is the sole approach to discovering ultimate truth (Fiave, 2019). The research gap identified in the previous chapter of the study helps to situate the study in the explanatory design perspective. The explanatory research design is described as a method of gathering data with the goal of explaining a phenomenon. The specific research approach adopted is the quantitative research approach as the dataset available for the study remained secondary data, which is numeric in nature. The choice of the philosophy, approach and design is because the study used a quantitative dataset to examine the knowledge acquisition dynamics of Ghanaian firms and the extent to which such dynamics influenced their propensity to sustainably innovate. Thus, specifically, the study investigated the main concepts by testing appropriate hypotheses in a scientific way. The strength of this philosophy lies in its emphasis on empirical objectivity;

however, its weakness is that it does not account for subjective measurements that could offer more detailed insights.

Sources of Data

Ghana Enterprise Survey: The roll-out of the survey by World Bank in Africa was done in 2012. The study was carried out in Ghana between the last quarter of 2012 through to the beginning of the third quarter of 2014. The survey's goal was to gather feedback from businesses on the condition of the private sector and to assist in the development of a collection of corporate data-set to enable researchers to study the dynamic climatic conditions of the business sector for effective impact evaluations. The survey sought to develop indicators for measuring the private sector business environment, which can be similar to related data in other nations. Private contractors were utilized by the World Bank to conduct the Enterprise Surveys, specifically chosen over government-associated entities due to the sensitivity of survey questions related to business-government relations and corruption.

Three levels of stratified random sampling were used to analyze data from 720 firms in Ghana: firm sector, firm size, and geographic location. The countrywide coverage of the survey included carefully chosen areas with an emphasis on important economic hubs, based on factors such as the number of establishments, employment contribution, and value contributed. In order to ensure a comprehensive analysis of the nation's business environment as part of the continuing World Bank Enterprise Surveys effort, stratification was used across industry categories (manufacturing and services), firm sizes (Small and Medium Scale as well as Large Scale Enterprises), and geographic areas (Accra, North, Takoradi, Tema). Industry stratification included four manufacturing sectors (food, textiles and garments, chemicals and plastics, and other manufacturing) and two service sectors (retail and other services). Size

stratification classified enterprises as small (5 to 19 employees), medium (20 to 99 employees), or large (over 99 employees). Regional stratification considered four key regions: Accra, North (Kumasi and Tamale), Takoradi, and Tema.

Most of the questions asked were geared towards extracting information relating to direct assessment of the private sector business environment, while a few opinion-based questions were also asked relating to obstacles faced by firms. Variables with related items captured in the survey include firm level characteristics, organizational performance, regulations and taxation, crime and corruption, as well as data on technology and innovative activities. Weights for the innovation survey were computed by modifying the initial Enterprise Survey weights, incorporating an upward adjustment achieved through the multiplication of weights by a cell-specific factor. This factor was determined by the proportion of originally completed Enterprise Survey interviews to interviews conducted for the innovation survey.

In this study, information on knowledge exploitation of utilization capacity was sourced from the Ghana Enterprise Survey (ES) data.

Ghana Innovation Follow-Up Survey (GIFS): This was a follow-up survey of which participants sampled were respondents from the 2013 Ghana Enterprise Survey (ES). The aim of GIFs was to provide reach information of innovation by ensuring a minimum of 75% of firms used in the ES were used. In all, the GIFS sampled 549 firms and number of questions asked was 177. The survey started in January, 2014 and lasted for 8 months.

Information on the various types of innovation, as well as innovative activities and the use of information technology, was provided in the GIFS data. Importantly, information about process and product innovation contains responses that cut across social, economic, and green dimensions. Specifically, for product innovation, specific

data exists on reasons for its introduction, ranging from cost reduction, expansion of product and market, and compliance with environmental regulations. On process innovation, specific questions asked to justify the reasons for its introduction by firms include; ensuring flexibility, quality, speed, reducing cost and waste, and also ensuring compliance with environmental regulations.

In this study, aside from information on sustainable product and process information, data on knowledge acquisition, transformation, and assimilation were sourced from the GIFS data set. Data on the control variables; age, sector and location were equally sourced from the GIFS data set.

Empirical Model Specification

To estimate the effects of the dimensions of absorption capacity (acquisition, assimilation, transformation, and exploitation) on sustainable innovation, the study modelled sustainability in general to encompass the concurrent introduction of both forms or otherwise. The second and third models are disaggregated models where sustainable product innovation and sustainable process innovation are used as dependent variables separately. Empirically, similar aggregated nature of sustainability were equally used (Calik & Bardudeen, 2016; Hermundsdottir & Aspelund, 2021).

The second and third models show the decomposed nature of sustainable innovation into its two main forms. In effect, the second and third models estimate the influence of absorption capacity on either forms of sustainable innovation separately. Empirical studies also adopted similar approaches by decomposing sustainable innovation into the types (Albort-Morant & Henseler, 2018; Calik & Bardudeen, 2016; Castaldi, 2021; Hermundsdottir & Aspelund, 2021).

The following were the major justifications for the above:

To estimates the effects of the absorption capacity dimensions on sustainable innovation (both process and product). And to estimate the individualized effect of the dimensions of absorption capacity on sustainable process and product innovations separately.

The ordered logistic regression was used to test the effects of the dimensions of absorption capacity on sustainable innovation of firms as shown below:

$$Sust_{innov(i)} = \propto + \beta_1 KACCAP_i + \beta_2 KASCAP_i + \beta_3\ KTRANSCAP_i + \beta_4\ KEXCAP_i + \beta_5\ Age_{firm(i)} + \beta_6\ Size_{firm(i)} + \beta_7\ Sector_{firm\,(i)} + \beta_8\ Location_{firm(i)} + \varepsilon_i \quad (1)$$

where $Sust_{innov}$ = Sustainable innovation, KACCAP= Knowledge Acquisition Capability of the firm, KASSCAP = Knowledge Assimilation Capability of the firm, KTRANSCAP = Knowledge Transformational Capability of the firm and KEXPCAP = Knowledge Exploitation Capability of the firm. $Age_{firm(i)}$ = Firm's Age, $Size_{firm}$= Firm Size and Sector of firm = $\beta_6\ Size_{firm(i)}$, and $Location_{firm(i)}$ = Location of the firms, ε_i = Error term and "i" = Individual firm level Observation.

Logit regression model was used to estimate the effects of absorption capacity on sustainable process or product innovation. Equation 2 shows the model for measuring the effects of absorption capacity on sustainable product innovation of firms. Equation 3 shows the model for measuring the effects of absorption capacity on sustainable process innovation of firms. They are shown below:

$$Sust\_Prod_{innov(i)} = \propto + \beta_1 KACCAP_i + \beta_2 KASCAP_i + \beta_3\ KTRANSCAP_i + \beta_4\ KEXCAP_i + \beta_5\ Age_{firm(i)} + \beta_6\ Size_{firm(i)} + \beta_7\ Sector_{firm\,(i)} + \beta_8\ Location_{firm(i)} + \varepsilon_i \quad (2)$$

$$Sust\_Proc_{innov(i)} = \propto + \beta_1 KACCAP_i + \beta_2 KASCAP_i + \beta_3\ KTRANSCAP_i + \beta_4\ KEXCAP_i + \beta_5\ Age_{firm(i)} + \beta_6\ Size_{firm(i)} + \beta_7\ Sector_{firm\,(i)} + \beta_8\ Location_{firm(i)} + \varepsilon_i \quad (3)$$

Theoretical Model Specification

Ordered Logistic Regression

To determine the effects of the dimensions of absorption capacity on sustainable innovation, the study adopts the ordered logistic regression model with empirical validation from Egbetokun (2015). Dichotomous sum was done on the levels of innovation to obtain an overall firm level innovation capability. The model analysed the likelihood of absorption capacity and cooperative resources on innovative capabilities. Radicic et al. (2019) also used same model to analyse base line determinants (firm size, age, sector and location) on innovative sales.

In this study, absorption capacity with 4 dimensions or categories was used as independent variable to show their extent of influence on innovative activities (sustainable innovation) of firms. The dependent variable used is naturally ordered with three categories (0, 1 and 2) to capture none introduction of sustainable innovation, introduction of one form of sustainable innovation and introduction of two forms of sustainable innovation respectively. This observation justified usage of the ordered logistic regression model.

The choice for ordered logistic model in this study was due to empirical validation for it producing more robust results relative to ordered probit. Logit uses the standard logistic distribution relative to the cumulative distribution function of probit. Due to its computational advantages and interpretability, logistic regression is often favoured over probit regression (Solnørdal & Thyholdt, 2019). Additionally, the logit coefficients can be easily interpreted as odds ratios, making it more accessible for researchers and practitioners to convey and apply the results (Solnørdal & Thyholdt, 2019).

The ordered nature of the dependent variable used in the study implies using Ordinary Least Square estimation will lead to biased findings. This necessitates the usage of regression model (such as the ordered logit model) that will provide ranges for the actual proportional odd ratios to fall within. The Ordered Logit relies on cumulative probabilities for every response variable and assumes equal distance between ordinal values used.

The Model for propensity to introduce sustainable innovation at the firm level is used is as shown below:

$$Y_i = \beta X_i + u_i \quad (4)$$

Where Y_i = f (Y^*_i), Y_i is a function of another variable (Y^*_i) which represents the natural order for level of sustainable innovation introduction.

$$Y_i^* \begin{cases} Y_0^* = \text{Introduced none of the two sustainable innovation forms} \\ Y_1^* = \text{Introduced only one (1) form of sustainable innovation} \\ Y_2^* = \text{Introduced the two (2)forms of sustainable innovation} \end{cases}$$

X_i= The dependent variables and u_i= error term

The latent model is then given as:

$$Y_i^* = \beta^*_0 + \beta^*_1 X_1 + \ldots + \beta^*_k X_k + \varepsilon_i \quad (5)$$

Where "k" = number of latent, cases of categories of sustainable innovation, = 3

ε_i = Error term from the latent regression.

The ordered nature of " Y_i^*" remains a threshold. The threshold for the three categories of sustainable innovation introduction gives:

$$Y_i^* \begin{cases} Y_0^* = 0, \text{ if, } & Y_0^* \le \tau_1 \\ Y_1^* = 1, \text{ if, } & \tau_1 \le Y_1^* \le \tau_2 \\ Y_2^* = 2, \text{if, } & Y_2^* \ge \tau_2 \end{cases}$$

Where "τ_1" and τ_2= Cut off points or thresholds of latent variable Y_i^* = to the discrete variable "Y_i".

The probability or predicted Odds to determine the marginal effects of depends on the number of latent variables used (in this case, 3). Hence, the predicted probabilities give:

$$P(Y_i>j) = \frac{exp^{(X\beta-k_j)}}{1+[exp^{(X\beta-k_j)}]}, j=1, 2, ..., \tau-1 \quad (6)$$

$$P(Y_i=1) = 1- \frac{exp^{(X\beta-k_1)}}{1+[exp^{(X\beta-k_1)}]} \quad (7)$$

$$P(Y_i=j) = \frac{exp^{(X\beta-k_{j-1})}}{1+[exp^{(X\beta-k_{j-1})}]} -1- \frac{exp^{(X\beta-k_1)}}{1+[exp^{(X\beta-k_1)}]}, j=2 ..., \tau-1 \quad (8)$$

$$P(Y_i=\tau) = \frac{exp^{(X\beta-k_{\tau-1})}}{1+[exp^{(X\beta-k_{\tau-1})}]} \quad (9)$$

exp =exponent of the function.

In this Study, the cases or categories for introduction of sustainable innovation are three and hence the model's threshold $(\tau) = 3$. The specific predicted probabilities of the categories of sustainable innovation are as shown below:

For non-introduction of any of the two forms of sustainable innovation which is outcome 1, the predicted probability value is given as:

$$P(Y_i= 1) = \frac{1}{1+[exp^{(X\beta-k_1)}]} \quad (10)$$

For introduction a form of sustainable innovation which is outcome 2, the predicted probability value is given as:

$$P(Y_i= 2) = \frac{1}{1+[exp^{(X\beta-k_2)}]} - \frac{1}{1+[exp^{(X\beta-k_1)}]} \quad (11)$$

For introduction the two main forms sustainable innovation which is outcome 3, the predicted probability value is given as:

$$P(Y_i= 3) = 1 - \frac{1}{1+[\ exp^{(X\beta-k_3)}\ ]} \quad (12)$$

Logistic Regression for Disaggregation of Sustainable Innovation

To estimate the effects of the 4 dimensions of absorption capacity on firms' likelihood to sustainably product or process innovate (disaggregated sustainable innovation), the study adopted the logistic regression model, which was empirically validated by Solnørdal and Thyholdt, (2019). The model analysed the likelihood of firms' introducing energy-efficient innovations using the various dimensions of absorption capacity.

In this study, sustainable product innovation and sustainable process innovation, which encompasses innovation across green, economic, and social dimensions, were added as the dependent variables. The dichotomous or binary nature of the two dependent variables justified the use of the logistic regression model. Thus, specifically, 0 and 1 were used to represent non-introduction of either forms of sustainable innovation or the introduction of a form of sustainable innovation, respectively. The choice of logit relative to probit was due to its efficiency and ease of interpretation coupled with the robustness of its results, which was justified empirically.

The model for firms' probability to sustainably product or process innovates in the presence of the dimensions of absorption capacity gives;

$$Y_i = \beta X_i + \mu_i \qquad (13)$$

where Y_i = Sustainable process or product innovation

$$Y_i \begin{cases} 0 = \text{Do not introduce any of the two forms of sustainable innovation} \\ 1 = \text{Introduced either one of the form of sustainable innovation} \end{cases}$$

μ_i= error term from the regression

The Logit Model for sustainable product or process innovation gives:

$$Logit(Y_i) = \beta_o + \beta_1 X_{ij} \qquad (14)$$

where "i" = vector covariates and "j"= firms level variables.

The resultant coefficient from the above regression will be difficult to interpret as reflecting the effect of the various independent variables on the dependent variables. As such, the odds are used, which represent the exponential function of the vector regression coefficients. Thus, e^{β_i}, where i = 1 to the j^{th} term,

The Odds represent the likelihood of "0" or "1" occurring and, in this case, represent the likelihood of the firms' not introducing any of the forms of sustainable innovation or otherwise, respectively. With such, the Odd equation can be given as:

$$\text{Odds } (\pi_i) = \frac{\pi_i}{1-\pi_i} \qquad (15)$$

where $\pi_i = X^l{}_i\beta$, and π_i= covariate function that is linear in nature. In the above equation, the lower the probability, the larger the Odds and the reverses is also true.

Taking Log of the above equation, gives:

$$\text{Logit } (\pi_i) = Log\, \frac{\pi_i}{1-\pi_i} \qquad (16)$$

Solving for π_i from the above equation gives:

$$\pi_i = \frac{exp^{X^l{}_i\beta}}{1+exp^{X^l{}_i\beta}} \qquad (17)$$

Thus the marginal effect each independent variable on π_i is the coefficient of the independent variables and its probability.

From the above, incorporating the variables of the study gives the probability of introducing either of the two forms of sustainable innovation as:

$$P_i(Y = 1/X) = \frac{exp^{X^l{}_i\beta}}{1+exp^{X^l{}_i\beta}} \qquad (18)$$

where $X^l{}_i$= the various independent variables used in the model.

Given that, $P_r(0) + P_r(1)$ =1, hence, the probability not to introduce either of the two forms of sustainable innovation as:

$$P_i(Y=0) = 1 - P_r(1) = \frac{1}{1+exp^{X^l{}_i\beta}} \quad (19)$$

Justification, Measurement of Variables and Sign Expectations

The study's choice for the various variables (explanatory, outcome and control variables) was based on three main factors. They are:

(a) support from extant literature (theoretical and empirical literature);

(b) the choice of model for the study; and

(c) availability of data

Dependent Variables:

The Ghana Innovation Follow-up Survey dataset provided data on the rationale behind firms' introduction of product and process innovation. Specifically, the data set on product innovation provided responses including the introduction of product innovation to help reduce costs, extend services, venture into new markets, and comply with environmental regulations. On the other hand, responses of the same calibre on process innovation include improving production quality, speed, and flexibility as well as complying with environmental regulation and cost reduction.

For both forms of sustainable innovation (product and process), the study grouped responses into socio-economic dimensions and green dimensions as justified by Calik and Bardudeen, (2016); Hermundsdottir and Aspelund, (2021). In this case, a firm that implemented both dimensions of a particular form of innovation is regarded as being sustainable, and otherwise, it was regarded as not sustainable.

For sustainable innovation, the outcomes from the two main forms of sustainable innovation were ranked to reflect firms that did not introduce either of them, those that introduced only a form, and those that introduced the two

concurrently. This approach received empirical validation where similar measures were used (exampled: Egbetokun, 2015; Radicic et al., 2019).

Independent Variables

Knowledge Acquisition Capacity: Firms acquire external knowledge through research or training activities (Albort-Morant & Henseler, 2018; Müller et al., 2020). The information for this variable was sorted from the Ghana Innovation Follow-up data. The dataset provided information relating to whether firms engaged in internal or external research and development activities as well as training to acquire knowledge. These constructs were used to measure knowledge acquisition capacity. In effect, firms that engaged in it were ranked to have knowledge acquisition capacity, and the reverse is also true. The study measured Knowledge acquisition capacity of firm by using their ability to acquire external knowledge through R&D initiative and or training activities. This proxy has received empirical justification from several scholars (such as Albort-Morant & Henseler, 2018; Müller et al., 2020). The role of this variable is to act as an initial phase for innovative endeavours, as companies identify and assimilate new knowledge for the advancement of such processes.

Knowledge Assimilation Capacity: Acquired knowledge requires the necessary environment for its interpretation and analysis. The data set (GIFS) provided responses on the use of ICT, such as the purchase of software for in-house purposes, designating employees for ICT and having internet connections. These items were used to measure firms' capacity to assimilate acquired knowledge. These variables received empirical validation from extant literature (Ferreras-méndez et al., 2015; Müller et al., 2020) that argued that the assimilation capacity of firms encompasses the capacity to identify new opportunities to serve, such as purchasing new IT-specific knowledge. In the study, knowledge assimilation was measured by assessing

whether firms integrated new equipment, machinery, or software to develop or produce innovative products, services, or processes, aligning with existing firm-level knowledge. This involved examining whether the establishment assimilated knowledge through the purchase or licensing of patented or non-patented inventions for the development of innovative products, services, or processes while aligning with existing firm-level knowledge. This variable's significance lies in its capacity to facilitate firms in leveraging assimilated knowledge for the utilization of knowledge, contributing to the enhancement of processes or products through the addition of features or services.

Knowledge Transformation Capacity: Information on this variable was sorted from the Ghana Innovation Follow-up data. The data set provided responses on whether firms purchase new equipment or machines or purchase any form of invention. These variables were used to measure the capacity of firms to recognize external knowledge by purchasing patent inventions to facilitate modernization. Similar constructs were used in extant literature (example; Albort-Morant & Henseler, 2018; Müller et al., 2020). The study measured knowledge transformation through questions aimed at assessing whether firms had adopted the internet for R&D to transform initial product ideas to meet market demands and whether they had implemented new approaches to online sales, marketing strategy, and purchasing in response to market or supplier demand. This variable is significant as it enables a firm to alter its production or distribution channels, contributing to the development of entirely new insights for novel processes, products, or services.

Knowledge Exploitation Capacity: Information on this variable was sorted from the Ghana Enterprise Survey. The data set provided responses on whether firms introduced a new product, service, or production mechanism. These variables were

used to measure knowledge utilization and have received empirical validation (example: Albort-Morant & Henseler, 2018; Baeshen et al., 2021; Müller et al., 2020). Knowledge utilization was a proxy for this variable. It remains the last and ultimate process of absorption; hence, its relevance cannot be underscored in the model.

Control Variables

Firm Age: Firm age was measured using the time or year of the survey minus the year of incorporation of a firm. Its inclusion as a control variable in the study was based on empirical reviews on similar topics (Afful & Owusu, 2019; Baeshen et al., 2021; Fiave, 2019). The various years of incorporation of the firms were stated in the dataset, making this calculation simple.

Firm Size: The two surveys provided information on the size of the firms, measured in three categories; small, medium, and large scale. Extant literature, however, justifies the combination of small and medium enterprises (Beuter et al., 2019; Dukeov et al., 2018; Sobczak et al., 2022). This approach was used in this study to allow for comparison between small and medium-scale enterprises and large-scale enterprises. The choice of this control variable was backed by similar studies that equally used firm size as a control variable (example; Afful & Owusu, 2019).

Sector of Firm: The data available contains information where firms were categorized into manufacturing and service sectors. The choice of this in the study was to aid comparative analysis where results can be compared between manufacturing and service sectors. This choice received empirical validation (example; Fiave, 2019).

Location of Firm: The two surveys were restricted to 4 industrial clusters (Accra, North, Takoradi and Tema). The choice of this in the study was to aid

comparative analysis where result can be compared between the various clusters. This choice received empirical validation (example; Fiave, 2019).

Variable Measurement and Expected Signs: The table below shows how the variables were measured as well as expected signs based on extant literature.

Table 1: Variable description, measurement and expected sign

Variables	Description	Measurement	Sign
$Sust_{innov}$	Sustainable innovation	= 0 if a firm did not implement any sustainable innovative form. = 1 if the firm implemented a form of sustainable innovation (product or process) = 2 if the firm engaged in an all-round sustainable innovation (process and product)	
$Sust\_Prod_{inno}$	Sustainable product innovation	=1 if a firm sustainably process innovate (both socio-economic and green dimensions) and =0 if otherwise	
$Sust\_Proc_{inno}$	Sustainable process innovation	=1 if a firm sustainably product innovate (both socio-economic and green dimensions) and =0 if otherwise	
KACCAP	Knowledge Acquisition Capacity	=1 if the entity engaged in research and development or training activities towards acquiring new knowledge, and = 0 if otherwise	+
KASSCAP	Knowledge Assimilation Capacity	=1 if the firm has needed supportive environment integrate knowledge, and = 0 if otherwise.	+
KTRANSCAP	Knowledge Transforma-tion Capacity	=1 if the firm has the capacity to modify knowledge to create new insights and = 0 if otherwise.	+
KEXCAP	Knowledge Exploitation Capacity	=1 if the firm engaged in any form of knowledge utilization/application, and =0 if otherwise.	+

Age_{firm}	Age of firm	Year of survey minus year of incorporation of a firm	+
$Size_{firm}$	Size of firm	0 = Large Scale Enterprise 1 = Small and Medium Scale	+/-
$Sector_{firm}$	Sector of firm	1= Manufacturing sector, and 2= Service Sector	+/-
$Location_{firm}$	Location of firm	Specific area firm is situated	+/-

Source: Author (2022), Outcome based on the 2013 ES and 2014 GIFS dataset.

Estimation Methods

The theoretical models used in the study necessitate the usage of the logistic cumulative probability function for its estimation. This estimation method assumes linearity in the cumulative probabilities of each logit relative to the covariate of the constants across varied responses (Fernandes et al., 2020). A significant advantage of this estimation method is that it has the least variance among normally distributed estimators (Fernandes et al., 2020).

The estimation technique used is Maximum Likelihood Estimation. This was used to estimate the predicted probabilities of the ordered logistic regression, which situates the result into three predicted categories for accurate interpretation. It is appropriate for the study as there are three response categories or levels of sustainable innovation, which were naturally ordered. This allowed the model to estimate the effects of the dimensions of absorption capacity on the likelihood of firms to sustainably innovate.

The Maximum Likelihood Estimation was also used to estimate the marginal effect of sustainable process or product innovations in the presence of absorption capacity dimensions. With this, the estimate was able to quantify the probabilistic

effects of absorption capacity dimensions on the dichotomous dimensions of sustainable product or process innovation.

Diagnostic Tests

The *Link test* was used to test the evidence that the structural equations used or the models might be mis-specified or need to include more variables. The *Hosmer-Lemeshow Test* of Goodness of Fit was used to test for model fitness and trustworthiness. The Likelihood Chi-Square was used to test if the model is statistical significance and if the exogenous variables in the models are correctly measured. A multicollinearity test was run to test if the independent variables used in the model were correlated. This was done using the Variance Inflation Factor. All diagnostic and post-estimation test results can be seen in the appendix column. It is worth nothing that all the knowledge variables used as independent variables in the model are self-reporting and are dummy variables and hence could be subject to endogeneity. This issue remains a limitation to the estimation techniques used in the study.

Chapter Summary

The study aimed to investigate the effects of absorption capacity dimensions on the sustainable innovation of Ghanaian firms. The chapter provided a thorough discussion of the research design employed. The study used the Ghana Innovation Follow-up data and the Enterprises Survey data set. In all, 3 empirical models were provided with theoretical justification. The ordered logistic and logistic models as theoretical models were discussed in detail with various equations. The Logistic Cumulative Distribution function coupled with Maximum Likelihood Estimations was discussed as the estimation method for the study. All methods of estimation and diagnostic tests were discussed.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

Introduction

The chapter provided tabular and graphical presentation of results and discussions. Initial section was devoted to descriptive results presentation as well as discussions. This was followed by presentation of ordered logistic regression outcomes to test the hypotheses of the study. Outcome discussions based on study objectives was also done in the chapter. The chapter ends with chapter summary.

Summary Statistics

The summary statistical results were presented in two main categories. The first part provided frequency tables and in some instances mean and standard deviation for continues variables used in the study. The second part includes bar charts that depict the cross-tabulation between sustainable innovations (as dependent variables) and key control variables. The outcome on the summary statistics are displayed below:

Table 2: Summary Statistics of Control Variables

	Obs	Scale	Freq	%	M	St.	Min	Max
Firm Size	549	SMEs	520	94.72%				
		LSEs	29	5.28%				
Firm Age	549				15.68	10.599	0	77
Sector of Firm	549	Manufacturing	284	51.73 %				
		Service	265	48.27%				
Firm Location	549	Accra	283	51.55%				
		North	103	18.76%				
		Takoradi	45	8.20%				
		Tema	118	21.49%				

Source: Author (2022), Outcome based on the 2013 ES and 2014 GIFS combined dataset.

The results displayed in Table 2 indicated that the majority of the firms were small and medium-scale enterprises (SMEs), constituting 520, which is 94.7 percent. Large Scale Enterprises (LSEs) were the minority, representing 29, which is 5.28 percent. This finding suggests that small and medium enterprises dominate the firms included in the two surveys. A plausible justification could be that SMEs, facing limited opportunities for development, are compelled to innovate in order to survive in the challenging environment they find themselves. The finding is in harmony with empirical validation in Ghana as provided by Okyere et al., (2018) in their study. They confirmed the existence of several SMEs in Ghana compared to LSE.

The outcome as displayed above indicates that, as at the time of the surveys, the mean age of the firms recorded was 15.68 years with a standard deviation of 10.5989.

The findings above indicated that out of the 549 firms, the majority, thus 284, representing 51.73 percent, are in the manufacturing sector, while 265 firms, representing 48.25 percent, are service-rendering firms. This outcome deviates from statistics on the dominance sector in Ghana per the Integrated Business Survey (IBES) report in 2017, where the service sector dominates relative to the manufacturing sector (Ghana Statistical Service, 2017). However, the result might be due to the industrial stratification used in the study where emphasis was laid on several manufacturing sector categorizations (food, chemicals, plastics, garments, textiles and other manufacturing firms) relative to only two categorizations for the service sector (retail and other services). Hence, assigning weights to these two sectors might suggest that the service sector was given the least weight.

283 of the 549 firms used in the two surveys are domiciled in Accra, representing 51.55 percent. 118 of them, representing 21.49 percent, are located in

Tema. 103 of them, representing 18.76 percent, are located in the North, while the least number, thus 45, representing 8.20 percent, are located in Takoradi. The plausible reason for the distribution of firms (based on their locations) used in the survey could be because of the stratified random sampling method employed where weights were assigned to the 4 industrial clusters. As such, with the Greater Accra region noted as an industrial hub, it could be that the weights favoured that assertion and hence more firms were sampled from Accra and Tema, relative to the other two industrial clusters.

Summary statistics of the main variables used are as shown below:

Table 3: Summary Statistics of dependent and key independent variables

Variable	Obs.	Scale	Frequency	Percentage
$Sust_{innov}$	549	None	453	82.51%
		One level	62	11.29%
		Two levels	34	6.19%
$Sust\_Prod_{innov}$	549	No	496	90.35%
		Yes	53	9.65%
$Sust\_Proc_{innov}$	549	No	477	86.89%
		Yes	72	13.11%
KACCAP	549	No	369	67.21%
		Yes	180	32.79%
KASSCAP	549	No	233	42.44%
		Yes	316	57.56%
KTRANSCAP	549	No	315	57.38%
		Yes	234	42.62%
KEXCAP	549	No	238	43.35%
		Yes	311	56.65%

Source: Author (2022), Outcome based on the 2013 ES and 2014 GIFS combined dataset.

The result as displayed in Table 3 indicates that the majority of the firms used in the two surveys, thus 453 firms representing 82.51 percent, neither process

innovate nor product innovate. Those who introduced a form of sustainable innovation are 62, representing 11.29 percent, while those who introduced at least two forms of sustainable innovation are 34, representing 6.19 percent. The trend in results might be due to the associated cost of attempting to green-innovate, which could deter most firms from introducing sustainable innovative productive activities or products. This outcome confirmed the reportage by the Center for Africa and Sustainable Development Solutions that the Ghanaian economy, in general, is performing relatively poorly in terms of SDG 9 (industrial innovation) coupled with SDG 11 (sustainable innovation) (UN-SDG Index Report, 2019).

From the table above, 496 firms, representing 90.35 percent, do not introduce sustainable innovative products at all, while 53 (representing 9.65 percent) introduce innovative products that cut across social, economic, and eco-friendly dimensions. In contrast, 477 firms (86.89 percent) do not implement sustainable innovative processes in their production or service delivery. However, 72 of them, representing 13.11percent sustainably-process innovates. The result indicates that the number of firms that sustainably process innovate is high relative to those that sustainably product innovate. A plausible reason for the above could be that firms were targeting the introduction of green innovative production processes, which are more cost-effective relative to the introduction of sustainable innovative products. This could also be that firms are not engaging more in sustainable product innovation as they fear customers have already developed a taste for existing-trusted products compared to introducing new ones. Another plausible reason could be that introducing new sustainable innovative products demands advertising, which will impose additional costs on firms. As such, most firms feel reluctant to innovate on green products. Rather, they focused on sustainable process innovation.

The result as displayed in Table 3 indicates that few of the firms invested in knowledge acquisition capacities, thus 180 firms representing 32.79 percent. 316(57.56%), however, invested in knowledge assimilation capacities, while 233 (representing 42.44 percent) did not invest in such capacities. 234 firms (42.62 percent) invested in knowledge transformational capabilities, while 315 firms (57.38 percent) did not invest in any capability that would allow them to integrate newly acquired knowledge with their existing knowledge repository. The majority of firms, 311 (56.65 percent), invested in knowledge exploitation capabilities, while 238 (43.35 percent) did not. The outcome shows that investment in assimilation and exploitation capacities remains the highest.

A plausible justification for the above could be that the dynamic nature of the business environment necessitates quick recognition, interpretation, and integration of acquired knowledge to ensure firms remain competitive in their various industries. As such, investment in technologies that create the enabling environment for knowledge assimilation and utilization remains the key. Empirical justification of the above can be seen in the works of Karakara and Osabuohien, (2020) as they concluded that investment in ICT adoption by firms in Ghana is on the ascendency.

Sustainable Innovation by firms' Size

Figure 2 shows sustainable innovation variations among firms based on size. The Figure indicates that the number of SMEs, thus 32(6.16%) that introduced the two forms of sustainable innovation, is higher relative to LSEs, thus 2(6.90%), that introduced both forms of sustainable innovation. Equally, SMEs, thus 61(11.73%), lead in the number of firms that introduced a form of sustainable innovation relative to LSEs, thus 1(3.94%). The outcome shows that the introduction of at least one form of sustainable innovation is higher for SMEs relative to LSEs. The outcome also

showed that SMEs are more likely to adopt a form of sustainable innovation, thus 61 (11.73%) relative to adopting the two forms, thus 32(6.16%). A plausible reason for the observed trend could be that, given their limited resources and the prospect of limited growth, SMEs may find it imperative to innovate as a means of surviving in challenging environments. Furthermore, due to their smaller scale, SMEs may be more effective at achieving significant increases in output through incremental innovations. This is because they can easily respond to changing market conditions, adopt new technologies, and experiment with new ideas without being hindered by the bureaucratic obstacles that larger businesses often encounter. The result is in line with the empirical justifications of Yin et al., (2022). They concluded that SMEs have a higher potential for acquiring and utilizing clean, innovative production processes and products. The outcome is shown in Figure 2 below shows sustainable innovation variations among Small Scale Enterprises (SMEs) and Large Scale Enterprises (LSEs).

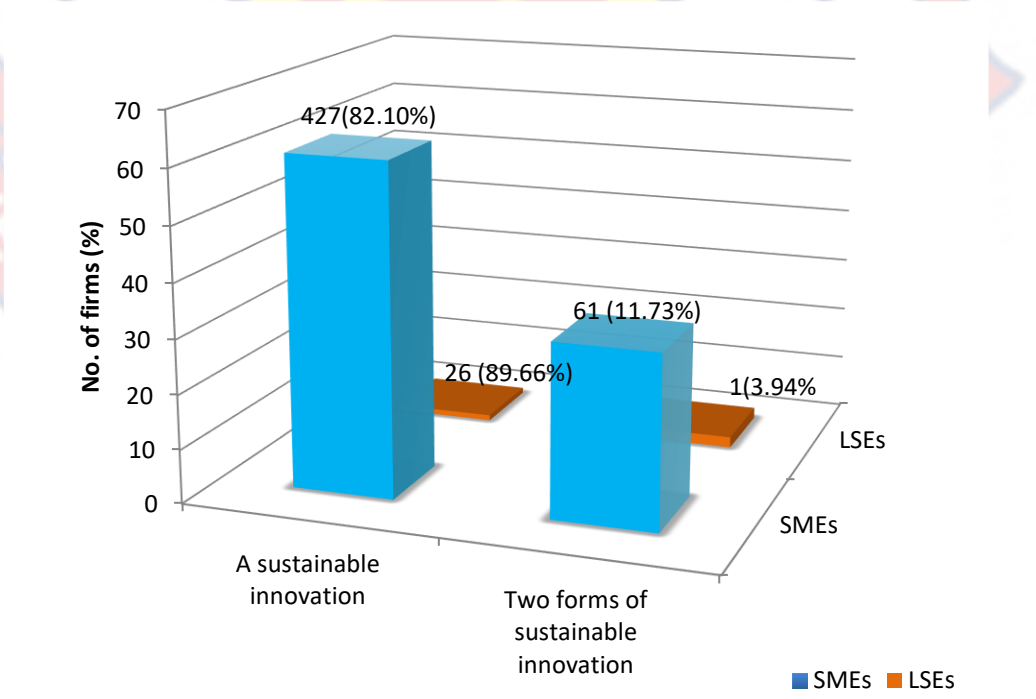

Figure 2: Sustainable innovation by firm Size
Source: Author (2022), Outcome based on the 2013 ES and 2014 GIFS-combined dataset.

Figure 3 shows the variation of sustainable product and process innovation by firm size. The result indicates that sustainable process innovation is more pronounced among SMEs than sustainable product innovation. Thus, 74(14.23%) compared to 51 (9.81%), respectively. The same outcome was recorded for LSE, thus 3(10.31%) relative to sustainable process innovation of 2(6.90%). The plausible reason for the above finding could be the dominance of manufacturing sector firms used in the survey (as indicated in Table 2). This is because process innovation is more pronounced among firms in the manufacturing sector, as it remains the foundation of such firms. The outcome could also be due to the profit motive of firms that entices them to introduce innovative processes to help minimize costs and remain eco-friendly as well.

The finding corroborates the empirical findings of Albort-Morant and Henseler, (2018). They concluded that at an early stage in the life of firms, they seem to focus more on their products due to dynamic consumer preferences and technological uncertainties. However, in the long run, when the dust settles, firms are geared towards ensuring sustainable process innovation, which promotes efficiency. A similar conclusion was provided by Sancho-zamora et al.(2021). They concluded that firms are more inclined towards incorporating measures to aid their green innovative production processes relative to green product innovation.

This viewpoint could be a plausible reason for the study's finding. This is because, with regard to the study, the mean age of firms used in the survey was 15.68 years (as shown in Table 2 above). This could be that the majority of the firms used have transcended beyond the short term stage of investing more into their capacities geared towards sustainable products but rather are more focused on sustainable

process innovations to reduce costs and ensure efficient production processes. The Figure (Figure 2) is as shown below:

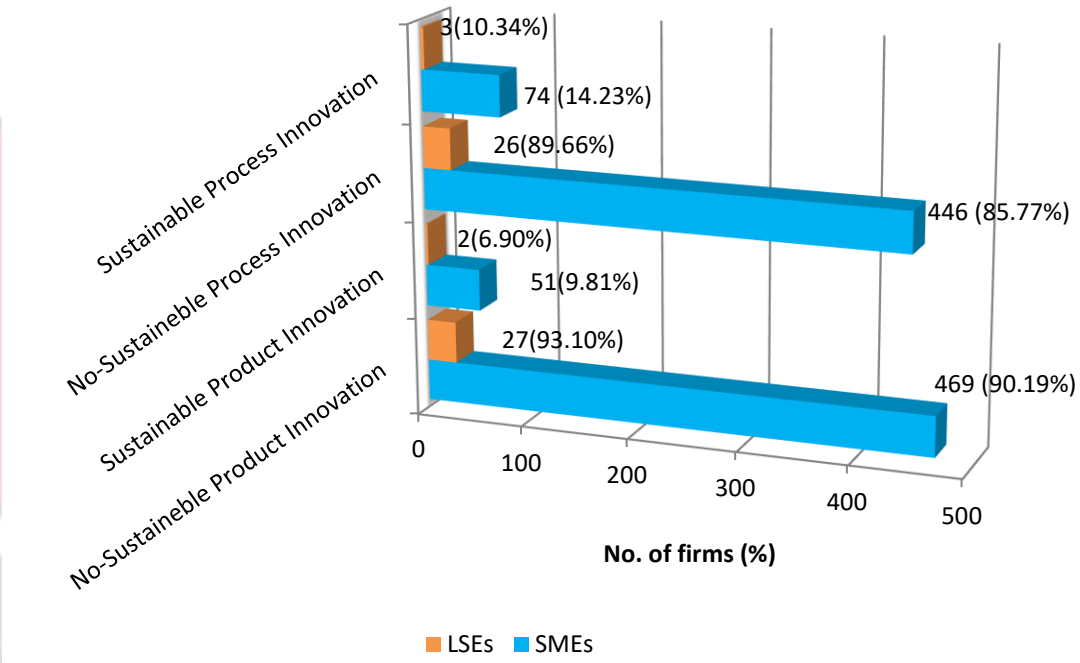

Figure 3: Sustainable Product or Process innovation by firm Size
Source: Author (2022), Outcome based on the 2013 ES and 2014 GIFS combined dataset.

Sustainable Innovation across Sector of firms

Figure 4 shows the variations in sustainable innovation across sectors. The result indicates that manufacturing sector firms, thus 40(14.08%), lead in the introduction of a form of sustainable innovation relative to firms in the service sector, thus 22(8.3%). The reverse was the case in the introduction of the two main forms of sustainable innovation together. Thus, 18 (6.79%) firms in the service sector introduced the two main forms of sustainable innovation, compared to 16 (5.64%) firms in the manufacturing sector that introduced the two forms of sustainable innovation. The probable reason for the above could be that the manufacturing sector dominates firms used in the two surveys. Coupled with the above, it is argued that the production process is the bedrock for manufacturing. With this, it could be that

several firms in the manufacturing sector only introduce innovative processes that are eco-friendly. Equally, innovation within the service sector (example: construction, retail, hotels, restaurants, transport, communications, and IT services) is argued to be both time and cost effective relative to manufacturing sector firms. This is due to the need for sophisticated technologies and machines that are required for green innovation in the manufacturing sector. As such, service sector firms could be targeting their output delivery (green innovative products), which could be brought about by engaging in green innovative production processes.

Figure 4 showing the variations in sustainable innovation across sectors (service and manufacturing sectors) is as below:

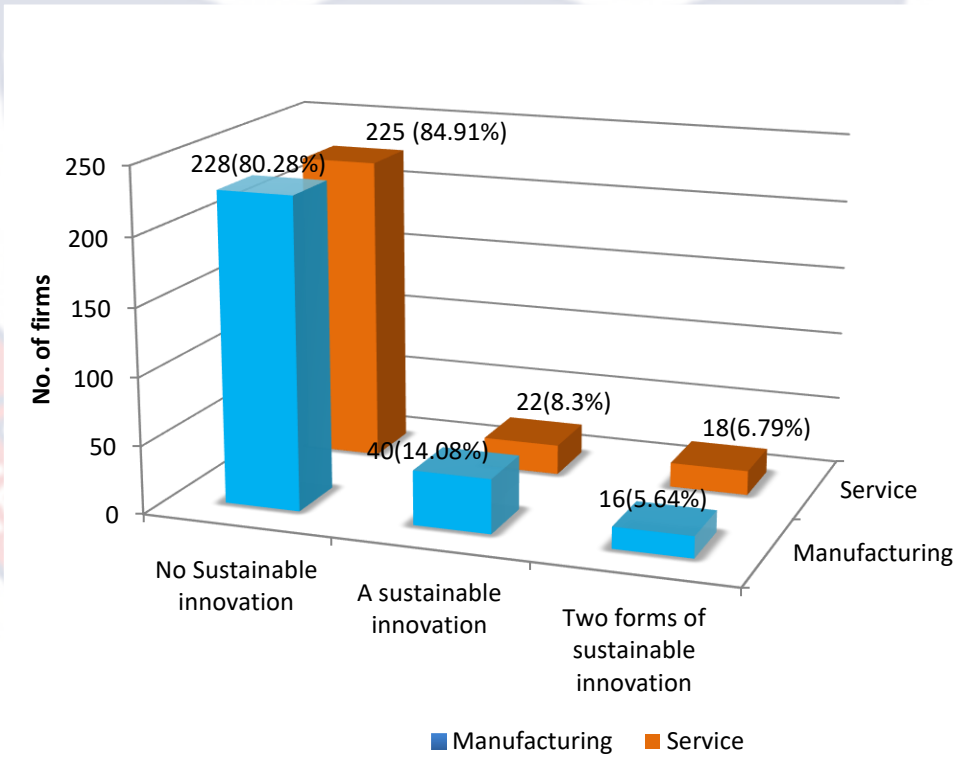

Figure 4: Sustainable innovation across sectors
Source: Author (2022), Outcome based on the 2013 ES and 2014 GIFS combined dataset

Figure 5 below indicates the variations of introduction of product or process sustainable innovation by sector. It can be observed from figure 5 that more firms in

the service sector, thus 29(10.94%), sustainably product innovate relative to firms in the manufacturing sector, thus 24(8.45%). For sustainably process innovation, more firms in the manufacturing sector, thus 48(16.90%) sustainably process innovates relative to firms in the service sector, thus, 29(10.94%). This outcome could be that service sector firms are targeting green final output to remain competitive, whiles manufacturing sector firms are focused more on sustainable production processes to minimize production cost and at the same time minimizing negative environmental impacts of their processes. The result conforms to the findings of Tetteh & Essegbey, (2014) that concluded that process innovation is predominant among service sector firms than manufacturing sector firms.

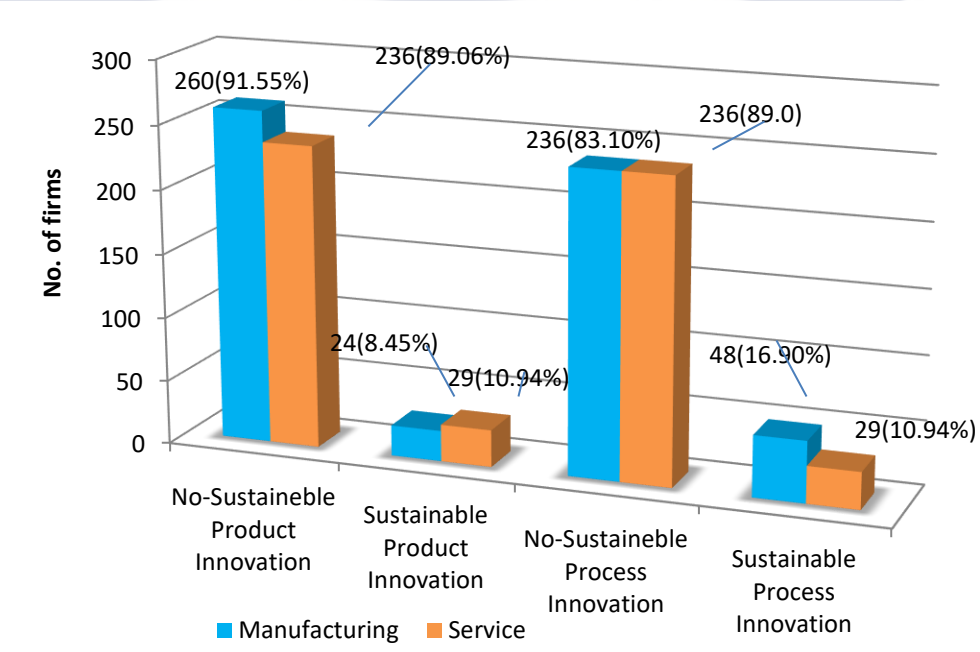

Figure 5: Sustainable Product or Process innovation across sectors
Source: Author (2022), Outcome based on the 2013 ES and 2014 GIFS combined dataset.

Sustainable Innovation across the 4-Industrial clusters (Location)

Figure 6, below, shows how introduction of sustainable innovation varies across the four industrial clusters used in the study. The result indicates that the relative percentage of firms that introduced a form of sustainable innovation across the four

industrial clusters used in the two surveys remains higher in relative terms in Accra than in the others. Thus, 33(11.6%) firms in Accra introduced a form of sustainable innovation compared to 14 (13.59%) firms in the North, 9(20%) in Takoradi and 6(5.08%) in Tema. There are more firms in the north, 14(13.59%), that introduced a form of sustainable innovation relative to those in Takoradi, 9(20%). The plausible reason for this outcome could be the level of development between the two clusters, which can affect the type of business that can flourish in such areas. Thus, the north remains less developed and hence could have several SMEs relative to Takoradi. As such, small-scale firms within the North could flexibly introduce sustainable innovative activities relative to several large-scale firms in Takoradi. The Figure (Figure 6) is shown below:

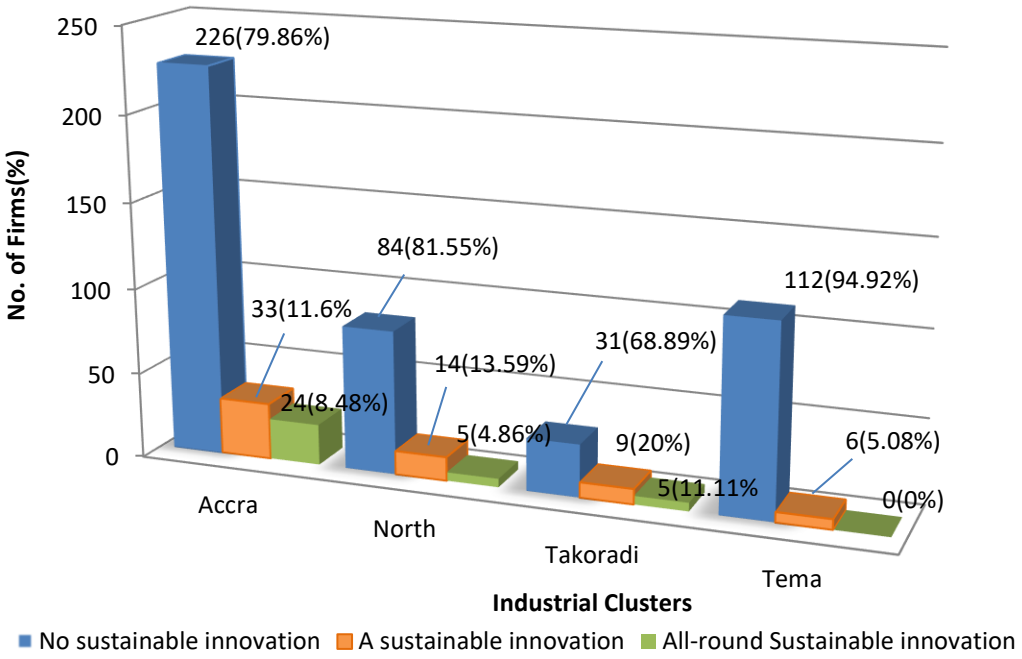

Figure 6: Sustainable innovation across Industrial Clusters
Source: Author (2022), Outcome based on the 2013 ES and 2014 GIFS data combined dataset.

Figure 7 provides the variation of sustainable product innovation across the four industrial clusters. Figure 6 below indicates that in marginal terms, majority of the firms that introduced sustainable product innovations are located in Accra relative to

the other clusters, thus, 34 (representing 12.01%). This was followed by 9(8.74%) in North, 7(15.56%) firms in Takoradi and lastly 3(2.5%) in Tema. The outcome indicates that firms in Tema are the least, among the 4 clusters in the introduction of product innovation. Figure 7 is as shown below:

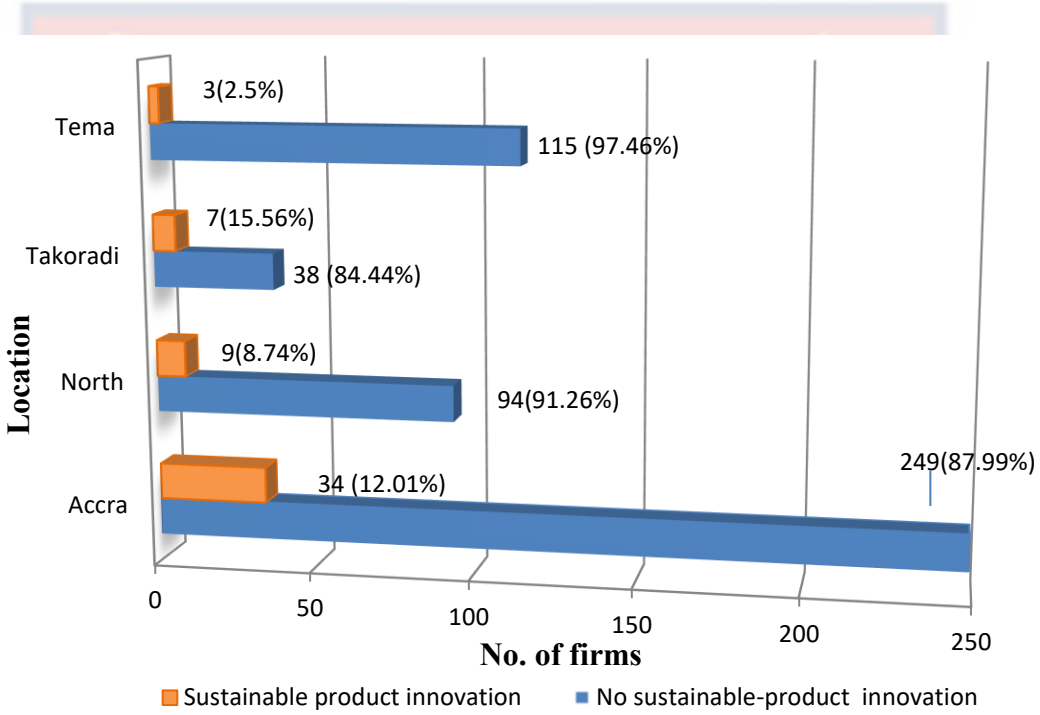

Figure 7: Sustainable product innovation across clusters
Source: Author (2022), Outcome based on the 2013 ES and 2014 GIFS dataset.

Figure-8 below shows locational distribution of sustainable-process innovation. Figure 7 above indicates that process innovation introduction is highly pronounced among firms in Accra relative to the other 3 industrial clusters. Thus, 47 firms representing 16.61 percent introduced sustainable process innovation in Accra. 15 of them in North (representing 14.56 percent) equally did same. 12 (26.67%) firms in Takoradi and lastly only 3 (2.54%) in Tema introduced production technologies that are ecologically friendly and cost effective.

From figure 7 and figure 8, comparatively, sustainable process innovation among firms across the 4 clusters was higher relative to sustainable product innovation. Thus, 47(16.61%), 15(14.56%), 12(26.67%) and 3(2.54%) firms in Accra,

North, Takoradi and Tema, respectively, introduced sustainable process innovation compared to 34(12.01%), 9(8.74%), 7(15.56%) and 3(2.5%), from the clusters respectively, that introduced product innovation. This could be that most of the firms that introduced sustainable innovation were targeting their production processes to help reduce production cost relative to the eco-friendly nature of output they produced. Another plausible reason for the above result could be that most firms were not commercializing new clean knowledge (thus introducing green innovative products) due to the reluctant nature of customers towards new offers (products) relative to already existing, trusted ones.

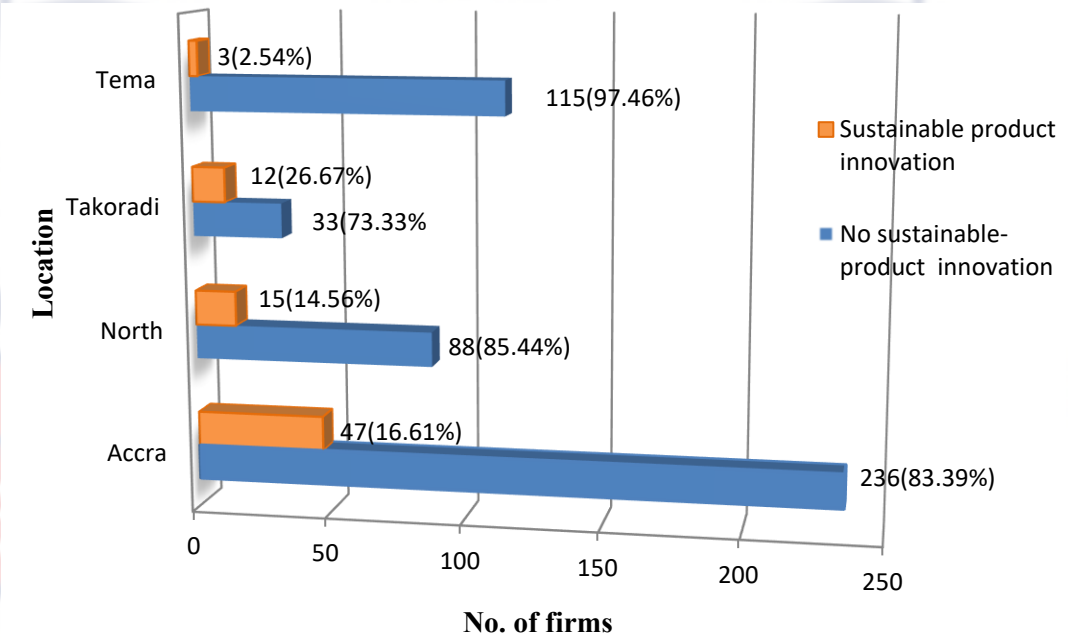

Figure 8: Sustainable process innovation across Location

Source: Author (2022), Outcome based on the 2013 ES and 2014 GIFS combined dataset.

Empirical Findings and Discussion of Results

This Section was devoted to presenting and analysing outcomes based on the logistic as well as ordered logistic regressions results. The target of the section was to provide outcomes that addressed the main aim of the study "dimensions of knowledge absorption capacity and sustainable innovation of firms".

Ordered Logistic Regression Estimates (Dependent Variable: Sustainable Innovation)

Table 4 shows the ordered logistic regression model results where sustainable innovation was used as the regressand. The model's predicted probabilities (pr), used to measure the marginal effects, reflect the three ordered ratings or levels of sustainable innovation. Hence, when pr = 0, it signifies that the firm did not engage in sustainable innovation, a value of 1 indicates involvement in one of the forms of sustainable innovation, and a value of 2 signifies comprehensive engagement in both forms of innovation.

The Likelihood Chi-Square value for the model is 0.000 signifying a 1percent level of statistical significance. This observation implies there is enough evidence to reject the null hypothesis, and this indicates that the exogenous variables in the model correctly measured the changes or variations in the regressand.

Also, Linktest was used to test the evidence that the structural equations used or the models might be mis-specified or need to include more variables. The null hypothesis tested was that there was no misspecification.

The predicted value square (hatsq) is statistically insignificant, implying we fail to reject the null hypothesis, which says there is no misspecification.

The model passed the Hosmer-Lemeshow test of goodness of fit as the probability value exceeded the minimum threshold for 'model not fit' prediction. The outcome implies that the model remain trustworthy.

The results of the various diagnostic regression outcomes are equally shown in Table 4 below.

Table 4: Effects of the dimensions of knowledge absorption capacity on firms' sustainable innovation

Variables	Coefficients (Std Error)	Marginal Effects *Pr(0)*	*Pr(1)*	*Pr (2)*
KACCAP	1.66624***	-0.1544	0.1113	0.0441
	(0.2978)			
KASSCAP	-0.0569	0.0053	-0.0038	-0.0015
	(0.3403)			
KTRANSCAP	0.6463**	-0.0604	0.0433	0.0171
	(0.2949)			
KEXCAP	1.0783***	-0.1008	0.0722	0.0286
	(0.3141)			
Firm Age	0.0202*	-0.0019	0.0013	0.0005
	(0.0116)			
Firm Size: *SMEs*	1.8566**	-0.0942	0.0690	0.0252
	(0.7896)			
Sector: *Service*	0.0394	-0.0037	0.0026	0.0010
	(0.2698)			
Location: *North*	-0.5301	0.0566	-0.0400	-0.0166
	(0.3509)			
Takoradi	0.1741	-0.0238	0.0163	0.0075
	(0.4081)			
Tema	-1.6690***	0.1174	-0.0846	-0.0328
	(0.4874)			
Diagnostic Tests				
Likelihood Ratio (x^2)	125.04***	Psuedo R^2	0.1973	
Log likelihood	-254.3459	No. of Observ.	549	
HL-Prob (> x^2)	0.8734			
Linktest (hatsq)	0.759			

*Note: ***, **, and * denotes significance levels at the 1%, 5% and 10% and robust standard errors were in parenthesis.*

Source: Author (2022), Outcome based on the 2013 ES and 2014 GIFS combined dataset.

The result displayed in Table 4 above indicates that the knowledge acquisition, transformation, and exploitation capabilities of firms exert a significantly positive influence on their probability of being sustainably innovative. It indicates that SMEs are more likely to introduce at least one form of sustainable innovation.

Furthermore, firm age has a significant positive influence on its ability to sustainably innovate. However, being located in Tema exerts negative influences on a firm's likelihood of being able to sustainably innovate.

The knowledge acquisition capacity of firms exerts a significantly positive influence on their propensity to sustainably innovate. The specific outcome from Table 4 indicates that firms with acquisition capacity have a 15.44 percent lower likelihood of not engaging in sustainable innovation. Moreover, they exhibit 11.13 percent likelihood of introducing a form of sustainable innovation, as well as a 4.41 percent likelihood of introducing both main types of sustainable innovation, in comparison to firms lacking such capacities. The finding is significant at 1percent level of significance.

The result conforms to the empirical finding of Hashim et al., (2015) that assessed the impacts of absorption capacity on green innovation among 79 construction firms in Scotland. They concluded that for sustainable innovative activities, the acquisition of new innovative ideas is a necessity. It also conforms to the conclusion of Amaranti et al., (2019) that assessed green dynamic capabilities as a precursor for green innovation of manufacturing sector firms in Indonesia. They found that firm-level green innovation is directly linked with knowledge gathering (acquisition). The finding is in line with the two theories reviewed in the study; the RBV and the Dynamic capabilities theory which places emphasis on significant of

knowledge as a resource for the firm performance and innovative activities towards survival.

The finding is in harmony with our prior expectations, mainly because a firm's investment in research and development activities as well as training of its employees will help it to identify new skills which are deficient within its operations and hence they thrive in the presence of their knowledge building. Specifically, the acquisition of new knowledge will serve as an antecedent for introducing clean innovative activities such as green innovation.

A plausible reason for the result could be that, from the survey, firms were seen to be engaging in external research and development, and this could be geared towards acquiring technological process innovations to aid the production of products that are sustainable.

Table 4 result indicates that knowledge transformation exerts a significantly positive influence on firms' propensity to sustainably innovate. The specific outcome from Table 4 indicates that firms with knowledge transformation capacity have a 6.04 percent lower likelihood of not engaging in sustainable innovation. Moreover, they exhibit a 4.3 percent likelihood of introducing a form of sustainable innovation, as well as a 1.71 percent likelihood of introducing both main types of sustainable innovation, in comparison to firms lacking such capacities. The finding is significant at 5percent level of significance.

The finding above is in line with the empirical conclusions of Zhang et al., (2018) in their study of 321 industrial sector firms in China. They concluded that transformational capacity exerts a positive influence on a firm's green product and process innovativeness. Thus, firms with more investment in external learning resources that are transformed are more likely to innovate, which in turn affects their

ecological and economic performance. It is equally in line with the findings of Albort-Morant and Henseler, (2018) assessed 112 Spanish automotive firms and concluded that when acquired knowledge is accurately interpreted by matching it with existing knowledge, utilization to yield sustainable or green outcomes becomes easy.

The outcome is in line with our prior expectation as investment in activities that enable them to refine acquired knowledge with the existing repository will be a step towards increasing its proficiency to implement or introduce innovation activities to yield green results. The plausible reason for this result could be that the firms were recognizing external knowledge by purchasing patent inventions to facilitate modernization, which could lead to sustainable production processes and sustainable products as final output for commercialization.

Table 4 outcome indicates that knowledge exploitation capacity of firms exerts significantly positive influence on their likelihood to sustainably innovate. The specific outcome from Table 4 indicates that firms with knowledge exploitation capacity have a 10.08 percent lower likelihood of not engaging in sustainable innovation. Moreover, they have 7.22 percent likelihood of introducing a form of sustainable innovation, as well as a 2.86 percent likelihood of introducing both main types of sustainable innovation, in comparison to firms lacking such capacities. The finding is significant at one percent level of significance.

The above result is in conformity with the empirical findings of Albort-Morant & Henseler, (2018). They found that clean or green innovative activities (such as sustainable innovation) flourish if an enabling organizational environment exists for such knowledge to be absorbed and utilized. Song et al., (2021) also assessed 233 manufacturing sector firms in China and concluded that utilization of newly acquired knowledge positively affects the green innovative performance of firms (sustainable

process and product innovation). The result is also in line with the conclusions of Baeshen et al., (2021) that used structural equation modelling to assess the determinants of green or sustainable innovation in 304 firms in Saudi Arabia. They concluded that acquired knowledge utilization remains the key main absorption capacity that drives sustainable innovative activities (process and product) of firms as there is a need for organizational support and human capital existence.

Equally, the results provide credence to the claims made by the Dynamic Capabilities Theory which emphasizes that a firm's capacity for knowledge exploitation has a major impact on its capacity for innovation and competitiveness in ever-changing business environments.

The above finding is in harmony with our prior expectations. This is because the final stage to ensure investment in new knowledge yields results is to ensure its utilization. Hence, a firm's investment in its capacity to utilize acquired knowledge remains a step in the right direction towards producing sustainable innovative results. The plausible reason for the finding could be that firms' acquisition of green knowledge through R&D goes hand in hand with applying acquired knowledge, and this could be toward realizing sustainable goals (sustainable production processes and products).

Firm's age also exerts a significantly positive influence on the firm's ability to sustainably innovate. Specifically, the result indicates that older-aged firms have a 0.19 percent lower likelihood of not introducing any of the two forms of sustainable innovation. Additionally, they exhibit a 0.13 percent higher probability of introducing one of the specific main forms of sustainable innovation and a 0.05 percent higher probability of introducing both main forms of sustainable innovation compared to firms with lesser age. This finding is significant at 10 percent significant level.

The result corroborate the findings of Yin et al., (2022) that assessed the moderating effect of the age of the firms on their ability to introduce sustainable innovations among 1667 firms in China for 10 years (2010 to 2019 inclusive). They found that the older the firm, the more pronounce it engages in sustainable innovations. Dukeov et al., (2018), in their study on firms in Russia, also provided similar conclusion. The result is in line with our prior expectations, and the plausible reason could be that older firms have a greater span of market experience, which could be useful towards the implementation of sustainable or green production processes that can transcend to green products. Another plausible reason could be that older firms already have established routines relating to entrepreneurial techniques to adopt in the industry, which could be essential for sustainable innovation

Being a Small and Medium Scale Enterprise exerts significantly positive influence on the firm's likelihood to sustainably innovate. The results indicate that Small and Medium-Scale Enterprises, relative to Large-Scale Enterprises, experience a 9.42 percent decrease in their likelihood of not introducing any of the two forms of sustainable innovation. Furthermore, they have a 6.90 percent higher likelihood of adopting a specific form of sustainable innovation and a 2.52 percent higher likelihood of adopting both main forms of sustainable innovation compared to Large-Scale Enterprises. The finding is significant at a 5 percent level of significance.

The result conforms to the findings of Tetteh and Essegbey (2014) that assessed the level of innovation among manufacturing and service sector firms in Ghana. They concluded that innovative activities and the size of firms in Ghana are inversely related as small firms tend to introduce several forms of innovation activities relative to large firms. Thus, specifically, they concluded that the smaller the firm, the more

likely it innovates. This could be due to the lack of bureaucratic processes, which could delay its implementation.

The result however, deviates from the finding of Baeshen et al., (2021) as they assessed firms in Saudi Arabia. They concluded that large firms have more resources (large scale and scope resources) that enable them to undertake innovative activities.

The result is in line with our prior expectations. A plausible reason for the observed trend could be that, given their limited resources and the prospect of limited growth, SMEs may find it imperative to innovate as a means of surviving in challenging environments. Furthermore, due to their smaller scale, SMEs may be more effective at achieving significant increases in output through incremental innovations. This is because they can easily respond to changing market conditions, adopt new technologies, and experiment with new ideas without being hindered by the bureaucratic obstacles that larger businesses often encounter.

Being in Tema has a significant negative influence on a firm's probability to introduce sustainable innovation, relative to firms in Accra. Specifically, firms in Tema compared to Accra have 11.74 percent more likelihood to introduce none of the two forms of sustainable innovation. They further have 8.46 percent less likelihood to adopt one of the two main types of sustainable innovation and 3.28 percent less likelihood to adopt the two main forms. The finding is significant at 5 percent level of significance.

The probable reason for this result could be the attribution differences between the two cities. A plausible justification could be that Tema's social priorities, local market demands, and economic situations might all be contributing factors. Thus, firms in Tema could face unique economic constraints and hence have more cautious

approach to innovation, prioritizing cost-effectiveness above all-encompassing environmental objectives.

Furthermore, resource allocation and the order in which businesses prioritize social elements in their innovation strategies may be influenced by geographical variations in social dynamics and community expectations existing between the two metropolis (Tema and Accra). The result, however, deviates from our prior expectation as implementations of green laws or regulations are expected to be more intense in industrial areas which are well noted for high industrial pollutions.

Logistic Regression Estimates (Dependent Variable: Sustainable Product Innovation)

Table 5 shows the logistic regression model results where sustainable product innovation was used as the regressand. The model's marginal effects were used to measure the propensity of introduction of sustainable product innovation. The Likelihood Chi-Square value for the model is 0.000 signifying a 1percent level of statistical significance. This observation implies there is enough evidence to reject the null hypothesis. This indicates that the exogenous variables in the model correctly measured the changes or variations in the regressand.

Also, Linktest was used to test the evidence that the structural equations used or the models might be misspecified or needs to include more variables. The null hypothesis tested was that there is no misspecification. The predicted value square (hatsq) is statistically insignificant implying we fail to reject the null hypothesis which says there is no misspecification. The model passed the Hosmer-Lemeshow test of goodness of fit as the probability value exceeded the minimum threshold for 'model not fit' prediction. The outcome implies that the model remain trustworthy.

The results of the various diagnostic regression outcomes are equally shown in Table 5 below:

Table 5: Effects of the dimensions of knowledge absorption capacity on firms' sustainable product innovation

Variables	Coefficients (Std Error)	Marginal Effects
KACCAP	1.5267***	0.0781
	(0.3771)	
KASSCAP	-0.1218	-0.0062
	(0.4116)	
KTRANSCAP	0.5763	0.0295
	(0.3708)	
KEXCAP	0.9121**	0.0467
	(0.3976)	
Firm Age	0.0123	0.006
	(0.0148)	
Firm Size: *SMEs*	1.2870	0.0411
	(0.8253)	
Sector: *Service*	0.5958*	0.0311
	(0.3165)	
Location: *North*	-0.5965	-0.0356
	(0.4607)	
Takoradi	-0.1728	-0.0123
	(0.4811)	
Tema	-1.5694**	0.0647
	(0.6682)	
Constant	-5.2904***	
	(1.0086)	
Diagnostic Tests		
Likelihood Ratio (x^2)	64.01***	
Log likelihood	-141.9521	
Psuedo R^2	0.1854	

HL-Prob (> x^2)	0.1945
Linktest (hatsq)	0.143

*Note: ***, **, and * denotes significance levels at the 1%, 5% and 10%. The robust standard errors presented in parenthesis.* Source: Author (2022) from ES & IFS

Table 5 indicates that the knowledge acquisition and utilization capacities of firms significantly influence their propensity to introduce new substantial changes in their products with green innovation considerations. Being in the service sector and domiciled in Tema exerts significantly positive and negative influences, respectively, on firms' likelihood to introduce sustainably product innovations.

Firms with higher knowledge acquisition capacities are more likely to introduce sustainable product innovations relative to those that do not have such capacities. Specifically, firms with knowledge acquisition capacities have 7.81 percent more likelihood to introduce new innovative products that are sustainable in nature, relative to those without such capacities. This result is significant at one percent significant level.

The finding conforms to the empirical results of Zhang et al., (2018) that assessed green innovation among 300 firms in China. They concluded that newly acquired knowledge is significant and serves as a great potential for bringing out new products or services that are green in nature. Albort-Morant and Henseler, (2018) also provided a similar conclusion in their study on 112 Spanish automotive firms. The result also corroborates with the findings of Song et al., (2021). They concluded that the most important preliminary stage of attempting to introduce a green product or service is acquiring newly relevant external knowledge.

The outcome is in line with our prior expectation because producing newly sustainable products, necessitate investment in research and development to help acquire new external knowledge. Thus, firms investing in creative works or

investments they outsource to private or public enterprises could be an investment that could yield the production of sustainable products.

The outcome aligns with the theories of Knowledge-Based View and Dynamic Capabilities, given that spending on research and development is essential to acquire external knowledge for the production of sustainable goods or services. Thus, companies investing in creative endeavours or outsourcing to private or public enterprises can be viewed as an investment strategy conducive to sustainable product development.

Knowledge utilization or exploitation capacity of firms exerts significantly positive influence on their likelihood to sustainably product innovate. The probability to sustainably product innovate by the firms in the presence of knowledge exploitation capacity is 4.67 percent higher relative to those firms without such capacities. This result is significant at 5 percent significant level.

The finding is in line with the conclusion of Albort-Morant and Henseler, (2018). They concluded that acquired knowledge without utilization results in ineffective green innovation outcomes, and hence exploitation capacity serves as a good nurturing environment for higher sustainable product innovation results. Amaranti et al., (2019) also provided similar conclusions in their study. The result also corroborates the findings of Baeshen et al., (2021) in their study on Saudi Arabian firms. They concluded that green product innovation can only be achieved if firms have the needed capacity to better utilize new ideas.

The result is consistent with our predictions because bringing new products into the market requires acquiring new external knowledge, which must be accurately utilized. Thus, utilization should be preceded by acquiring an innovative idea. Another plausible reason is that most firms that invest in external R&D and

training could have the needed capacity to competitively utilize them to achieve innovative products that are non-toxic and eco-friendly in nature. This could be reflected in their applications for patents, utility models, industrial designs, trademarks, and copyrights.

The result is also consistent with the Knowledge-Based View and Dynamic Capabilities theories, highlighting the critical role that knowledge exploitation ability plays in increasing the possibility that businesses would develop their goods in a sustainable manner. This validates the theoretical proposition that sustains a competitive advantage and promotes innovation requires efficient utilization of knowledge resources.

Being in the service sector exerts a significantly positive influence on firms' propensity to sustainably-product innovate relative to those in the manufacturing sector. Firms in the service sector, in particular, have a 3.11 percent higher likelihood of introducing new environmentally friendly products than firms in the manufacturing sector. This outcome is significant at 10 percent significant level.

This result corroborates the findings of Osoro et al., (2016) as well as Fiave, (2019) in their studies in Tanzania and Ghana, respectively. For instance, in the work of Fiave, (2019), he concluded that product innovation is high for firms in the service sector relative to those in the manufacturing sector. With this, it could be that several firms in the service sector that introduced product innovation made room for such products to remain eco-friendly.

The result is in line with our prior expectation because service sector firms have a shorter testing cycle (of their innovative ideas) and a greater ability to leverage internally obtained innovations for new products relative to manufacturing sector firms. As such, in the short run, the ability of service sector firms to introduce

sustainable innovations will be higher compared to those in the manufacturing sector. Another plausible reason for the result could be that, considering the nature of setup for service sector firms, the cost of introducing green product innovation could be lower relative to manufacturing sector firms.

Being in Tema has a significantly negative influence on a firm's probability of introducing sustainably innovative products, compared to firms in Accra. Firms in Tema, in particular, have a 6.47 percent lower propensity to introduce sustainable product innovation than firms in Accra. The finding is significant at 5 percent level of significance. A plausible justification could be that social priorities, local market demands, and economic situations might all be contributing factors. Thus, firms in Tema could face unique economic constraints and hence have more cautious approach to innovation, prioritizing cost-effectiveness above all-encompassing environmental objectives. Furthermore, resource allocation and the order in which businesses prioritize social elements in their innovation strategies may be influenced by geographical variations in social dynamics and community expectations existing between the two metropolis (Tema and Accra).

Logistic Regression Estimates (Dependent Variable: Sustainable Process Innovation)

Table 6 shows the logistic regression model results where sustainable process innovation was used as the regressand. The model's marginal effects were used to measure the propensity for the introduction of sustainable process innovation. The model's Likelihood Chi-Square value is 0.000, indicating a 1percent level of statistical significance. This observation implies there is enough evidence to reject the null hypothesis and it indicates that the exogenous variables in the model correctly

measured the changes or variations in the regressand. The result is as displayed below:

Table 6: Effects of the dimensions of knowledge absorption capacity on firms' sustainable process innovation

Variables	Coefficients (Std Error)	Marginal Effects
KACCAP	1.8891***	0.1165
	(0.3451)	
KASSCAP	0.0494	0.0030
	(0.3700)	
KTRANSCAP	0.5747*	0.0354
	(0.3238)	
KEXCAP	1.0364***	0.0639
	(0.3609)	
Firm Age	0.0185	0.0011
	(0.0151)	
Firm Size: *SMEs*	1.7279**	0.0583
	(0.7895)	
Sector: *Service*	-0.3337	-0.0205
	(0.2982)	
Location: *North*	-0.5654	-0.0430
	(0.3751)	
Takoradi	0.2935	0.0313
	(0.4590)	
Tema	-2.0410***	-0.0911
	(0.6390)	
Constant	-5.376***	
	(0.9659)	
Diagnostic Tests		
Likelihood Ratio (x^2)	120.04***	
Log likelihood	-162.558	
Psuedo R^2	0.2697	
HL-Prob (> x^2)	0.4091	
Linktest (hatsq)	0.5970	

Source: Author (2022), Outcome based on the 2013 ES and 2014 GIFS combined dataset.

In the model specification, Linktest was used to test whether or not the model might be misspecified. The result indicates that there is no misspecification as the predicted value square (hatsq) was statistically insignificant. The Hosmer-Lemeshow test of goodness of fit was used to test for model fitness. The result indicates that the model is correctly specified, trustworthy, and the independent variables are exogenous.

Table 6 indicates that the knowledge acquisition, transformation, and exploitation capacities of firms significantly influence their propensity to introduce innovative production processes that are green and economical in nature. Being an SME significantly exerts positive effects on firms' likelihood to sustainably-process innovate. Equally, being domiciled in Tema exerts significantly negative influences on firms' likelihood to introduce sustainable process innovations.

The result displayed in Table 6 above indicates that the knowledge acquisition capacity of firms exerts a significantly positive influence on their probability of sustainable process innovation. The results show that firms with a higher capacity to recognize, understand the importance of, and obtain external knowledge required for the organization's operations are 11.65 percent more likely to engage in sustainable, innovative production processes. The level of statistical significance of the above outcome is one percent.

The result is in line with our prior expectation, and the plausible reason could be that acquisition of external knowledge helps firms overcome green inertia, so they are likely to engage in green technological production processes. Thus, firms that acquire more knowledge could channel those acquisitions towards production processes that are sustainable in nature. The result corroborates the empirical conclusions provided by Albert-Morant and Henseler (2018). They concluded that learning and strategic

disposition (acquisition of new knowledge and training) result in dynamic developments that lead to sustainable process innovation.

Table 6 also indicates that the knowledge transformation capacity of firms exerts a significantly positive influence on their probability of engaging in sustainable-process innovation. Firms with higher transformation capacities are 3.54 percent more likely to engage in sustainable and innovative production processes, according to the findings. The above result has a level of statistical significance of 10 percent. Since the existing proxies for evaluating knowledge transformation may not adequately convey the complexity of the phenomena, the study adopted a more relaxed significance threshold of 10%. This approached received validation from (Kim & Choi, 2021) in their article entitled "choosing the level of significance: a decision-theoretic Approach", as they argued that "when more important variables or proxies are suspected to exist but are not included in the dataset, researchers may choose to use a more lenient threshold in order to increase the statistical significance."

The outcome is consistent with our expectations, as firms with a greater ability to develop and refine routines that facilitate combining existing and newly acquired knowledge, as well as assimilate them, could channel them into their green production processes. Thus, firms with more adaptable capacities to help transform acquired knowledge could champion such practices towards their green production processes. Another plausible reason for the above result could be that firms' existing technologies were built on old knowledge already acquired. As such, the acquisition of new perspectives on how to improve existing activities needed to be synchronized with the old knowledge progressively to ensure a better production process.

The result is in conformity with the empirical conclusions of Zhang et al. (2018) as they assessed industrial sector firms. They concluded that firms' propensity to

recognise the usefulness of newly acquired knowledge through renovation, personnel training, reconfiguration, and sharing of informal experiences (knowledge transformation) could have rippling positive effects on their green production processes.

Table 6 indicates that the knowledge exploitation capacity of firms exerts a significantly positive influence on their probability of being sustainably innovative. The outcome shows that firms with higher utilization capacities have a 6.39 percent higher likelihood of engaging in sustainable, innovative production processes. The level of statistical significance of the above outcome is one percent.

The result conforms to our prior expectation because exploitative innovation is linked to manufacturing efficiency. This is because firms absorb newly acquired green knowledge into their production processes to lower costs and minimize negative effects on the environment. Thus, firms make use of acquired knowledge to realize green innovative goals. The result is in harmony with the findings of Sancho-Zamora et al., (2021) as they assessed 800 Spanish companies. They concluded that higher knowledge absorption capacity culminates in greater process innovation for firms.

Being an SME exerts a positive influence on the firm's likelihood of implementing production processes that are less harmful to the environment. Thus, SMEs are 5.83 percent more likely than LSEs to innovate in green processes. This outcome is significant at a 5percent significance level. The result is in harmony with the empirical findings of Baeshen et al., (2021), as they assessed "the determinants of Green Innovation to Achieve Sustainable Business Performance using Saudi Arabian SMEs." They concluded that SMEs have greater flexibility in introducing innovative processes relative to firms that are large-scale enterprises.

Firms in Tema are less pronounced in bringing about the implementation of new production processes that are sustainable in nature compared to those within Accra. As a result, firms in Tema are 9.11 percent less likely to implement sustainable process innovation than firms in Accra. The result is significant at a one percent level of significance.

Chapter Summary

The following major findings can be deduced from the results presentation and discussions above: Knowledge acquisition (investment in research and development) and exploitation capability (utilization capacity) of firms exert a significantly positive influence on a firm's propensity to undertake at least one of the major forms of sustainable innovation. Firms that can effectively transform acquired knowledge are more likely to implement either sustainable process innovation or both types of sustainable innovation. The knowledge assimilation capacity of firms does not significantly influence their likelihood of introducing any sustainable innovation activities. The age of the firm exerts a significant positive effect on its likelihood of introducing the two forms of sustainable innovation concurrently. Its likelihood of influencing either form of sustainable innovation, however, remains insignificant. Firms in the service sector have a higher propensity to introduce either form of sustainable innovation, but the outcome for both forms, simultaneously, is insignificant. Small and medium-scale enterprises are more likely to introduce either sustainable process innovation or both forms of sustainable innovation. However, its influence on sustainable product innovation is insignificant. Being located in Tema exerts a significantly negative influence on firms' likelihood to introduce at least a form of sustainable innovation.

It is worth to note that the study's reported level of statistical significance at 10 percent indicates a deliberate departure from conventional thresholds. Recognizing the potential limitations of existing proxies for assessing knowledge transformation and exploitation, the research opted for a more relaxed significance threshold. This strategic choice aligns with the validation provided by Kim and Choi (2021), who argued that in cases where significant variables or proxies might be omitted from the dataset, researchers may opt for a lenient threshold to enhance statistical significance. By acknowledging the complexity of the phenomena under investigation, this approach seeks to capture nuanced aspects of knowledge transformation and exploitation that may be inadequately represented by more stringent statistical criteria

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

The aim of the study is to investigate the dimensions of absorption capacity and sustainable innovation among Ghanaian firms. The chapter provided a summary of the study. It also discussed the conclusions derived from the findings. Recommendations were provided for policy making and suggestions were provided for future studies based on the limitations of the study.

Summary

The global and dynamic landscape of the business environment necessitates firms to effectively assimilate, transform, and exploit their newly acquired knowledge to ensure the ultimate innovative result. However, innovation is a creative-destruction, as it could yield both positive and negative rippling effects. It is thereby imperative for firms to ensure that the implementation of their innovative activities, facilitated by effective firm-level absorption capacity, transcends beyond the economic dimension of sustainability to incorporate ecological and social dimensions. Considering the need to ensure protection of the environment, it is important to find out how the various dimensions of knowledge absorption capacity of firms affect their level sustainable innovation.

The study examined the influence of the dimensions of absorption capacity on the sustainable innovation of firms. The study decomposed absorption capacity into its four main dimensions (acquisition, assimilation, transformation, and exploitation) and examined how they influence firms' propensity to introduce the two main forms of sustainable innovation (product and process) concurrently. The study also investigated the influence of the four dimensions of absorption capacity on firms'

likelihood to introduce sustainable product innovation and sustainable process innovation as major segregated components of sustainable innovation.

The study reviewed the Resource-Based View and the Dynamic Capabilities theories which emphasizes the need to acquire and development of essential functional capabilities for effective utilization of acquired knowledge towards competitive advantage and innovative goals

The study used the Ghana Enterprise Survey combined with the Ghana Innovation Follow-up Survey, conducted in 2013 and 2014 respectively. Ordered logistic regression model was used to measure the aggregated sustainable innovation whiles logistic regression was used to measure the decomposed sustainable innovation.

Based on empirical evidence on the dimensions of absorption capacity, four main independent variables were used. They are: knowledge acquisition capacity, knowledge assimilation capacity, knowledge transformation capacity, and knowledge exploitation capacity. The control variables used were the age of the firm as at the time of the survey, the size of the firm (either a small and medium-scale enterprise or a large-scale enterprise), sector of activity (either service or manufacturing sector), and the cluster in which the firm is located.

The study found that knowledge acquisition capacity of firms has a positive effect on firms' propensity to engage in sustainable innovation. Knowledge transformation ability of firms was found to positively affect their likelihood to introduce either sustainable process innovation or both forms of sustainable innovation simultaneously.

Knowledge exploitation capacity of firms increases the firms' likelihood to introduce sustainable innovation.

Conclusions

The study finding shows that the knowledge acquisition capacity of firms (investment in research and development and training activities) exerts a positive and a significant effect on firms' likelihood to undertake at least one of the two main forms of sustainable innovation. A firm's ability to recognise, understand the importance of and obtain newly external knowledge significantly influences its propensity to engage in at least a form of sustainable innovation. This validate the Resource Bases View that places emphasis on firms' knowledge as essential resource.

Furthermore, the study found that the knowledge assimilation capacity of firms does not exert any significantly positive effect on their propensity to concurrently introduce the two main forms of sustainable innovation nor introduce either sustainable product or process innovation. This is deviates from our a priori expectations as integrated knowledge is expected to yield positive impacts on sustainable innovation.

Moreover, the study found that the knowledge transformation ability of firms (ability to synchronize existing knowledge with newly acquired knowledge to create new insights) exerts significantly positive effect on their likelihood to introduce the two main forms of sustainable innovation simultaneously. Its influence on firms' likelihood to introduce sustainable process innovation, separately, is significant, while that of sustainable product innovation is insignificant. This is in line with our priori expectations. This validates both the argument of the RBV and the Dynamic Capabilities theories that argued for existence of dynamic internal capacities towards knowledge transformation to ensure effective knowledge utilization to achieve competitive and innovative goals.

The study equally found that knowledge exploitation capacity of firms exerts significantly positive effect on firms' likelihood to undertake at least one of the two main forms of sustainable innovation. Firms with a higher capacity to utilize acquired and transformed knowledge are more likely to introduce productive processes and products that are eco-friendly and cost-effective. This is in line with our priori expectations. The result confirms the assertions of the Resource-Based View (RBV) and Dynamic Capabilities theories, supporting the notion that the primary objective of knowledge acquisition is its effective utilization to generate competitive and innovative outcomes.

More so, the study found that the age of the firm exerts significantly positive effects on firms' likelihood to introduce the two main forms of sustainable innovation concurrently. Its influence on firms' likelihood to introduce either of the two main forms of sustainable innovation, separately, is however insignificant.

Being a small-scale enterprise exerts a significantly positive influence on firms' propensity to simultaneously introduce the two main forms of sustainable innovation, relative to large-scale enterprises. Equally, the study found that small and medium-scale enterprises are more likely to introduce production processes that are eco-friendly and cost-effective compared to large-scale enterprises. However, in comparison to large-scale enterprises, the likelihood of SMEs introducing only sustainable innovative products is insignificant.

Service sector firms are more likely to introduce sustainable product innovations compared to manufacturing sector firms. However, being in the service sector does not significantly influence firms' propensity to introduce process innovation.

Lastly, firms in Tema are less likely to introduce either process innovations or product innovations or both relative to firms in Accra.

Recommendations

The study made the following policy-level recommendations: The government, through the Ministry of Trade and Industry, in collaboration with the Ministry of Finance, should support research and development of firms. Specifically, the government should invest in firm-level research and development support programs and policies by granting firms research and development subsidies and interest-free loans for research and development purposes. This will give firms more financial leveraging flexibility to invest in new opportunities for sustainable innovative benefits. The government, through the Ministry of Environment, Science, Technology, and Innovation, should also formulate policies to incentivize firms in Ghana to invest a proportion of their profits into research and development as well as in-house training towards acquiring new knowledge for sustainable innovation benefits.

Firms should prioritize investment in state-of-the-art machinery, ultra-modern equipment, and cutting-edge software to facilitate seamless knowledge transformation within the organization. Specifically management of firms in Ghana should establish a regular review process to ensure technology remains up-to-date and aligned, with industry standards. This will help to always ensure acquired knowledge is transformed to create new insights for sustainable innovative goals.

The Ghana Investment Promotion Centre (GIPC) should coordinate routine regular industry-specific forums within the industrial hub, bringing together firms, experts, and policymakers. These forums should facilitate targeted discussions on challenges and opportunities related to knowledge utilization for sustainable

innovation within specific sectors. Equally, Ghana Tech Lab, should provide incubation spaces and support for pilot projects within the hub. This initiative will enable firms to experiment with innovative ideas, guided by experts and resources available within the hub, fostering a real-world application of knowledge utilization principles

Areas for Further Research

The study suggested that future research should focus on the following: firstly, new studies should explore the effects of the dimensions of absorption capacity on the four types of sustainable innovation. This is because only two main forms were used in this recent study. Such studies can aid policy recommendations towards the other two forms of innovation not captured in this study. Furthermore, new studies should investigate the dimensions of absorption capacity and sustainability of firms using current data which can be primary data in nature. This will allow for contemporaneous rather than retrospective analysis. Moderating effects (interaction) of each of the dimensions of absorption capacity on sustainable innovation is also worth investigating.

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APPENDICES

A. Sector of Firms by Location

	Accra	North	Takoradi	Accra	Total
Manufacturing	147	61	17	59	284
Service	136	42	28	59	265
Total	283	103	45	118	549

B. Firm Size across Sectors

	LSEs	SMEs	Total
Manufacturing	15	269	284
Service	14	251	265
Total	29	250	549

C. Firm Size by Location

	Accra	North	Takoradi	Accra	Total
SMEs	261	102	44	113	520
LSE	22	1	1	5	29
Total	283	103	45	118	549

POST ESTIMATIONS

D. Misspecification Test (Sustainable Innovation Test Model-12)

$Sust_{innov}$	Coefficient	St/ Error	Significant Level
-hat	**0.8251**	**0.5767**	**0.153**
-hastsq	**0.0225**	**0.0733**	**0.759**
/cut 1	**4.9059**	**1.0802**	
/cut 2	**6.3361**	**0.0874**	

E. Misspecification Test (Sustainable Product Innovation Model-13)

$Sust\_Prod_{innov}$	**Coefficient**	**St/ Error**	**Significant Level**
-hat	1.5869	0.4400	0.00
-hastsq	01370	0.0935	0.143
Constant	0.4356	0.4280	0.309

F. Misspecification Test (Sustainable Process Innovation Model-14)

$Sust\_Proc_{innov}$	**Coefficient**	**St/ Error**	**Significant Level**
-hat	0.8581	0.2866	0.003
-hastsq	-0.4523	0.0856	0.597
Constant	-0.0350	0.2045	0.864

G. Goodness of fit Test (Sustainable Innovation Model-12)

Test	Number of Test	Statistics	Significant Level
HL-Test	10	10.665	0.8734
PR (Chi sqr)	16	55.187	0.5434
PR(Deviance)	16	57.256	0.4656

H. Goodness of fit test (Model 13 and Model 14)

Construct	**Model 13**	**Model 14**
Observation	**549**	**549**
Group	**10**	**10**
HL (Chi Sqr)	**11.13**	**8.25**
Probability	**0.1945**	**0.4091**

I. Test for Multicollinearity

Variable	**VIF**	**1/VIF**
KACCAP	1.27	0.7892
KTRANSCAP	1.24	0.8092
KASSCAP	1.14	0.8741
KEXCAP	1.12	0.8915
Age of Firm	1.10	0.9095
Size of Firm	1.09	0.9145
Sector of Firm	1.04	0.9635
Location of firm	1.02	0.9785
Mean VIF	1.13	