International Journal of
Supply Chain Management
(IJSCM)

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IPRJB
INTERNATIONAL PEER REVIEWED JOURNAL AND BOOK PUBLISHING

International Journal of Supply Chain Management
ISSN 2518-4709 (Online)
Vol.10, Issue 1, No.3, pp 31 - 51, 2025

www.iprjb.org

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Article History

Received 11th January 2025

Received in Revised Form 14th February 2025

Accepted 19th March 2025

How to cite in APA format:

Njagi, C. M., Osoro, A., & Nyangau, S. (2025). Lean Operations and Performance of Manufacturing Firms in Kenya. *International Journal of Supply Chain Management*, *10*(1), 31–51. https://doi.org/10.47604/ijscm.3271

Abstract

Purpose: The performance of manufacturing sector has been on the decline compared to other sectors such as the financial sector. This study sought to examine the influence of lean operations on performance of manufacturing firms in Kenya. The study also sought to find out the moderating effect of ICT adoption on the relationship between lean operations and performance of manufacturing firms in Kenya.

Methodology: The study adopted the cross-sectional research design since it's interested in establishing relationships without interfering the with variables. In this study the unit of analysis was the 46 registered manufacturing firms while the unit of observation in this study was management employees in the supply chain department, procurement department, IT department and finance department. The total target population was 1,104 respondents. The sample size was determined using the Taro Yamane Formulae which was formulated by Tara Yamane in 1967. Therefore, the sample size was 294. The study used purposive sampling to select the respondents. Data was collected using a structured questionnaire administered both on the online platforms and also face to face. The reliability of these instruments was assessed during the pilot study. A review by professionals helped in refining the instruments to make the results reliable and valid. The data was analyzed using the SPSS software. The analytical model included descriptive statistics, correlation analysis, regression analysis and moderation analysis using the SPSS software.

Findings: The study found that lean operations have a positive and significant effect on performance of manufacturing firms in Kenya. The study also found that ICT adoption has a positive and significant moderating effect on the relationship between lean operations and performance of manufacturing firms in Kenya.

Unique Contribution to Theory, Practice and Policy: The Resource-Dependency Theory anchors these concepts. The information theory explains the role of ICT as a moderating variable. From the findings the study recommends that should develop and implement flexible HR policies that allow for adaptive workforce planning. Encourage cross-training of employees to enhance versatility and agility in responding to changing production needs.

Keywords: *Lean Operations, ICT Adoption, Performance of Manufacturing Firms*

INTRODUCTION

Supply chain management is a business service which assist the organizations to source for goods and services. The information gathering is a critical component of the process and it makes a deference wealth (Abushaikha, Salhieh & Towers, 2018). The main goal is to optimize the possibilities and come up with advisories which can maximize the shareholders in order to succeed key business processes must be integrated from customers to organizations to suppliers and then finally to the manufacturers. These business stakeholders must work together to achieve the goal (Rodrigues, 2019). The supply chain function must coordinate these actors in order to achieve the maximum benefit. The system must work together to ensure that the procurement of services and goods meet the desired criterion. A properly managed system will impact the product development in order to maximize the customer experience (Susilawati, Tasri, & Arief, 2019).

Other commentators view supply chain as the process of managing and planning all the activities involved in the procurement and sourcing of the goods and services. It transcends the process of just buying but involves coordinating with customers, suppliers and even the manufacturers in order to receive the right goods at the right time. It is therefore a middle office function; it sits between the various stakeholders and its main aim it to ensure that all the stakeholders are happy. It is noteworthy to mention that logistics management is a subset of supply chain management which enables the goods to move within the stakeholders (CSCMPs, 2018). To achieve better results there must be efficient flow of information from all the stakeholders. This will enable the organization to plan their deliveries based on production runs and customer request. A properly managed system should lead manufacturing. This will not only help the manufacturers also the consumers to manage their inventory properly.

The modern business is becoming complex, customers' demands are fast changing. The organization has to innovate and develop relationship with its suppliers and manufacturers to keep pace with competition. There is need for greater involvement in the process of designing and producing goods. The sourcing of raw materials and transportation of the goods are equally important in the process. The feedback mechanism which enables both the stakeholders to engage in meaningful conversations about how the process can be improved is equally an important function (Stehn, 2018). Therefore, supply chain can be viewed as a synchronization function, the element which coordinate plans and links the stakeholders to ensure that the customer is happy. A lean supply chain system does not only shorten the time to delivery but also reduces the cost of manufacturing and transportation.

The manufacturing sector contributes 25% of the GDP in Kenya, this is expected to increase to 45% by 2030 to achieve the industrialization goal (KNBS, 2016). The economic development and attainment of suitable economic goals require that a nation produces most of its resources. In Kenya manufacturing has not only helped the industrialization process but also contributed to the increase in employment. On the investment side manufacturing has contributed immensely to the wealth creation for the investors. Additionally, this sector contributes immensely to the exports since some of the goods produced locally are exported to the neighboring countries and to the globe at large. Consequently, this contributes to the stabilization of the Kenya shillings against the foreign currencies (Mwangi, & Kitheka, 2018).

In Kenya the manufacturing firms are both locally owned and foreign owned, however the small manufacturing firms are predominantly owned by the locals. The distribution of these firms are however concentrated in Nairobi, Machakos and Thika. The KAM (2019) Report

indicates that 80% of the firms are in Nairobi and its environs. The Kenyan manufacturers mainly manufacture semi processed goods such as coffee, tea and soda ash. On the contrary the manufacturing firms import raw materials such as steel, clinker and iron (Kenya Economic Sector Survey, 2017).

Statement of the Problem

Most developing countries rely on the manufacturing sector to contribute to their growth in GDP. A well-functioning manufacturing sector should contribute about 20% of the GDP in order to impact the socio-economic development of a nation (Hallward & Navyar, 2018). However, in the recent past Kenyan manufacturing has experienced a sharp decline in growth. The sector's contribution to the GDP continues to be below the expected average for a growing nation. For instance, in 2018 the sector contributed 12.5% while in 2019 the sector contributes 12.8% (RoK, 2019). This is below the target contribution of 20%. The dismal performance of the sector continues to affect the aggregate supply, job creation, and return on investment from the suppliers. The decline in productivity can be blamed on the constrained supply chain due to corvid 19. The prices of key elements have not only increased but also have become unavailable. This has negatively impacted the lead time and consequently affected the performance and customer experience.

There is a need for stakeholders to devise methods that can be used to strengthen the manufacturing sector. A mix of policy interventions and internal management brilliance can resuscitate the sector. One of the opportunities available for internal management is to optimize supply chain practices. They can leverage modern ICT to support the lean supply chain philosophy. This strategy can augment the other concepts such as quality assurance, and total quality management which have not yet been helpful in the absence of lean supply chain management. Empirical literature shows that lean supply chain management leads to increased efficiency (Panwar, Nepal, Jain & Rathore, 2015). Additionally, the use of information communication technology improves the success rate of lean supply chain management (Nallusamy,2016). The use of technology enhances the collaborations between the supplier's manufacturers and clients. A shared technology can enhance communications within the value chain while reducing costs. Technology also helps to improve accountability; management can see when the orders were placed and when they were successfully delivered. Therefore, technology enables the management to identify and take corrective action thus leading to improved productivity.

In order to address the gaps in manufacturing, most companies have adopted lean manufacturing practices. However, little is known about them because most studies linking lean supply chain and performance have been done in developed countries. Even so, these studies have provided inconclusive evidence. Some studies aver that lean supply chain management increases performance while other studies found no statistical relationship yet other studies found a negative relationship. There is therefore a need to investigate if there are moderating variables that affect the relationship between lean supply chain practices and performance. ICT is one of those variables and therefore this study is desirous of investigating the moderating role of ICT on the relationship between lean supply chain practices and performance. As a result, this study sought to establish the effect of lean supply chain practices on performance of manufacturing firms in Kenya.

Specific Objectives

The study was guided by the following specific objectives

i. To establish the influence of lean operations on the performance of manufacturing firms in Kenya.

ii. To find out the moderating effect of ICT adoption on the relationship between lean operations and performance of manufacturing firms in Kenya.

Theoretical Framework

Resource-Dependence Theory

The resource dependency theory was proposed through the seminal works of Pfeffer and Alison (1987). The theory postulates that organizations depend on their relationships with other stakeholders in order to acquire the strategic resources needed to achieve their goals. A resource qualifies to be strategic if it is uniquely valuable, rare to find, and difficult to imitate. Hence making strategic resources non-substitutable in nature. These resources provide a competitive advantage because the competition cannot easily acquire them at will (Allway & Corbett, 2017). A strategic organization will therefore enhance its bargaining power through strategic relationships. These relationships provide a competitive advantage since the organization is given preferential treatment. The relationships also help the suppliers to improve their service offering due to collaborations. The shared prosperity and coordination can also help improve quality due to improved communication (Allway & Corbett, 2018).

This theory is relevant for this study because it provides a logical explanation of how the various dependencies work together to achieve a common goal. The reliance on ICT to improve the relationship between supplier relationships cannot be overlooked. The systems support the tracking of orders and consequently, this leads to improved performance. The resource dependency theory also explains the importance of establishing strategic relationships with other stakeholders in order to gain a competitive advantage (Arlbjorn *et al.* 2017). For example, good relationships with suppliers are likely to lead to improved lead times and hence reduce the inventory costs. Good relationships also help the supply chain minimize waste through coordination. While traditional supply chain believes in consolidating power and opportunistic behaviors. The modern supply chain is premised on win-win relationships (Crook & Combs, 2017). Dependency is therefore not viewed as a weakness but as a strategic advantage, that benefits not only the organization but also its suppliers.

Information Theory

Information theory was proposed through the seminal works of Shannon (1948) as a mathematical theory of communication. The theory explains how messages can be passed from the sender to the receiver efficiently. The theory assumes that the sender has more information than the receiver and that they can chose what to share. This theory has been extended to include the economic sense of information. This theory assumes that information is a strategic resource which can be used to gain competitive advantage. Therefore, the economic benefit of information is lost when it is shared. In supply chain management information sharing is considered strategic to the extent that the stakeholders in the value chain have to share crucial information in order to achieve the best results (Agrawal, & Narain, 2018).

The design of customer centric products is enhanced by information sharing, information oils the relationship between the partners striving to achieve the ultimate goal of waste elimination.

The suppliers must share the information about the buyers' desires with the manufacturers. The lean operations require that the employees share the information about the processes with colleagues to enable them perform multiple tasks. In the same strength strategic integration is all about information sharing. Partners share their technologies and process in order to extract information seamlessly. The lean distribution is also dependent on the information sharing between the parties involved. Based on the assumptions of this theory it is expected that the ICT will have a significant positive impact on the relationship between supply chain management and performance of organizations (Farahani, Meier, & Wilke, 2017).

Conceptual Framework

The relationship between the variables is shown in a pictorial presentation through a conceptual framework (Yarkoni, & Westfall, 2019). This framework shows how the predictor, variables relate with the dependent variables. The independent variable in this study include lean operations, the moderating variable is ICT adoption while the dependent variable is performance of manufacturing firms in Kenya. Figure 1 represent this relationship.

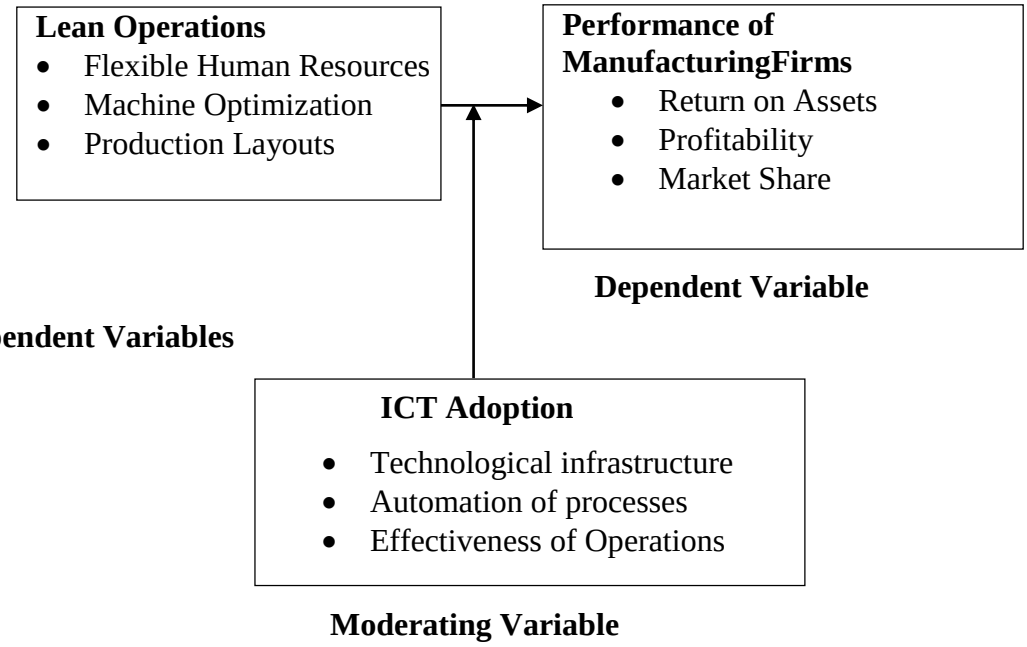

Figure 1: Conceptual Framework

Lean Operations

Lean Operations is a management philosophy and set of practices aimed at improving the efficiency and effectiveness of an organization by reducing waste, enhancing value, and optimizing processes. Rooted in the principles of lean manufacturing, this approach focuses on identifying and eliminating non-value-adding activities throughout the entire production or service delivery process (Argus & Iteng, 2023). Flexible human resources refer to the ability of a workforce to adapt to changing demands, roles, and work environments with minimal disruption to productivity. This concept involves creating a versatile workforce where employees possess diverse skills and can be reallocated across different tasks or departments as needed (Okpala, 2023). Flexible human resources are crucial in lean operations because they allow organizations to respond quickly to fluctuations in demand, unforeseen challenges, or process changes without requiring additional recruitment or extensive training. Employees in

a flexible workforce are often cross-trained, meaning they can perform multiple roles or handle different responsibilities, which increases the overall agility of the organization (Kanyanya, 2020).

Machine optimization is the process of improving the performance, efficiency, and reliability of machines used in production or operations. In the context of lean operations, machine optimization aims to reduce downtime, increase output, and minimize waste caused by machine inefficiencies or breakdowns (Iteng, Rahim & Ahmad, 2021). This can be achieved through various means, such as regular preventive maintenance, upgrading machinery to improve speed and accuracy, and implementing predictive maintenance techniques using data analytics to anticipate failures before they occur. Machine optimization also involves aligning machinery capabilities with production needs to ensure that the equipment operates at peak efficiency without unnecessary downtime or energy consumption (Ofori-Nyarko, *et al*, 2023). Production layouts refer to the arrangement of machinery, equipment, workstations, and materials in a manufacturing or production facility, with the goal of maximizing efficiency and minimizing waste. The design of a production layout directly impacts the flow of materials and the overall effectiveness of the production process (Mbevi & Ndeto, 2024). There are several types of production layouts, including process layouts, product layouts, and cellular layouts, each suited to different types of production environments. In a process layout, similar machines or workstations are grouped together based on their function, which is ideal for producing a variety of products in small batches (Argus & Iteng, 2023). A product layout, on the other hand, arranges workstations in a linear flow, which is most effective for high-volume, repetitive production of a single product or a few variants. Cellular layouts organize equipment into cells designed for specific product families, optimizing flow and reducing lead times while enhancing flexibility.

ICT Adoption

ICT (Information and Communication Technology) adoption refers to the process by which an organization or individual integrates and utilizes various technological tools, systems, and infrastructure related to information and communication into their daily operations or personal activities. This can include adopting technologies such as computers, software applications, the internet, mobile devices, cloud computing, and data management systems (Agrawal, & Narain, 2022). Technological infrastructure refers to the foundational technology systems, hardware, software, and networks that support and enable the operations of an organization. It encompasses everything from servers, databases, and networking equipment to cloud platforms, cybersecurity systems, and enterprise software (Farahani, Meier & Wilke, 2023). A robust technological infrastructure is essential for the smooth operation of digital tools, ensuring that information can be efficiently stored, processed, and accessed by the organization. This infrastructure also supports communication and collaboration across departments and locations, and facilitates integration with external systems such as suppliers or customers (Kanyamuhanda & Shale (2023).

Automation of processes involves the use of technology to perform repetitive tasks with minimal human intervention, improving the efficiency and consistency of business operations. This can include automating tasks such as data entry, invoicing, inventory management, customer service inquiries, and even production processes. By implementing automation, organizations can reduce human error, lower operational costs, and free up employees to focus on more value-added activities such as strategic decision-making, innovation, and customer

relationship management (Wanjiru & Abdalla, 2021). Factors that contribute to operational effectiveness include process optimization, efficient resource allocation, skilled employees, and the ability to respond quickly to changes in demand or market conditions. Organizations that focus on improving the effectiveness of their operations typically invest in continuous improvement practices, such as Lean and Six Sigma, to eliminate inefficiencies and drive innovation (Chaudhary *et al,* 2021).

Empirical Review

Lean Operations

Gusman, *et al* (2021) also looked at lean operations and business performance of Indonesian manufacturing firms. This study incorporated customer experience in its matrices for performance. A study found that lean operations lead to improvement in sales, profitability, and customer experience. This study contributed to the literature by incorporating the customer experience in the model. However, the study did not look at the moderating impact of ICT on the relationship between lean operations and performance. The concept of lean accounting and lean business philosophy was explored by Okpala (2023) in Nigeria. Evidence was collected from 53 manufacturing companies from a sample of 2246 employees. This study found that the lean philosophy was not well implemented in these firms. This study however did not relate the concepts of lean operations to performance it just explored how the organizations practiced the lean philosophy.

Keitany and Riwo-Abudho (2023) looked at the concept of lean operations and organizational performance in the milling firms in Kenya. Performance was conceptualized in terms of product quality and production efficiency. The study found that lean operations lead to higher product quality and eliminate waste. Flexibility in the production process alongside continuous improvement was found to be responsible for the JIT production. This reduced the inventory costs and thus led to better product quality since most of the products are produced only when needed. This study also found that firms can improve their lean operations by adopting modern technologies. It is evident from the foregoing that the study did not look at the mediating role of ICT on the relationship between lean operations and performance.

Iteng, Rahim and Ahmad (2021) investigated on lean operations and business performance in Malaysian manufacturing industries. This study deployed a quantitative, cross-sectional research methodology utilizing primary data collection. This study utilizes two hundred and five manufacturing companies, selected randomly from the Federation of Malaysian Manufacturers Directory. The study found that lean operations significantly contribute to the operational performance of the companies. The study concluded that lean operations have significant positive relationship with operational performance.

Ofori-Nyarko, *et al* (2023) assessed on the effect of lean operations in manufacturing on firm performance: the case of manufacturing firms in Accra. A correlational design was employed, and a sample of 162 participants was drawn from a targeted research population of beverage manufacturing firms in Accra. The study found that lean operations had a positive effect on operational and financial performance but not marketing performance. None of the controlled variables or firm characteristics (i.e. firm size, firm age, operational capital, total asset) had a significant effect on firm performance. The study concluded that firm performance in terms of operational and financial performance improves as lean management enhances in practice.

Oduor, Gulali and Mise (2024) examined on the relationship between lean operations and

performance of parastatals in Kenya. A census approach was applied with a target population of 34, comprising 102 respondents, out of which 12 respondents were sampled using a cluster technique and 86 for the actual study. The study found that lean operations had a significant effect on performance. The study concludes that lean operations have a significant and positive impact on the performance of parastatals in Kenya.

Mbevi and Ndeto (2024) conducted a study on lean operations and performance of cement manufacturing firms in Machakos County, Kenya. The study adopted a descriptive research design. The target population was seventy-two. The study used a census approach and hence the whole population was included in the study. The study found that lean operations had a positive and significant effect on performance of cement manufacturing firms in Machakos County, Kenya. The study concluded that lean operations have an effect on performance of cement manufacturing firms in Machakos County, Kenya.

ICT Adoption

Kanyamuhanda and Shale (2023) investigated on the effects of ICT adoption on procurement performance in government ministries in Rwanda. case of ministry of health. This study adopted a descriptive research design. Both primary and secondary data was used in the study. A total of 472 employees of the Ministry of Health formed the target population. Though stratified random sampling a sample size of 218 respondents was determined using Yamane's formula. The study found that there is a positive significant relation between procurement performance and ICT adoption. The study concluded that ICT adoption lead to a significant improvement in procurement performance in the ministry of health.

Agha and Ndukwe (2022) assessed on ICT adoption and employee performance in drug manufacturing companies in Enugu State. This study used survey research design. Data for this study were obtained from primary source of data. The population of the study was 375 while the sample size of 194 was determined using the Taro Yamane's formula. The study found that the use of ICT has significant positive effect on employees' commitment in the studied organizations. The study concluded that without proper use of ICT applications on work performance to assist in disseminating information to users, employees in drug manufacturing companies will be unable to function effectively and efficiently and the low use of ICT to drive operations in such organizations would result in inefficiency and ineffectiveness of the company's operations and job performance.

Wanjiru and Abdalla (2021) researched on the effects of information communication technology adoption on procurement process in Kenya's oil industry: a survey of Total Kenya Limited Mombasa County. The population of study comprised of 300 employees of Total Kenya Limited. Stratified random sampling technique was used to select the sample. The sample size for this study was 45 respondents. The study found that perceptions regarding the benefits, costs and risks of e-enabled procurement systems significantly affect its adoption. The study concluded that the adoption of ICT applications is not exclusively a matter of resources. On the contrary, operational compatibility and the level of collaboration are two of the factors that play a determinant role in increased ICT adoption and impact.

Atisa and Mose (2024) examined on ICT adoption and procurement performance of large manufacturing firms in Nairobi City County, Kenya. This study used a descriptive research design. The study targeted 630 management employees working in 105 large manufacturing firms. Stratified random sampling technique was used to select a sample of 239 respondents from the target population. The study found that perceived cost of ICT adoption and ICT

technical capacity has a positive and significant effect on procurement performance of large manufacturing firms in Nairobi City County, Kenya. The study concluded that implementing intuitive and easy-to-use procurement tools enhances user adoption and efficiency, leading to improved overall procurement performance.

METHODOLOGY

Research Design

The study used cross-sectional survey design. A cross-sectional survey research design enables collection of data about a given phenomenon within a limited time horizon which can help describe incidences of events or provide an explanation of factors related to an organization or industry (Saunders, 2013; Theuri 2015).

Positivism has been selected because the variables under the study are objectively quantifiable and the relationships are anchored on theories (Crowther & Lancaster, 2012). The research took a deductive approach where facts are verified in a systematic manner without interference from the researcher.

Target Population

The target population comprises all the possible companies and the individuals to be studied (Kothari, 2019). The unit of analysis in this study was all the manufacturing companies in Kenya. The estimates of the Kenya Association of manufacturers indicate that there are 46 registered manufacturing concerns. In this study the unit of analysis was the 46 registered manufacturing firms while the unit of observation in this study was management employees in the supply chain department, procurement department, IT department and finance department. In each department, the study targeted 1 top manager, 2 middle level managers and 3 lower level managers. This implies that the total target population was 1,104 employees

Table 1: Target Population

Category	Target Population	Percent
Top Level Managers	184	16.7%
Middle Level Managers	368	33.3%
Lower Level Managers	552	50%
Total	**1,104**	**100%**

Source: (KAM, 2018)

This study consists of 1,104 respondents from manufacturing companies. The study used purposive sampling to select the qualifying respondents. This technique has been selected to enable the researcher to select the qualifying respondents (Neetij & Bikash, 2017).

The sample size was determined using the Taro Yamane Formulae which was formulated by Tara Yamane in 1967. The mathematical illustration is as follows;

$n=N/ (1+N (e)^{2})$

Where;

n signifies the sample size

N signifies the population under study in this case 1,104

e stands for the margin error which could be 0.10. 0.05 Or 0.01

When the margin of error is taken to be 0.05

$n= 1,104/ (1+1,104(0.05)^2)$

n= 293.6

Therefore, the sample size was 294

Table 2: Sample Size

Category	Target Population	Sample Size
Top Level Managers	184	49
Middle Level Managers	368	98
Lower Level Managers	552	147
Total	**1,104**	**294**

Source: Author (2023)

Data Collection Instruments

The tools used by the researcher to collect data from the respondents are called data collection instruments. These tools include questionnaires and data templates, in this study the researcher used structured questionnaires to collect data about the concepts under the study. The structured questionnaire is preferred as a data collection tool because it allows the respondents to focus on the area of study and consequently this makes it easy for analysis (Saunders & Thornhill, 2019). Secondary data about the performance of the manufacturing firms will be collected from the financial statements.

Data Analysis and Presentation

The study used cross-sectional and inferential statistics to analyze the data generated from the study. Qualitative data was analyzed using cross-sectional analysis. This system allows the researcher to form meaningful themes from the qualitative data. It assists in data summarization, particularly in qualitative data. This methodology not only organized the analysis of qualitative but also eliminated researcher bias (Saunders *et al.*, 2019). On the other hand, inferential statistics was used to come up with relationships and to help other researchers to infer about the population based on the analysis from the selected sample.

These data models were developed with the help of SPSS (Statistical Package of Social Sciences) version 26. The regression model helped in establishing the effect of lean operations on the performance of manufacturing firms. This model provided estimates of the weights of predictor variables as provided in the regression model below.

$Yp = \beta_0 + \beta_1 X_1 + \varepsilon$

Where:

Y = Performance of manufacturing firms in Kenya.

β_o = The constant performance which is not related to any other variable under the study

$\beta_{1-=}$ Coefficient of independent variable

X_1= lean operations

ε = error term

FINDINGS AND DISCUSSION

Descriptive Analysis

In this section the study presents findings on Likert scale questions where respondents were asked to indicate their level of agreement with various statements that relate with the influence of lean operations and performance of manufacturing firms in Kenya and the moderating effect of ICT adoption. They used a 5-point Likert scale where 1-strongly disagree, 2-disagree, 3-moderate, 4-agree, 5-strongly agree.

Lean Operations and the Performance of Manufacturing Firms

The first objective of the study was to establish the influence of lean operations on the performance of manufacturing firms in Kenya. Respondents were therefore asked to indicate their level of agreement with statements on lean operations and the performance of manufacturing firms in Kenya. Table 3 presents summary of the findings obtained.

On Flexible Human Resources, the respondents agreed the organization has optimized its human capital in such a way that if one resource is not available another worker can perform his responsibility (M= 3.948, SD= 1.258). In addition, the respondents agreed that the workers are cross trained to perform several duties within a production run (M= 3.935, SD= 0.983). It was also agreed that the firm has adequate and qualified employees who are able to complete their tasks on time (M= 3.823, SD= 0.845). The respondents agreed that production workforce can shift from one workstation to the other depending on the demand on the station (M= 3.754, SD= 0.797).

Regarding machine optimization, the respondents agreed that the company uses general-purpose machines which can perform several basic functions for multiple processes (M= 4.000, SD= 0.938). In addition, they agreed that their company has adequate number of machines to ensure continuous operations (M= 4.077, SD= 0.560). Further, the respondents agreed that there are adequate machine operators in their company hence all machines are functioning (M= 3.962, SD= 1.038). The respondents also agreed that when one machine is broken down there are other alternative machines which can be used to replace the faulty machine (M= 3.877, SD= 1.172).

On production layouts, the respondents established that their company has located the production processes close together in order to minimize material movements (M= 3.977, SD= 0.902). In addition, the respondents agreed that production facilities are arranged in relation to each other to optimize material handling (M= 3.908, SD= 0.895). Further, they agreed that sequence of material flow can be changed in case of a breakdown in one machine (M= 3.839, SD= 1.104). The respondents also agreed that the production at a particular workstation is dependent on the current demand of its subsequent workstation (M= 3.777, SD= 0.688).

These results concur with the findings of Kanyanya, (2019) who confirmed that most manufacturing firms have adopted lean operations as a strategy. Additionally, the study assessed the challenges faced by organizations while implementing lean operations. Top management commitment, employee resistance to change, and lack of the requisite expertise were ranked as the top three challenges experienced while implementing lean operations. Similarly, Keitany and Riwo-Abudho (2018) revealed that lean operations lead to higher product quality and eliminate waste. Flexibility in the production process alongside continuous improvement was found to be responsible for the JIT production. This reduced the inventory costs and thus led to better product quality since most of the products are produced only when

needed

Table 3: Lean Operations

	Mean	Std. Dev.
Flexible Human Resources		
The organization has optimized its human capital in such a way that if one resource is not available another worker can perform his responsibility	3.948	1.258
The workers are cross trained to perform several duties within a production run	3.935	0.983
Our firm has adequate and qualified employees who are able to complete their tasks on time	3.823	0.845
production workforce can shift from one workstation to the other depending on the demand on the station	3.754	0.797
Machine Optimization		
The company uses general-purpose machines which can perform several basic functions for multiple processes	4.000	0.938
Our company has adequate number of machines to ensure continuous operations	4.077	0.560
There are adequate machine operators in our company hence all machines are functioning	3.962	1.038
when one machine is broken down there are other alternative machines which can be used to replace the faulty machine	3.877	1.172
Production Layouts		
Our company has located the production processes close together in order to minimize material movements	3.977	0.902
production facilities are arranged in relation to each other to optimize material handling	3.908	0.895
sequence of material flow can be changed in case of a breakdown in one machine	3.839	1.104
the production at a particular workstation is dependent on the current demand of its subsequent workstation	3.777	0.688
Aggregate Score	**3.840**	**0.932**

ICT Adoption and Performance of Manufacturing Firms

The second objective of the study was to find out the moderating effect of ICT adoption on the relationship between lean supply chain management and performance of manufacturing firms in Kenya. Respondents gave their level of agreement on statements on ICT adoption on performance of manufacturing firms in Kenya. Table 4 presents summary of the findings obtained.

Concerning technological infrastructure, the respondents agreed that their company has purchased adequate computers for all departments (M= 3.946, SD= 1.008). In addition, the respondents agreed that computers in their company are maintained on regular basis (M= 3.900, SD= 1.030). It was also agreed that non-functioning computers in their organization are replaced immediately (M= 3.876, SD= 0.786). The respondents agreed that all the existing computers in our organization are regularly updated (M= 3.885, SD= 0.909).

Regarding automation of processes, the respondents agreed that most operations in their organization are automated hence ensuring efficiency and effectiveness of operations (M= 3.908, SD= 1.258). In addition, they agreed that the system is capable of calculating reorder levels based on the orders received from the customers and the forecast (M= 3.881, SD= 1.177). Further, the respondents agreed that the system is capable of sending order requests to suppliers automatically based on the demand (M= 3.869, SD= 0.765). The respondents also agreed that the system is capable of processing and sending exemption alerts when an abnormal order is received. This helps the organization in demand and supply balancing (M= 3.786, SD= 0.786).

On effectiveness of operations, the respondents established that adoption of information technology has led to effectiveness of operations in their organization (M= 3.923, SD= 0.796). In addition, the respondents agreed that the quality of work done in their organization has improved as a result of IT adoption (M= 3.891, SD= 0.874). Further, they agreed that they are satisfied with the effectiveness of operations in our organization as a result of IT adoption (M= 3.863, SD= 1.129). The respondents also agreed that in their organization, manufacturing operations are effective in meeting customer demands (M= 3.815, SD= 0.983).

The study findings concur with those of Agrawal, and Narain, (2018) who established that in lean supply chain management ICT assist in order creation, order transmission, and order tracking. Additionally, the goods are tagged using a digital naming system which makes it easy to trace the defective goods. Moreover, ICT assists the partners in the supply chain to communicate promptly. Systems have also been designed to manage inventory. Technology is also used to optimize the operations, efficiency in operations can only be achieved with an optimal combination of machine and digital processes (Chaudhary *et al*., 2018).

Table 4: ICT Adoption

	Mean	Std. Dev.
Technological infrastructure		
Our company has purchased adequate computers for all departments	3.946	1.008
Computers in our company are maintained on regular basis	3.900	1.030
Non-functioning computers in our organization are replaced immediately	3.876	0.786
All the existing computers in our organization are regularly updated	3.885	0.909
Automation of processes		
Most operations in our organization are automated hence ensuring efficiency and effectiveness of operations	3.908	1.258
The system is capable of calculating reorder levels based on the orders received from the customers and the forecast.	3.881	1.177
The system is capable of sending order requests to suppliers automatically based on the demand	3.869	0.765
The system is capable of processing and sending exemption alerts when an abnormal order is received. This helps the organization in demand and supply balancing	3.786	0.786
Effectiveness of Operations		
Adoption of information technology has led to effectiveness of operations in our organization	3.923	0.796
The quality of work done in our organization has improved as a result of IT adoption	3.891	0.874
Am satisfied with the effectiveness of operations in our organization as a result of IT adoption	3.863	1.129
In our organization, manufacturing operations are effective in meeting customer demands	3.815	0.983
Aggregate Score	**3.913**	**0.993**

Test for Hypothesis One

The first objective of the study was to establish the influence of lean operations on the performance of manufacturing firms in Kenya. The corresponding hypothesis was:

Ho_1: Lean operations has no significant effect on performance of large manufacturing firms in Kenya.

A univariate analysis was therefore conducted to test the null hypothesis. From the model summary findings in Table 5, the r-squared for the relationship between lean operations and performance of large manufacturing firms in Kenya was 0.269; this is an indication that at 95% confidence interval, 26.9% variation in performance of large manufacturing firms in Kenya can be attributed to changes in lean operations. Therefore, lean operations can be used to explain 26.9% change in performance of large manufacturing firms in Kenya. However, the remaining 73.1% variation in performance of large manufacturing firms in Kenya suggests that there are other factors other than lean operations that explain performance of large manufacturing firms in Kenya.

Table 5: Model Summary for Lean Operations

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.519[a]	.269	.267	.68365

a. Predictors: (Constant), lean operations

The analysis of variance was used to determine whether the regression model is a good fit for the data. From the analysis of variance (ANOVA) findings in Table 6, the study found out that that Prob>$F_{1,270}$= 0.000 was less than the selected 0.05 level of significance. This suggests that the model as constituted was fit to predict performance of large manufacturing firms in Kenya. Further, the F-calculated, from the table (601.87) was greater than the F-critical, from f-distribution tables (3.877) supporting the findings that lean operations can be used to predict performance of large manufacturing firms in Kenya.

Table 6: ANOVA for Lean Operations

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	51.159	1	51.159	601.87	.000[b]
	Residual	22.816	270	0.085		
	Total	**73.975**	**271**			

a. Dependent Variable: performance of large manufacturing firms in Kenya

b. Predictors: (Constant), Lean Operations

From the results in Table 7, the following regression model was fitted.

$$Y = 0.292 + 0.476\ X_2$$

(X_2 is Lean Operations)

The coefficient results showed that the constant had a coefficient of 0.292 suggesting that if lean operations was held constant at zero, performance of large manufacturing firms in Kenya would be at 0.292 units. In addition, results showed that lean operations coefficient was 0.476 indicating that a unit increase in lean operations would result in a 0.476 increase in performance of large manufacturing firms in Kenya. It was also noted that the P-value for lean operations coefficient was 0.000 which is less than the set 0.05 significance level indicating that lean operations was significant. Based on these results, the study rejected the null hypothesis and accepted the alternative that lean operations has a positive and significant influence on performance of large manufacturing firms in Kenya.

Table 7: Beta Coefficients for Lean Operations

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.292	.067		4.358	.000
	Lean Operations	.476	.099	.481	4.808	.000

a. Dependent Variable: Firm performance

Test for Hypothesis Two

The second objective of the study was to find out the moderating effect of ICT adoption on the relationship between lean operations and performance of manufacturing firms in Kenya.

Moderation happens when the relationship between the dependent variable and the independent variables is dependent on a third variable (moderating variable). The effect that this variable has is termed as interaction as it affects the direction or strength of the relationship between the dependent and independent variable. To achieve the second research objective, the study computed moderating effect regression analysis. This (moderating effect regression analysis) also guided the study in testing the second research hypothesis. ICT adoption (M) was introduced as the moderating variable.

Ho_2: ICT adoption has no significant moderating effect on the relationship between lean operations and performance of manufacturing firms in Kenya.

The study combined the variable (lean operations) to form a new variable X. The study then used stepwise regression to establish the moderating effect of ICT adoption (M) on the relationship between independent variable (X) and performance of manufacturing firms in Kenya (Y).

From the model summary findings in Table 8, the first model for which is the regression between lean operations (X) without moderator, ICT Adoption (M) and interaction, the value of R-squared was 0.336 which suggests that 33.6% change in performance of manufacturing firms in Kenya can be explained by changes in lean operations. The p-value for the first model (0.000) was less than the selected level of significance (0.05) suggesting that the model was significant. The findings in the second model which constituted lean operations, ICT adoption and performance of manufacturing firms in Kenya (X*M) as predictors, the r-squared was 0.568. This implies that the introduction of ICT Adoption in the second model led to a 0.232 increase in r-squared, showing that ICT Adoption positively moderates performance of manufacturing firms in Kenya.

Table 8: Model Summary for Moderation Effect

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.580[a]	.336	.334	.65170	.336	386.860	1	270	.000
2	.754[b]	.568	.564	.52727	.232	537.10	3	268	.000

a. Predictors: (Constant), lean operations

b. Predictors: (Constant), lean operations, ICT Adoption, Interaction (X*M)

From the model summary findings in Table 9, the F-calculated for the first model, was 795.91and for the second model was 1,121.06. Since the F-calculated for the two models were more than the F-critical, 3.877 (first model) and 2.638 (second model), the two models were good fit for the data and hence they could be used in predicting the moderating effect of ICT Adoption on performance of manufacturing firms in Kenya.

Table 9: ANOVA for Moderation Effect

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	63.832	1	63.832	795.91	.000[b]
	Residual	21.675	270	0.0802		
	Total	**85.507**	**271**			
2	Regression	107.958	3	35.986	1,121.06	.000[c]
	Residual	8.622	268	0.0321		
	Total	**116.58**	**271**			

a. Dependent Variable: Performance of manufacturing firms in Kenya

b. Predictors: (Constant), lean operations

c. Predictors: (Constant), lean operations, ICT adoption, Interaction

Further, by substituting the beta values as well as the constant term from the coefficient's findings for the first step regression modelling, the following regression model will be fitted:

Y = 1.387 + 0.608 X

Where X is lean operations

The findings show that when lean operations is held to a constant zero, performance of manufacturing firms in Kenya will be at a constant value of 1.387. The findings also show that lean operations has a statistically significant effect on performance of manufacturing firms in Kenya as shown by a regression coefficient of 0.608 (p-value= .000).

By substituting the beta values as well as the constant term from model 2 emanating from the second step in regression modeling the following regression model was fitted:

Y= 3.876 + 0.220 X + 0.325 M + 0.283 X*M

Where X is lean operations; M is ICT adoption and X*M is the interaction term between lean operations and ICT adoption.

The findings show that when lean operations, ICT adoption, interaction (X*M) are held to a constant zero, performance of manufacturing firms in Kenya will be at a constant value of 3.876. The model also indicated that lean operations had a positive and statistically significant effect on performance of manufacturing firms in Kenya as shown by a regression coefficient of 0.220 (p-value= 0.002). It is also seen that ICT adoption had a positive and significant effect on performance of manufacturing firms in Kenya as shown by a regression coefficient 0.325. On the other hand, interaction of lean operations and ICT adoption (X*M) also had a positive and significant effect on performance of manufacturing firms in Kenya as shown by a regression coefficient of 0.283 (p-value= 0.000).

It is therefore seen that lean operations on its own has 22% effect on performance of manufacturing firms in Kenya. However, when interacted with ICT adoption, it has an effect of 28.3%. This is a clear indication that introduction of ICT adoption as moderating variable has positive influence on performance of manufacturing firms in Kenya. The study therefore rejects the null hypothesis and accepts the alternative that ICT adoption has significant moderating effect on the relationship between lean operations and performance of manufacturing firms in Kenya.

Table 10: Beta Coefficients for Moderation Effect

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.387	.194		7.163	.000
	lean operations	.608	.050	.580	12.260	.000
2	(Constant)	3.876	1.009		3.841	.000
	lean operations	.220	.067	.782	3.284	.002
	ICT adoption	.325	.048	.310	6.748	.000
	Interaction (X*M)	.283	.065	1.661	4.357	.000

a. Dependent Variable: performance of manufacturing firms in Kenya

CONCLUSION AND RECOMMENDATIONS

Conclusion

Lean Operations and Performance of Manufacturing Firms

The study found that lean operations have a positive and significant effect on performance of manufacturing firms in Kenya. Findings revealed that flexible Human Resources, machine Optimization and production Layouts influence performance of manufacturing firms in Kenya. This implies that improvement in lean operations (flexible Human Resources, machine Optimization and production Layouts) would lead to improvement in performance of manufacturing firms in Kenya.

ICT Adoption and Performance of Manufacturing Firms

The study found that ICT adoption has a positive and significant moderating effect on the relationship between lean operations and performance of manufacturing firms in Kenya. Findings revealed that technological infrastructure, automation of processes and effectiveness of Operations influence performance of manufacturing firms in Kenya. This implies that improvement in ICT adoption (technological infrastructure, automation of processes and effectiveness of Operations) would lead to improvement in performance of manufacturing firms in Kenya.

Recommendations

Lean Operations

The management of manufacturing firms should develop and implement flexible HR policies that allow for adaptive workforce planning. Encourage cross-training of employees to enhance versatility and agility in responding to changing production needs. Consider flexible work schedules or arrangements to accommodate fluctuations in demand. In addition, the management should conduct regular assessments of machinery and equipment to ensure they are operating at peak efficiency. Invest in technology upgrades and automation to streamline production processes.

ICT Adoption

The study recommends the management of manufacturing firms in Kenya to invest in tailored technology solutions that align with the specific needs of the manufacturing sector. This can be achieved by providing access to affordable, scalable, and user-friendly ICT tools, such as Enterprise Resource Planning (ERP) systems, cloud-based platforms, and data analytics

software. These tools can facilitate real-time data sharing, improve communication across supply chain networks, and optimize inventory management, which in turn supports lean practices.

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