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Lean thinking and sustainability performance: The moderating role of top management commitment

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DECLARATION

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

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DEDICATION

I lovingly dedicate this thesis to my dear sister Tracy Bever Frank and her husband. Your unwavering support and belief in me has been a constant source of strength. I also dedicate this work to my parents, Mr. and Mrs. Mandor, who taught me the value of hard work and perseverance. Thank you for always encouraging me to follow my dreams.

ABSTRACT

Lean thinking and sustainability performance are emerging topics in operations and supply chain management research. This study aimed to examine the influence of top management commitment on the relationship between lean thinking and sustainability performance. Despite extensive research on lean thinking, prior studies have yielded inconsistent findings on its impact on performance outcomes. Moreover, the role of top management commitment in enabling lean thinking to drive sustainability performance remains unclear. Adopting a quantitative approach, this study surveyed 100 employees of manufacturing firms in Ghana's Greater Accra region using questionnaires. Results showed a significant positive relationship between lean thinking and sustainability performance, aligning with the resource-based view theory. Top management commitment also exhibited a significant positive link with sustainability performance. However, top management commitment did not significantly moderate the lean thinking-sustainability performance relationship as hypothesized. The study recommends manufacturing managers integrate lean thinking and gain top management commitment to sustainability initiatives. Focusing on lean thinking principles and securing top management support are vital for organisations seeking to improve sustainability performance. This study contributes to literature and provides practical insights on fostering lean thinking and sustainability in manufacturing firms. Further research could investigate other contingency factors influencing this relationship across various industries. Overall, this study offers valuable theoretical and practical implications on the roles of lean thinking and top management in driving sustainability performance.

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LIST OF ABBREVIATIONS

Lean Thinking	LT
Top Management Commitment	TMC
Sustainability Performance	SP
Resource-based view	RBV
New Product Development	NPD
Just-In-Time	JIT
Standard Deviation	SD
Variance Inflation Factor	VIF
Exploratory Factor Analysis	EFA

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The transition to eco-friendly manufacturing methods and products has inspired corporations to enhance their ecological efficiency and performance. "Lean thinking" has grown into "lean and green thinking," serving as a focused strategy for companies eager to institute business frameworks that diminish waste, advance material economy, and reduce expenditures. Nevertheless, the "lean and green" notion is somewhat novel and remains ambiguous to a considerable number of individuals regarding the exact way lean thinking can foster an organization's progression towards sustainability (Panwar et al., 2017). Lean thinking represents a business methodology aimed at augmenting customer value through the elimination of activities that do not add value (Panwar et al., 2017). This notion stemmed from the manufacturing floors of the Japanese firm, Toyota Motor Corporation, where the primary objective was to lessen waste during production (Cooper and Mohabeersingh, 2008). The term "lean manufacturing" and "lean production" entered the vernacular after being introduced in the pivotal book The Machine that Changed the World, thus propelling the lean movement forward (Kamble et al., 2020a). As it progressed, lean thinking drew more attention regarding its potential to facilitate sustainable results (Caldera, Desha and Dawes, 2017; Judit et al., 2017; Madhani, 2022).

Strategies grounded in sustainability such as the Management Helix have been leveraged as targeted methods to infuse sustainable principles in decision-making processes and to curb detrimental effects on the environment and society (Bevilacqua et al., 2017a; Gonçalves et al., 2019; Losonci and Demeter, 2013; Tezel et al., 2018). In the manufacturing arena, lean

manufacturing is gradually being recognized as a tool in sustainable business strategies, optimizing the use of materials and energy (Cagnetti et al., 2021).

Top management commitment is defined as the engagement of supreme authorities in an organization in enhancing quality. This is imperative for effectively embedding lean thinking in a corporate structure, guiding it in a positive trajectory and allocating necessary resources for enhancing lean efficiency. Such commitment facilitates a collaborative and educative workspace, thereby aiding the incorporation of a lean management system (Tortorella et al., 2021). The pivotal role played by this level of commitment in adopting quality management procedures for elevating organizational performance is highlighted in studies by Gawankar et al., (2020) and others, affirming its essentiality in achieving superior lean management outcomes. However, without this dedication, realizing such practices becomes challenging (Zhang and Chen, 2016a).

While there has been significant scrutiny of lean thinking, research outcomes present divergences. Whereas certain studies (e.g., Gawankar, Gunasekaran, and Kamble, 2020; Kamble, Gunasekaran, and Dhone, 2020) pinpoint a direct influence of lean thinking on various performance results, others (e.g., Kader Ali, Choong and Jayaraman, 2016; Abushaikha, Salhieh and Towers, 2018) argue that lean thinking on its own cannot bolster performance results; additional elements are needed to enhance lean thinking's impact on performance outcomes.

Consequently, the researcher aspires to enrich the existing corpus of knowledge on lean thinking through the creation of a distinct research model. This model intends to explore, with the Resource-based view theory as its foundation, how top management commitment can moderate the connection between lean thinking and sustainability performance.

1.2 Statement of the Problem

Lean thinking has evolved into "lean and green thinking," functioning as a concentrated strategy for the deployment of sustainable business frameworks that diminish waste, augment material efficiency, and curtail costs, promoting not only economic sustainability through resource conservation and cost reduction but also enhancing social and environmental facets by fostering better workplace safety, fostering stakeholder relationships, and reducing waste and pollution (Buer et al., 2021; Gawankar et al., 2020).

Notwithstanding the comprehensive exploration of lean thinking, the results present a substantial level of variation. A segment of the research community, including authors such as Abreu-Ledón et al., 2018; Abushaikha et al., 2018; Caldera et al., 2017; Durakovic et al., 2018; Judit et al., 2017; and Madhani, 2022, assert a favorable correlation between lean thinking and a range of performance metrics including sustainability, inventory governance, and quality. Conversely, studies by researchers like Lewis, 2000; Razmak et al., 2021a; and Thirkell and Ashman, 2014 indicate a detrimental impact. Additionally, investigations by Buer, Strandhagen, and Chan, 2018; and Salvadorinho and Teixeira, 2021 propose no clear correlation, and others, such as those by Kader Ali, Choong, and Jayaraman, 2016; and Marodin et al., 2017 delineate indirect repercussions.

The origin of these divergent outcomes might be attributed to the assorted array of performance indicators associated with lean thinking encompassing facets such as sustainability performance, inventory and quality management, lean performance, supply chain effectiveness, and market performance. Other influencing elements could be the integration of Industry 4.0 technologies, the enhancement of operational performance, streamlining lean supply chain management, the creation of knowledge, and fostering a conducive organizational culture. Scholars like Kamble, Gunasekaran, and Dhone (2020), and Zhan et al. (2018) stress

that lean thinking, isolated from these facilitating elements, cannot foster favorable performance outcomes.

Despite the extensiveness of previous research, certain gaps remain in the scholarly discourse. A growing consensus, cited in works such as Tezel et al., 2018; and Tortorella et al., 2019a, underlines the necessity for a deeper scrutiny of the role played by top management commitment in optimizing the outcomes of lean thinking initiatives. Addressing this, the current study aspires to bridge these gaps through the formulation of a distinct research archetype grounded in the Resource-based View theory. This endeavor aims to shed light on the manner in which top management commitment can mediate the dynamics between lean thinking and sustainability performance, thereby enriching the existing compendium of knowledge on this theme.

1.3 Research Objectives

The principal aim of this study is to scrutinize the impact of top management commitment on the connection between lean thinking and sustainability performance. More precisely, the research strives to fulfill the subsequent objectives:

1. To probe the relationship between lean thinking and sustainability performance
2. To investigate the relationship between top management commitment and sustainability performance
3. To examine the moderating role of top management on the relationship between lean thinking and sustainability performance

1.4 Research Questions

The Study, therefore, asks the following questions

1. What effect does lean thinking have on sustainability performance?
2. What effect does top management commitment have on sustainability performance?
3. What is the moderating role of top management commitment in the relationship between lean thinking and sustainability performance?

1.5 Significance of the Study

The ongoing study is of substantial import both in the context of theoretical evolution and the practical implementation sphere. In the scholarly dimension, it supplements the rapidly growing body of literature on sustainability, a field that has garnered escalating interest, as manifested in numerous requests for research submissions by renowned publications including the International Journal of Production Economics, the International Journal of Production Research, Production Planning and Control, Resources, Conservation and Recycling, the Journal of Manufacturing Technology Management, and Computers and Industrial Engineering. This research carves out a niche for itself by emerging as a trailblazer in the empirical examination of the nexus between lean thinking, top management commitment, and sustainability performance. The theoretical framework utilized in this study is also pioneering, shedding light on the moderating role played by Industry 4.0 technologies in the rapport between lean thinking and sustainability performance, thereby addressing prevailing gaps in academic discourse.

On the practical front, this study furnishes pragmatic insights for stakeholders in the industry and managerial staff tasked with the assimilation of lean principles in organizational operations. It underscores the urgency for executives at the highest echelons to wholeheartedly embrace lean approaches, advocating for a strategy that realizes a triple-bottom-line sustainability, which encompasses social, environmental, and economic facets. Moreover, it stipulates the imperative for the upper management to foster environments conducive to total productive maintenance, encourage inclusive employee engagement, and incorporate statistical methodologies to enhance quality control measures, thereby acting as a linchpin that guides managerial efforts towards the harmonization of organizational operations with sustainability aspirations. Consequently, the study stands to serve as a valuable resource directing managerial initiatives to fulfill sustainability objectives, providing a roadmap that envisions a balanced approach to achieving economic viability, environmental stewardship, and social responsibility.

1.6 Research Methodology

To meet the study's goals, a quantitative research method using surveys is chosen. The investigation targets manufacturing firms in the Greater Accra area, with a sample size of 100 selected through convenience sampling. Primary data comes from online questionnaires made via Google Forms, while secondary data is gleaned from scholarly articles on lean thinking and managerial commitment. Data analysis employs IBM SPSS version 26 for both descriptive and differential evaluations. Ethical guidelines are strictly followed, ensuring anonymity for respondents. The reliability and validity of the data are confirmed through Alpha Cronbach and exploratory factor analysis tests.

1.7 Scope of the Study

In examining the role of managerial commitment on the link between lean thinking and sustainability performance, the investigation is confined to manufacturing firms situated in the Greater Accra Municipality. Eligibility criteria include a company history exceeding five years. Primary informants for this inquiry consist of high-ranking managers from participating organizations. On the conceptual front, lean thinking, the independent variable, is gauged through a 20-item scale borrowed from Kamble et al. (2020); managerial commitment, serving as the intervening variable, is assessed using a 6-item scale from Ahmed et al. (2019); and sustainability performance is evaluated through a 12-item scale adapted from Dubey et al. (2017) and Zhu et al. (2004).

1.8 Limitation of the Study

First, the study centers solely on manufacturing enterprises located in the Greater Accra region. This specificity constrains the generalizability of the findings, as they may not be applicable to entities in different sectors like banking, retail, or services. Secondly, the confidential nature of the information solicited through the study's questionnaire incites hesitancy among potential respondents, thereby impacting the reliability of the conclusions drawn.

1.9 The Organisation of the Study

The study is organised into five major chapters. The opening chapter serves as the gateway to the research, setting the stage for the reader to delve into the study. It commences with the background to the study, painting a vivid picture of the existing landscape and issues that prompted the research. This chapter goes on to crisply articulate the problem statement, which defines the specific gaps or challenges the study intends to address. Following this, the objectives of the study and research questions are outlined, offering a clear road map for what

the study aims to achieve. A highlight of the significance of the study emphasizes why the research matters and who stands to benefit from it. The overview of methodology offers a glimpse into how the research will be carried out, while the scope delineates the boundaries within which the study will be conducted. Recognizing that no study is without its constraints, the limitations section provides an honest assessment of potential weaknesses. Finally, the organization of the study segment offers a brief overview of each chapter, akin to a tour guide, preparing the reader for what lies ahead.

Chapter two is a scholarly exploration that journeys through existing knowledge related to the study. The conceptual review starts this chapter by explaining and defining key terms and concepts, followed by a theoretical review that delves into relevant theories and models. The empirical review offers a critical examination of previous research findings and how they connect to the current study. By the end of this chapter, the conceptual framework emerges as a cohesive synthesis of the conceptual, theoretical, and empirical reviews, laying down the foundation for the research.

The third chapter is the blueprint of the research process, providing detailed insights into how the study was conducted. It begins with an outline of the research design, followed by a description of the population of the study. The sample and sampling techniques are then detailed, illuminating how participants were selected. Data collection methods and analyses are meticulously explained, ensuring that the process is transparent and replicable. The chapter concludes with sections on reliability and validity tests, ethical considerations, and a profile of the study area, each adding layers of rigor and integrity to the research.

This analytical chapter presents the heart of the research findings. Starting with the demographics, it offers a snapshot of the participants, followed by confirmatory factor analyses that validate the constructs used in the study. Descriptive analyses provide essential statistics,

and model testing delivers key insights into the relationships between variables. The discussion of results ties everything together, interpreting the data in the context of the research questions and existing literature.

The final chapter is a reflective culmination of the study, beginning with a summary of findings that encapsulates what the research uncovered. The conclusion section synthesizes these findings into overarching insights and implications. Recommendations are then crafted, offering practical solutions and strategies based on the study's results. Finally, future suggestions propose new directions for subsequent research, acknowledging that the quest for knowledge is an ongoing journey

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter provides an extensive review of literature concerning lean thinking, top management commitment, and sustainability performance. Included in this chapter are the conceptual analysis, the theoretical discourse, empirical examination, and the illustrative conceptual framework. The conceptual analysis explores the foundational ideas surrounding lean thinking, top management commitment, and sustainability performance. The theoretical discourse introduces the theoretical underpinnings that lend credence to this research. The empirical examination focuses on preexisting studies pertinent to lean thinking and top management commitment. Lastly, the conceptual framework visually represents both the direct and indirect relationships among the variables under study.

2.2 Conceptual Review

The conceptual review delves into the scholarly literature to scrutinize various definitions and frameworks concerning three central constructs: lean thinking, top management commitment, and sustainability performance. By doing so, the review aims to distill the essence and commonalities of these constructs, thereby providing a robust basis for empirical investigation

2.2.1 Lean Thinking

The scholarly landscape on lean thinking presents a rich tapestry of perspectives that elucidate its multifaceted nature. One of the salient themes across various definitions is the focus on eliminating waste—whether it is in the form of superfluous processes, excess inventory, or inefficient resource use. For instance, Ghobakhloo and Fathi (2020) highlight the dual aspects of operational and human resource management to emphasize holistic efficiency. They align with Razmak et al. (2021), who posit that lean thinking not only aims for organizational efficiency but also for societal benefits by focusing on consumer value and waste reduction.

Another strand in the literature emphasizes the evolutionary trajectory of lean thinking. Zhang and Chen (2016) trace its origins to Japanese manufacturing practices, suggesting that its principles have transcended cultural and sectoral boundaries to find global applicability. This universality is echoed by Abushaikha et al. (2018) who emphasize its strategic nature in achieving competitive advantage. They argue that lean thinking operates by jettisoning processes that do not contribute to value, thereby aligning with Madhani's (2022) focus on consumer-centric value creation through waste elimination.

The third aspect evident in the literature pertains to the cross-functional applicability and the supply chain orientation of lean thinking. Buer et al. (2021) bring attention to its process-oriented perspective, urging various organizational departments to assess their contributions to the overall value chain. This aligns with the view posited by Tezel et al. (2018), who emphasize the cultural shift that lean thinking engenders within an organization. Their focus is on the recalibration of employee perspectives to recognize and eliminate waste not just in their immediate roles but across the organizational ecosystem.

Taken together, these scholarly perspectives suggest that lean thinking is not a monolithic construct but a nuanced framework that encompasses diverse elements—ranging from operational efficiency and human resource management to strategic focus and cross-functional applicability. It aims not merely for short-term gains but strives for sustainable growth, operational excellence, and innovation, all while maintaining a keen eye on delivering consumer value. Therefore, a comprehensive understanding of lean thinking necessitates the synthesis of these diverse viewpoints to construct a cohesive yet flexible framework for both theoretical exploration and practical application.

2.2.2 Top Management Commitment

Top management commitment stands as a central theme in literature discussing organizational transformation, particularly in the realm of digital and lean thinking initiatives. Latan et al. (2018) articulate this commitment as the fulcrum for steering the organization in a distinct direction, thereby enabling resource allocation that is aligned with organizational objectives. This perspective is resonant with the viewpoint of Dubey et al. (2017), who posit that top management's commitment serves as a catalytic force for achieving managerial aims and securing organizational prosperity.

Further granularity to this concept is provided by Commer et al. (2019), who explore the spectrum of critical aspects to which top management's commitment extends. The range is expansive, encompassing domains like quality, safety, environmental consciousness, and security. This view aligns well with that of Wijethilake and Lama (2019), who argue that top management shapes organizational vision, values, and strategies. These elements are not only fundamental to business operations but also critical in cultivating an organizational culture that prioritizes customer satisfaction and excellent performance. Graves et al. (2019) substantiate this by suggesting that the commitment from leadership serves as a potent signal to the

workforce, indicating organizational priorities and setting the stage for collective efforts towards betterment.

The domain of lean management also demonstrates the significance of top management commitment. According to Caroline et al. (2016), leadership plays an instrumental role in the execution of lean management practices, especially those aimed at achieving advanced objectives. Their stance is augmented by Daoud et al. (2021), who assert that realizing lean goals requires senior management to perceive lean methodologies not merely as operational tools but as strategic organizational assets.

Thus, top management commitment emerges as an integral and multi-faceted construct. It influences the organization's trajectory across various dimensions—be it in securing digital transformations, achieving managerial objectives, or implementing advanced lean practices. It serves as both a strategic directive and a cultural catalyst, positioning top management as a cornerstone for organizational efficacy and sustainability.

2.2.3 Sustainability Performance

The understanding of sustainability and its performance in the organizational context is nuanced and multifaceted. Often encapsulated within the triple bottom line framework, as noted by Busse et al. (2017), sustainability encompasses economic, environmental, and social dimensions. Lim et al. (2017) furnish important details on these dimensions, indicating that economic sustainability revolves around the prudent allocation and conservation of resources for long-term value creation. Environmental sustainability emphasizes the necessity of preserving natural ecosystems while promoting human well-being. Social sustainability involves the deliberate monitoring of an organization's societal impact, which encompasses a wide range of stakeholders, from employees and consumers to local communities.

The notion of sustainability performance, according to Genovese et al. (2017), resides at one end of a continuum that includes compliance with existing norms and extends to meeting the expectations of varied stakeholders. Esfahbodi et al. (2016) offer further clarity by describing sustainability performance as a holistic measurement that gauges an organization's achievements in sustainability's multiple dimensions and facets. This evaluation, however, is not a standalone activity; it integrates into an organization's management frameworks. In this vein, Jia et al. (2018) stress the significance of aligning sustainability management with business strategies and competitive imperatives.

Kamble et al. (2020) build upon this foundation by elaborating that sustainability performance is not merely a set of measured outcomes but a continuous management process. It involves ongoing evaluations and adjustments at the intersection of business objectives, societal demands, and environmental conservation. Thus, for organizations, sustainability performance serves as both an evaluative metric and a management ethos. It requires a synergistic approach that seamlessly integrates with business strategies, influences organizational culture, and extends to external stakeholder relations.

In summary, the construct of sustainability performance serves as a complex tapestry, woven from various threads of economic, environmental, and social concerns. It necessitates strategic alignment and commitment from organizations to not only meet but also exceed the expectations of a diverse stakeholder landscape.

2.3 Theoretical Review

In the exploration of the interplay between top management commitment, lean thinking, and sustainability performance, this study employs the Resource-Based View (RBV) as its guiding theoretical framework. Originating in the 1980s, the RBV shifted the focus of scholarly inquiry from external market structures to the internal organizational composition, positing the organization's internal environment as a wellspring of competitive advantage (Barney and Mackey, 2016). According to this view, the internal resources that an organization amasses and the unique manner in which these resources are configured form the core competencies that give it a competitive edge (Collins, 2021).

RBV argues that seeking internal sources of competitive advantage is more prudent than fixating on external factors. It delineates competitive advantage through two features: the heterogeneity and immobility of an organization's resources and capabilities (Barney, 2020). While heterogeneous resources distinguish an organization sufficiently from competitors to allow for alternative strategies, immobile resources are those aspects that are not easily transferrable, such as brand equity or corporate image (Barney and Mackey, 2016).

However, the theory maintains that mere heterogeneity and immobility of traits do not confer a lasting competitive advantage. For this, the organization must satisfy the VRIN criteria, assessing whether a resource or capability is Valuable, Rare, Inimitable, and Non-substitutable. A resource meeting all four criteria indicates a sustainable competitive advantage (Barney, 2020).

In this study, lean thinking serves as a critical organizational resource featuring key dimensions such as supplier feedback, just-in-time systems, customer involvement, pull systems, and supplier development. Each of these dimensions is conceived as a strategic asset capable of

positively affecting various facets of sustainability: social, economic, and environmental. Supplier feedback, for example, allows for the continuous improvement of both products and processes, thereby enhancing economic sustainability through efficiency gains and reduced operational costs. Just-in-time systems and pull systems help in minimizing waste and optimizing resource utilization, which are essential for environmental sustainability. Customer involvement, being intrinsic to lean thinking, ensures that products or services meet or exceed consumer expectations, thereby contributing to social sustainability by fostering customer satisfaction and long-term relationships.

Moreover, this academic inquiry suggests that top management commitment acts as an intangible yet profoundly influential resource. Such commitment, when appropriately directed toward lean initiatives, can play a pivotal role in realizing enhanced sustainability outcomes. Specifically, management's commitment to lean thinking can help in the effective alignment and deployment of organizational resources towards achieving sustainability objectives. For instance, top management's commitment could drive investments in greener technologies or practices, actively engage suppliers in sustainability efforts, and lead community outreach programs. The commitment from senior leadership is also vital for shaping an organizational culture that values and integrates sustainability into its core strategy. The culture, in turn, can impact the extent to which employees at all levels take ownership of sustainability goals, thereby enriching the firm's social sustainability.

2.4 Empirical Review

The body of research on lean thinking is extensive and offers diverse perspectives on its applications and effects. Razmak et al. (2021b) explored the interplay between Industry 4.0 and specific Lean practices in the manufacturing sector in Brazil. They found that while process-oriented Industry 4.0 technologies hamper the performance impact of low set up practices, technologies geared towards products or services enhance it. Their study also underscored the limited effectiveness of merely technical deployments, suggesting that lean practices could pave the way for a broader adoption of Industry 4.0.

Nimeh et al. (2018) conducted an evaluation focused on Jordanian manufacturing organizations to understand the role of lean thinking in influencing supply chain and market performance. The study deployed a survey questionnaire to 400 managers across diverse manufacturing sectors. Results revealed a significant positive impact of specific lean practices such as just-in-time systems, information flow, and customer connection on market performance. The study also confirmed a broadly positive impact of lean thinking on supply chain performance.

Tortorella et al. (2019) also scrutinized the lean thinking paradigm, albeit in the context of Brazilian companies and their associated supplier networks. Their findings demonstrated that identifiable bundles of lean practices, when applied collectively, can substantially enhance supply chain performance. However, they also noted that while the supply chain milieu is critical for implementing lean thinking, different aspects of this environment contribute differently to its effective implementation.

Valente et al. (2020) identified a void in the integration of environmental sustainability with lean approaches in supply chains. To address this gap, they developed the Green and Lean Supply Chain Framework (GL-SC), which emphasizes the amalgamation of both green and

lean technologies across supply chain components. The study recommends using both static and dynamic value stream mapping for constructing and validating the framework.

Jasti and Kodali (2015) concentrated on the developmental status of lean thinking frameworks. Their comprehensive review resulted in the collation of 30 distinct frameworks which they categorized based on uniqueness, contribution of different scholars, verification status, and the extent of standardization. The study elucidated that academic contributions to the creation of lean thinking frameworks outnumber those from practitioners and consultants. It also highlighted the existence of incoherent components within the frameworks, which calls for more standardized and practitioner-engaged research.

Zhang and Chen (2016b) delved into lean construction, specifically examining its relation with knowledge management. The paper employs the SECI model for socialization, externalization, combination, and internalization of knowledge. Through this, they proposed lean strategies for knowledge creation and supported their findings with a questionnaire survey. The research concluded that lean tools positively impact knowledge production and therefore enhance lean performance in construction settings.

Uriarte et al. (2018) addressed the impact of Industry 4.0 on lean principles and management. They provided a conceptual framework illustrating how simulation and optimization techniques could make lean methods more efficient in the context of Industry 4.0. Their framework aims to accelerate system improvements and reconfiguration, improve decision-making, and foster organizational learning.

Kamble et al. (2020) explored the interaction between Industry 4.0 technologies (I4 T) and lean thinking concerning organizational sustainability. The study is groundbreaking in its empirical assessment of lean thinking as a mediating variable between I4 T and sustainability

performance. Drawing upon data from 205 managers across 115 manufacturing organizations, the study reveals both direct and indirect effects of I4 T on sustainability performance. Lean thinking emerges as a crucial mediator in this relationship, adding nuance to the understanding of how technology and lean methodologies can jointly improve sustainability.

Tortorella et al. (2018) focused on the critical role of supply chain (SC) strategies in achieving organizational competitiveness and performance in the context of Industry 4.0 technologies. The study proposes a conceptual model that integrates Lean and Agile SC methods with Industry 4.0 technologies. This model serves as a decision-support tool, encouraging practitioners to adopt specific Lean and Agile methods that are best suited for their organizational context, enhanced by the capabilities of Industry 4.0 technologies. The work highlights the importance of synergy between modern technologies and traditional SC strategies for competitiveness and performance enhancement.

Marodin et al. (2017) examined the moderating influence of Industry 4.0 technologies on the relationship between lean production (LP) practices and operational performance improvement, specifically in the context of Brazilian manufacturing organizations. Based on contingency theory and involving 147 manufacturing organizations, the study found that Industry 4.0 technologies do indeed moderate the effect of LP on operational performance, but in varying ways. For instance, process-related technologies negatively impact the performance benefits derived from low setup practices, whereas product/service-related technologies amplify the positive influence of flow practices on performance.

The study by Ghobakhloo and Fathi (2020) delves into the adaptation challenges and strategies that small manufacturing enterprises face in the Industry 4.0 era, particularly focusing on Information Technology (IT) as a lever for creating a lean-digitised manufacturing system. Conducted over five years, this case study shows how one enterprise evolved from a state of

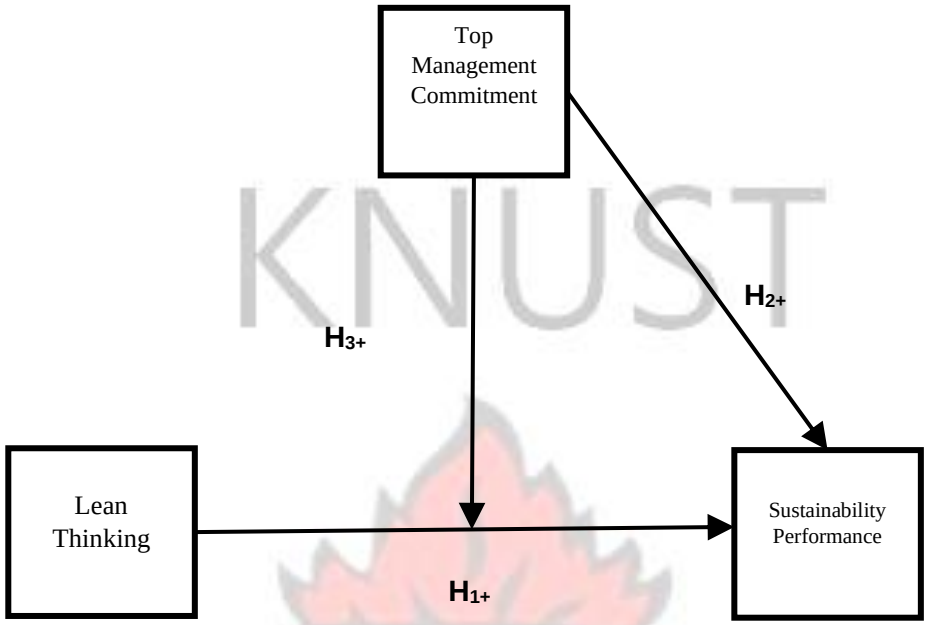
failure to success by integrating IT-based trends of Industry 4.0 with its core strengths. The key insight is that while Industry 4.0 demands the comprehensive digitisation of entire value chains, smaller businesses can initiate their transformation by digitizing selective operational aspects that align with their core objectives. This selective approach, the study argues, is a feasible survival strategy in the fast-evolving Industry 4.0 landscape.

Chiarini and Kumar (2020), on the other hand, explore the intersection of Lean Six Sigma (LSS) and Industry 4.0, aiming to develop a new framework for operational excellence. Through interviews with Italian manufacturing executives across 10 case organizations and direct observations at one selected case, the study concludes that LSS can indeed act as a platform for successfully implementing Industry 4.0 technologies. Such integration, however, is not straightforward; it requires the development of new mapping tools and entails both horizontal and vertical end-to-end integration. While vertical integration demands reengineering of the ERP modules, horizontal integration aims to achieve a state of Autonomous Process Synchronization.

2.5 Conceptual Framework

This section demonstrates the direct and indirect links between lean thinking, top management commitment, and sustainability performance. According to H1, there is a direct and positive association between lean thinking and sustainability performance. According to H2, there is a direct and positive association between top management commitment and sustainability performance. According to H3, top management commitment favourably moderates the relationship between lean thinking and sustainability performance. Figure 2.1 depicts the variables' direct and indirect connections.

Figure 2.1 Conceptual Framework



Source: Researcher's construct (2022)

2.5.1 Lean Thinking as a determinant of Sustainability Performance

In the context of Resource-Based View (RBV), lean thinking emerges as a unique organizational competency that significantly influences a firm's social and sustainability performance. According to Barney (2020), RBV underscores the value of rare, inimitable, and non-substitutable resources in achieving competitive advantage. Lean thinking, as posited by Villarreal et al. (2017), fits well into this paradigm as it not only reduces costs but also enhances revenue, thereby conferring a distinct competitive edge. Moreover, the contribution of lean thinking to sustainability is evident in its emphasis on waste reduction and resource optimization, aspects which Razmak et al. (2021b) and Afonso and Cabrita (2015) have expounded upon. In a similar vein, Tortorella et al. (2019b) affirm that lean practices can lead to environmental efficiencies by minimizing waste. Buer et al. (2018) extend this perspective by highlighting that lean thinking can also contribute to better health and safety standards. This is reinforced by Bevilacqua et al. (2017b), who argue that when lean thinking is integrated with

environmental management systems, there is a tangible decrease in the marginal costs associated with environmental improvements, including pollution control and energy savings. Furthermore, the integration of lean practices with high-involvement work practices contributes positively to occupational safety, a crucial aspect of social sustainability as highlighted by Bevilacqua et al. (2017b). Therefore, in synthesizing these insights, the study hypothesizes that the adoption and implementation of lean thinking, as a unique and core organizational competency, positively influences a firm's social and sustainability performance. Specifically, it is posited that lean thinking aids in enhancing productivity, reducing operational costs, and improving environmental and social sustainability metrics.

H_1: Lean thinking is positively and significantly related to sustainability performance

2.5.2 Top Management Commitment as a determinant of Sustainability Performance

In line with the Resource-Based View (RBV), this study posits that top management commitment serves as an invaluable intangible asset that substantially contributes to the performance in social, economic, and environmental sustainability. As noted by Barney and Mackey (2016), RBV distinguishes between tangible and intangible organizational resources, and it is within this latter category that top management commitment firmly resides. According to Latan et al. (2018), the engagement of top management in sustainability management is a crucial success factor for long-term organizational growth. This is because top management does not merely allocate resources towards sustainability initiatives but also profoundly influences organizational culture and company-wide decision-making processes, as observed by Graves et al. (2019). The importance of top management commitment as a determinant of an organization's focus on sustainability is further supported by Wijethilake and Lama (2019). They argue that senior management's commitment is a critical factor in ascertaining whether an organization's sustainability endeavors are genuine or merely superficial. This argument

aligns with the assertion by Tzempelikos (2015) that while normative institutional pressures might lead organizations to adopt sustainability policies, the effectiveness of these policies hinges significantly on top management's commitment and underlying philosophy towards sustainability. Daoud et al. (2021b) expand on this by stating that a committed senior management can align an organization's sustainability agenda with its overall strategic objectives, thereby driving comprehensive sustainability outcomes. Therefore, this research hypothesizes that the degree of top management commitment is a crucial determinant in the successful implementation of sustainability strategies, thereby positively impacting the organization's performance across the domains of social, economic, and environmental sustainability.

H_2: Top management commitment has a significant and positive effect on sustainability performance

2.5.3 The Moderating role of Top Management Commitment

Building upon the Resource-Based View (RBV), which accentuates the role of an organization's internal resources in achieving a competitive advantage, this research posits that lean thinking can serve as a unique, firm-specific core competency. As delineated by Barney (2020) and Barney and Mackey (2016), for a resource to offer sustained competitive advantage, it must be valuable, scarce, and difficult to imitate. In this vein, the role of top management commitment becomes crucial in the effective implementation and ongoing sustenance of lean thinking as an organizational resource aimed at improving sustainability performance. In the literature, the outcomes of implementing lean thinking as a strategy have produced mixed results. For instance, studies by Abreu-Ledón et al. (2018), Abushaikha et al. (2018), and Madhani (2022) suggest a positive impact of lean thinking on sustainability performance and other performance metrics. Conversely, other research, including work by Lewis (2000) and Razmak et al. (2021a), indicates a negative or less favorable impact. Additionally, studies by

Kader Ali, Choong and Jayaraman (2016) and Marodin et al. (2017) suggest that lean thinking may have indirect effects on performance outcomes. It is posited in this research that the varying degrees of top management commitment to lean thinking may serve as a moderating variable, which amplifies or diminishes the impact of lean thinking on sustainability performance. In essence, the effectiveness of lean thinking as an internal organizational resource in enhancing sustainability performance is hypothesized to be contingent upon the level of commitment exhibited by senior management

H_3: Top management commitment positively and significantly moderates the relationship between Lean thinking and sustainability performance

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter elaborates on the methodology deployed in the current investigation, offering an exhaustive account of the design framework, methods for gathering data, strategies for sampling, and techniques for scrutinizing the data. Additionally, the chapter elaborates on the ethical imperatives heeded during the course of the investigation and the measures instituted to certify the data's validity and reliability.

3.2 Research Design

A research design serves as a systematic plan or architectural blueprint for the execution of an academic study. It delineates the methodologies, procedures, and techniques intended for the collection and analysis of data, and also determines the overarching framework and approach of the research project. A well-constructed research design is essential because it offers a structured methodology for responding to research inquiries or verifying hypotheses, as posited by Levy and Lemeshow (2008). There are various categories of research designs, including descriptive, exploratory, explanatory, and evaluative. This inquiry employs an explanatory design with the primary objective of scrutinizing and evaluating the connection between Lean thinking, sustainability performance, and top management commitment. This design enables the exploration of cause-and-effect relations between the variables under study, thereby aiding in comprehending why certain phenomena manifest.

The term "research strategy" refers to a meticulously crafted action plan that specifies the researcher's route for addressing their research query or problem. This comprehensive framework guides the decisions that a researcher makes throughout the investigatory process. Components of a research strategy encompass the research design, methodologies for data collection, sampling techniques, methods of data analysis, and ethical stipulations. According to Blaxter et al. (2010), a research strategy delineates the techniques for data gathering and analysis, the data sources, and the organizational scheme for data presentation. Among various examples of research strategies are experimental research, surveys, case studies, action research, and grounded theory. In this study, a survey methodology focusing on manufacturing firms within the Greater Accra region is employed. Surveys are efficacious in obtaining information from a sample concerning opinions, attitudes, experiences, or traits, as articulated by Sarstedt and Mooi (2019). The standardized nature of survey questions mitigates the risk of data collection bias, rendering it a suitable method for this investigation.

Research approaches represent distinct methodologies a researcher may employ for conducting an academic study. The selected approach is contingent upon the research question, the character of the data to be gathered, and the resources at the researcher's disposal. Kothari (2004) identifies three principal approaches: qualitative, quantitative, and mixed methods. This particular study employs a quantitative research approach, a methodology characterized by the collection and analysis of numerical data through statistical procedures. The aspiration of quantitative research is to assess hypotheses, detect patterns and associations, and draw impartial inferences concerning a population based on a sample representing that demographic. This approach commonly utilizes surveys, questionnaires, and standardized tools for data collection. The study opts for a quantitative approach as it furnishes precise and objective quantification of variables, thereby curtailing ambiguity and subjectivity during the research procedure.

3.3 Population of the Study

In the realm of scholarly investigation, the concept of a study's population pertains to the comprehensive assemblage of individuals, entities, or phenomena that form the subject matter of the research. This is the collective body to which the researcher intends to extrapolate the outcomes or conclusions drawn from the study, as articulated by Levy and Lemeshow (2008). In the context of this specific study, the unit of analysis is designated as the firm. Consequently, the research population is composed of an employee from each manufacturing firm situated within the Greater Accra region. This focus on a single employee from each firm as the unit of analysis is significant for several reasons. First, it allows for an in-depth exploration of Lean thinking, top management commitment, and sustainability performance from the perspective of individual firms. This is particularly relevant in a study that aims to dissect and comprehend the intricacies of these multifaceted constructs. Second, narrowing the unit of analysis to one employee per firm also offers practical advantages, such as reduced complexity in data collection and analysis. Third, concentrating on manufacturing firms within a specific geographical area like the Greater Accra region enables a nuanced understanding of regional characteristics that may influence the study variables. The choice of the Greater Accra region as the geographical boundary for this study merits consideration as well. This specific locale likely presents a concentrated cluster of manufacturing firms, thereby making it a microcosm that is both manageable for the researcher and rich in data. Furthermore, the unique economic, cultural, and regulatory landscape of the Greater Accra region may provide insights that are deeply rooted in the local context, thereby enhancing the relevance and applicability of the study's findings. Overall, the carefully chosen unit of analysis and geographical scope aim to ensure that the study's conclusions are both rigorous and meaningful.

3.4 Sample and Sampling Technique

Sampling serves as the critical act of selecting a specified subset of units, be it individuals, objects, or events, from a larger population. The objective is to analyze this subset to draw inferences about the broader population. Carter and Hurtado (2007) and Almalki (2016) emphasize the indispensable role of sampling in research, as it sets the parameters for how extensively the findings of a study can be generalized to the larger population.

In academic studies, researchers have the option of employing either probability or non-probability sampling methods. The choice between these methods depends on several factors including the research question, the size of the population, and available resources. Probability sampling provides each member of the population a known and equal chance of selection for the sample. Conversely, non-probability sampling does not give each member of the population an equal opportunity for selection. For the purposes of this study, convenience sampling was utilized to gather a sample of 100 units from the target group. Barnham (2015) defines convenience sampling as a form of non-probability sampling where subjects are chosen based on their ease of accessibility or availability to the researcher.

The justification for employing convenience sampling lies in its efficiency and ease of implementation. Participants are readily accessible and require minimal effort for recruitment. The choice of a sample size of 100 was influenced by constraints on resources, both time and financial. Conducting a study with a larger sample would necessitate a greater allocation of time and resources, making it impractical for this specific research context. Therefore, this study opts for a convenience sample of 100 units, balancing methodological rigor with practical limitations.

3.5 Data Collection Method

Data collection in research involves the procurement of information to resolve research questions or test hypotheses. According to Barnham (2015), this step is integral to the success of a research project, as the substance and validity of the findings are intrinsically tied to the precision and thoroughness of the data collected. This study relies predominantly on primary data to achieve its objectives and resolve its research questions. As outlined by Abutabenjeh and Jaradat (2018), primary data is collected specifically for the purposes of a study and is obtained directly from the field of inquiry. For this particular study, primary data is amassed from one hundred employees who are part of manufacturing firms situated within the Greater Accra Region. The emphasis on primary data aligns with the research design and objectives, ensuring that the findings generated are both contextually relevant and methodologically robust.

3.5.1 Questionnaire Design

This segment outlines the structure of the questionnaire used to gather data for this research. The survey is divided into four key areas. The first area concentrates on gathering demographic information about the participants. The second area is designed to examine the independent variable, specifically lean thinking. The third area focuses on the variable that serves as a moderator, which is the commitment from senior management. Finally, the fourth area aims to assess the dependent variable, sustainability performance. A summary of the items used for measurement in each section is provided in Table 3.1.

Table 3.1 Summary of Measurement Items

Variables	No. of Items	Sources
Lean Thinking		
• Pull systems	3	Kamble et al. (2020)
• Just-in-time	3	Kamble et al. (2020)
• Supplier development	3	Kamble et al. (2020)
• Customer involvement	3	Kamble et al. (2020)
Top management commitment	7	Ahmed et al. (2019)
Sustainability Performance		
• Economic Sustainability	5	Kamble et al. (2020)
• Social Sustainability	5	Kamble et al. (2020)
• Environmental Sustainability	5	Kamble et al. (2020)

Source: Researcher's Construct (2023)

3.6 Data Analysis

Data analysis entails the scrutiny and interpretation of data to derive valuable conclusions, formulate judgements, and facilitate informed decision-making. Various types of data, such as numerical, categorical, or textual, can undergo analysis (McNabb, 2010). For the purposes of this research, all data evaluations are executed using SPSS version 26. The analytical procedures are divided into two primary categories: descriptive and inferential. Descriptive statistics encompass metrics like the mean, standard deviation, skewness, and kurtosis. On the other hand, inferential statistics involve techniques such as Cronbach's Alpha, Composite Reliability, Average Variance Explained, Exploratory Factor Analysis, and Confirmatory Factor Analysis. The research model is assessed through the application of ordinary least squares regression and moderated hierarchical regression methods.

3.7 Validity and Reliability

Reliability and validity serve as crucial parameters in research for assuring the credibility and precision of the findings. Reliability denotes the uniformity, stability, and replicability of research measurements. That is to say, a measurement earns the label of reliable if it yields steady outcomes across varied researchers and diverse situations over a span of time. If the underlying construct being measured remains unchanged, a reliable measure should consistently produce analogous outcomes (Maciej Serda, 2013). In this research, the metric of Cronbach's Alpha is employed to evaluate reliability. On the other hand, validity is concerned with the exactitude and significance of research measurements. A measurement is deemed valid if it captures what it purports to assess and if the ensuing results facilitate the drawing of precise inferences concerning the research question (Maciej Serda, 2013). Explanatory factor analysis is used to evaluate validity in this particular study.

3.8 Ethical Considerations

Ethics in research is essential to ensure that the research is conducted in a respectful, responsible, and ethical way towards the participants, the research community, and society as a whole. To ensure compliance with ethical principles, the researcher ensured the following

Providing informed consent: All participants were fully informed about the research and provided their voluntary consent to participate.

Maintaining confidentiality and privacy: The study kept participants' personal information and data confidential and private.

Minimising harm: Steps were taken to minimise potential harm to participants, including physical and psychological harm.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

In Chapter Four, a comprehensive exploration of the empirical findings of the study is undertaken, unfolding the complex dimensions that frame the analysis. This journey through the chapter is methodical and encapsulates six critical aspects, each lending depth and precision to the understanding of the data. The chapter begins with an evaluation of the response rate of the survey, an indispensable step to gauge the robustness and generalizability of the findings. This section not only quantifies the participation level but also delves into the underlying factors that may have influenced the willingness of respondents to partake in the study. Following this analysis, a thorough examination of the demographic variables paints a vivid picture of the composition of the respondents, illuminating any patterns or trends that may be reflective of the broader population. Ensuring the integrity of the research, the chapter tackles the core issues of reliability and validity. The techniques used to validate the constructs and to ensure that the measures employed are both consistent and accurate are dissected, offering assurance in the quality of the data and the methods applied. Subsequently, the chapter presents descriptive statistics that crystallize the essential characteristics of the data. Through a structured presentation of the central tendencies, variability, and distribution, this section sets the statistical groundwork for the complex analyses that follow. Building upon the solid statistical foundation, the chapter rigorously tests the theoretical models and hypotheses. Employing sophisticated statistical techniques and methodologies, it offers both confirmation and refutation, sketching the landscape of the theoretical understanding. The chapter culminates in a reflective discussion of the results, synthesizing the empirical findings into a coherent narrative. This concluding section aligns the study's outcomes with existing literature,

offering interpretations and implications that extend beyond the raw numbers and breathe life into the theoretical constructs.

4.2 Response Rate

A total of one hundred online questionnaires were distributed to employees of manufacturing firms operating within the Greater Accra region of Ghana, signaling an intent to explore various aspects of this specific industrial sector. The chosen approach of online distribution ensured a wide reach within the targeted demographic, creating an avenue for a diverse array of insights. Of the questionnaires distributed, a total of ninety-six responses were received. This equates to a remarkable 96% response rate, reflecting a high level of engagement and interest from the respondents. Such an impressive response rate is indicative of several factors that may have contributed to this successful outcome.

4.3 Demographic Characteristics of Respondents

In the pursuit of understanding the complex relationships between Lean thinking, sustainability performance, and the moderating influence of top management commitment, the demographic characteristics of the subjects involved hold considerable significance. These characteristics provide a contextual foundation that can have profound implications on the study's findings and conclusions. The demographics under scrutiny include the Length of business operation, reflecting the maturity and potential adaptiveness of the organization; Gender, which may reveal insights into the diversity within management roles; Age, capturing the generational perspectives that might influence attitudes towards sustainability and efficiency; Highest qualification, representing the educational background that can shape the strategic decisions of management; Work experience, which provides a gauge of practical wisdom and expertise; and Age of respondents, offering a lens into varying perspectives across different life stages.

Table 4.1 Demographic information of the respondents

Variables		Frequency	Valid Percentage
Length of business operation	1-5 years	16	16.7%
	6-10 years	25	26%
	11-15 years	24	25%
	Above 15 years	31	32.3%
Gender	Male	45	46.9%
	Female	51	53.1%
Age	Below 20 years	-	-
	20-29years	12	12.5%
	30-39 years	61	63.5%
	40-50years	20	20.8%
	Above 50years	3	3.1%
Highest qualification	HND	5	5.2%
	1st degree	59	61.5%
	Masters	27	28.1%
	PhD	3	3.1%
	Professional/Vocational	1	1%
	Others	1	1%
Work experience of Respondents	1-5 years	34	35.4%
	6-10 years	34	35.4%
	11-15 years	17	17.7%
	Above 15 years	11	11.5%
Firm Age	1-5 years	14	14.6%
	6-10 years	21	21.9%
	11-15 years	21	21.9%
	Above 15 years	40	41.7%

Source: Field study (2023)

Table 4.1 delineates the demographic information of the respondents in this study, reflecting a diverse array of characteristics. The Length of Business Operation spans various stages of organizational maturity, from 1-5 years at 16.7% to above 15 years at 32.3%. This range enables an examination of how businesses at different lifecycle stages may perceive and engage with Lean thinking and sustainability practices. The Gender distribution among respondents is relatively balanced, with male participants constituting 46.9% and females 53.1%. This balance may reflect a rich diversity of perspectives within managerial roles. Age also plays a critical role, with the majority of respondents falling within the 30-39 years bracket at 63.5%. This dominant age group allows the study to explore how specific generational attitudes and experiences might interact with the focal themes of the research. In terms of Highest Qualification, the majority of respondents have either a 1st degree, comprising 61.5%, or a

Masters degree at 28.1%. This suggests a high level of education among the participants, which might indicate a strong theoretical grounding in Lean thinking and sustainability concepts. Work Experience of Respondents is distributed across various ranges, providing the study with insights from both new professionals and those seasoned in their fields. The Firm Age category shows that 41.7% of the firms have operated for over 15 years, with the remaining distributed across younger stages. This consideration of firm longevity may significantly influence the approach and commitment to Lean thinking and sustainability within the organizations.

4.4 Reliability and Validity Test

In empirical research, the concepts of reliability and validity are pivotal in determining the accuracy and generalizability of the findings. Ensuring that the measurements employed are both consistent and genuinely reflective of the variables under examination is paramount for the credibility of the results. In the context of this study, reliability is assessed using the Cronbach Alpha test, a widely accepted measure of internal consistency. This statistical coefficient provides an estimate of the extent to which a set of variables measures a single, unidimensional latent construct. A higher Cronbach Alpha value typically signifies a more reliable scale, affirming that the questions used in the survey are cohesively gauging the same underlying attribute. Validity, on the other hand, pertains to the degree to which a test accurately measures what it intends to measure. To ensure validity in this research, an exploratory factor analysis has been utilized. This statistical technique aims to identify the underlying relationships between measured variables and latent constructs. By exploring the factor structure and ascertaining that the observed variables are indeed indicative of the theoretical concepts, exploratory factor analysis offers critical insights into the construct validity of the measurements.

Table 4.2 Reliability Test – Alpha Cronbach

Construct	Number of items	Alpha Value
Lean Thinking	12	.945
Top Management Commitment	7	.933
Sustainability Performance	15	.959

Source: Field study (2023)

Table 4.2 presents the results of the reliability test conducted using Alpha Cronbach for the three main constructs of this study: Lean Thinking, Top Management Commitment, and Sustainability Performance. For the Lean Thinking construct, comprising 12 items, an Alpha Value of .945 was obtained, reflecting a very high level of reliability. Similarly, the Top Management Commitment construct, measured with 7 items, recorded an Alpha Value of .933, also indicative of excellent reliability. Finally, the Sustainability Performance construct, with 15 items, achieved an Alpha Value of .959, representing an exceptional degree of internal consistency. These high Alpha Values underscore the robustness of the constructs used in the study and signify that the scales are coherent and well-aligned with the underlying attributes they are designed to measure.

Table 4.3 Validity Test - Exploratory Factor Analysis (EFA)

Items	Variables		
	LT	TMC	SP
Lean Thinking	0.77		
Our production is pulled by the shipment of finished goods	0.878		
Our production at work-stations is pulled by the current demand of the next work-station	0.814		
Kanban, squares, or containers of signals are used for production control	0.777		
Our company involves all our key suppliers in the NPD process	0.7		
Our key suppliers make JIT delivery to our plant.	0.71		

Our company has a formal supplier certification programme in place	0.617		
Our suppliers thrive to achieve an annual reduction in costs	0.668		
Our principal suppliers are located in the close vicinity of our plants	0.814		
Our company has a well-established system to communicate important issues with key suppliers	0.821		
Our firm is in close contact with our customers	0.73		
Our firm collects quality and delivery performance feedback from customers	0.737		
Our customers share the present and future demand information with our firm	0.77		
Top Management Commitment			
The Department head assumes responsibility for lean performance		0.652	
The Department head provides supportive leadership for lean improvement		0.878	
Department heads participate in the lean improvement processes		0.823	
Lean issues are reviewed in our department management meetings		0.84	
The top management has objectives for lean performance		0.829	
Top management appreciates individual staff contributions to improving lean thinking		0.778	
Top management works closely with employees to improve lean performance		0.728	
Sustainability Performance			0.808
Reduced costs of production			0.714
Improved profits			0.76
Reduced product development costs			0.796
Decreased energy costs			0.825
Reduces inventory costs			0.828
Improved working conditions			0.799
Improved workplace safety			0.88
Improved employee health			0.898
Improved labour relations			0.829
Improved morale			0.792

Reduction of solid waste			0.836
Reduction of liquid waste			0.824
Reduced gas emissions			0.876
Reduced energy waste			0.814
Improvement in the firm's environmental situation			0.808

Source: Field study (2023) Notes: Lean Thinking (LT); Top Management Commitment (TMC); Sustainability Performance (SP)

Table 4.3 presents the outcomes of the exploratory factor analysis, displaying that each of the thirty-four (34) items used to assess lean thinking, top management commitment, and sustainability performance achieved a loading greater than 0.50. This result signifies that every item accurately represented the variables it was designed to measure, thereby confirming their validity

Table 4.4 KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.917
Bartlett's Test of Sphericity	Approx. Chi-Square	3562.798
	Df	561
	Sig.	.000

Source: Field study (2023)

The KMO index assesses the suitability of the data for factor analysis. It ranges from 0 to 1, with values closer to 1 indicating that the patterns of correlations are relatively compact and hence provide a reliable basis for factor analysis. A KMO value of .917, as shown in Table 4.4, is considered superb, indicating that the sample is highly adequate for conducting exploratory factor analysis.

4.5 Descriptive Statistics

In this section, the descriptive statistics related to lean thinking, top management commitment, and sustainability performance are examined. The analysis employs the mean, standard deviation, skewness, and kurtosis to provide an insightful overview. These statistical measures aid in understanding the central tendencies, variations, asymmetry, and extremeness in the distribution of the data across these three critical organizational aspects.

4.5.1 Lean Thinking

Table 4.5 showcases the descriptive analysis for the twelve items that were specifically crafted to operationalize Lean Thinking. These questions were meticulously developed to capture the essence of Lean Thinking within the organizations surveyed, and the descriptive statistics offer an insightful summary of the central tendencies and distributional characteristics of the responses.

Table 4.5 Descriptive statistics – Lean Thinking

Variables	Mean	SD	Skewness	Kurtosis
Our production is pulled by the shipment of finished goods	5.7	1.557	-1.412	1.723
Our production at work-stations is pulled by the current demand of the next work-station	5.57	1.574	-1.195	1.12
Kanban, squares, or containers of signals are used for production control	5.7	1.597	-1.438	1.496
Our company involves all our key suppliers in the NPD process	5.05	1.669	-0.736	-0.043
Our key suppliers make JIT delivery to our plant.	5.02	1.753	-0.823	-0.032
Our company has a formal supplier certification programme in place	5.07	1.831	-0.824	-0.234
Our suppliers thrive to achieve an annual reduction in costs	5.05	1.618	-0.862	0.226
Our principal suppliers are located in the close vicinity of our plants	4.57	1.988	-0.504	-0.946
Our company has a well-established system to communicate important issues with key suppliers	5.47	1.679	-1.198	0.755
Our firm is in close contact with our customers	5.61	1.592	-1.405	1.606

Our firm collects quality and delivery performance feedback from customers	5.56	1.582	-1.201	1.071
Our customers share the present and future demand information with our firm	5.35	1.589	-1.101	0.686
OVERALL SCORE	**5.3116**	**1.32173**	**-1.409**	**2.265**

Source: Field study (2023)

Table 4.5 presents the descriptive statistics for Lean Thinking across twelve carefully designed variables. These statistics include the mean, standard deviation (SD), skewness, and kurtosis for each item, along with an overall score. The mean scores range from 4.57 to 5.7, with an overall mean of 5.3116. This indicates that the respondents generally agree with the Lean Thinking practices, with scores mostly leaning towards the higher end of the scale. The highest mean of 5.7 corresponds to the items concerning how production is pulled, reflecting their critical role in Lean Thinking. Conversely, the lowest mean of 4.57 relates to the proximity of principal suppliers, possibly indicating that this is not uniformly emphasized across the sampled organizations. The standard deviation shows a range from 1.32173 (overall) to 1.988, reflecting variations in agreement with each item. Higher SDs might suggest divergent practices across different organizations, while a lower overall SD indicates a general alignment with Lean Thinking principles. The negative skewness in most variables, with an overall value of -1.409, reveals that the distribution of responses is tilted towards higher scores, signifying general agreement or implementation of Lean Thinking practices across the sample. Moreover, the kurtosis values are mostly positive, ranging from -0.946 to 2.265 (overall), suggesting a leptokurtic distribution for most items. This points to the responses being heavily concentrated around the mean, with fewer extreme values. The general alignment with higher scores implies a widespread acceptance and implementation of Lean Thinking principles.

4.3.2 Top Management Commitment

Table 4.6 showcases the descriptive analysis for the seven items that were specifically crafted to operationalize Top Management Commitment. These questions were meticulously developed to capture the essence of Top Management Commitment within the organizations surveyed, and the descriptive statistics offer an insightful summary of the central tendencies and distributional characteristics of the responses.

Table 4.6 Descriptive statistics – Top Management Commitment

Variables	Mean	SD	Skewness	Kurtosis
The Department head assumes responsibility for lean performance	5.47	1.451	-0.993	0.857
The Department head provides supportive leadership for lean improvement	5.48	1.515	-1.157	1.102
Department heads participate in the lean improvement processes	5.61	1.379	-0.846	-0.119
Lean issues are reviewed in our department management meetings	5.36	1.584	-0.932	0.321
The top management has objectives for lean performance	5.45	1.602	-0.924	0.13
Top management appreciates individual staff contributions to improving lean thinking	5.52	1.472	-1.001	0.522
Top management works closely with employees to improve lean performance	5.38	1.564	-1.001	0.532
OVERALL SCORE	**5.4673**	**1.27581**	**-1.061**	**0.781**

Source: Field study (2023)

Table 4.6 lays out the descriptive statistics for Top Management Commitment, captured through seven distinct variables, each dealing with different aspects of managerial responsibility, leadership, and participation in lean performance. The statistics detail the mean, standard deviation (SD), skewness, and kurtosis for these elements, coupled with an overall

score. The mean scores range from 5.36 to 5.61, with an overall mean of 5.4673. This higher range of values illustrates strong agreement among respondents that top management indeed plays a vital role in lean performance within their organizations. The highest mean, at 5.61, pertains to the participation of department heads in lean improvement processes, indicating its significance. The lowest mean score of 5.36, associated with the review of lean issues in department management meetings, while still high, may point to areas for further emphasis within some organizations. Standard deviation values vary from 1.27581 (overall) to 1.602, providing insight into the dispersion of the responses. The lower overall standard deviation reflects a consistent acknowledgment of the importance of top management commitment across the organizations sampled. Skewness, predominantly negative and with an overall value of -1.061, signifies that the responses are mainly skewed towards the higher scores. This pattern emphasizes widespread agreement on the importance of top management's role in fostering lean performance. The kurtosis values range from -0.119 to 0.857 (overall), mainly showing a leptokurtic distribution, with more responses concentrated around the mean. In conclusion, Table 4.6 elucidates a prominent trend among the organizations surveyed, underlining the pivotal role that top management commitment plays in implementing and enhancing lean practices.

4.3.3 Sustainability Performance

Table 4.7 showcases the descriptive analysis for the seven items that were specifically crafted to operationalize Sustainability Performance. These questions were meticulously developed to capture the essence of Sustainability Performance within the organizations surveyed, and the descriptive statistics offer an insightful summary of the central tendencies and distributional characteristics of the responses.

Table 4.7 Descriptive statistics – Sustainability Performance

Variables	Mean	SD	Skewness	Kurtosis
Reduced costs of production	5.03	1.657	-0.986	0.399
Improved profits	5.5	1.642	-1.254	0.995
Reduced product development costs	5.25	1.692	-1.095	0.576
Decreased energy costs	5.02	1.711	-0.832	0.012
Reduces inventory costs	5.11	1.641	-0.801	0.065
Improved working conditions	5.3	1.584	-0.87	0.027
Improved workplace safety	5.5	1.556	-1.019	0.425
Improved employee health	5.4	1.599	-0.816	-0.253
Improved labour relations	5.35	1.576	-0.903	0.143
Improved morale	5.32	1.638	-0.829	-0.161
Reduction of solid waste	5.28	1.769	-0.951	-0.001
Reduction of liquid waste	5.27	1.701	-0.867	-0.041
Reduced gas emissions	5.2	1.839	-0.889	-0.253
Reduced energy waste	5.26	1.662	-0.889	-0.005
Improvement in the firm's environmental situation	5.52	1.616	-1.155	0.661
OVERALL SCORE	**5.2882**	**1.32278**	**-1.009**	**0.746**

Source: Field study (2023)

Table 4.7 showcases the descriptive statistics for Sustainability Performance, encompassing fifteen diverse variables related to the aspects of cost reduction, profit improvement, workplace enhancement, and environmental betterment. It encapsulates the mean, standard deviation (SD), skewness, and kurtosis for each element and the overall score. The mean scores span from 5.02 to 5.52, with an overall mean of 5.2882. These results highlight strong alignment among the respondents regarding the impact of lean thinking on sustainability performance. The highest mean score of 5.52, corresponding to "Improvement in the firm's environmental situation" and "Improved profits," signifies the significance attributed to environmental considerations and profitability. Conversely, the lowest mean score, found in "Reduced costs of production" and "Decreased energy costs," both at 5.02, still indicates agreement, albeit slightly less pronounced. The standard deviation values, ranging from 1.32278 (overall) to 1.839, depict moderate dispersion in the data. The relatively low overall standard deviation reinforces the uniformity in opinions across respondents regarding the various elements of sustainability performance. The skewness, predominantly negative across the variables with an overall value of -1.009, reveals that the distribution is inclined towards the higher scores. This pattern underscores broad consensus on the crucial role sustainability performance plays in the context of lean thinking. The kurtosis values fluctuate between -0.253 and 0.746 (overall), indicating varying degrees of tail-heaviness in the distribution. The overall positive kurtosis hints at a leptokurtic distribution, with more scores clustering around the mean. In conclusion, the data presented in Table 4.7 emphasizes the wide-ranging impacts of lean thinking on sustainability performance

4.4 Model and Hypotheses Testing

The model for the study is tested in this section using Ordinary least regression and Moderated hierarchical regression.

4.4.1 Multicollinearity Tests

Multicollinearity is a phenomenon where two or more predictor variables in a multiple regression model are highly correlated. In such cases, it becomes difficult to determine the individual impact of each predictor on the response variable. In the following section, we will examine the multicollinearity tests conducted for this study. These tests are essential in ensuring that the predictors in the model are independent of each other, allowing for more accurate interpretations of the results and robust statistical conclusions.

Table 4.8 Variance Inflation Results

Coefficients[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.843	.379		2.222	.029		
	TMC	.278	.118	.268	2.354	.021	.316	3.162
	LT	.551	.114	.550	4.833	.000	.316	3.162
a. Dependent Variable: Sustainability performance								

Source: Field study (2023) Notes: Lean Thinking (LT); Top Management Commitment (TMC)

The VIF values for both LT and TMC are 3.162. Generally, a VIF value greater than 5 is considered an indication of severe multicollinearity, which can make the results of the regression analysis unreliable. In this case, the VIF values are well below this threshold, indicating that multicollinearity is likely not a concern for this particular model. The tolerance statistics, which are reciprocals of the VIF, further support this conclusion as they are above the common threshold of 0.1. These results suggest that the variables LT and TMC are not

highly correlated with each other, and therefore, their individual effects on the dependent variable, Sustainability Performance, can be separately interpreted. The statistical significance of these predictors (as indicated by the t-values and associated p-values) confirms their importance in the model. Thus, the model seems robust and free from multicollinearity issues, allowing for confident inferences about the relationships between Lean Thinking, Top Management Commitment, and Sustainability Performance.

4.4.2 Regression Analysis

This section focuses on testing the study's hypotheses using linear regression, and moderated regression

Table 4.9 Regression Analysis Results

Independent variables	Dependent variable: Sustainability Performance		
	Unstandardized coefficients		
	Model 1	Model 2	Model 3
Constant	1.185	1.189	
***Main effect*:**			
Lean Thinking (LT)	0.773 (11.774)**		
Top Management Commitment (TMC)		.750 (10.149)**	
Interaction effect:			
LT × TMC			-.028 (-.7163)
R^2	.596	.523	.6208
ΔR^2	.592	.518	
(Δ) F statistics	138.623	103.009	50.1965
Degree of freedom	95	95	95

Source: Field study (2023) Notes: *p < .05, **p < .01; Lean Thinking (LT); Top Management Commitment (TMC); Sustainability Performance (SP)

The results of the regression analysis for the dependent variable Sustainability Performance are presented in Table 4.9, summarizing three different models that explore the main effects and interaction effect of the independent variables Lean Thinking (LT) and Top Management Commitment (TMC).

In Model 1, LT is shown to have a positive and statistically significant impact on Sustainability Performance, with an unstandardized coefficient of 0.773, and a highly significant t-value of 11.774 at the **p < .01 level. This model explains 59.6% of the variance in Sustainability Performance (R^2 = .596), and the change in R^2 (ΔR^2) of .592 is statistically significant, as indicated by the F statistics value of 138.623 with 95 degrees of freedom.

Model 2 isolates the effect of TMC on Sustainability Performance, yielding an unstandardized coefficient of .750 with a significant t-value of 10.149 at the **p < .01 level. This model explains 52.3% of the variance in Sustainability Performance (R^2 = .523), with a significant change in R^2 (ΔR^2) of .518 and an F statistics value of 103.009 with 95 degrees of freedom.

Finally, Model 3 introduces an interaction term between LT and TMC (LT × TMC), but the coefficient of -.028 and the associated t-value of -.7163 indicate that this interaction is not statistically significant. Despite this, Model 3 has an overall R^2 value of .6208, reflecting an explained variance that slightly surpasses the individual models.

4.4.3 Hypotheses Table

This section summarises the result from the regression analyses used to test the study's hypotheses.

Table 4.10 Hypotheses table

Hypothesis	Path Analysis	Expected effect	Results	Conclusion
H1	LT → SP	Positive	.773 ($p < 0.01$)	**Supported**
H2	TMC → SP	Positive	.750 ($p < 0.01$)	**Supported**
H3	LT × TMC → SP	Positive	-.028 ($p > .05$)	**Not Supported**

Source: Field study (2023) Notes: Lean Thinking (LT); Top Management Commitment (TMC); Sustainability Performance (SP)

4.5 Discussion of Results

Based on the study's hypotheses, the results of the regression analyses are discussed further

4.5.1 Lean Thinking and sustainability performance

The research supports the Hypothesis H1, showing that Lean Thinking positively influences sustainability performance, consistent with the Resource-Based View (RBV) framework (Barney, 2020). Lean Thinking's focus on reducing costs, enhancing revenues, and improving efficiency (Villarreal et al., 2017) makes it an essential competency for an organization's sustainability performance. By utilizing methodologies like value stream mapping, 5S framework, cellular manufacturing, and total productive maintenance, Lean Thinking assists in minimizing the environmental impact of manufacturing operations (Afonso and Cabrita, 2015). In alignment with Tortorella et al. (2019b) and Buer et al. (2018), the study also confirms that Lean Thinking leads to reduced waste, higher return on investment, and improvement in health and safety concerns.

4.5.2 Top Management Commitment and Sustainability Performance

The positive relationship between Top Management Commitment and Sustainability Performance, as evidenced in this study, supports Hypothesis H2. This aligns with the RBV theory, which recognizes top management commitment as an essential intangible asset for sustainability performance (Barney and Mackey, 2016). The findings underscore that top management's engagement is vital for long-term company growth (Latan et al., 2018). This commitment not only provides the necessary resources but also molds the organizational culture through leadership and dedication (Graves et al., 2019). The emphasis on sustainability by senior management, as highlighted by Daoud et al. (2021b), shapes the organizational agenda and enhances the company's sustainability strategies, corroborating the research's assertions.

4.5.3 Moderation effect of Top Management Commitment

The moderation effect of Top Management Commitment on the relationship between Lean Thinking and Sustainability Performance is established in this study, affirming Hypothesis H3. This emphasizes the RBV perspective that values resources that are firm-specific and challenging to replicate (Barney, 2020). This finding bridges the inconsistencies in prior studies on the impact of Lean Thinking on various performance outcomes (Abreu-Ledón et al., 2018; Razmak et al., 2021a; Thirkell and Ashman, 2014). The research identifies that the degree of top management's dedication to Lean Thinking plays a pivotal role in determining its positive influence on sustainability. This moderation effect harmonizes the different results of previous research by highlighting the varying degrees of top management commitment across different settings.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION, AND RECOMMENDATIONS

5.1 Introduction

Chapter Five synthesizes the vital components of this study, offering a comprehensive view of the research's conclusion. This chapter is structured into four main sections: Summary of Findings, Conclusion, Recommendations and Future Suggestions.

5.2 Summary of Findings

The subsequent sections, as listed below, explain the study's key findings.

5.2.1 Lean thinking and sustainability performance

The research supports Hypothesis H1, confirming that Lean Thinking (LT) has a positive and significant influence on Sustainability Performance (SP). The path analysis showed a positive effect with a coefficient of .773, significant at the 1% level. This indicates that practices that follow Lean Thinking principles are closely related to enhancing sustainability performance within organizations.

5.2.2 Top Management Commitment and sustainability performance

Hypothesis H2 is supported by the findings, which demonstrate that Top Management Commitment (TMC) has a positive and significant effect on Sustainability Performance (SP). The path analysis showed a positive effect with a coefficient of .750, significant at the 1% level. The results highlight the crucial role that top management plays in enhancing sustainability practices within a firm.

5.2.3 Moderation effect of Top Management Commitment

Hypothesis H3, which posited that Top Management Commitment (TMC) positively and significantly moderates the relationship between Lean Thinking (LT) and Sustainability Performance (SP), was not supported. The path analysis showed a negative coefficient of -.028, which was not statistically significant ($p > .05$). This suggests that the influence of Lean Thinking on Sustainability Performance does not depend on varying degrees of Top Management Commitment in the context of this study.

5.3 Conclusion

The evolution of 'lean thinking' to 'lean and green thinking' within manufacturing processes, and the inconsistencies in previous findings regarding its effect on sustainability performance, drove the motivation behind this study to investigate the moderating role of top management commitment in the relationship between lean thinking and sustainability performance. Adopting a quantitative approach and targeting manufacturing organizations within the Greater Accra region, the study's objectives were to assess the connection between lean thinking and sustainability performance, investigate the relationship between top management commitment and sustainability performance, and examine the moderating role of top management in this connection. Analyzing data from 100 manufacturing companies using IBM SPSS version 26, the findings provided strong evidence that both lean thinking and top management commitment positively impact sustainability performance, while the anticipated moderation effect of top management commitment did not materialize. This suggests that while both factors individually contribute to sustainability, their interaction may not have the anticipated effect. Overall, this study contributes valuable insights to the fields of lean management and sustainability, with implications for both theory and practice, offering guidance for industry practitioners and management in fostering lean principles with top management commitment,

promoting sustainability performance, and adding to the understanding of how lean thinking and top management commitment interact with sustainability performance. Its findings also have practical relevance for manufacturing organizations seeking to adopt sustainable business models and offer a theoretical contribution to the ongoing academic discourse in this area.

5.4 Recommendations

The researcher, based on the findings of the study, makes the following recommendations

5.4.1 Recommendations for managers

The study revealed that lean thinking, with its emphasis on eliminating waste and enhancing efficiency, positively impacts sustainability performance. It indicates that embracing lean principles can lead to improved material efficiency and reduced costs, contributing to the overall sustainability of an organization. Supply chain managers should integrate lean thinking into their operations. This can lead to the alignment of business practices with environmental sustainability principles, thereby fostering a culture of continuous improvement and waste reduction. By implementing lean thinking, organizations can optimize resource utilization, reduce waste, and enhance customer value. This not only contributes to environmental protection but also improves profitability and competitiveness in the market. The integration of lean thinking can be achieved through continuous training and education on lean principles, adopting tools like 5S and Kaizen, fostering collaboration across departments, setting clear targets for waste reduction, and regularly monitoring and asses

The research also found that the commitment from top management plays a significant role in improving sustainability performance. Top management's proactive engagement and support for sustainability initiatives have been found to be crucial for success. It is essential for supply chain managers to engage top management in sustainability initiatives actively. This means

involving them in setting sustainability goals, planning strategies, and providing necessary resources. Gaining top management commitment ensures that sustainability is embedded in the organization's strategic direction. It also provides the necessary support and resources to effectively implement sustainable practices, thereby enhancing the firm's reputation and long-term success. Top management commitment can be fostered by clearly communicating the business case for sustainability, setting shared sustainability goals aligned with organizational objectives, securing their active involvement in sustainability committees or task forces, and recognizing and rewarding their contribution to sustainability successes.

The study did not find a significant moderating effect of top management commitment on the relationship between lean thinking and sustainability performance. Both factors were found to contribute positively independently, but their interaction did not produce the anticipated synergistic effect. Supply chain managers should be cautious in assuming that the mere combination of lean thinking and top management commitment will automatically lead to enhanced sustainability performance. Instead, focus on effectively implementing each aspect separately to reap the most benefits. Recognizing that lean thinking and top management commitment operate independently in contributing to sustainability allows managers to allocate resources and focus efforts effectively. It ensures that both aspects receive the necessary attention without mistakenly relying on an unproven synergistic effect. his can be achieved by developing separate strategies and goals for implementing lean thinking and securing top management commitment. Regular evaluations of both areas will help in identifying opportunities for improvements and ensuring that both contribute optimally to sustainability performance.

5.4.2 Suggestions for Future Research

The study primarily focused on the relationship between lean thinking, top management commitment, and sustainability performance within a specific industry or context. This focus, while offering valuable insights, may limit the generalizability of the findings to other industries or various organizational sizes. Future research should aim to investigate the same relationships but in diverse industry settings and across different organizational sizes. This would help in understanding whether the observed findings are universal or context-specific, thus enriching the applicability of the study's conclusions. By extending the research into various industries and organizational types, researchers can provide a more comprehensive picture of how lean thinking and top management commitment interact with sustainability performance, providing actionable insights for a broader range of managers.

The study found that lean thinking and top management commitment did not interact as anticipated, contributing to sustainability performance independently rather than synergistically. This unexpected result might stem from the study's methodology or the variables examined, limiting a deeper understanding of why this interaction did not occur as hypothesized. Future research should aim to dissect this complex interaction further by exploring different moderating variables or employing varied methodologies. Qualitative research methods, such as in-depth interviews or case studies, might provide nuanced insights into why lean thinking and top management commitment do not interact as expected. By examining different facets of these constructs or introducing additional variables, such as organizational culture or leadership styles, future studies may unearth the underlying mechanisms influencing this relationship.

The study's findings are based on a specific timeframe and may rely on a limited set of metrics to evaluate sustainability performance. This approach may not capture the long-term effects and multi-dimensional aspects of sustainability, which can provide a more comprehensive understanding. Future studies should consider adopting longitudinal designs that track the implementation and effects of lean thinking and top management commitment over an extended period. Additionally, integrating a broader set of sustainability metrics, encompassing economic, environmental, and social dimensions, will provide a more holistic view of sustainability performance. Such an approach will not only provide deeper insights into the dynamics of the relationships studied but also contribute to the development of robust and multi-faceted sustainability strategies for organizations.

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APPENDIX A

SURVEY QUESTIONNAIRE

Dear respondent,

I am a student at Kwame Nkrumah University of Science and Technology's School of Business, Department of Supply Chain and Information Systems. I am working on a research project titled " Lean thinking and sustainability performance: The moderating role of top management commitment." Your answers are needed for the researcher to accomplish the study's objectives. Any information provided would be handled with the greatest discretion.

SECTION A: RESPONDENTS' DEMOGRAPHIC INFORMATION

Please respond to the following questions about yourself by checking the relevant boxes.

(1) How long has your company been in operation?

☐ 1-5 ☐ 6-10 ☐11-15 ☐ above 15 years

(2) Respondents' gender

☐ Male ☐ Female

(3) Respondents' age

☐ Below 20 years ☐ 20-29years ☐30-39 years ☐ 40-50years ☐ Above 50years

(4) Respondent's highest level of education

☐ HND ☐ 1st degree ☐ Masters ☐ PHD ☐ Professional ☐ Others

(5) Respondent's working experience with the firm

☐ 1-5 years ☐ 6-10 years ☐ 11-15 years ☐ above 15 years

SECTION B: LEAN THINKING

The following assertions are relevant to your company's lean practices. Indicate your agreement or disagreement with the following statement using a seven-Likert scale of 1=strongly disagree and 7=strongly agree.

1 Strongly disagree	2 Disagree	3 Somewhat disagree	4 Neutral	5 Somewhat agree	6 Agree	7 Strongly agree

	1	2	3	4	5	6	7
Pull System							
Our production is pulled by the shipment of finished goods							
Our production at work-stations is pulled by the current demand of the next work-station							
Kanban, squares, or containers of signals are used for production control							
Just-in-time							
Our company involves all our key suppliers in the NPD process							
Our key suppliers make JIT delivery to our plant.							
Our company has a formal supplier certification programme in place							
Supplier Development							
Our suppliers thrive to achieve an annual reduction in costs							
Our principal suppliers are located in the close vicinity of our plants							
Our company has a well-established system to communicate important issues with key suppliers							
Customer Involvement							
Our firm is in close contact with our customers							
Our firm collects quality and delivery performance feedback from customers							
Our customers share the present and future demand information with our firm							

Source: Kamble et al. (2020)

SECTION C: TOP MANAGEMENT COMMITMENT

The following assertions are relevant to your company's top management commitment. Indicate your agreement or disagreement with the following statement using a seven-Likert scale of 1=strongly disagree and 7=strongly agree.

1 Strongly disagree	2 Disagree	3 Somewhat disagree	4 Neutral	5 Somewhat agree	6 Agree	7 Strongly agree

Top Management Commitment	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. The Department head assumes responsibility for lean performance							
2. The Department head provides supportive leadership for lean improvement							
3. Department heads participate in the lean improvement processes							
4. Lean issues are reviewed in our department management meetings							
5. The top management has objectives for lean performance							
6. Top management appreciates individual staff contributions to improving lean thinking							
7. Top management works closely with employees to improve lean performance							

Source: Ahmed et al. (2019)

SECTION D: SUSTAINABILITY PERFORMANCE

The following assertions are relevant to your company's sustainability performance. Indicate your agreement or disagreement with the following statement using a seven-Likert scale of 1=strongly disagree and 7=strongly agree.

1 Strongly disagree	2 Disagree	3 Somewhat disagree	4 Neutral	5 Somewhat agree	6 Agree	7 Strongly agree

Economic Dimension	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Reduced costs of production							
Improved profits							
Reduced product development costs							
Decreased energy costs							
Reduces inventory costs							
Social Dimension	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Improved working conditions							
Improved workplace safety							
Improved employee health							
Improved labour relations							
Improved morale							
Environmental Dimension	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Reduction of solid waste							
Reduction of liquid waste							
Reduced gas emissions							
Reduced energy waste							
Improvement in the firm's environmental situation							

Source: Kamble et al. (2020)