FOURTH INDUSTRIAL REVOLUTION TECHNOLOGIES AND LEAN MANUFACTURING IN KENYA: A CASE STUDY OF ALMASI BEVERAGES LIMITED –ELDORET.

SHEILAH JEPKURUI BARNO

A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER IN BUSINESS ADMINISTRATION, SCHOOL OF BUSINESS, UNIVERSITY OF NAIROBI

2022

DECLARATION

This research project is my original work and has not been previously published or presented for the award of a degree in any other university.

Signature…Sheilah Barno…………   Date……25/11/2022…………………

Sheilah Jepkurui Barno

D61/30305/2019

This research project has been presented for examination with my approval as the universitysupervisor.

Signature……………………………   Date……23/11/2022……………….

Stephen O. Nyamwange

Lecturer Department of Management Science

University of Nairobi

ACKNOWLEDGEMENTS

Glory to the Almighty God for the wisdom, strength as well as sufficient grace to finalize this project.

I wish to state my deep and sincere appreciation to my supervisor S.O Nyamwange and my moderator Zipporah Kiruthu for their invaluable time, tremendous direction and continuous guidance throughout the supervision period.

Finally, many thanks to my husband Dr. Abel Cheruiyot, my daughter Aaliyah Shayna Cheruto Songok, my parents Mr. and Mrs. Joseph Barno, my siblings (June and Brian) and my uncle Abraham Birech for their financial, moral and spiritual assistance in the course of the study.

DEDICATION

I dedicate this research study to my husband Dr. Abel Cheruiyot, my daughter Aaliyah Shayna Cheruto Songok my parents Mr. and Mrs. Joseph Barno, and my siblings June and Brian.

TABLE OF CONTENTS

LIST OF TABLE

ABBREVIATIONS

4IR: Fourth Industrial Technologies

ABL: Almasi Beverages Limited

CPS: Cybe Physical Systems

CR: Cloud Robotics

GDP: Gross Domestic Products

ICDC: Industrial and Commercial Development Corporation

IoT: Internet of Things

LM: Lean Manufacturing

RBV: Resource Based View theory

RFID: Radio Frequency Identification

SMEs: Small & Medium Enterprises

TAM3: Technology Acceptance Model

ABSTRACT

The study's goal was to ascertain the impact of technologies from the fourth industrial revolution on lean manufacturing processes at Almasi Beverages Limited in Eldoret, Kenya. The study was centered on the following theories; Technology Acceptance Model and the resource based view theory. Case study was the research design utilized. Quantitative research methods was used in this investigation. The primary tools for gathering data for this study was questionnaires. Data analysis was done using SPSS (Version 24.0). Descriptive and inferential statistics was used to assess the data correlation and regression model. The findings showed that cloud robotics contributes to the level of lean manufacturing. Correlation analysis was conducted then the findings on correlation between internet of things and lean manufacturing showed Pearson correlation value of 0.894 which indicated a positive relations between the variables. The findings on correlation between cyber-physical systems and lean manufacturing showed Pearson correlation rank value of 0.880 which indicated a positive relationship between the variable items. Finally, the findings discovered that there is strong relationship between 4IR technologies and lean manufacturing. The study concluded that technologies from the 4IR have an impact on lean manufacturing processes at Almasi Beverages Limited in Eldoret, Kenya. There is strong positive relationship between 4IR technologies (cloud robotics, internet of things plus cyber-physical systems). In particular, Cyber-physical system has the highest impact followed by cloud robotics and closely followed by internet of things.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Growing technological and industrial advancements over the past few years have given rise to many new global concepts such as Industry 4.0. It is a novel industrial model that combines a number of cutting-edge technologies and has huge potential for businesses. The primary goal of Lean Production, is about decreasing wastes while increasing productivity while still meeting consumer demands (Kushwaha, 2012). The Fourth Industrial Revolution (4IR) is revolutionizing the entire system of production and management of the labor market (Schwab, 2016). Malone (2004) asserts that it has been expected that those that give the intellectual and physical capital, notably innovators, stockholders, and investors, will stand to gain the most from the 4IR.

Many nations have seized the opportunity to benefit from the various fourth industrial revolution's technologies, some have laid up strategies that will enable them develop intelligent factories that make use of 4IR technologies. China's , Germany's and the United States' (China 2025, industry 4.0s and advance manufacturing respectively) are a few examples of public policies that have made an attempt to explain strategies for implementating the fourth industrial revolution (Liao, Loures, Deschamps, Brezinski, & Venâncio, 2018). Making sure that developing countries are not left behind is crucial in this new era of smart manufacturing, accelerated development timelines, and mass customization. A few developing countries have started to move towards direction of the 4IR which is crucial because their economies are reliant on their manufacturing sectors. Collaboration is required between public in conjunction with private entities; the role of the government should be to promote and support innovation by providing the essential infrastructure, start-up capital for companies pursuing innovation in the essential industries, and tax breaks.

Wakiaga (2021) asserts that prior to COVID-19, the globe was preparing for the $IRand the impact of the crisis has made Industry 4.0 more significant than ever. Currently, businesses are having problems remaining afloat and we must create systems that support the economy whether there is a crisis or not as we move toward rebound plans. According to Wakiga (2021), Industry 4.0 has the ability to address these gaps by maintaining continuity, cutting costs while improving production through system automation, which is one of the corporate survival strategies and a launching pad for rebound tactics. The manufacturing sector has continued to seek ways to keep the economy running, such as assuring enough supply and collaborating with the government on recovery initiatives.

In recent years, the worldwide market has changed significantly. As a result, buyers no longer find products with poor quality, lengthy lead times, and little variety appealing. Need from consumers keeps rising, and conventional production methods are unable to meet this new demand. The greatest strategy, known as lean production, has been used by numerous businesses worldwide.

1.1.1 Fourth Industrial Revolution Technologies

The word "Industry 4.0" was originally used at the German Hannover Messe in 2011. 4IR, is currently in motion and is distinguished by the following features: connection, collaboration, better services, and advanced manufacturing methods. 4IR is a futuristic vision of industry and manufacturing in which information technologies are intended to increase efficiency and competitiveness through the interconnectedness of all resources along the value chain. Its goal is to establish a smart manufacturing environment within the production system. Information technologies and operation technologies are the two primary smart manufacturing technology pillars of the Fourth Industrial Revolution (Malavasi & Sanetti, 2017). Unavoidably, the significant transformation that 4IR technologies have brought about will affect the manufacturing industry resulting in the attempt to integrate 4IR with the current corporate strategy. The fact that around 90% of the highest-grossing manufacturing organizations have achieved this status, it's effective adoption of LM principles and techniques highlights the crucial relationship between 4IR technologies and lean manufacturing (Golchev, 2019).

1.1.2 Lean Manufacturing

Lean manufacturing is one of the most effective production approaches used by manufacturing companies around the world over. The idea of lean manufacturing was invented in Japan in the early 1950s as a survival tactic to address the problems that the country's manufacturing sector was confronting in the wake of World War II. The fundamental concept was to use less input while producing more output. The two main goals of lean manufacturing are customer satisfaction and profitability. Understanding the needs of the customer and the price they are prepared to pay is essential since every step taken during manufacturing must deliver necessary value to the final consumer. An organization that practices lean management recognizes the value of its customers and concentrates all of its efforts on maximizing that value by designing a waste-free or minimally wasteful value generating process. Lean Manufacturing's primary goal is to streamline processes so that they can produce goods at the required rate to meet customer demand and continuously reduce the time between an order and delivery by getting rid of everything that adds time or expense (Machado,2019).

1.1.3 Kenyan manufacturing

10% of Kenya's gross domestic product (GDP) 13% of its comes from formal employment, while 12.5% of its exports come from manufacturing. However, this contribution is in jeopardy since, according to World Bank data, the unpredictability of the operating environment has led to a decline in the profitability of Kenyan manufacturers over the past five years, Mutai (2018). Estimates state that as a result of contingencies brought on by subpar supply chain management, in Kenya, industrial businesses have lost seventy percent of market share in East Africa (KAM, 2014). The fact that Kenya's capital goods and intermediate industries are still in their infancy means that import dependence is high in the country's food manufacturing sector. 10% of Kenya's exports are made up of food produced locally. A rapid consumer products company's demise, such as winding up of Cadbury its Nairobi facility as a result to subpar performance, may be an indication of the subpar due to increased production costs experienced by food beverages companies (RoK, 2014). Other Kenyan industrial enterprises, like those that make tea, have implemented energy-efficiency methods to limit energy waste and lower production costs. It is necessary to investigate the 4IR technologies for lean manufacturing practices used by manufacturing firms. Murigi (2014) contend that lean practices have a correlation with performance of the supply chain management process, with wastage and costs accounting for 57.1% of that performance.

1.1.4 Almasi Beverages Limited in Eldoret, Kenya

When East Kenya Bottling of Machakos moved into the area in 2000, only six bottlers remained (Kibera. & Waruinge, 2008). With assistance from the Industrial and Commercial Development Corporation (ICDC), a government-run program to promote investment, Nairobi Bottlers eventually became incorporated in the late 1960s. Coastal Bottlers, Mt. Kenya Bottlers as well as

East Kenya Bottlers and Equator Bottlers came later. Kisii Bottlers and Flamingo Bottlers in addition to Mt. Kenya Bottlers were among the other seven bottlers in Kenya. All of these share ownership in ICDC even though the other investment owners differ.

Nairobi Bottlers Limited was bought by Coca-Cola South Africa Bottling Company (Sabco) and a regional investment partner. Three Coca-Cola bottlers in Kenya, according to Mburu, intend to collaborate to form Almasi Beverages Limited (2012). Mount Kenya bottlers, Rift Valley, as well as Kisii Bottlers, are anticipated to increase their combined worth by 26% amounting to 5.7 billion shillings ($67 million). Three businesses are jointly owned by the Industrial & Commercial Development Organization and Centum, a publicly traded investment corporation (ICDC). Centum Investment owns 23.8 percent of Kisii, 28.6 percent of Mount Kenya, and 44 percent of the Rift Valley. The competition, rising costs of doing business, and currency rate risks all contributed to the merger by slowing the individual companies' growth and reducing their profit margins. As a result of the merger of three beverage-bottling companies, Almasi Beverage Limited comprising of, Kisii, and Mount Kenya (bottlers limited), Almasi Beverages Limited (ABL) was created in 2013. The franchise that the company uses to conduct business is owned by The Coca-Cola Company. The three bottling companies were independent businesses before the merger. The businesses were merged to address issues they faced and to benefit from emerging opportunities in the sector. It is anticipated that the combination will result in joint investments in the development of additional capacity and products. The new company made use of combined management and support staff, better geographic coverage and product penetration. The newly established firm was in a position to aggressively pursue growth, revenue synergies, cost savings, and other goals as a result of increased participation and alignment with the key stakeholders. The combination is expected to increase value by 50% of the current valuation over the subsequent four years (K'Ogallah, 2016).

1.2 Research Problem

Profitability in manufacturing sector has increased thanks to the Fourth Industrial Revolution. Employees are no longer obliged to undertake manual labor, which frees them up to focus on developing their more advanced problem-solving abilities. More than 20 years ago, Lean Manufacturing was the dividing issue, making the businesses that adopted it significantly more productive and competitive. (Yang, 2015). The ability of the businesses using lean approaches to adapt to and make use of new technology will be crucial to their future success. The adoption of 4IR technologies could greatly widen the gap between rival companies operating in the same sector. Therefore, applying 4IR technologies may be seen as a strategy to outperform competitors.

The marriage of I4.0 with cutting-edge automation technologies has shown immense promise, but the process of achieving that potential is being hindered by the lack of comprehensive frameworks that integrate Lean and I4.0. Combining I4.0 and Lean Manufacturing is recognized to benefit users (Kolberg & Zuhlke, 2015). Despite the inclusion of I4.0 in strategic as well as research strategies, firms still struggle to comprehend their present I4.0 situation, identify how I4.0 technologies can support their processes, understand implementation specifics, and take into account potential benefits (Erol, Jäger, Hold, Ott, & Sihn, 2016) & (Liao *et al*., 2017). The 4IR is distinct from earlier industrial revolutions in terms of pace, scale, complexity, and revolutionary impact, according to Smith and Pourdehnad (2018). An industrial revolution is expected to have a profound impact on manufacturing. I4.0 changes the way operations are implemented by replacing traditional forecast-based production planning with real-time production planning and self-optimization. The intelligent automation system in the manufacturing line synchronizes itself with the entire value chain, from material ordering to product delivery (Wolfsberg, Sanders, & Elangeswaran, 2016).

Lean manufacturing, which prioritizes customer satisfaction and profitability, is influenced by 4IR. Understanding the needs of the customer and the price they are prepared to pay is essential since every step taken during manufacturing must deliver necessary value to the final consumer. A business that practices lean management recognizes the value of its customers and tailors its operations to steadily increase it by designing a waste-free or drastically reduced value generating process. Lean Manufacturing's primary goal is to streamline business processes in order to produce goods at a rate that meets consumer demand and steadily reduce the amount of time it takes to complete an order and deliver it. I4.0 and Lean manufacturing, according to Roy, Mittag, & Baumeister (2015), work well together and advance the firms' internal Lean techniques rather of competing with one another. Lean Manufacturing is expected to gradually include Industry 4.0 technologies, enhancing flexibility in addition to productivity, lowering costs, and raising quality (Buer, Strandhagen & Chan, 2018). According to Khanchanapong et al. (2014), using both principles together has a much greater performance impact than doing so alone.

Academics and businesses have been studying the relationship between 4IRtechnology and lean production in recent years, but it is unclear how each 4IR technology might fit into lean practices and tools despite the fact that this topic has been covered in multiple studies. By examining the effects and opportunities of the integration between these two domains at the Almasi Beverages Limited in Eldoret, this research will evaluate our understanding of how technologies provided by 4IR technology might augment and potentiate lean techniques.

1.3 Research Objective

The research's goal was to ascertain the impact of technologies from the fourth industrial revolution on lean manufacturing processes at Almasi Beverages Limited in Eldoret.

1.4 Value of the Study

More knowledge on how 4IR technology and lean manufacturing are related will be relayed to government through this work. A more efficient and effective manufacturing sector could raise the nation's GDP and, consequently, create more jobs. This may help with the formation of rules and regulations that can help. A more efficient manufacturing process could benefit from increased trade, lower export costs that encourage exports, higher prices for products, and a stable industrial sector. The study may be helpful to manufacturing companies because it may help them better understand how lean manufacturing principles underlie the operations of their businesses and may put them in a better position to address challenges that stand in the way of successful lean manufacturing. Lean manufacturing that is efficient and effective will lay the groundwork for organizational development, increased productivity, lower production costs, enhanced distribution, higher-quality goods, and more customer satisfaction.

The work could contribute to the expanding amount of lean manufacturing literature, which could be helpful to the academic community. It might provide a framework of lean manufacturing traits that could operate as a basis for further research. Based on a case study of Kenya, this project will advance the theory and practice of adopting, implementing, and upgrading lean manufacturing in a variety of cultural and professional contexts. The findings are particularly important from a theoretical standpoint for scholars since they identify emerging patterns in 4IR technologies and lean management as well as uncharted territory.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The evaluation of literature concentrated on combing prior research on the influence of technologies from the fourth industrial revolution (4IR) on lean manufacturing procedures. Fourth Industrial Revolution technologies employed in lean operations are discussed in this section, along with how they relate to manufacturing.

2.2 Theoretical Foundations

Technology Acceptance Model in addition to The resource based view theory guided this research.

2.2.1 Technology Acceptance Model

TAM 3 has been singled out without a doubt as the widely held popular idea as how technical systems are implemented in enterprises. According to TAM 3, the two key factors that influence how efficiently a company uses its IT resources are perceived system usability and perceived system ease of use. Venkatesh and Bala (2008), professed utility is the degree to which employees believe that IT resources have improved their performance. Some factors that influence how valuable individuals think information systems are include subjective norm, job relevance of the target system, output quality of IT use, outcome demonstrability or observable repercussions of IT deployment, and perceived ease of using the resources. Organizations are able to successfully integrate IT systems with high perceived value because people display a behavioral purpose to use the resources in their operations. Perceived ease of use is the second element that influences IT implementation. Perceived ease of use, according to Venkatesh & Bala (2008), refers to how little effort a person believes utilizing IT systems will need. External factors that influence how simple information systems are perceived to be to use include computer self-efficacy, or personal confidence in one's ability to use the tools, anxiety when using the system, computer playfulness, or perceived enjoyment of the system, and the system's actual suitability for completing tasks.

Apparent ease of use has a positive impact on the intention to use the system, which results in the adoption of the technology. The TAM 3 hypothesis applies to the research because it defines the factors influencing IT adoption in businesses. The idea is that a company's decision to adopt a new technology like Industry 4.0 depends on how advantageous and straightforward it is seen to be. Additionally, there are links between the two traits and both internal and external factors. The study focused on these elements to determine the extent of Industry 4.0 implementation in the firms.

2.2.2 Resource-Based View Theory

RBV focuses on the organization's internal qualities and performance (Jambekar, 2008). According to the theory, organizations have a variety of resources that can be divided into two groups: competitive and financial and cooperative and strategic. The thesis is predicated on the idea that organizations have unique strategic resources rather than identical ones, they are heterogeneous because they are not entirely movable. Organizations are therefore collections of resources, and the less rare a collection of organizational resources is, the less competitive advantage it actually possesses (Lander & Liker, 2007). Additionally, the RBV theory places equal emphasis on capabilities and resources; organizations develop capabilities by utilizing their existing resources in an efficient and effective manner to meet their objectives (Hausman, 2010). Functional, positional, cultural, and regulatory differentials are the four basic categories into which capabilities are categorized. These skills and experiences come from prior actions and preferences (positional), the individual's beliefs of the establishment's stakeholders (cultural), the firm’s policies and regulations (regulatory), or both (functional) (Vore, 2002). Therefore, the theory suggests that an organization will achieve higher levels of continues improvement capabilities in the context of continues improvement if it has a culture that supports it, if there are already process-based change regulations in place, and if it has prior experience leading projects for it.

RBV theory and lean manufacturing processes have a lot in common because they both guarantee continuous improvement (Paneru, 2011). The shared assumption that an organization's resources and capabilities are finite leads to the tendency for surviving organizations to use their resources efficiently. Performing at their best can help firms gain a competitive advantage. However, to maintain a competitive advantage, businesses may need to make constant improvements to set themselves apart from rivals (Paneru, 2011). When a company is able to develop value from its skills and is taking advantage of them, they can gain a sustained competitive advantage.

2.3 Fourth Industrial Revolution Technologies

The substantial revolution brought about by 4IR technologies will undoubtedly have an impact on the manufacturing industry. 4IR is a futuristic vision of industry and manufacturing in which information technologies are intended to increase efficiency and competitiveness through the interconnectedness of all resources along the value chain. Its purpose is to create a smart manufacturing environment within the manufacturing system. Cloud robotics has two significant benefits on organizations, according to Harvard Business Review (2015): greater responsiveness and cost savings. The cloud has a significant impact on how the IT department's activities change (Harvard Business Review 2015). Cloud computing and virtualization are the two most important drivers boosting production (Borangiu *et al*. 2019). Borangiu *et al*. (2019) also admit that, while cloud computing is often adopted at the business process layer, it is implemented substantially more slowly at the manufacturing layer. High-performance computing, system architecture, and information integration can be major challenges in cloud computing deployment (Borangiu *et al*, 2019).

The usage of cloud robots in procurement management is still in its early stages (Jede & Teuteberg 2015). The key factors driving the acceptance of cloud in supplies chain management are increasing competitive advantage (expecting higher IT in value and performance, better enabling Supply Chain Management) and cost-saving (expecting the lowest IT operational cost) (Jede & Teuteberg 2015). The security thread is the most commonly addressed danger in cloud computing and supply chain management literature (Jede & Teuteberg 2015). Cloud computing is also referred to as cloud-based supply chain management. (Giannakis *et al*, 2019). Furthere, they noted that cloud computing improves supply chain receptiveness, which is regarded as essential in today's purpose of organizations to better respond to customer demand and environmental changes. Lorenz *et al.* (2019) examined the connection between Lean and cloud robots using an empirical methodology. Using survey data from Swiss manufacturing companies triangulated with later interviews, the authors discovered a positive relationship between a firm's development in digitalization and its maturity in lean operations. In line with the two perspectives presented by Dombrowski *et al*. (2017), Lorenz *et al.* (2019) claimed that digitalization and lean can complement one another by, for example, reducing shop floor complexity through digital shop floor management, enhancing flow through digital planning techniques, increasing transparency through data mining, and improving quality through the use of AA. By shortening the procedure and facilitating the data collecting phase, Lean was asserted to help digitization from the opposing viewpoint. Additionally, it was said that it would help spread technology that complement Lean thinking (Lorenz, *et al*., 2019). Subsequently, latter viewpoint emphasizes how crucial it is to have established Lean techniques before thinking about adopting I4.0.

A study by Khan (2017) on the use of IoT in healthcare monitoring noted that the use of IoT when fused with other technologies similar to wireless produce robust outcome against certain emergencies that may arise. It is the cornerstone of efficiency and effectiveness in ensuring that emergency services are handled diligently to the satisfaction of the customers and the general management. On the other hand, Tan and Wang (2010) reasoned that we are moving to an era where radio frequency identification (RFID) techniques will be the foundation of internet of things. The infusion will provide for a platform for future development of technologies that spur production efficiency especially in the manufacturing organizations. IoT has been very helpful in ensuring transformation and modernization of both the industry and the society as whole for digitalization of the knowledge by ensuring that it cannot only be sensed but also actuated in a real-time (Manjula & Rajasekaran, 2020). They further that even though IoT has contributed a lot in the digitalization, it has challenges especially on security since there is a problem with the many different gadgets and equipment used which in most cases are heterogeneous making it difficult to handle security measures adequately.

Baheti and Gill (2011) characterized cyber-physical systems (CPS) as new generational systems that usually integrate computational in addition to physical capabilities that are able to interact with human beings by various novel modalities. Their capacity to work together with the human in addition to the physical world has enabled the expansion of the physical word through efficient computation, communication as well as control thereby enabling future development of technology. Cyber-physical systems are meant to integrate knowledge of computer with engineering principles in the areas of electrical, engineering, computer, networking and controls among others (Wolf, 2009). Attachment of computers to production equipment has helped the production efficiency of the company. This has led to increased output as well as increased productivity and eventual lean manufacturing. Lee (2008) studied how cyber physical affects design changes and noted that with the variability in physical and other components of the computer oriented programs and the equipment, there are various abstractions that exists which need to embrace the physical dynamics in addition to computations but in a unified manner.

Industry-wide adoption of 4IR technologies is likely to encounter opposition in a variety of forms. Such opposition creates obstacles that provide management with a number of difficulties. Managers who make decisions must have policies in place that support the I4.0 environment. Agostini & Filippini (2019) assert that the successful adoption of I4.0 technologies depends heavily on Continuous Intergration procedures. They identified three "groups" in relation to the extent of I4.0 technology deployment for SMEs in Italy using a mixed research methodology. The article also describes statistically significant links between the managerial and organizational methods used by the companies within each cluster and the companies that belong to each cluster. As a result, the adopters share more organizational and management practices related to Lean on a process and supply chain level. According to the survey, businesses that use I4.0 technologies more actively also tend to adopt lean manufacturing and employ lean tools (Agostini & Filippini, 2019). It was not debated if the observed enhanced management and organizational practices for adopters were a result of the greater adoption of I4.0 technologies or vice versa. According to Dombrowski *et al*. (2017), there are two ways to look at the relationship between Lean and CloudRobotics: "Lean as an enabler towards I4.0" and "I4.0 as enhancing

Lean production systems" (Dombrowski, *et al.*, 2017). The results of a structured literature review conducted by Buer *et al* (2018) provide support for the two points of view.

2.4 Lean Manufacturing

Lean manufacturing strategies aim to create a fluid production flow by reducing waste and raising the value of the activities (Dan, 2020). In Streimikiene's (2019) opinion, environmental lean techniques, lean procurement practices, lean transformation methods, and lean transportation practices are all part of lean manufacturing strategies. Tsuchiya (2010) claims that in order to decrease non-value-added processes, lean manufacturing is a way of thinking and a philosophy that is applied to every action that includes a supplier and a customer. In a volatile business environment where good quality, quick delivery, and low prices are necessary, lean manufacturing is a critical competitive strategy (Panwar,2015). When a company increases labor efficiency while decreasing cycle time, customer lead times, and production costs, it may perform better (Womack & Jones, 2009; Sohal, 2007). Lean manufacturing is an integrated system comprised of interconnected procedures. Managers should be able to detect the contribution of each individual principle and distinguish the tight association and aggregate relevance of each practice when pursuing lean manufacturing due to the substantial inter correlation between practices (Huang *et al.*, 2012). Organizations employ lean manufacturing methods such as environment enablers, big just in time, and small just in time Lean manufacturing techniques, according to Dan (2020), aim to establish a fluid production flow by reducing waste and raising the value of operations. When the lean principles are acknowledged then lean manufacturing practices be used (Nepal, 2015). In their study on metrics of lean output, Jain (2015) proposes ten core traits of lean manufacturing.

Cook and Rogowski (2008) propose the same set of characteristics, but they expand the definition of process control to include standard work, process definition and focus, visual controls, cultural sensitivity, and evidence of daily accountability. Additionally, Basu (2020) categorizes employee involvement in the categories of the organization's capacity for continuous improvement and root-cause problem-solving. Dan (2020) created a scorecard for supplier development that focuses on the same traits as those listed above but also takes leadership, Lean product development, and organizational transparency into account. According to Rother and Shook, it is challenging to determine the relationship between lean manufacturing and firm operational success because of the characteristics of lean manufacturing, their cultural impact, the business breadth of implementation, and the firm operational performance indicators they affect (2009). This is particularly true for businesses applying lean manufacturing in sectors like the auto industry that are distinct from those in which it was created. Blindly focusing on specific Lean manufacturing characteristics may also cause organizations to miss out on beneficial procedures that are exclusive to a given industry and aren't covered by any predetermined and exhaustive Lean manufacturing characteristic. These techniques might emphasize supply chain pipeline inventories or retail and distribution networks (Prabhushankar, 2015).

2.5 Empirical Literature Review

The empirical analysis showed that research on 4IR technologies for lean manufacturing had been conducted in developing nations, but not with a comprehensive strategy. Reviews indicated that established nations like the European Union, the United States, and advanced Asian nations had been overlooked in studies in favor of emerging nations like Africa. Hallam and Contreras (2017), Shahram Taj (2018), and Womack *et al* (2010). Shahram Taj, (2008) studied the effectiveness of lean manufacturing in China by evaluating 65 manufacturing facilities. The results were positive. The push-pull relationship between lean manufacturing concepts and green manufacturing practices in American implementation was the focus of Hallam and Contreras' 2017 study. When businesses incorporated technologies from the fourth industrial revolution into lean production processes, they discovered a profitable association. The primary claim made by academics—that adopting lean manufacturing will boost performance and give businesses a competitive edge over rivals in developed nations—was also supported by our empirical investigation (Krafcik, 1988; MacDuffie, 2015; Chang & Lee, 2015; Lewis, 2010) (Taj and Morosan, 2011; Belekoukias, *et al.,* 2014) all conducted studies on the impact of lean manufacturing technology from the fourth industrial revolution on organizational performance in industrialized nations. However, first world countries like Europe and America had more developed organizational structures that could easily support the implementation of lean manufacturing, in contrast to poorer countries (Jorge, *et al.*, 2014). According to Onyeizugbe & Ike (2016) and Noah, *et al*., (2014) there was little research on developing countries whereas all of the preceding studies tended to focus more on the developed world .

In Kenya, studies on the impact of lean manufacturing on organizational performance were conducted by Keitany & Riwo-Abudho (2014), Ondiek & Kisombe (2012), & Openda (2013). However, little has been written about lean manufacturing in Africa, and more specifically, there has been very little research on the impact of 4IR technologies on lean manufacturing in Kenya. Lean manufacturing processes have been widely embraced in a variety of industries across the manufacturing sector in the western developed countries, according to Shibani & Ahmed's (2015) research. In fact, there is a ton of evidence that successful lean implementation has given western organizations a competitive edge, increased efficiency, increased production, and improved results. Among others, Timans (2012). According to Shibani & Ahmed (2015), the findings of the literature review identified a number of factors ranging from the ones inside the firm as well as the ones that originate from outside and probably beyond their control. Therefore, it was necessary to reevaluate studies on the effects of fourth industrial revolution technologies on lean manufacturing on organizational performance because the findings of developed countries could not be applied to other countries or reflect the entirety of developed countries.

2.6 Conceptual Framework

Conceptual framework gives credibility to the study by allowing for a variety of research-related thoughts. Conceptual model and hypothesis for the quantitative study were developed based on the theories and empirical research used in earlier investigations. Fourth-generation technology and lean manufacturing were connected, according to the conceptual framework. Lean manufacturing is conceptualized as a dependent variable in the framework, whereas technologies from the fourth industrial revolution are conceptualized as independent variables Hibani & Ahmed (2015) agreed with the research's conclusions.

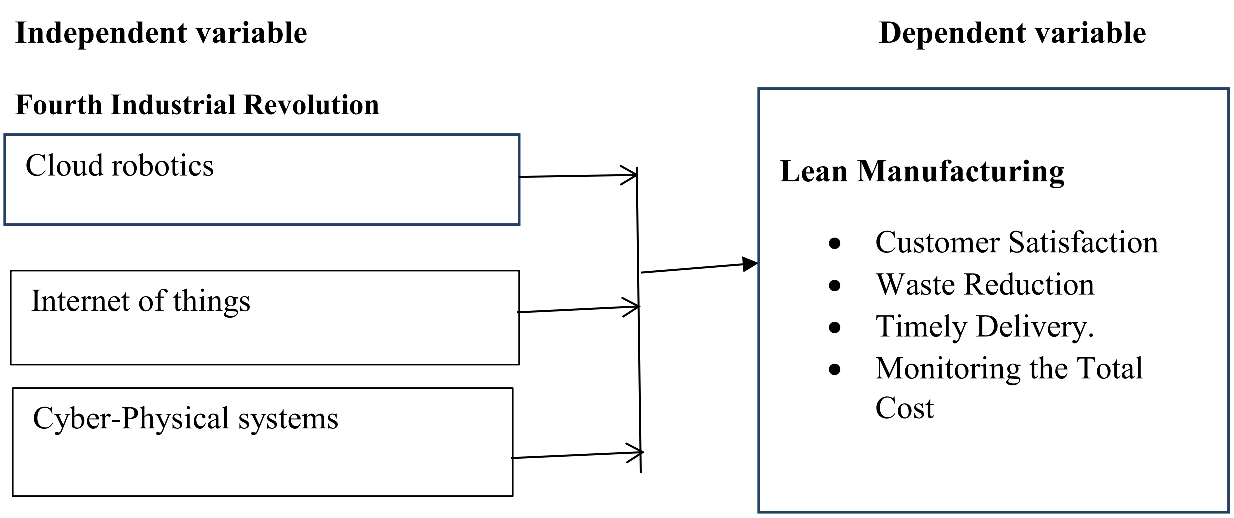

Figure 2.1: Conceptual framework

(Source: Researcher, 2022)

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the study methodology, which comprised the research design, the target population, the sample design, the data gathering techniques, the data processing steps, and the data presentation.

3.2 Research Design

Making a research question into a testing endeavor is the goal of a research design. The research questions determine the ideal design because it specifies what questions to investigate, what data to gather, how to interpret the findings, and what data are relevant, the research design is referred to as a blueprint for research. It improves data collection and use so that the needed information can be acquired with sufficient accuracy to allow for the proper testing of the hypothesis (Kothari, 2013). Since the study is attempting to focus solely on one company in isolation, a case study research approach was utilized. With the help of this research strategy, the study will be able to fully explore the research issue and concentrate on Almasi Beverages Limited in Eldoret, Kenya. The organization was visited to complete this. To prevent extraneous factors from influencing the research outcomes, the research was restricted to this one company. Because it enables the study to gather thorough information on an organization from respondents utilizing research employed questionnaires that was given a detailed account of the state of affairs in the company (Kothari, 2013), The research design used was case study.

3.3 Case Selection

Qualitative in addition to quantitative research methods was used in this investigation. Almasi Beverages Limited was the subject of the study since it is impacted by Kenya's adoption of lean manufacturing practices and technologies from the fourth industrial revolution.

3.4 Data Collection Instruments

The primary tools for gathering data for this study were questionnaires, which was carefully created to cover the pertinent categories or study issues. The choice to use questionnaires as a data collection tool was made after carefully and thoroughly analyzing the research's objectives and its target audience. A questionnaire is a type of research tool whose purpose is to give the researcher the information they need and to obtain the desired response in the form of empirical data they need to achieve their intended goal (Debois, 2016). The study organization's operational head got questionnaires from the researcher. The term "population" describes the whole set of individuals or components that share at least one characteristic. The unit of analysis encompassed the heads of departments and sub-departments who are usually involved with operational activities in the organization. The 67 operational heads at Almasi Beverages limited was the study's target population.

3.5 Data Analysis

To help with analysis, data was acquired and then cleaned, classified, and coded. Second, the data collected was examined using descriptively and inferentially. Examination of data was done by use of SPSS (Version 24.0). Descriptive plus inferential statistics were used to assess the data correlation and regression model. Regression model was applied to compare lean operations and technologies from the fourth industrial revolution statistically, with a significance threshold of

0.05. The results was presented in tables and evaluated and discussed in relation to study objectives.

The regression model:

Where:

Y= Lean manufacturing

= y intercept

B_{1-3} = Coefficient of independent variables

CR = Cloud Robotics

IT = Internet of things

CP = Cyber - physical systems

ε = Error term

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSIONS

4.0 Introduction

Analysis in addition to discussion of study results were based on study objectives and variables of the study. Ascertain the impact of technologies from the fourth industrial revolution on lean manufacturing processes at Almasi Beverages Limited in Eldoret, Kenya was the main goal of the research work. The independent variables were cloud robotics, internet of things in addition to cyber-physical systems while the dependent variable was lean manufacturing (customer satisfaction, waste reduction, timely delivery and monitoring total cost).

4.1 Questionnaire Response Rate

Respondents were issued with 67 questionnaires. Sixty four (64) were dully filled and returned. This amounted to 95.5% questionnaire return rate. This response rate is adequate for one to conduct research and give a good representation of the sample (Kothari, 2012).

Table 4.1 Questionnaire response rate

Issued	Returned	Response rate (%)
67	**64**	**95.5**

(Source; researcher, 2022)

4.2 Background Information

Information on the gender, age range, professional qualification as well as years of work in the station were vital since it provided preliminary information that formed the foundation for comprehension of the content.

Table 4.2 Background information

Categories		Frequency	%	Valid%	Cumulative %
Gender	Male	49	76.6	76.6	76.6
	Female	15	23.4	23.4	100.0
	Total	64	100.0	100.0	
Age bracket	18- 30	13	20.3	20.3	20.3
	31-40	29	45.3	45.3	65.6
	Above 40	22	34.4	34.4	100.0
	Total	64	100.0	100.0	
Professional qualification	Certificate	4	6.3	6.4	6.3
	Diploma	14	21.9	21.9	28.2
	Degree	34	53.1	53.1	81.3
	Masters degree	12	18.7	18.7	100.0
	Total	64	100.0	100.0	
Years worked	Less than 1year	6	9.4	9.4	9.4
	1-2years	9	14.1	14.1	23.5
	3-5years	30	46.9	46.9	70.4
	More than 5 years	19	29.6	29.6	100.0
	Total	64	100.0	100.0	

(Source; researcher 2022)

4.2.1 Gender

Gender of the respondents was important so that the research would indicate the degree of skewness of the gender. The results disclosed that male respondents were 49(76.6%). On the other hand, female respondents were 15(23.4%). The mainstream populace were of the male gender. Results disclosed that the organization's head of operations is male dominated.

4.2.2 Age bracket

Results showed that operational heads aged in the range of 18- 30 were 13(20.3%). The findings further indicated that those respondents aged in the range of 31-40 were 29(45.3%) while those above 40 were 22(34.4%). The bulk of the respondents were over thirty one years of age while minority were of the ages below thirty years. This indicates that the heads of operations in the organization are in their prime age of work-life and hence are able apply the technologies in order to spur lean manufacturing.

4.2.3 Professional qualification

The study findings indicated that certificate holders were 4(6.3%) while respondents with diploma were 14(21.9%). Similarly, degree holders were 34(53.1%) while the ones with masters degree were 12(18.7%). The results discovered that majority of operations heads were graduates constituting more than a half of all the heads. Just a few of the heads of operations were having mere college certificate. With majority being graduates, there is indication that they are able to comprehend not only the subject matter but also the operational activities that require the use technology like cloud robotics, internet of things as well as cyber physical systems.

4.2.4 Years worked in work station

Years of experience was sought from the respondents and the findings showed that those who had worked in the station for less than 1year were 6(9.4%). This constituted the least of the heads that had worked in their current workstation for few years. Additionally, some 9(14.1%) had worked in the workstation for between 1-2years. Those who had worked in the work station for 3-5years were 30(46.9%) while some 19(29.6%) had worked in the work station for more than 5 years.

4.3 4IR

The study looked at various elements of 4IR. Rating in the scale ofof 1-5 where 1 is strongly disagree and 5 strongly agree was required from the respondents. Elements and results are present as follows:

4.3.1 Cloud robotics

Cloud robotics elements namely: cloud and virtualization, information integration in addition to real-time updates were identified and discussed.

Table 4.3: Cloud robotics

Statement	N	Mean	Std. Deviation
Cloud and Virtualization are the main drivers to speed up in manufacturing	64	4.2000	.89057
Information integration is one of the main challenges in implementing Cloud robotics in the lean operations	64	3.9402	.71314
Cloud robotics facilitate real-time updates of manufacturing cycle time.	64	4.6701	.64698
Cloud robotics facilitates real time updates of failure issues notifications	64	4.5412	.62925
Relying on cloud robotics is a valid solution to guarantee high level of security of the company network	64	2.8332	.87498

(Source: Researcher, 2022)

Table 4. 3 indicated that cloud and Virtualization are the main drivers to speed up in manufacturing as supported by a mean of 4.2000 and standard deviation of .89057. They help the organization to increase productivity in addition to efficient production and operational improvement. The results further revealed that information integration is one of the main challenges in implementing Cloud robotics in the lean operations as evidenced in table 4.3 presenting a mean of 3.9402 with standard deviation of .71314. High-performance computing, system architecture, and information integration can be major challenges in cloud computing deployment (Borangiu *et al*, 2019).

Correspondingly, cloud robotics facilitate real-time updates of manufacturing cycle time and that cloud robotics facilitates real time updates of failure issues notifications. This was supported by a mean of 4.6701 and standard deviation .64698 and a mean of 4.5412 with standard deviation of .62925 respectively. It is very easy to come up with remedial or corrective actions when failures and issues are reported promptly. It assists in preventing failure overlaps and adverse effect on other operational activities. A cloud-based supply chain management system improves supply chain responsiveness, which is regarded as essential in today's purpose of organizations to better respond to customer demand and environmental changes (Giannakis *et al*, 2019). However, the findings showed that relying on cloud robotics is not a valid solution to guarantee high level of security of the company network as evidenced through a mean of 2.8332 plus standard deviation of .87498. There are other features in the devices that have been paired that may pose as a challenge and fail to guarantee security.

Table 4.4 Correlation between cloud robotics and lean manufacturing

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Interval by Interval	Pearson's R	.872	.023	12.822	.000[c]
Ordinal by Ordinal	Spearman Correlation	.756	.033	12.552	.000[c]
N of Valid Cases		64			

(Source: Researcher, 2022)

Table 4.4 showed relationship between cloud robotics and lean manufacturing with results producing Pearson's correlation of R=0.872. The findings showed that cloud robotics contributes to the level of lean manufacturing. The results corresponds with arguments by Borangiu *et al* (2019) that cloud computing and virtualization are the two most important drivers boosting production. The use of cloud robotics and other related systems enhances lean manufacturing and provides competitive advantage to the firms that have absorbed its use.

4.3.2 Internet of things

The study looked at various internet of things elements and results are presented in table 4.5 as follows.

Table 4.5 Internet of things

Category	N	Mean	Std. Deviation
The application of IoT and Big Data in manufacturing is set to increase the efficiency	64	4.1062	.70608
IOT helps firms' competitiveness through the interconnection of every resource within the value chain	64	4.5488	.78972
IoT allows for improved planning as well as more effective coordination through with data analytics.	64	3.2763	.78266
IOT helps prompt informing for over-production, waste and renewal	64	4.2938	.72143
New abilities facilitated by intelligence in addition to connectivity aid elimination of waste	64	3.2311	.96799
IoT allows connected devices to sense and interact, allowing remote control across connected network infrastructure,	64	4.4532	1.10980
IOT allows for creation of an opportunity of direct incorporation of physical components into computer-based systems translating into increased efficiency and accuracy	64	4.0254	.65302

(Source: Researcher, 2022)

Table 4.5 indicated the results of the findings on internet of things (IoT). The results discovered that the application of internet of things and big data in manufacturing is set to increase the efficiency as demonstrated by a mean of 4.1062 and standard deviation of .70608. This is because it lives up to the principle of lean manufacturing in which perfection, flow in addition to value streaming is the key. Operational efficiency is very fundamental in not only ensuring lean manufacturing but also increasing operational performance in general. Manufacturing has been dependent on information technology to ensure that there is production maximization with minimum wastages. Information technologies and operation technologies are the two primary smart manufacturing technology pillars of the Fourth Industrial Revolution. (Malavasi & Sanetti, 2017).

Consequently, the findings revealed that internet of things helps firms' competitiveness through the interconnection of every resource within the value chain as represented with mean of 4.5488 and standard deviation (SD) of .78972. The outcomes however revealed that mainstream populace were not sure whether internet of things allows for improved planning as well as more effective coordination through with data analytics as represented by a mean of 3.2763 and standard deviation of .78266. This could be attributed to the fact that planning is actually done without the use of fourth industrial technologies since the environment dictates the kind of plans to be utilized.

Internet of things helps instantaneous signaling for overproduction, waste and replenishment. This was evidenced in table 4.4 by a mean of 4.2938 and SD of .72143. Internet of things has been very helpful in ensuring transformation and modernization of both the industry and the society as whole for digitization of the knowledge by ensuring that it cannot only be sensed but also actuated in a real-time (Manjula & Rajasekaran, 2020). In the contrary, respondents did not agree to a large extent that new abilities facilitated by intelligence in addition to connectivity aid elimination of waste as this was supported with a mean of 3.2311 and SD of .96799. Intelligence and connectivity is about ensuring that several devices are linked together but it cannot work in isolation unless comprehended by human awareness.

IoT allows connected devices to sense and interact, allowing remote control across connected network infrastructure as evidenced by a mean of 4.4532 and SD of 1.10980. Connectivity through IoT allows for multifaceted technology comprising of an array of devices linked with some elements of artificial intelligence and connectivity. The findings further revealed that internet of things allows for creation of an opportunity of direct incorporation of physical components into computer-based systems translating into increased efficiency and accuracy as represented with a mean of 4.0254 and SD of .65302. This allows for object oriented production that reduces labour intensity through automation of production.

Table 4.6 Correlation between Internet of things and lean manufacturing

		Value	**Asymp. Std. Error[a]**	**Approx. T[b]**	**Approx. Sig.**
Interval by Interval	Pearson's R	.894	.028	14.352	.000[c]
Ordinal by Ordinal	Spearman Correlation	.782	.238	12.224	.010[c]
N of Valid Cases		64			

(Source: Researcher, 2022)

Table 4.6 shows findings on correlation between internet of things and lean manufacturing. Findings showed Pearson correlation value= 0.894 which indicating positive relationship between the variable (internet of things and lean manufacturing).

4.3.4 Cyber-physical systems

The study looked at various 4IR elements and results are presented in table 4.7 as follows.

Table 4.7 Cyber-physical systems

Statements	N	Mean	Std. Deviation
Heightened uninterrupted flow can be created by automatic scheduling alterations by cyber-physical System as well as Intelligence	64	4.8664	.68802
Operators' competencies can be enhanced by virtual tools	64	4.2608	.76323
The redundant use of digital capacities of smart manufacturing technologies gives rise to digital waste	64	3.8833	.87320
Cyber-physical Systems ensure enhanced process time by progressive analytics and uninterrupted flow	64	3.9165	.82062
Cyber-physical leads to increased production and material data efficiency	64	3.2722	.66480

(Source: Researcher, 2022)

Table 4.7 showed results of the findings on cyber-physical systems. Findings indicated that Heightened uninterrupted flow can be created by automatic scheduling alterations by cyber-physical System as well as Intelligence as supported by a mean of 4.8664 and standard deviation of .68802 while on the same note, results showed as supported by a mean of 4.2608 and standard deviation of .76323 that operators' capabilities can be enhanced through virtual tools. When the firm uses automation in production process, the efficiency by which the orders are processed, customers are served in addition to the efficiency in production leads to a leaner manufacturing and increased performance at the same time. Baheti & Gill (2011) characterized cyber-physical systems (CPS) as new generational systems that usually integrate computational in addition to physical capabilities that are able to interact with human beings by many new modalities.

The redundant use of digital capacities of smart manufacturing technologies gives rise to digital waste though not to a very large extent as supported by a mean of 3.8833 and standard deviation of .87320. Similarly, respondents were of the view that cyber-physical systems ensure enhanced process time through progressive analytics and uninterrupted flow as this was supported by a mean of 3.9165 and standard deviation of .82062. This leads to improved operational cost coming as a result of use of devices that operates like cybernetics in production. The findings are in tandem with Agostini & Filippini (2019) who carried a survey and noted out that businesses who use I4.0 technologies more actively also tend to adopt lean manufacturing and employ lean tools.

However, the study findings indicated that respondents were of the view that cyber-physical does not lead to a large extent increased production and material data efficiency as supported by a mean of 3.2722 and standard deviation of .66480. Production of the firm is influenced by several factors both internal and external not withstanding that cyber physical systems are choices made by the management.

Table 4.8 Correlation between Cyber-physical and lean manufacturing

		Value	**Asymp. Std. Error[a]**	**Approx. T[b]**	**Approx. Sig.**
Interval by	Pearson's R	.880	.027	11.392	.000[c]

Interval					
Ordinal by Ordinal	Spearman Correlation	.784	.038	11.624	.000[c]
N of Valid Cases		64			

(Source: Researcher, 2022)

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Table 4.8 shows findings on correlation cyber-physical systems and lean manufacturing. Results showed Pearson correlation value=0.880 indicating positive relations between the variable. These findings echoes results from Jain (2015) that cyber-physical systems and related systems are very valuable in ensuring efficiency and making sure that there is lean production systems. In his study on metrics of lean output, Jain (2015) proposes ten core traits of lean manufacturing.

4.4 Lean manufacturing

The study looked at various lean manufacturing elements and results are presented in table 4.9 as follows. Rating in a scale of 1-5 where 1 is strongly disagree while 5 is strongly agree was desired from respondents.

Table 4.9 Lean manufacturing

Statement	N	Mean	Std. Deviation
Main objective of lean production is reducing wastes and improving productivity	64	4.5464	.80674
Customers' requirements can better be met through lean operations	64	3.8134	.61804
Innovators, shareholders and investors have greatly benefited from the application of lean operations	64	3.0776	.64266
The application of Industry 4.0 in lean manufacturing has ensured continuity in production	64	3.9887	1.04490
Reduction of costs have been effected by automation of systems	64	3.7542	.62822
There is increased output as a result of automation of systems	64	4.1566	.67729

(Source: Researcher, 2022)

Table 4.9 showed results for lean manufacturing. The findings indicated that the main objective of lean production is reducing wastes and improving productivity as supported by a mean of 4.5464 and standard deviation of .80674. This results resonates with the results according to Wakiga (2021), that Industry 4.0 has the ability to address these gaps by maintaining continuity, cutting costs while improving production through system automation, which is one of the corporate survival strategies and a launching pad for rebound tactics. The results further showed that customers' requirements can better be met through lean operations as evidenced by a mean of 3.8134 and standard deviation of .61804. The results however indicated that innovators, shareholders and investors have not greatly benefited from the application of lean operations as this was supported by a mean of 3.0776 and standard deviation of .64266.

On the other hand, respondents were in agreement that the application of Industry 4.0 in lean manufacturing has ensured continuity in production as evidenced in table 4.9 with a mean of 3.9887 and standard deviation of 1.04490. The results are in correspondence with findings by Golchev (2019) that grossing manufacturing organizations have achieved this status as a result of the organization's effective adoption of Lean Manufacturing principles and techniques highlights the crucial relationship between 4IR technology and lean manufacturing.

The results showed that generally, reduction of costs have been effected by automation of systems to some extent as supported by a mean of 3.7542 and standard deviation of .62822. Consequently, the findings indicated that as supported by a mean of 4.1566 and standard deviation of .67729 that there is increased output as a result of automation of systems. Lean Manufacturing's primary goal is to streamline processes so that they can produce goods at the required rate to meet customer demand and continuously reduce the time between an order and delivery by getting rid of everything that adds time or expense (Machado,2019).

4.5 4IR and lean manufacturing

The study looked at the relationship between 4IR and lean manufacturing. Regression analysis was used to determine the degree of relationship. The study sought to find the general contribution of the predictors to the dependent variable by deriving a model fit. Findings to this was presented in table 4.10 as shown below.

Table 4.10 Regression model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.730[a]	.533	.505	.4464	.533	58.410	4	60	.000	2.031

a. Predictors: (Constant), Cloud Robotics , Internet of things, Cyber physical systems

b. Dependent Variable: Lean manufacturing

Table 4.10 indicated R square as 0.533 while adjusted R square 0.505, this means that 50.5% change in 4IR as a measure of lean manufacturing. 49.5% of the unexplained variances is because of factors not included in the study.

ANOVA was used to determine the level of fit of regression at confidence level of 95% .

Table 4.11 ANOVA for Combined Effect of Independent Variables on lean manufacturing

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	56.675	4	11.143	58.410	.000[b]
	Residual	54.199	60	.178		
	Total	110.874	64			

a. Dependent Variable: Lean manufacturing

b. Predictors: (Constant), Cloud robotics, Internet of things, Cyber physical systems

The F- ratio represents the proportion of improvement in prediction that results from fit in the regression model, comparative to the imprecision that subsists in the model. The F- ratio realized was 58.410 which was coincidental and was significant (P< .000). The model considerably improved the ability to predict the degree of lean manufacturing in Almasi limited.

Since the model was found to be fit, establishment how a unit of predictors contributes to the dependent variable.

Table 4.12 Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	.188	.154		1.4	.290
	Cloud robotics	.372	.036	1.114	31.2	.022
	Internet of things	.328	.348	.301	3.6	.212
	Cyber-physical systems	.482	.042	.242	7.8	.323

a. Dependent Variable: Lean manufacturing

Findings on coefficients in table 4.12 shows that 1 unit of cloud robotics contributes to 37.2% of lean manufacturing while 1 unit of internet of things contributes to 32.8% of lean manufacturing. Lastly, 1 unit of cyber-physical systems contributes to 48.2% of lean manufacturing.

The multiple regression model is as follows:

Where: Y= Lean manufacturing

= y intercept

$B_{1-3} =$ Coefficient of independent variables

CR = Cloud Robotics

IT = Internet of things

CP = Cyber-physical systems

ε = Error term

Y= 0.188 +0.372+ 0.328+ 0.482+0.154

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Overview

The chapter contained five main sections namely: findings, summary, study conclusions, limitations of the study, recommendations and suggestions for future research.

5.2 Summary of the study

Results showed that the majority of the respondents were of the male gender indicating that the organization's head of operations is male dominated. On the years worked on the work station, the findings revealed that those who had worked for less than one year constituted the least of the heads that had worked in their current workstation while those who had worked in the work station for between 3-5years were the majority. The findings revealed on matters age that most heads were over thirty one years of age while minority were of the ages below thirty years. This indicates that the heads of operations in the organization are in their prime age of work-life and hence are able apply the technologies in order to spur lean manufacturing.

The results indicated that cloud and Virtualization are the main drivers to speed up in manufacturing and in the same findings further revealed that information integration is one of the main challenges in implementing cloud robotics in the lean operations. Correspondingly, cloud robotics facilitate real-time updates of manufacturing cycle time and that cloud robotics facilitates real time updates of failure issues notifications. However, the findings showed that relying on cloud robotics is not a valid solution to guarantee high level of security of the company network. Finally, the findings that relationship between cloud robotics and lean manufacturing. The findings showed that cloud robotics contributes to the level of lean manufacturing.

Results showed that the application of IoT and Big Data in manufacturing is set to increase the efficiency and further revealed that internet of things helps firms' competitiveness through the interconnection of every resource within the value chain. Similarly, the findings however revealed that respondents were not sure whether internet of things allows for enhanced planning in addition to a more effective organization with upstream stream through data analytic. Internet of things helps instantaneous signaling for overproduction, waste and replenishment. This was evidenced in the findings. In the contrary, respondents did not agree to a large extent that new competencies permitted by Intelligence in conjunction with Connectivity aids elimination waste whereas the findings on the other hand revealed that internet of allows connected devices to sense and interact, allowing remote control across connected network infrastructure. The findings further revealed that internet of things allows for creation of an opportunity of direct integration of physical components into computer-based systems translating into increased efficiency and accuracy. Correlation analysis findings between internet of things and lean manufacturing showed Pearson correlation value of 0.894 which indicated a positive relationship between the variable items.

The analysis was also carried on cyber-physical systems. Findings indicated that enhanced uninterrupted stream can be created by automatic scheduling alterations through cyber-physical System and Intelligence while on the same note, results showed that operators' capacities can be improved by virtual tools. The redundant use of digital capacities of smart manufacturing technologies gives rise to digital waste. Similarly, cyber-physical systems ensure enriched process time by progressive analytics and uninterrupted flow. However, the study findings indicated that respondents stated that cyber-physical does not lead to a large extent increased production and material data efficiency. The findings on correlation between cyber-physical systems and lean manufacturing showed a positive relationship between the variable items.

Concerning lean manufacturing, the findings indicated that the main objective of lean production is reducing wastes and improving productivity and further indicated that customers' requirements can better be met through lean operations. The results however indicated that innovators, shareholders and investors have not greatly benefited from the application of lean operations. On the other hand, respondents were in agreement that the application of Industry 4.0 in lean manufacturing has ensured continuity in production. Subsequently, the results showed that generally, reduction of costs have been effected by automation of systems to some extent and in addition, findings indicated there is increased output as a result of automation of systems. Finally, the findings revealed that there is strong relationship between 4^{th} industrial technologies and lean manufacturing.

5.3 Conclusion of the study

Conclusion made that technologies from the fourth industrial revolution have an impact on lean manufacturing processes at Almasi Beverages Limited in Eldoret, Kenya. There is strong positive relationship between fourth industrial technologies (cloud robotics, IoT and cyber-physical systems. In particular, Cyber-physical system has the highest impact followed by cloud robotics and closely followed by internet of things.

5.4 Recommendations for further studies

Recommendations are made on the influence of fourth industrial technologies on the performance of manufacturing companies. A further study can be carried on the role of fourth industrial technologies on operational efficiency. This will open new knowledge on to help in spreading the use of 4IR in companies so that production can be enhanced. It will also enable the government to come up with policies that will make it easy for manufacturing companies to introduce 4IR.

5.5 Limitations of the study.

Almasi Limited was the center of the study which locked out other companies. It was particularly delimited on Almasi limited, Eldoret. The study was mainly narrowed on primary data only. It also covered 4IR and lean manufacturing. The variables under study were cloud robotics, IoT and cyber-physical systems which does not include all the 4IR elements.

5.6 Suggestions for further studies

The study suggest a research to be carried out on 4IR and performance of manufacturing companies in Kenya.

REFERENCES

9,418,328.Washington,DC:U.S.PatentandTrademarkOffice.

Abu, F., Gholami, H., Saman, M. Z. M., Zakuan, N., & Streimikiene, D. (2019). The

Alcácer,V., &Cruz-Machado,V.(2019).Scanningthe industry4.0: literaturereviewontechnologies for manufacturing systems. *Engineering Science and Technology, anInternationalJournal*.

Asiamah, N., Mensah, H. K., &Oteng-Abayie, E. F. (2017). General, target, and accessiblepopulation:Demystifyingtheconceptsforeffectivesampling.T*he*

Azubuike, M. V. (2015). The Impact Of Information Technology On The Performance OfStaffInNigeriaBankingSector:*ACaseStudyOfKeystoneBankLimited* (Doctoraldissertation,Obafemi Awolowo University,Ile-Ife, Nigeria.

Baheta, R. & Gill, H. (2011). Cyber-physical systems. The impact of control technology, 12(5), 161-166.

Bala,M.,&Kumar,D.(2011).Supplychainperformanceattributesforthefastmovingconsumer goods industry. *Journal of Transport and Supply Chain Management*, *5*(1), 23-38.

Basu, P., & Dan, P. K. (2020). A comprehensive study of manifests in lean manufacturing implementation and framing an administering model. *International Journal of Lean Six Sigma*.

Bhandari, R. (2014). Impact of technology on logistics and supply chain management. *IOSRJournalof Business and Management*, *2*, 17.

De Pace F, Manuri F, Sanna A (2018) Augmented Reality in Industry 4.0. Am J ComptSciInformTechnol Vol.6 No.1:17.doi: 10.21767/2349-3917.100017

Devaraj, S., Krajewski, L., & Wei, J. C. (2007). Impact of eBusiness technologies on operationalperformance: the role of production information integration in the supply chain. *JournalofOperations Management*, *25*(6), 1199-1216.

Erboz, G. (2017, November). How to Define Industry 4.0: Main Pillars Of Industry 4.0. In *7thInternationalConferenceon Management(ICoM 2017)*.

Eshikumo,S.M.,&Odock,S.O.(2017).GreenManufacturingandOperationalPerformanceofa Firm: Case of Cement Manufacturing in Kenya. *International Journal of Business andSocialScience*, *8*(4).

Feigin, G. E., Katircioglu, K., & Yao, D. D. (2003). Distribution resource planning systems: Acritique and enhancement. In *Analysis and Modeling of Manufacturing Systems* (pp. 37-68).Springer, Boston, MA.

Fettermann, D. C., Cavalcante, C. G. S., Almeida, T. D. D., &Tortorella, G. L. (2018). How doesIndustry 4.0 contribute to operations management?. *Journal of Industrial and ProductionEngineering*,*35*(4), 255-268.

Frank, A. G., Dalenogare, L. S., & Ayala, N. F. (2019). Industry 4.0 technologies:Implementation patterns in manufacturing companies. *International Journal ofProductionEconomics*, *210*, 15-26.

Gengel,G.W.,Hadley,M.A.,Pounds,T.,Schatz,K.D.,&Drzaic,P.S.(2016).*U.S.PatentNo.*

Güleş, h. K., Cağliyan, v., &Bedük, M. (2012).The Strategic Impact of Information TechnologiesonSupplyChain and Business Performance.*Journalof Business Research–Türk*.

He,K., &Jin,M.(2016).Cyber-PhysicalsystemsformaintenanceinIndustry4.0.

Hitt, L. M., &Snir, E. M. (1999). The role of information technology in modern production:complementorsubstitutetootherinputs.In *WorkshoponInformationSystemsandEconomics*.

Hwang,G.,Han,S.,Jun,S.,&Park,J.(2014).OperationalPerformanceMetricsinManufacturing Process: Based on SCOR Model and RFID Technology. *InternationalJournalof Innovation, Management and Technology*,*5*(1), 50-55..

implementation of lean manufacturing in the furniture industry: A review and analysis on the motives, barriers, challenges, and the applications. *Journal of Cleaner Production*, *234*, 660-680.

Ivantysynova,L.,Klafft,M.,Ziekow,H.,Günther,O.,&Kara,S.(2009,July).RFIDinmanufactu ring: The investment decision. In *Pacific Asia International Conference onInformationSystems, Hyderabad, India*.

Jadhav, V. V. (2015). Role of information technology in supply chainmanagement. *International Journal of Management Research & Review, IJMRR*, *5*, 369-379.

Khan, S.F. (2017). Health care monitoring system in internet of things (IoT) by using RFID. *International conference on industrial technology and management* (ICITM), 198-204.

Lee, E.A. (2008).Cyber physical systems: Design changes. 11th IEEE international systema on object and component-oriented real-time distributed computing (ISORC), 363-369.

Manjula, V. & Rajasekaran, R.T. (2020). Security vulnerability in traditional wireless sensor networks by an intern on IoT, blockchain technology for data sharing in IoT. Principles of internet of things (IoT) ecosystem: insight paradigm, 579-597.

Panwar, A., Nepal, B. P., Jain, R., & Rathore, A. P. S. (2015). On the adoption of lean manufacturing principles in process industries. *Production Planning & Control*, *26*(7), 564-587.

Prabhushankar, G. V., Kruthika, K., Pramanik, S., & Kadadevaramath, R. S. (2015). Lean manufacturing system implementation in Indian automotive components manufacturing sector-an empirical study. *International Journal of Business and Systems Research*, *9*(2), 179-194.

QualitativeReport,*22*(6), 1607-1621.

Tan, L. & Wang, N. (2010). Future internet. The internet of things. *3rd international conference on advanced computer theory and engineering (ACACTE)*, 5(5), 376-380.

Wolf, W. (2009). Cyber-physical systems. Computers 42(3)

APPENDIX I: INTRODUCTORY LETTER

Dear respondent,

I am a student researcher from University of Nairobi. I am currently conducting an academic research on the ‘Effect of Fourth Industrial Revolution Technologies on Lean Manufacturing in Kenya; A case of Almasi Beverages Limited’. The questionnaire below is for collecting data purely for academic purposes. You are requested to provide information required with utmost sincerity. All the information given will be treated with utmost confidentiality.

Kindly fill the questionnaire.

Yours faithfully;

Sheilah Barno

Appendix II: QUESTIONNAIRE

Dear Sir/madam,

. The answers to the inquiries on this form will be provided by the staff of Almasi Beverages Limited. Keeping the information confidential will be our key ethical concern. The study's objective is to evaluate, using Almasi Beverages Limited as an illustration, how technology from the Fourth Industrial Revolution have affected lean manufacturing in Kenya. Please take the time to honestly answer the following questions.

SECTION A: Demographic Details

What tick your gender?

Male ( )

Female ( )

What is your age bracket?

18-30 years ( )

31-40 years ( )

Above 40 years ( )

What is your professional qualification?

Certificate ( )

Diploma ( )

Degree ( )

Masters Degree ( )

Others ( ) please specify……………………………….

How many years have you worked in your current work station?

Less than one year ( )

1-2 years ( )

3-5 years ( )

More than 5 years ( )

SECTION B: Cloud Robotics

In a scale of 1-5, Indicate your level of agreement on the effect of cloud robotics on lean manufacturing.1-Strongly Disagree, 2-Disagree, 3-Uncertain, 4-Agree, 5- Strongly Agree.

Statement	1	2	3	4	5
Cloud and Virtualization are the main drivers to speed up in manufacturing					
Information integration is one of the main challenges in implementing Cloud robotics in the lean operations					
Cloud robotics facilitate real-time updates of manufacturing cycle time.					
Cloud robotics facilitates real time updates of failure issues notifications					
Relying on cloud robotics is a valid solution to guarantee high level of security of the company network					

SECTION C: Internet of Things

In a scale of 1-5, indicate your level of agreement on the effect of Internet of Things and Lean manufacturing. The scale as follows is applicable; 1-Strongly Disagree, 2-Disagree, 3-Uncertain, 4-Agree, 5- Strongly Agree.

Statement	1	2	3	4	5
The application of Internet of Things and Big Data in manufacturing is set to increase the efficiency					
IOT helps firms' competitiveness through the interconnection of every resource within the value chain					
IoT allows for better planning and more effective coordination with upstream supply through data analytics.					
IOT helps instantaneous signaling for overproduction, waste and replenishment					
New capabilities enabled by Intelligence and Connectivity help eliminate waste					
IoT allows connected devices to sense and interact, allowing remote control across connected network infrastructure,					
IOT allows for creation of an opportunity of direct integration of physical components into computer-based systems translating into increased efficiency and accuracy					

SECTION D: Cyber-physical Systems

In a scale of 1-5, indicate your level of agreement on the effect of cyber-physical Systems and Lean manufacturing. The scale as follows is applicable; 1-Strongly Disagree, 2-Disagree, 3-Uncertain, 4-Agree, 5- Strongly Agree.

Statement	1	2	3	4	5
Enhanced continuous flow can be established by automatic scheduling adjustments through cyber-physical System and Intelligence					
Operators' capabilities can be enhanced through virtual tools					
The redundant use of digital capabilities of smart manufacturing technologies give rise to digital waste					
Cyber-physical Systems ensure improved process time through advanced analytics and continuous flow;					
Cyber-physical leads to increased production and material data efficiency					

SECTION E: Lean Manufacturing

In a scale of 1-5, indicate your level of agreement on the measures of lean manufacturing. The scale as follows is applicable; 1-Strongly Disagree, 2-Disagree, 3-Uncertain, 4-Agree, 5- Strongly Agree.

Statement	1	2	3	4	5
Main objective of lean production is reducing wastes and improving productivity					
Customers requirements can better be met through lean operations					
Innovators, shareholders and investors have greatly benefited from the application of lean operations					

The application of Industry 4.0 in lean manufacturing has ensured continuity in production					
Reduction of costs has been effected by automation of systems					
There is increased output as a result of automation of systems					

Thank You for Your Cooperation