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TOPIC:

Lean supply chain management and firm performance: The role of industry 4.0 technologies and top management commitment

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DECLARATION

I hereby declare that this submission is my own work toward the MSc. Logistics 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 dedicate this research to my beloved parents, Mr. and Mrs. Simon Kedey Hotor, whose unconditional love, support, and encouragement have been my source of strength throughout this journey. Everything I achieve is a reflection of your love.

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ABSTRACT

This study was motivated by inconsistent findings on the relationship between lean supply chain management and firm performance, and calls for examining the roles of industry 4.0 technologies and top management commitment. The main objective was to examine the impact of industry 4.0 technologies and top management commitment on the relationship between lean supply chain management and firm performance. The study was underpinned by the Resource-based view theory. A quantitative approach with a survey method was adopted, with data gathered from 387 employees of manufacturing firms in Ghana's Greater Accra region. Key findings revealed a positive relationship between lean supply chain management and firm performance. Industry 4.0 technologies positively mediated this relationship. Top management commitment positively moderated the relationship between industry 4.0 technologies and firm performance. Recommendations include managers adopting lean practices, implementing industry 4.0 technologies, and demonstrating commitment to optimize efficiency. The study contributes by providing new insights into the factors driving lean supply chain management success.

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LIST OF ABBREVIATIONS

LSCM: Lean Supply Chain Management

TMC: Top Management Commitment

I4.0: Industry 4.0 Technologies

FP: Firm Performance

SEM: Structural Equation Modeling

PLS: Partial Least Squares

CFA: Confirmatory Factor Analysis

AVE: Average Variance Extracted

ROI: Return on Investment

ROS: Return on Sales

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CHAPTER ONE

INTRODUCTION

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1.1 Background to the Study

Supply chain management (SCM) is the process of managing the flow of items from supplier to customer via manufacturing and distribution networks. SCM, according to Afonso and Cabrita (2015), must progress from ad hoc efforts to integrated and comprehensive plans. This is in reaction to market pressures for faster lead times, lower costs, and higher quality. To satisfy these objectives, Hartono et al. (2015) recognised the usage of lean manufacturing (L.M.) concepts inside supply chain integrative approaches. In general, lean manufacturing seeks to reduce waste, increase customer value, and improve operational performance (Garcia-Buendia et al., 2021). This has resulted in the development of the lean supply chain (LSC), which Garcia-Buendia et al. (2021) define as a set of enterprises that collaborate to decrease cost and waste while meeting the particular needs of clients.

Efficient management of a lean supply chain is expected to boost firm performance, as lean strategies focus on removing errors and inefficiencies and improving information flow (Afonso and Cabrita, 2015). This approach to lean allows firms to produce more with fewer resources, leading to savings in time, money, and improving quality. Firm performance, as noted by Tortorella and Fettermann (2018), reflects a company's ability to utilize its resources to achieve its objectives.

However, the success of lean supply chain management heavily relies on top management's commitment, which includes their active participation in the organization's lean practices (Tzempelikos, 2015a). The support and guidance from senior leadership, along with a cooperative and empathetic workplace culture, are vital (Caroline, Harriet, and Anne, 2016). If senior management is not committed, adopting lean management practices within an organization becomes challenging (Amir and Chaudhry, 2019).

Moreover, the implementation of Industry 4.0 technologies (IR4) strengthens lean supply chain management. In line with the philosophy of minimizing waste and maximizing productivity (Raji and Rossi, 2019), Industry 4.0 innovations are a natural fit with lean supply chain management. They assist in saving time, money, energy, and resources when deployed collectively (Zhang et al., 2020).

However, research on lean supply chain management has presented conflicting findings. While some studies have shown a direct effect of lean supply chain management on performance outcomes (Jasti and Kodali, 2015; Tortorella et al., 2018; Moyano-Fuentes et al., 2019; Khorasani et al., 2020), others have argued that lean supply chain management alone cannot drive these outcomes, and other factors play a role (Kader Ali et al., 2016; Abushaikha et al., 2018). The intent of this study is to enrich the existing literature on lean supply chain management. It will develop a distinctive research model, grounded in Resource-based view theory, to explore how top management commitment and Industry 4.0 technologies interact with lean supply chain management to influence firm performance.

1.2 Motivation

Kamble et al. (2020a) in their research acknowledge the direct effects of Industry 4.0 technologies (I4 T) on lean manufacturing practices (LMP) and sustainable performance (SOP), and how LMP positively impacts SOP. Despite these findings, the integrated influence of I4 T and LMP on SOP has not been thoroughly explored empirically. Kamble et al. (2020a) endeavored to fill this void by probing into the indirect effects of I4 T on SOP, using LMP as the mediating variable, and sought to either confirm or deny the direct effects of I4 T on LMP and SOP.

However, there are still gaps in the scholarly literature. There is an increasing demand for research that examines the impact of certain variables on lean supply chain management, such as top management commitment, Industry 4.0, and knowledge generation. Scholars such as Tezel, Koskela, and Aziz (2018), as well as Tortorella, Giglio, and van Dun (2019), have emphasised the importance of this necessity.

With this context in mind, the current study is poised to expand on the research model of Kamble et al. (2020a). It seeks to enhance understanding of lean by focusing on how Industry 4.0 technology and top management commitment interact in the relationship between lean supply chain management and company performance. As a result, the study will provide new insights and a more nuanced knowledge of the variables that drive the success and efficiency of lean methods in today's business context.

1.3 Statement of the Problem

Lean supply chain management has evolved into the notion of "lean and green thinking," which enables firms to create sustainable business models that decrease waste, boost material efficiency, and lower prices (Ciccullo et al., 2018). This type of management, according to Garcia-Buendia, Moyano-Fuentes, and Maqueira-Marn (2021), leads to satisfied customer expectations, improved profitability, lower inventory levels, just-in-time solutions, and a competitive edge.

Yet, research on lean supply chain management has yielded inconsistent findings. While studies such as those conducted by Jasti and Kodali (2015), Tortorella et al. (2018), and Moyano-Fuentes et al. (2019) have shown a positive link between lean supply chain management and various performance outcomes like sustainability, inventory, quality, and supply chain performance, others like Jasti and Kurra (2017) and Tortorella et al. (2017) have failed to demonstrate any connection. In another dimension, researchers like Fullerton et al. (2014a), Melton (2005), Razmak et al. (2021a), and Thirkell and Ashman (2014a) have identified indirect impacts of lean supply chain management on performance outcomes.

These disparities might have arisen from studies considering a diverse range of performance outcomes and failing to recognize various influencing variables in the relationship between lean supply chain management and performance. Recognizing the complexity, authors like Kader Ali et al. (2016) and Abushaikha et al. (2018) have emphasized that factors such as Industry 4.0 technologies, operational performance, knowledge creation, and organizational culture are vital to enhancing lean supply chain management's effectiveness.

However, despite extensive research, gaps remain. Some scholars, including Tezel, Koskela, and Aziz (2018), and Tortorella, Giglio, and van Dun (2019), have specifically called for exploration into the role of top management commitment and Industry 4.0 technologies in lean supply chain management.

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In response, this study aims to fill these gaps by constructing a novel research model underpinned by the Resource-based view theory. This model will look at how top management commitment and Industry 4.0 technologies interact in the relationship between lean supply chain management and company performance. Through this approach, the research seeks to offer fresh insights that could reconcile the inconsistent findings in existing literature and pave the way for a more comprehensive understanding of lean supply chain management in today's rapidly changing business environment.

1.4 Research objectives

The primary goal of the research is to investigate the impact of top management commitment and industry 4.0 technologies on the relationship between lean supply chain management and firm performance.. Specifically, the research seeks to achieve the following objectives.

1. To examine the relationship between lean supply chain management and firm performance.
2. To examine the role of industry 4.0 technologies on the relationship between lean supply chain management and firm performance
3. To examine the role of top management in the relationship between industry 4.0 technologies and firm performance

1.5 Significance of the Study

The study concerning lean supply chain management carries significant implications both in theoretical and practical realms.

The burgeoning interest in the subject of lean supply chain management is manifested in the numerous calls for research papers from well-regarded journals like Procedia Engineering, Procedia Manufacturing, CIRP Journal of Manufacturing Science and Technology, Production Planning & Control: The Management of Operations, International Journal of Productivity and Performance Management, and International Journal of Supply Chain Management. This study, in particular, contributes to the theoretical landscape by being one of the first empirical investigations to explore the relationship between lean supply chain management, top management commitment, industry 4.0 technologies, and firm performance. By examining these connections, the study adds depth and nuance to the existing body of literature on lean supply chain management.

The findings of the study also resonate profoundly with industry practitioners and managers who are engaged in the implementation of lean principles. The study's results underscore the necessity for top management to ardently commit to lean principles across all echelons of the supply chain. This endorsement not only reinforces the concept but also helps in establishing a culture of continuous improvement and efficiency within the organization. Moreover, the study's outcomes serve as a guiding beacon for managers to carefully evaluate and apply the various dimensions of lean supply chain management. This includes a focus on lean supply, procurement, manufacturing, warehousing, and transport concepts.

1.6 Research Methodology

In pursuit of the Study's objectives, the researcher adopts a survey and a quantitative approach. The target population for the Study is manufacturing organisations within the Greater Accra region. Using the convenient sampling technique, four hundred (400) sample is drawn from the target population. Data is collected using online questionnaires designed using google forms. To derive meaning from the data gathered, the researcher conducts descriptive and inferential analyses using IBM SPSS version 26. The study complies with all ethical considerations by ensuring that the survey questionnaire protects respondents' identities. Alpha Cronbach and exploratory factor analysis will be used to test the data gathered for reliability and validity.

1.7 The organisation of the Study

The study is organised into five major chapters. The first Chapter is the introduction. The introduction presents the background to the study, statement of the problem, research objectives, significance of the study, an overview of the research methodology, and organisation of the Study. The literature review is the second Chapter. This contains the conceptual review, theoretical framework, empirical review and conceptual framework development. Research methodology is the third Chapter and contains the research design, study population, sampling technique, data collection method, data analysis, reliability and validity analysis and ethical considerations. Data analysis is the fourth Chapter. It contains both descriptive and differential analyses and a discussion of findings. The last Chapter, Chapter five, is the conclusion and recommendation. It contains the summary of findings, recommendations, conclusions and suggestions for future studies.

CHAPTER TWO

LITERATURE REVIEW

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2.1 Introduction

Chapter Two of this work offers a comprehensive exploration into the arena of lean supply chain management and its impact on firm performance. This critical examination centers on the role that Industry 4.0 technologies and top management commitment play in shaping the supply chain process, thereby influencing a firm's operational efficiency and overall productivity.

The first section, the conceptual review, delves into the essential principles and definitions underpinning lean supply chain management. It offers an examination of the core concepts, theories, and methodologies that form the basis of lean practices in the supply chain, explicating how they have been implemented and developed over time.

Following the conceptual review, the theoretical review provides a detailed scrutiny of the existing literature related to lean supply chain management, Industry 4.0 technologies, and top management commitment. This section amalgamates various theories that interlink these elements, thus presenting a cohesive understanding of the interconnectedness of these factors in determining firm performance.

The empirical review section is dedicated to the analysis of previous empirical studies conducted in the field. It includes a critical assessment of different research methodologies, findings, and interpretations that have contributed to the understanding of how lean supply chain management

practices, coupled with Industry 4.0 technologies and top management commitment, affect firm performance.

Finally, the conceptual framework section synthesizes the insights gathered from the conceptual, theoretical, and empirical reviews to construct a holistic framework. This framework outlines the underlying relationships between lean supply chain management, Industry 4.0 technologies, top management commitment, and firm performance. It serves as the foundation for the empirical analysis to be undertaken in the subsequent chapters of this work, offering a robust platform for investigation and reflection on these critical aspects of modern business operations.

2.2 Conceptual Review

The concepts of lean supply chain management, firm performance, industry 4.0 technology and top management commitment are reviewed in this section.

2.2.1 Lean Supply Chain Management

Lean supply chain management (LSCM) represents a concerted effort in the manufacturing and supply processes to minimize waste, efficiently manage resources, streamline operations, and produce according to demand. This approach centers on the fundamental idea of waste reduction, where waste, known as "Muda" in Japanese, is identified as any activity consuming resources without adding value (Ghobakhloo and Fathi, 2020). Examples of waste include overproduction, excess processing, inventory surpluses, rework, needless motion, and underutilization of skills and resources.

The concept of "lean" encapsulates techniques aimed at waste elimination, rework reduction, cutting non-value-added operations, and enhancing those that add value (Razmak et al., 2021b). As Zhang and Chen (2016) articulate, lean represents the coordinated effort by all members of an organization to systematically eradicate waste across all components of the value stream. This definition emphasizes a collective approach where every part of the organization contributes to efficiency and waste reduction.

However, other perspectives on LSCM exist. Fullerton et al. (2014), for example, define Lean supply chain management as a philosophy aimed at shrinking the time between customer order and delivery through the eradication of waste sources in production. In this view, time efficiency and responsiveness to customer demand are central to the lean approach.

According to Thirkell and Ashman (2014), LSCM is "a network of firms connected by upstream and downstream flows of goods, services, information, and money that cooperate to decrease cost and waste by effectively extracting what is required to suit the demands of individual customers." This concept emphasises the networked aspect of LSCM by stressing cooperation across the supply chain.

The benefits of implementing Lean supply chain management are many. These benefits include higher manufacturing efficiency, significant cost savings, increased flexibility, and better competitiveness (Ghobakhloo and Fathi, 2020). Aside from these advantages, LSCM promotes the free movement of commodities, information, and technology across supply chain participants, resulting in more transparent and coordinated operations (Durakovic et al., 2018).

2.2.1.1 Supplier feedback

Supplier feedback is the exchange of information between a buyer and a supplier concerning a given procurement operation (Ahmed et al., 2021). According to Zhu et al. (2018), this feedback should be a two-way street, with the buyer routinely seeking the supplier's input as part of bids or evaluations. This enables the provider to provide insights and recommendations on tender procedures, corporate documentation, and possible future changes (Hartono et al., 2015).

2.2.1.2 Just-in-time

JIT is a method of inventory management in which products are received from suppliers only when they are needed (Ciccullo et al., 2018). This strategy tries to reduce inventory holding costs while increasing inventory turnover. A JIT inventory system, according to Garcia-Buendia et al. (2021), is a management strategy that matches the receipt of items as near as possible to the time when they are really required.

2.2.1.3 Customer Involvement

Customer engagement refers to the many levels of personal interest that each prospective customer may have, and it entails studying and identifying the factors that drive consumer decision-making (Khorasani et al., 2020). It is also defined as a subjective psychological state that reflects a consumer's personal relevance and importance of a product or service (Vaidya et al., 2018). Customer participation enables information to be digested clearly, influencing attitudes and choices. This kind of interaction aims to improve the consumer's perception and promote favourable sentiments (Schumacher et al., 2016).

2.2.2 Top Management Commitment

Top management commitment refers to top executives' active engagement in an organization's digital transformation and operational strategy, including lean management principles (Sarkis et al., 2019). This commitment acts as a strong guiding force, giving the essential direction and resources to help the firm achieve its corporate goals.

Top management commitment is often seen as the major driver for organisational development and success, and is regarded as critical to attaining management's objectives (Ahmed et al., 2021b). Leaders shape the organization's policy, strategic planning, vision, values, objectives, and processes. This fundamental leadership lays the groundwork for an organisational culture centred on customer happiness and good performance (Tzempelikos, 2015b). Furthermore, the leadership's commitment to ongoing development acts as a model for other workers (Wijethilake and Lama, 2019).

In the context of lean management, top executives help cultivate organizational awareness and bolster employees' commitment to achieving superior lean objectives (Latan et al., 2018). To reach these goals, top management must articulate the lean objectives clearly and recognize lean as a vital organizational aspect. Graves et al. (2019) suggest that top managers need to emphasize quality standards, allocate adequate resources for ongoing lean improvements, and assess employees based on performance.

However, a lack of commitment from top management in delegating authority and empowering employees has led to failures in many organizations seeking to enhance their cost performance (Dubey et al., 2017). Successful implementation of a lean management system necessitates a

committed leadership that empowers employees for lean performance. By entrusting employees with greater responsibility for their work, continuous improvement can be fostered to attain lean organizational goals (Commer et al., 2019).

In essence, top management commitment is not merely a concept but an actionable strategy that has profound impacts on various facets of an organization, from lean practices to digital transformation and overall growth. Its influence permeates the organizational culture, strategies, and performance, underlining its pivotal role in shaping success.

2.2.3 Industry 4.0 technologies

Industry 4.0, also referred to as the "fourth industrial revolution," characterizes the modern era of industrial activity, marked by the integration of diverse technologies, including various digital innovations, materials, and processes (Dalenogare and Benitez, 2018). It has substantial impacts on the manufacturing, production, and distribution of products and services, influencing both productivity and performance (Dalenogare, 2019).

The phrase "Industry 4.0" was coined in 2011 at the Hannover Messe as part of a German government drive to boost the competitiveness of the country's industrial sector (Vaidya et al., 2018). Since then, the notion has gained popularity, becoming a focal point of the 2016 World Economic Forum (Tortorella and Fettermann, 2018). Despite great attention, there is still a lack of agreement on a specific and unambiguous meaning of the word, resulting in a lack of globally recognised definitions (Chiarini and Kumar, 2021; Schumacher et al., 2016).

According to Szász et al. (2021), Industry 4.0 is "the sum of all disruptive innovations produced and implemented in a value chain to match the trends of digitization, autonomy, transparency,

mobility, modularization, network-collaboration, and socialising of products and processes." It represents "a new degree of organisation and control over the whole lifespan of goods inside the value chain, as well as a collective name for value chain organisation technologies and ideas" (Zhang et al., 2020).

The multifaceted technologies of Industry 4.0 interconnect machines, equipment, devices, products, and logistical instruments, enabling real-time communication between them. This interconnected system generates and utilizes information automatically, adding value to the production process (Jamwal et al., 2021). In essence, Industry 4.0 embodies a transformative wave in industrial operations, driving innovation, efficiency, and a new paradigm of interconnected, intelligent manufacturing and distribution systems.

2.2.4 Firm Performance

Firms often have codified or incorporated goals and objectives into their strategic and long-term plans, which they seek to achieve over a certain period. There is no consensus on the definition and assessment of company performance (Maroufkhani *et al.*, 2019). Generally, firm performance relates to how successfully a company achieves its goals and objectives. According to Nugroho (2021), corporate performance compares a firm's output to its stated goals and objectives. As a result, it compares an organisation's actual performance to its projected performance. Firm performance is a critical notion included as a dependent variable in various studies. When assessing a business's performance, it is essential to establish a range of credible metrics that provide a more realistic basis for comparing its profile and growth over time (Tajvidi and Karami, 2021). Consequently, many scholars (Rossi, 2016; Tajvidi and Karami, 2021)argue for the

inclusion of financial and market performance indicators as critical factors for determining a company's success.

Among the most often used firm performance metrics are return on investment (ROI), return on assets (ROA), return on equity (ROE), and profitability. On the other side, market performance indicates how well a company's product offering performs in the market (Taouab and Issor, 2019). Customer loyalty, customer happiness, sales growth, and market share are all performance metrics in the market. In accordance with the existing body of knowledge, this research evaluated company performance on a multidimensional level, taking financial and market performance indicators into account (Selvam *et al.*, 2016)

2.3 Theoretical Review

The study draws on the Resource-based view theory to examine the roles of industry 4.0 technologies and top management commitment in the relationship between lean supply chain management and firm performance.

According to the resource-based view theory, company growth and development depend on the business's available resources. According to the notion, for a corporation to have a competitive edge in the market, it must have sufficient resources to establish the ability to participate in market activities (Barney and Mackey, 2016). According to Chahal et al. (2020), resources are the most important driver of company performance and capacity. The RBV determined that enterprises with a competitive advantage had appropriate resources within their sector (Hossain *et al.*, 2022)

However, corporate resources must be distinct so enterprises can effectively use them to accomplish growth and development (Almada and Borges, 2018). According to the RBV

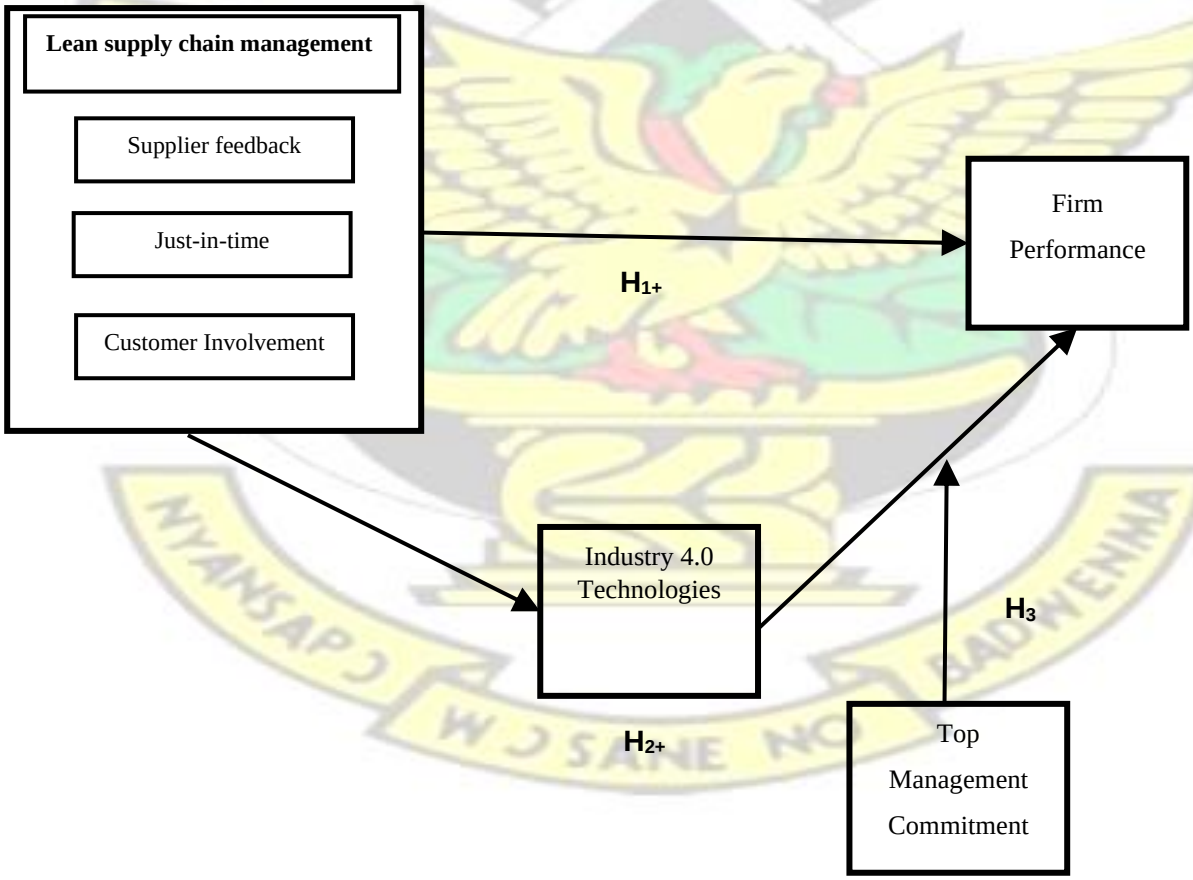
hypothesis, a company's available resources determine its superiority, comparativeness, and advantage in the market. The theory establishes a firm's ability and capability to use corporate resources to accomplish desired goals. According to the notion, firm resources are varied, and a company's strength is its resource competitiveness (Collins, 2021). Managers must guarantee that resources within the industry are appropriately used to fulfil specified goals and objectives before a business may dominate in the market. The RBV theory demonstrates the importance of company resources in the business area, as well as how businesses' internal resources may be used to improve operational performance (Miller *et al.*, 2015)

According to the Resource-Based View (RBV) theory, firm resources play a pivotal role in determining success and capabilities, and the utilization of these resources is vital for a firm to gain a competitive advantage in the market environment. Within this theoretical framework, the adoption and application of lean principles across supply chains are seen as key factors that may bolster a firm's corporate performance. By aligning lean practices with the firm's resources, RBV posits that organizations can optimize efficiency, minimize waste, and enhance value, thereby positioning themselves more favorably within the competitive landscape.

2.4 Conceptual Framework

This section illustrates the direct and indirect relationships between lean supply chain management, industry 4.0 technologies, top management commitment and firm performance. H1 posits a direct and positive relationship between lean supply chain management and firm performance. The study further posits industry 4.0 technologies positively mediate the relationship between lean supply chain management and firm performance. H3 posits that top management commitment positively moderates the relationship between industry 4.0 technologies and firm performance. Figure 2.1 illustrates the direct and indirect relationships between the variables.

Figure 2.1 Research Model



Source: Researcher's Construct (2022)

2.4.1 Lean supply chain management and firm performance

Lean supply chain management entails removing non-value-added tasks from a production process to save energy and eliminate waste. Lean supply chain management ensures that product quality and performance are constantly improved (Salvadorinho and Teixeira, 2021). Again, employee involvement and training in quality planning provide employees with the necessary information and abilities to remove waste in the product's manufacturing process. This decreases a product's negative environmental impact by utilising fewer resources and consuming less energy (Tortorella *et al.*, 2018). Lean supply chain management ensures quality compliance, product superiority, and competitive business advantage. Lean supply chain management may cause enterprises to source high-quality raw materials for production, resulting in higher-quality products (Khorasani *et al.*, 2020). Furthermore, lean thinking improves a company's competitiveness and boosts customer satisfaction by fulfilling their various needs effectively and efficiently (Hartono *et al.*, 2015). In terms of Reduced Inventory, reduced faults and failures in operational processes, and improved ability to detect and remove bottlenecks, Lean supply chain management is anticipated to significantly reduce supply chain cost and operational cost(Zhu *et al.*, 2018). Jasti and Kurra (2017) discovered that lean supply chain management favours certain operational and business performance metrics. Lean management methods aim to enhance a company's value by reducing waste and improving customer happiness and profitability (Tortorella *et al.*, 2017). Lean, via JIT, increases performance by lowering inventory levels and operating expenses while increasing customer response (Chiarini and Kumar, 2021). Along these lines, the researcher proposes the following hypothesis:

H1. Lean supply chain management has a significant and positive effect on firm performance.

2.4.2 The mediating role of industry 4.0 technologies

Although Industry 4.0 technologies are highly beneficial for companies, their true potential can be unlocked by integrating them with Lean Production. This integration aids in enhancing Standard Operating Procedures, allowing businesses to streamline their processes (Dalenogare and Benitez, 2018). When Industry 4.0 and Lean Production tools are combined, it accelerates the growth of lean systems within manufacturing companies and mitigates the perceived risk associated with the high costs of implementing Industry 4.0 tools (Dalenogare, 2019). The fusion of Industry 4.0 tools with Lean Production leads to a strategy known as Lean Automation (LA), aiming for increased variability and expedited information flows to address future market demands (Vaidya et al., 2018). This integration provides many advantages, including cost reduction in areas where integration might otherwise be challenging. Lean Supply Chain Management (LSCM) presents enormous opportunities for the incorporation of innovative automation technologies in manufacturing. It is argued that Industry 4.0 technologies (I4 T) assist manufacturing organizations in overcoming obstacles in lean implementation (Raji and Rossi, 2019). The real-time data facilitated by I4 T proves invaluable in creating precise value stream maps, which are considered the foundational step in the lean manufacturing implementation process (Schumacher et al., 2016). Along these lines, the researcher proposes the following hypothesis:

H2. Industry 4.0 positively meditates the relationship between lean supply chain management and firm performance

2.4.3 The moderating role of top management commitment

The Resource-Based View (RBV) highlights an organization's internal environment as a source of competitive advantage, emphasizing the unique, firm-specific resources developed to compete (Barney, 2020). Under RBV, merely having diverse and immovable traits is not enough to sustain a competitive advantage; a resource must be valuable, rare, and challenging to imitate (Enginoğlu et al., 2016). In the context of this study, the influence of Industry 4.0 technology on the relationship between lean supply chain management and firm performance is seen to depend on varying levels of top management commitment. While several studies have found a positive and direct correlation between lean practices and various performance outcomes (e.g., Ahakchi et al., 2012; Fullerton et al., 2014; Lewis, 2000; Razmak et al., 2021; Zhang and Chen, 2016), others argue that lean supply chain management alone is insufficient to drive performance improvements (e.g., Bevilacqua et al., 2017; Kamble et al., 2020; Tortorella et al., 2019). These studies contend that other factors, either moderating or mediating, enable the links between lean practices and performance outcomes. Hence, the precise relationship between lean practices and sustainability remains ambiguous. This study posits that top management's commitment to Industry 4.0 technologies will amplify the positive mediating effect of Industry 4.0 on the connection between lean supply chain management and firm performance. By aligning the principles of RBV with lean supply chain management, top management's commitment, and Industry 4.0 technologies, the study aims to unravel the complex interplay between these factors and contribute to a nuanced understanding of how they collectively influence firm performance

H_3: Top management commitment positively and significantly moderates the relationship between industry 4.0 technologies and firm performance

2.5 Empirical Review

This section empirically reviews previous studies conducted on lean supply chain management.

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2.5.1 Lean supply chain management and firm performance

Various research studies have been conducted on lean supply chain management (LSCM) in the past, reflecting diverse approaches and findings.

Nimeh et al. (2018) examined the effect of LSCM techniques on Jordanian manufacturing firms' supply chain and market performance. Their research identified five key LSCM practices: the just-in-time system, information flow, supplier connection, customer relationship, and waste reduction. Through a survey of 400 managers across different sectors and sizes of manufacturing firms, the study found that three LSCM practices, specifically the just-in-time system, information flow, and customer connection, positively and significantly impacted market performance. Additionally, all LSCM practices were found to have a positive and substantial effect on supply chain performance, which, in turn, positively affected market performance.

Jasti and Kodali (2015) contributed to the emerging field of LSCM by investigating existing LSCM frameworks and proposing a new one. Their study analyzed 30 LSCM frameworks through an extensive literature review, categorizing them based on originality, researcher contribution, verification state and method, and the degree of standardization of LSCM components. They found that many academics had proposed new frameworks, but there was a noticeable lack of participation from practitioners and, to a lesser extent, consultants in LSCM framework development. The study also identified inconsistencies in the components used across different LSCM frameworks.

In another study, Tortorella et al. (2017) explored the relationship between LSCM and supply chain performance in 89 Brazilian companies. Their findings highlighted the importance of identifying and empirically validating bundles of LSCM practices across various business sectors and supply chains. They also emphasized that the supply chain environment plays a role in LSCM implementation, but not all elements affect it to the same degree.

Together, these studies reflect the multifaceted nature of LSCM and the continued exploration of its practices, frameworks, and impact on various performance measures. They provide insights into the field and contribute to the broader understanding of how LSCM can be implemented and optimized across different organizational and geographical contexts.

2.5.2 The Moderating role of top management commitment

Amir and Chaudhry (2019) conducted a study to examine the connection between environmental strategy and firm performance, specifically focusing on the sequential mediation role of environmental management accounting and top management commitment. Utilizing survey data, they collected 308 questionnaires to test their hypotheses. The analytical methodology involved the application of structural equation modeling and sequential mediation, employing tools such as SPSS and AMOS. Hayes' Model 6, featured in PROCESS with bootstrap methods, was utilized to examine sequential mediation. The findings from their research revealed a positive and direct relationship within the study model. Importantly, the sequential mediating effect of environmental strategy on firm performance, through the channels of environmental management accounting and top management commitment, was found to be positive and significant.

2.5.3 The mediating effect of industry 4.0 technologies

In a study focusing on the Brazilian manufacturing sector, Razmak et al. (2021b) assessed the moderating influence of Industry 4.0 on the relationship between three Lean practices (pull, flow, low set up) and improvements in operational performance such as productivity, delivery service level, inventory, quality, and safety. Their findings concluded that process-related Industry 4.0 technologies negatively moderate the effects of low set up practices on performance, while product/service-related technologies positively moderate the effect of flow practices on performance. The study underscored that a mere technological implementation would not lead to sustained improvement and results, and Lean practices could act as a precursor to Industry 4.0 implementation.

In another research effort, Kamble et al. (2020) examined the direct effects of Industry 4.0 technologies (I4 T) on lean manufacturing practices (LMP) and sustainable organizational performance (SOP). While the direct influence of I4 T on LMP and SOP is recognized in the current literature, the integrated effect of both on SOP had not been empirically examined. Kamble et al. performed a research utilising data gathered from 205 managers in 115 manufacturing enterprises to address this gap. Their data indicate that I4 T has large direct and indirect impacts on SOP, with LMP functioning as a prominent mediating variable. The paper identifies I4 T as a facilitator of LMP, resulting in improved SOP, and offers implications for future research and practise.

Tortorella et al. (2019) also investigated the influence of Industry 4.0 technologies in regulating the link between lean production (LP) and operational performance improvement in Brazil's growing economy. Using performance measures such as safety, delivery, quality, productivity, and

inventory, they surveyed representatives from 147 manufacturing businesses and examined three internally connected lean practise bundles and two Industry 4.0 technology bundles. Based on contingency theory, the research discovered that Industry 4.0 moderates the influence of LP methods on operational performance improvement in several ways. Process-related technologies, in particular, were shown to negatively moderate the influence of low setup procedures on performance, while product/service-related technologies were discovered to favourably mediate the effect of flow practises on performance.

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CHAPTER THREE

METHODOLOGY

3.1 Introduction

Chapter Three of this scholarly work delineates the methodology adopted to investigate the nexus between lean supply chain management and firm performance, with a particular focus on the role of Industry 4.0 technologies and top management commitment. This chapter is vital as it sets the research parameters, ensuring that the study is conducted with scientific rigor and integrity.

The initial section on research design elucidates the overall blueprint of the research, laying out the structure, strategy, and methods employed. It elucidates the choice between qualitative, quantitative, or mixed-method research and the rationale behind such selection, thus outlining the pathway that guides the investigation.

Following this, the population of the study section provides an insight into the target group or entities from which the data are to be collected. It offers a detailed description of the criteria for inclusion and exclusion, ensuring that the selected population accurately represents the subject of inquiry.

The section on sample and sampling technique then delves into the precise methods used to select a subset of the population for actual study. It encompasses an exploration of the sampling methods used, whether random, stratified, or systematic, and elaborates on how these choices enhance the study's generalizability and relevance.

In the data collection methods section, the various tools and techniques used to gather information are thoroughly discussed. It highlights the instruments such as surveys, interviews, observations, or experiments, detailing how each contributes to the accuracy and comprehensiveness of the data collected.

Subsequently, the data analyses section delineates the statistical or thematic techniques employed to interpret and make sense of the collected data. It offers an understanding of the methods used to process the information, ensuring that the analyses are aligned with the research questions and hypotheses.

The validity and reliability section ensures that the research's quality and trustworthiness are maintained throughout the study. It discusses the measures undertaken to ensure that the results are not only accurate and consistent but also applicable and reflective of the reality being investigated.

Lastly, the ethical considerations section addresses the moral principles guiding the research. It emphasizes the commitment to integrity, confidentiality, informed consent, and respect for participants, ensuring that the research complies with the highest standards of academic ethics.

3.2 Research Design

This research design offers a framework for collecting and interpreting data while accounting for various components of the research process. It takes into account the requirement to define causal linkages between variables, generalise to larger populations, comprehend behaviour in particular circumstances, and recognise the timing of social events and their relationships. Examples of methods that might be used include experimental, cross-sectional survey, and longitudinal approaches, such as case studies and comparative research (Babbie, 1982). In this particular study, a survey method is employed, concentrating on manufacturing firms in the Greater Accra area, with an explanatory approach to investigate the connections between the variables.

A research approach is a complete method for doing social science research. The two major methods are quantitative research and qualitative research. The quantitative method emphasises data collection and quantification while linking theory to research findings in an organised fashion. The emphasis here is on putting hypotheses to the test. A qualitative approach is a method that emphasises words over numbers when collecting and analysing data, and it emphasises a connection between theory and research via an inductive approach with a focus on theory building. For this study, the researcher used a quantitative method.

3.3 Population of The Study

The study population is the group (typically individuals) from whom the researcher intends to conclude (Polit and Hungler, 1999). The study's target population is manufacturing firms in the Greater Accra Region.

3.4 Sample and Sampling Technique

According to Babbie (2013), researchers cannot look at everyone in the population who piques their interest and, therefore, cannot make every conceivable observation about them. A population sample would have to be obtained. A sample is a subset of a larger population chosen for research reasons. Methods of selection may be probabilistic or non-probabilistic. Probability sampling covers certain random selection methods and is based on probability theory. An equal probability of selection method (EPSEM), a probability proportional to size (PPS), and simple random sampling (SRS) are all examples of probability sampling (SRS). Non-probability sampling is a sampling method in which the researcher chooses samples based on their subjective opinion rather than random selection. Examples include using easily available subjects and purposive (judgmental), quota, and snowball sampling.

The researcher uses convenient sampling to choose a sample of four hundred (400) employees from the target population. Convenience sampling is a type of sampling that involves the sample being drawn from that part of the population that is close to hand. The researcher considered cost, time, and sampling size adequacy while deciding on the study's sample size.

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3.5 Data Collection Methods

This section covers data sources, and the instrument(s) used to gather data.

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3.5.1 Data sources

This study utilised primary data to achieve its research objectives. While one researcher gathers primary data to address a certain issue, another researcher collects secondary data for an entirely unrelated purpose. Primary data collection included the use of online questionnaires

3.5.2 Measures

This section delves into the primary data collection tool used in this study. Four variables are included in the study's research model: predictor, moderator, mediator and predicted variables. The items used to operationalise these variables are summarised in Table 3.1 below

Table 3.1 Summary of Measurement Items

Variables	No. of Items	Sources
LEAN SUPPLY CHAIN MANAGEMENT		
• **Supplier Feedback**	**3**	**Kamble et al. (2020)**
• **Just in Time**	**3**	**Kamble et al. (2020)**
• **Customer Involvement**	**3**	**Kamble et al. (2020)**
TOP MANAGEMENT COMMITMENT	**6**	**Daoud et al. (2021)**
INDUSTRY 4.0 TECHNOLOGIES	**6**	**Kamble et al. (2020)**
FIRM PERFORMANCE	**6**	**Selvam et al. (2016)**

Source: Author's Construct (2022)

3.5.3 Data Collection procedure

The study's instrument was transformed into an online version, created using Google forms, to collect the necessary data from the four hundred (400) respondents in Accra's Manufacturing sector. The respondents ' permission is obtained before sending the online questionnaires through their chosen social media sites.

3.6 Data Analysis

Because the research method is quantitative, data analysis involves testing the study's hypotheses. The study's hypotheses were tested using ordinary least regression, moderated and mediated hierarchy regression. Descriptive analyses included the use of mean, kurtosis, skewness, and standard deviation to characterize the variables in the research. All of these analyses are carried out using IBM SPSS version 26.

3.7 Reliability and Validity

Data is considered reliable if it produces the same outcome every time applied to the same item. The two kinds of dependability are internal reliability and inter-observer consistency. The degree to which an empirical measure properly represents the real meaning of the concept under investigation is validity. Establishing validity includes face validity, concurrent validity, predictive validity, concept validity, and convergent validity (Babbie, 2013). SPSS was used to conduct exploratory factor analysis (validity) and Cronbach Alpha (reliability) analysis to verify that this research satisfies validity and reliability criteria.

3.8 Ethical Consideration

Ethics is described as adhering to a profession's or group's standards of conduct. The researcher did the following to guarantee that all ethical standards for social research are met: Participation was entirely voluntary (respondents were not forced to take part in the study); there was no risk to the participants (the research did not expose them to any risks); Anonymity (the research questionnaire did not ask for respondents' names or identities) and confidentiality (the study questionnaire did not ask for respondents' names or identities) Trustworthiness (all data collected were used only for academic purposes).

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CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS

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4.1 Introduction

To answer the research questions and reach the conclusion of this study, data was mostly collected from the field. The data analysis and research results are presented in this chapter. The presentation is broken down into six sections. The first part discusses the respondents' demographics. The second section discusses the constructs' reliability and validity, the third section discusses the descriptive statistics of the research constructs, and the fourth section discusses partial least square (PLS) structural equation modeling. The fifth portion gives the confirmation and rejection of hypotheses and the sixth section discusses the results from the study.

A questionnaire was created and given to employees of Greater Accra-based manufacturing firms. Four hundred (400) questionnaires were sent, and three hundred and eighty-seven (387) were returned, for a response rate of 97 percent. The 387 replies were entered into SPSS and then imported into SMART PLS for analysis. The results of the analyses are reported in the following sections.

4.2 Demographics of the Respondents

The demographics of the respondents are included in this section to present information on the subject individuals and the firms that participated in the research. The key data taken from the respondent individuals are gender, age, highest qualification, work experience, managerial level and position at the firm.

Table 4.1 Demographics of Respondents

Variable	Items	Frequency	Percent (%)
Gender	Male	260	67.2
	Female	127	32.8
Age of respondents	29 years and below	100	25.8
	30 to 39 years	234	60.5
	40 to 49 years	47	12.1
	Above 50 years	6	1.6
Educational Level	Secondary school or related Certificate	16	4.1
	Diploma/HND	99	25.6
	1st Degree	213	55
	2nd Degree or more	59	15.2
Working experience	0 – 5 years	109	28.2
	6 – 10 years	153	39.5
	11 – 15 years	61	15.8
	Above 15 years	64	16.5
Managerial level	Supervisor	220	56.8
	Line manager	121	31.3
	Senior manager	46	11.9
Position	Supply chain manager	71	18.3
	Logistics managers	81	20.9
	Operations manager	80	20.7
	Others	155	40.1

Source: Field Study (2022)

4.2.1 Gender

Out of the 387 valid responses, 260 individuals representing 67.2 percent were male whiles 127 individuals representing 32.8 percent were female. This information shows that more males

participated in the study than females but the proportionate difference is not substantial so there is no justification for a self-selection bias in the responses.

4.2.2 Age Respondents

Out of the 387 respondents, 100 individuals representing 25.8% were aged 29 years and below; 234 individuals representing 60.5 percent were also within 30 – 39 years old; 47 individuals representing 12.1 percent were within 40 – 49 years old and the remaining 6 individuals representing 1.6 percent aged above 50 years. This distribution shows a fair representation from various age groups, so the responses are considered widely distributed across the age categories. Furthermore, majority of the respondents aged above 29 years, indicating that majority of the respondents were matured to respond rightly to the research instrument. The essence of presenting this data is to justify that minors were not included in the study for ethical concerns and over-aged persons who may not be able to provide reasonable answers were not included in the study.

4.2.3 Education Level

Out of the 387 respondents, 16 individuals representing 4.1 percent have secondary education as their highest qualification; 99 respondents representing 25.6 percent have diploma or an HND; 231 respondents representing 55 percent have 1st degree and 59 individuals representing 15.2 percent have 2nd degree or more. This distribution shows that majority of the respondents have the requisite academic qualification to respond rightfully to the study instrument.

4.2.4 Working Experience

Out of the 387 respondents, 109 individuals representing 28.2 percent have between 0 to 5 work experience; 153 individuals representing 39.5 percent have 6 to 10 years work experience; 61 individuals representing 15.8 percent have 11 to 15 work experience; and the remaining 64 individuals representing 16.5 percent above 15 work experience. This shows that majority of the respondents selected for this study have the requisite experience to provide valid responses to the questionnaire.

4.2.5 Managerial Level

Out of the 387 respondents, 220 individuals representing 56.8 percent are supervisors; 121 individuals representing 31.3 percent are line managers and the remaining 46 individual representing 11.9 percent are senior managers.

4.2.6 Position with firm

Out of the 387 respondents, 71 individuals representing 18.3 percent are supply chain managers; 81 individuals representing 20.9 percent are logistics managers; 80 individuals representing 20.7 percent are operations managers and the remaining 155 individual representing 40.1.9 percent are other managers.

4.3 Reliability and Validity Test

The study conducts a reliability analysis to assess the consistency of the variables, and a validity analysis to gauge how accurately the variables measure the constructs. To evaluate reliability, the Cronbach alpha value and composite reliability are used, which indicate the consistency of the metrics in assessing the variables. Acceptable values for both measures are 0.7 (Hair et al., 2013). To appraise the validity of the gathered data, confirmatory factor analysis is initially employed to ascertain the factor loadings of each item to its underlying variable. An item is considered valid if it loads above 0.50. Additionally, the study measures convergent validity through the average variance extracted value (AVE), with values expected to exceed the acceptable threshold of 0.5 (Hair et al., 2013). Discriminant validity is assessed using the Fornell-Larcker criteria, requiring that the correlation of each item with itself should be greater than its correlation with any other variable.

Table 4.2 Cronbach Alpha, Composite Reliability, and Average Variance Extracted

Construct	Number of items	Cronbach Alpha (CA)	Composite Reliability (CR)	AVE
Lean supply chain	9	0.95	0.96	0.75
Top Management	7	0.96	0.96	0.79
Industry 4.0	6	0.94	0.95	0.77
Firm Performance	6	0.95	0.96	0.80
Total	**28**			

Source: Field Study (2022)

Table 4.2 above gives the score of the variables for CA, CR, and AVE. Lean supply chain management, the predictor variable had 0.95 and 0.96 as Cronbach Alpha and Composite

Reliability values respectively. Top management commitment, the moderating variable had 0.96 and 0.96 as Cronbach Alpha and Composite Reliability values respectively. Industry 4.0 technologies, the mediating variable had 0.94 and 0.95 as Cronbach Alpha and Composite Reliability values respectively. Firm performance, the outcome variable had 0.95 and 0.96 as Cronbach Alpha and Composite Reliability values respectively. All four variables had loaded above the 0.70 threshold and therefore exhibited strong internal consistency. The data gathered for the study is therefore reliable.

For the Average Variance Extracted (AVE), Lean supply chain management had 0.75, Top Management commitment 0.79, Industry 4.0 technology 0.77 and Firm Performance 0.80. All four variables scored above the 0.50 threshold, implying that all the items develop to measure these variables together measure their intended latent variables. Convergent validity is therefore valid.

Table 4. 3 Fornell – Larcker Criterion

Construct	LSCM	TMC	I4T	FP
Lean supply chain management (LSCM)	**0.87**			
Top Management commitment (TMC)	0.80	**0.89**		
Industry 4.0 technologies (I4T)	0.80	0.82	**0.88**	
Firm Performance (FP)	0.81	0.85	0.82	**0.90**

Source: Field Study (2022)

In terms of discriminant validity, the study employed the Fornell Larcker Criteria. While convergent validity evaluates how precisely the latent variables measure the primary variable, discriminant validity ensures that the latent factors don't measure other variables in comparison to

their own latent variables. According to the Fornell Larcker criteria, the square root of each variable's AVE must have a stronger correlation with itself than with other latent variables.

For instance, Lean supply chain management correlated with itself at 0.87, higher than its correlations with top management commitment, industry 4.0 technology, and firm performance, which were 0.80, 0.80, and 0.81, respectively. Similar patterns were found for top management commitment, industry 4.0 technology, and firm performance, each demonstrating higher self-correlations than with other variables, confirming the validity of each variable.

Figure 4.1 in the study illustrates the confirmatory factor analysis (CFA), a statistical method used to validate the factor structure of observed variables. CFA allows the researcher to examine the hypothesis that relationships exist between observed variables and their underlying latent constructs. For validity, each item is expected to load above 0.50 on each latent variable it is designed to measure.

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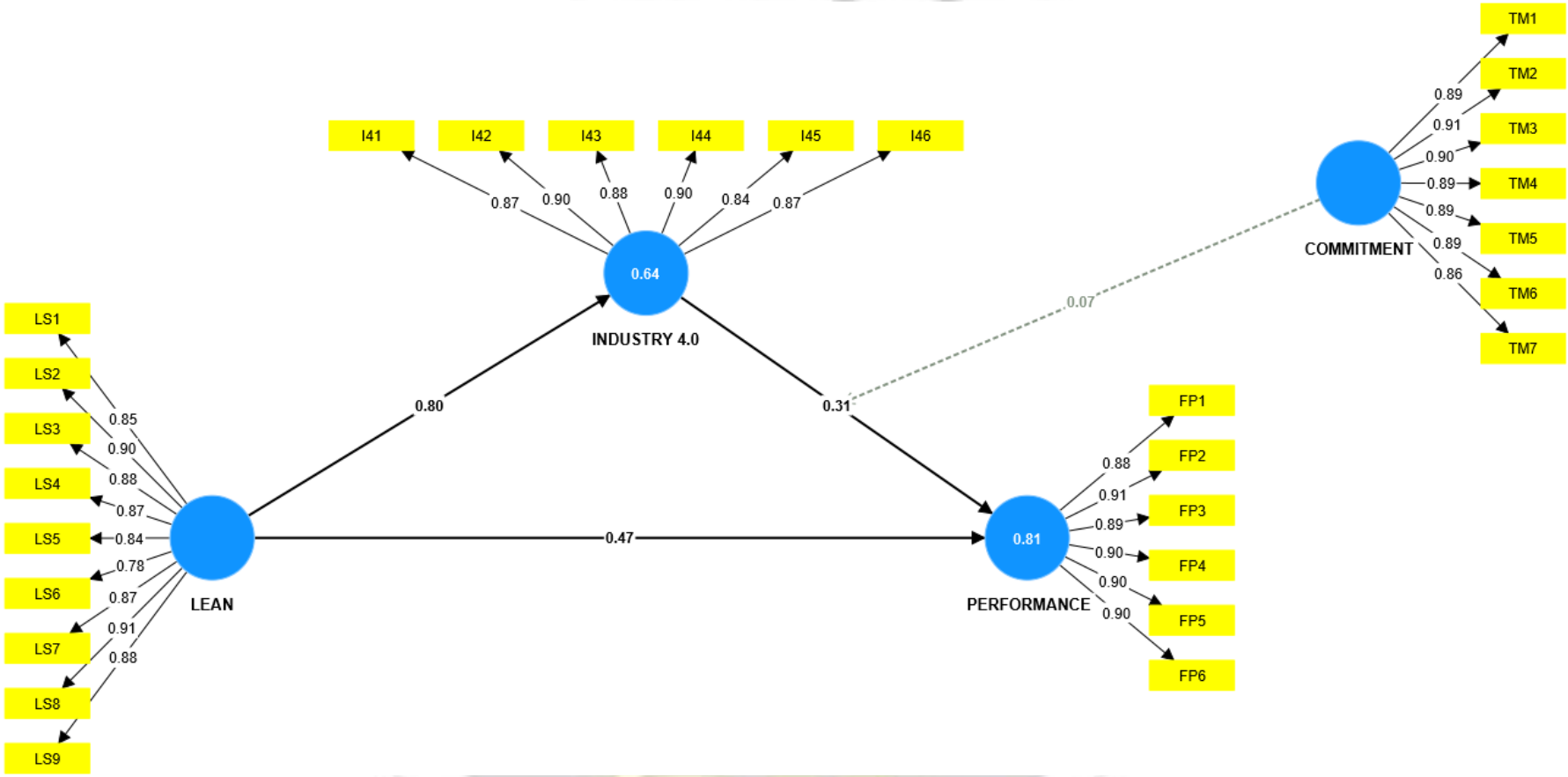
Figure 4. 1 Confirmatory Factor Analysis



Source: Field Study (2022)

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4.4 Descriptive Statistics

The descriptive statistics is presented to present the score of the individual variables used to measure the three main constructs of the study. The Likert scale of 1 – 7 measured the extent of the agreement so the score is matched against the Likert scale to explain the extent to which the indicators of the variables occur in the logistics service providing industry. The scale was rated as 1 = Strongly disagree; 2 = Disagree; 3 = Somewhat disagree; 4 =Neutral, 5 = Somewhat agree, 6 = Agree, and 7 = Strongly agree. The criteria for analysis of the descriptive results are 1.00 – 2.99 = very minimal/less occurrence of the phenomenon, 3.00 – 4.99 = minimal/less occurrence of the phenomenon 5 – 5.99 = a fair occurrence of the phenomenon, and 6.00 – 7.00 = frequent occurrence of the phenomenon. The subsequent sections describe each construct in detail:

4.4.1 Lean Supply Chain Management

The predictor variable for the study lean supply chain management was conceptualized by Zhang and Chen (2016) as the systematic elimination of waste by all members of an organisation in all parts of the value stream. Nine items adopted from Kamble et al. (2020) were used to operationalize lean supply chain management. Table 4.4 below presents the descriptive statistics on lean supply chain management.

Table 4.4 Descriptive Statistics on Lean Supply Chain Management

Latent variables	Mean	Min	Max	Std. Dev
Our company is always in close contact with our key suppliers	4.56	1	7	2
Our company provides quality and delivery performance feedback to all our key suppliers.	4.67	1	7	1.74
Our company puts maximum efforts into developing a long-term relationship with our key suppliers	4.93	1	7	1.73

Our company involves all our key suppliers in the new product development (NPD) process	4.72	1	7	1.73
Our company has a formal supplier certification programme in place	4.72	1	7	1.71
Our company has a formal supplier certification programme in place	4.75	1	7	1.74
Our firm is in close contact with our customers	4.8	1	7	1.87
Our firm collects quality and delivery performance feedback from customers	4.79	1	7	1.77
Our firm involves direct involvement of customers in existing product improvement and NPD process	4.76	1	7	1.78
Overall	**4.74**	**1**	**7**	**1.54**

Source: Field Study (2022)

The descriptive statistics for lean supply chain management are presented in Table 4.4. According to the table, there is a high implementation of lean supply chain management amongst manufacturing firms operating within the regional capital. This is confirmed by an overall mean of 4.74 and standard deviation of 1.54 on a 7-point Likert scale.

4.4.2 Top Management Commitment

The moderator variable for the study, top management commitment was conceptualized in this study as the involvement of top-level executives in the organisation's digital transformation operations (Sarkis *et al.*, 2019). Seven items adopted from Daoud et al. (2021) were used to operationalize top management commitment. Table 4.5 below presents the descriptive statistics on Top Management Commitment.

Table 4.5 Descriptive Statistics on Top Management Commitment

Latent variables	Mean	Min	Max	Std. Dev
The Department head provides supportive leadership for lean improvement	4.57	1	7	2
Department heads participate in the lean improvement processes	4.68	1	7	1.72
Lean issues are reviewed in our department management meetings	4.84	1	7	1.68
The top management has objectives for lean performance	4.8	1	7	1.62

Top management appreciates individual staff contributions to improving lean thinking	4.86	1	7	1.65
Top management works closely with employees to improve lean performance	4.86	1	7	1.65
The Department head assumes responsibility for lean performance	4.88	1	7	1.7
Overall	**4.79**	**1**	**7**	**1.53**

Source: Field Study (2022)

The descriptive statistic for top management is presented in Table 4.5. According to the table, there is higher top management commitment and involvement within the firms of manufacturing companies operating within the regional capital. This is confirmed by an overall mean of 4.79 and standard deviation of 1.53 on a 7-point Likert scale.

4.4.3 Industry 4.0 Technologies

The mediating variable for the study, Industry 4.0 Technologies was conceptualized in this study as the convergence of various technologies, from multiple digital technologies to innovative materials and processes (Dalenogare and Benitez, 2018). Six items adopted from Kamble et al. (2021) were used to operationalize Industry 4.0 Technologies. Table 4.6 below presents the descriptive statistics on Industry 4.0 Technologies.

Table 4.6 Descriptive Statistics on Industry 4.0 Technologies

Latent variables	Mean	Min	Max	Std. Dev
Our firm is in the process of implementing or implemented cloud computing	4.51	1	7	1.93
Our firm is in the process of implementing or implemented big data analytics	4.56	1	7	1.73
Our firm is in the process of implementing or implemented Internet of Things	4.78	1	7	1.73
Our firm is in the process of implementing or implemented additive manufacturing	4.66	1	7	1.7
Our firm is in the process of implementing or implemented robotic systems	4.52	1	7	1.83
Our firm is in the process of implementing or implemented augmented reality	4.56	1	7	1.76

Overall	**4.6**	**1**	**7**	**1.56**

Source: Field Study (2022)

The descriptive statistics for industry 4.0 technologies are presented in Table 4.6. According to the table, there is a high adoption of Industry 4.0 Technologies amongst manufacturing firms operating within the regional capital. This is confirmed by an overall mean of 4.6 and standard deviation of 1.56 on a 7-point Likert scale.

4.4.4 Firm Performance

The mediating variable for the study, Firm Performance was conceptualized in this study as the how successfully a company achieves its goals and objectives (Nugroho, 2021). Six items adopted from Selvam et al. (2016) were used to operationalize Firm Performance. Table 4.7 below presents the descriptive statistics on Firm Performance.

Table 4.7 Descriptive Statistics on Firm Performance

Latent variables	Mean	Min	Max	Std. Dev
Our profitability has grown over the past three years.	4.56	1	7	1.89
Our diluted profits per share have increased over the last three years.	4.64	1	7	1.71
These last three years have seen a significant return on investment (ROI) increase.	4.68	1	7	1.67
Our sales growth rate has accelerated during the past three years.	4.63	1	7	1.68
Growth in return on sales (ROS) has accelerated during the past three years.	4.65	1	7	1.67
Market share has increased during the last three years.	4.71	1	7	1.76
Overall	**4.65**	**1**	**7**	**1.55**

Source: Field Study (2022)

Descriptive statistics for firm performance are presented in Table 4.7. According to the table, there is a strong corporate performance of manufacturing firms operating within the regional capital. This is confirmed by an overall mean of 4.65 and standard deviation of 1.55 on a 7-point Likert scale.

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4.5 Structural Equation Modelling

The PLS Structural Equation model was run to test the path coefficients (i.e. direct effects), the indirect effect (mediation) and moderation relationship between the variables. A bootstrap of 5000 was run to calculate the path coefficients of the research model.

Table 4.8 Structural Equation Model (SEM) Result

Path	Coefficients	T-value	P-value
	Direct Effects		
LSCM → FP	0.47	4.63	0.00
LSCM → I4.0	0.80	26.05	0.00
I4.0 → FP	0.31	4.90	0.00
	Indirect Effects		
LSCM → I4.0 → FP	0.25	4.53	0.00
	Moderation Effect		
I4.0 × TMC → FP	0.07	2.74	0.01

Source: Field Study (2022) Notes: LSCM (Lean Supply Chain Management); I4.0 (Industry 4.0 Technology); TMC (Top Management Commitment); FP (Firm Performance)

Table 4.8 presents the results of the structural equation model to test the direct, indirect and moderation relationships between the variables.

According to the table, lean supply chain management has a positive and significant effect on firm performance, given the path coefficient results $\beta = .047$, $t = 4.63$, $p < .01$. This indicates for every unit of lean supply chain management, firm performance increases by 0.47 units. With a t-value of

4.63 being above the 1.96 threshold, there is further support for the above relationship. A $p < 0.01$ also lends significant support for H1, which stated that lean supply chain management has a significant and positive effect on firm performance.

The table also shows a positive mediation effect of Industry 4.0 technology on the relationship between lean supply chain management and firm performance, given the path coefficient results $\beta = .025$, $t = 4.53$, $p < .01$. This implies that when lean supply chain management increases by 1-unit, firm performance increases by 0.025 due to the indirect (mediated) influence of industry 4.0 technology. The output also indicates a T-value of 4.35, which is by far greater than the 1.96 threshold. The effect of lean supply chain management through industry 4.0 technology on firm performance is significantly different from zero at the 0.01 level ($p < .01$). There is strong support for H2, which states that Industry 4.0 technology mediates the relationship between lean supply chain management and firm performance.

Lastly, the study sought to examine the moderating role of top management commitment on the relationship between Industry 4.0 technologies and firm performance. The SEM output shows a positive moderation effect of top management commitment on the relationship between Industry 4.0 technologies and firm performance, given the path coefficient results $\beta = .07$, $t = 2.74$, $p < .05$. This indicates that for every unit of interaction between Industry 4.0 technology and top management commitment, there is an increase of .07 in firm performance. T-value of 2.74 is higher than the 1.96 threshold, whiles a $p < 0.5$ lends significant support to H3 which stated that top management commitment moderates the relationship between industry 4.0 technologies and firm performance.

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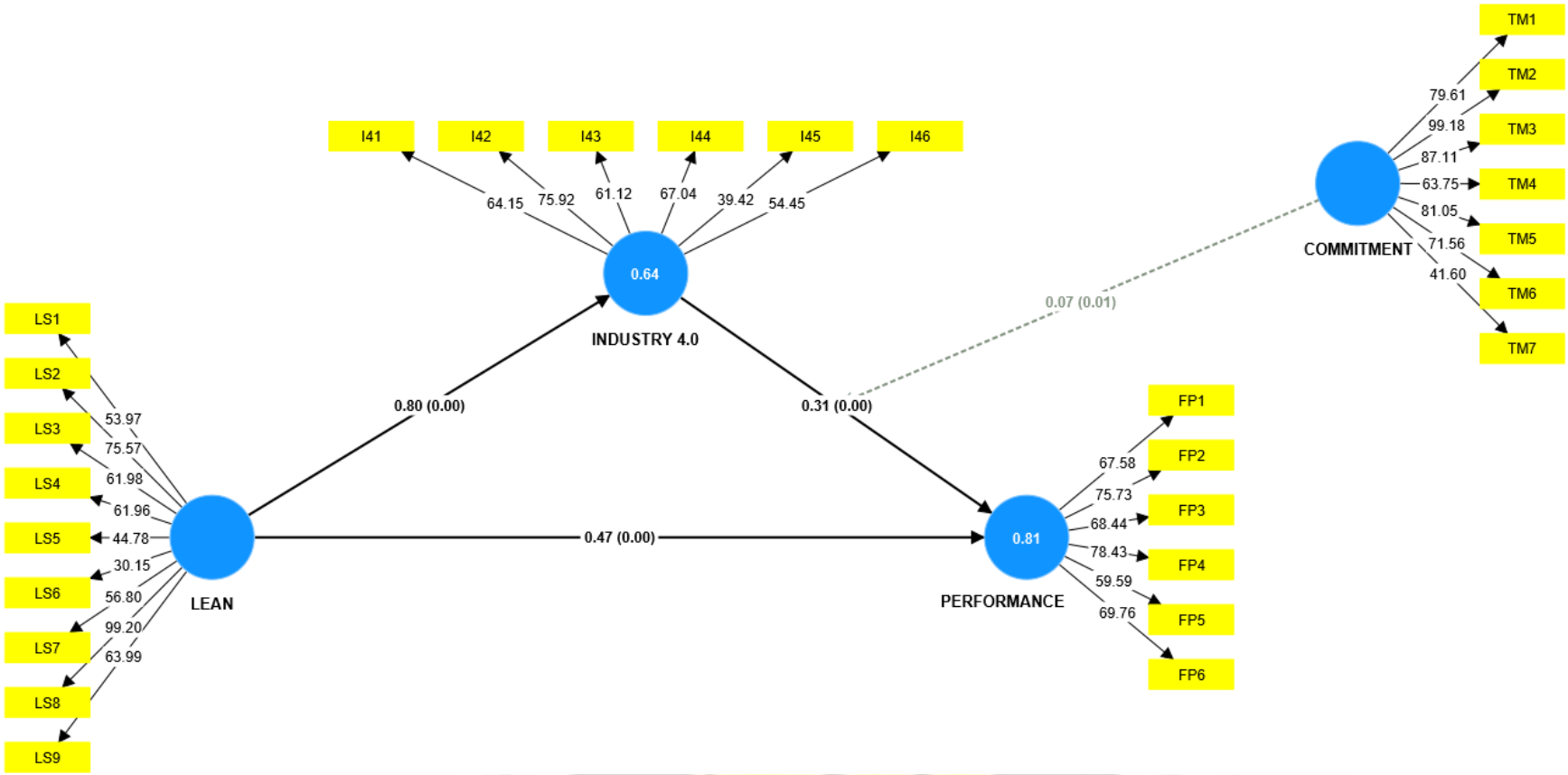
Figure 4.2 Structural Equation Model



Source: Field Study (2022)

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4.6 Hypotheses Confirmation

From the prior literature reviewed, three hypotheses were developed for this study. The data gathered are analysed to confirm or refute each of these hypotheses. All the hypotheses were supported. The summary of the hypotheses confirmation are presented in table 4.9 below

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Table 4.9 Hypothesis Confirmation

Hypothesis	Path	T-value	Coefficient (P-value)	Decision
H_1	LSCM → FP	4.63	.0.47; $p < 0.01$	**Supported**
H_2	LSCM → I4.0 → FP	4.53	.25; $p < 0.01$	**Supported**
H_3	I4.0 × TMC → FP	2.74	.07; $p < .05$	**Supported**

Source: Field Study (2022) Notes: LSCM (Lean Supply Chain Management); I4.0 (Industry 4.0 Technology); TMC (Top Management Commitment); FP (Firm Performance)

4.7 Discussion of Results

The findings made in this study is discussed in the context of the literature reviewed and also the theories adopted for this study. The detail discussion of the findings is presented below based on the objectives set for the study.

4.7.1 Lean Supply Chain Management and Firm Performance

Lean supply chain management entails removing non-value-added tasks from a production process to save energy and eliminate waste. Lean supply chain management ensures that product quality and performance are constantly improved (Salvadorinho and Teixeira, 2021). Again, employee involvement and training in quality planning provide employees with the necessary information and abilities to remove waste in the product's manufacturing process. This decreases a product's negative environmental impact by utilising fewer resources and

consuming less energy (Tortorella *et al.*, 2018). Lean supply chain management ensures quality compliance, product superiority, and competitive business advantage. Lean supply chain management may cause enterprises to source high-quality raw materials for production, resulting in higher-quality products (Khorasani *et al.*, 2020). Furthermore, lean thinking improves a company's competitiveness and boosts customer satisfaction by fulfilling their various needs effectively and efficiently (Hartono *et al.*, 2015). In terms of Reduced Inventory, reduced faults and failures in operational processes, and improved ability to detect and remove bottlenecks, Lean supply chain management is anticipated to significantly reduce supply chain cost and operational cost(Zhu *et al.*, 2018). Jasti and Kurra (2017) discovered that lean supply chain management favours certain operational and business performance metrics. Lean management methods aim to enhance a company's value by reducing waste and improving customer happiness and profitability (Tortorella *et al.*, 2017). Lean, via JIT, increases performance by lowering inventory levels and operating expenses while increasing customer response (Chiarini and Kumar, 2021). The result from this study is consistent with the above reviewed literature given the path coefficient results $\beta = .047$, $t = 4.63$, $p < .01$.

4.7.2 The Mediating effect of Industry 4.0 Technologies

While Industry 4.0 tools are highly beneficial for companies, their integration with Lean Production can further enhance their value. According to Dalenogare and Benitez (2018), such integration can significantly improve Standard Operating Procedures within companies. Moreover, merging Industry 4.0 and Lean Production tools not only speeds up the growth of lean systems in manufacturing firms but also mitigates the perceived risks arising from the substantial implementation expenses of Industry 4.0 tools (Dalenogare, 2019). This cohesive integration between Industry 4.0 tools and Lean Production, often referred to as Lean Automation (LA), allows for greater adaptability and streamlined information flows to respond

to future market needs (Vaidya et al., 2018). In the realm of manufacturing, Lean Supply Chain Management (LSCM) provides substantial opportunities to introduce innovative automation technologies. Many believe that Industry 4.0 technologies (I4 T) assist manufacturing organizations in overcoming the challenges associated with implementing lean processes (Raji and Rossi, 2019). Furthermore, the real-time information facilitated by I4 T proves invaluable in creating precise value stream maps, a critical initial step in the lean manufacturing implementation process (Schumacher et al., 2016). The findings of this study align with the aforementioned literature, demonstrated by the path coefficient result $\beta = .025$, $t = 4.53$, $p < .01$, further substantiating the advantageous link between Industry 4.0 and Lean Production practices.

4.7.3 The Moderating effect of Top Management Commitment

The RBV emphasises an organisation's internal environment as a source of competitive advantage and the resources that certain organisations have developed to compete in the environment (Barney, 2020). According to the RBV, organisations must develop unique, firm-specific core competencies to outperform competitors by organising things differently. According to the RBV, diverse and immovable traits do not provide a sustainable competitive advantage; the resource must be valued, rare, and difficult to imitate ((Enginoğlu et al., 2016). According to this study, the influence of industry 4.0 technology on the relationship between lean supply chain management and firm performance is reliant on varying degrees of top management commitment. Although several studies have discovered a positive and direct relationship between lean practices and various performance outcomes (e.g., Ahakchi et al., 2012; Fullerton et al., 2014; Lewis, 2000; Razmak et al., 2021; Zhang and Chen, 2016), others (e.g., Bevilacqua et al., 2017; Kamble et al., 2020; Tortorella et al., 2019) contend that lean supply chain management, although could drive improvement in performance outcomes, are

inadequate to do so, but are rather enabled by factors that either moderate or mediate the links. Therefore, the exact relationship between lean practices and sustainability is unclear. This study argues that the extent top management is committed to industry 4.0 technologies will intensify the positive mediating effect of industry 4.0 on the relationship between lean supply chain management and firm performance. The result for this study is also consistent with the above reviewed literature given the

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CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

The main objective of this study was to examine the role of industry 4.0 technologies and top management commitment on the relationship between lean supply chain management and firm performance. Based on data obtained from 387 employees of manufacturing firms operating within the Greater Accra Region, the study provides the summary of findings, logical conclusion, recommendations for managers and suggestions for future studies

5.2 Summary of Findings

This section provides a summary of the results from the descriptive statistics, as well as the results from the structural equation model.

5.2.1 Lean Supply Chain Management

The descriptive statistics on lean supply chain management sought to identity the extent of lean application by the responding firms. The study showed that lean thinking principles applications were high amongst manufacturing firms operating within the Regional capital.

5.2.2 Top Management Commitment

The descriptive statistics on Top Management Commitment sought to identity the extent of commitment from senior managers. The descriptive results indicated a higher level of commitment from senior managers of firms operating within the Regional capital.

5.2.3 Industry 4.0 Technologies

The descriptive statistics on Industry 4.0 Technologies sought to examine the extent of Industry 4.0 Technologies implementation across supply chains of manufacturing firms operating within the Greater Accra region. The study revealed a higher adoption of Industry 4.0 technologies by the manufacturing firms operating within the Greater Accra region.

5.2.4 Firm Performance

The study also revealed a strong corporate performance of manufacturing firms operating within the regional capital in terms of profitability, return on investment, sales growth, return on sales and market share.

5.2.5 Lean Supply Chain Management and Firm Performance

The study revealed a Strong, positive and significant relationship between lean supply chain management and firm performance. Key lean supply chain management dimensions such as supplier feedback, just-in-time and customer involvement enhances corporate performances such as profitability, return on investment, sales growth, return on sales and market share.

5.2.6 Mediation effect of Industry 4.0 Technologies

The study also revealed an indirect effect of lean supply chain management on firm performance via Industry 4.0 Technologies. Key lean supply chain management dimensions such as supplier feedback, just-in-time and customer involvement could be bolstered through the use of industry 4.0 technologies such as big data analytics, system integration and additive manufacturing.

5.2.7 Moderation effect of Top Management Commitment

Lastly, the study revealed a positive moderation effect of top management commitment on the relationship between industry 4.0 technologies and firm performance.

5.3 Conclusion

The main objective of this study was to examine the roles of industry 4.0 technology and top management commitment on the relationship between lean supply chain management and firm performance. The study draws on the Resource based view theory as the theoretical foundation. The study used an explanatory research design and adopted a quantitative research approach. SmartPLS was used to analyse the study's assumptions and test for hypotheses. Based on data obtained from 387 employees of manufacturing firms operating within the Greater Accra region, the study concludes that the adoption and implementation of lean practices such as just-in-time, customer involvement and supplier feedback impact positively on a firm's corporate performance such as profitability, return on investment, sales growth, return on sales and market share. Furthermore, industry 4.0 technologies such as big data analytics, additive manufacturing, systems integration and artificial intelligence bolster a firm's lean supply chain management, increasing its impact on their corporate performance.

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5.4 Recommendations

This section provides recommendations to managers based on the findings from the study and also makes future suggestions based on the identified limitations

5.4.1 Recommendations for Managers

First, the study revealed a positive relationship between lean supply chain management and firm performance. Based on this, the study recommends supply chain managers take actions to enhance and promote lean principles throughout their supply chain through (1) the elimination of all waste in the supply chain; (2) Considering advancements in technology to improve the supply chain; (3) Making customer usage visible to all members of the supply chain; (4) Reducing lead time; (5) Using Pull Systems, Like Kanban; and (6) Creating a level flow. These would improve a firm's lean supply and further enhance their corporate performance.

The study also revealed a partial mediation effect of industry 4.0 technologies on the relationship between lean supply chain management and firm performance. The study, based on this finding recommends that, managers seeking to increase their corporate performances through the application of lean practices, also consider the implementation of industry 4.0 technologies. Through industry 4.0 technologies, these manufacturing firms could automate every aspect of their supply chain operation, thereby eliminating waste of time, motion and overprocessing.

5.4.2 Suggestions for Future Research

The first limitation relates to how generalizable the research findings are. All of the information was gathered from Ghanaian manufacturing companies in the Greater Accra area. Future research should consider broadening the geographical and contextual scope to include other industries such as the service, construction and retail industry. To enables generalization from the study to be extrapolated onto the wider populace. The model of this study examine the mediating role of industry 4.0 technology on the relationship between lean supply chain management and firm performance and how top management commitment moderates the relationship between industry 4.0 technologies and firm performance. To advance literature and address gaps, future studies are also encouraged to develop a model that expanses this study model by introducing relevant control variables such as firm size, firm industry and firm age.

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APPENDIX A

SURVEY QUESTIONNAIRE

I am a postgraduate student at Kumasi's Kwame Nkrumah University of Science and Technology's Supply Chain and Information Systems Department. This survey instrument was designed to aid me in studying the following topic: **Lean supply chain management and firm performance: The role of industry 4.0 technologies and top management commitment**. Any information you provide will be used exclusively for academic purposes and kept strictly confidential.

SECTION A: RESPONDENT'S PROFILE

Kindly pick all that pertains to the following questions by checking (✓).

1. Gender of respondents ☐ Male ☐ Female

2. Age (years) ☐ 29 and below ☐ 30 to 40 ☐ 40 to 49 ☐ 50 or more

3. Education level ☐ Secondary school or related Certificate ☐ diploma/HND ☐ 1st Degree ☐ 2nd Degree or more

4. Working experience ☐ 0-5years ☐ 6-10years ☐ 11-15years ☐ above 15 years

5. Managerial level ☐ Supervisor ☐ line manager ☐ Top level

6. Position within the organisation Supply chain manager ☐ logistics managers ☐ operations manager ☐ Others ☐

SECTION B: LEAN SUPPLY CHAIN MANAGEMENT

On a scale of 1 to 7 (strongly disagree to strongly agree), rate your firm's Lean supply chain management practices on the following criteria:

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

Supplier Feedback	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Our company is always in close contact with our key suppliers							
Our company provides quality and delivery performance feedback to all our key suppliers.							
Our company puts maximum efforts into developing a long-term relationship with our key suppliers							
Just in Time	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Our company involves all our key suppliers in the new product development (NPD) process							
Our company has a formal supplier certification programme in place							
Our company has a formal supplier certification programme in place							
Customer Involvement	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Our firm is in close contact with our customers							
Our firm collects quality and delivery performance feedback from customers							
Our firm involves direct involvement of customers in existing product improvement and NPD process							

Source: (Kamble, Gunasekaran and Dhone, 2020)

SECTION C: TOP MANAGEMENT COMMITMENT

On a scale of 1 to 7 (strongly disagree to strongly agree), rate your firm's Top management commitment on the following criteria:

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

Source: (Daoud *et al.*, 2021)

SECTION D: INDUSTRY 4.0 TECHNOLOGIES

On a scale of 1 to 7 (strongly disagree to strongly agree), rate your firm's Industry 4.0 technologies application on the following criteria:

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

	1	2	3	4	5		7
Our firm is in the process of implementing or implemented cloud computing							
Our firm is in the process of implementing or implemented big data analytics							
Our firm is in the process of implementing or implemented Internet of Things							
Our firm is in the process of implementing or implemented additive manufacturing							
Our firm is in the process of implementing or implemented robotic systems							
Our firm is in the process of implementing or implemented augmented reality							

Source: (Kamble, Gunasekaran and Dhone, 2020)

SECTION E: FIRM PERFORMANCE

On a scale of 1 to 7 (strongly disagree to agree strongly), rate your firm's performance during the last three years on the following criteria:

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
(1) Our profitability has grown over the past three years.							
(2) Our diluted profits per share have increased over the last three years.							
(3) These last three years have seen a significant return on investment (ROI) increase.							
(4) Our sales growth rate has accelerated during the past three years.							
(5) Growth in return on sales (ROS) has accelerated during the past three years.							
(6) Market share has increased during the last three years.							

Source: (Selvam *et al.*, 2016)