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EFFECT OF SUSTAINABLE LEAN SIX SIGMA ON OPERATIONAL EFFICIENCY IN SOUTHEAST NIGERIA'S FOOD INDUSTRY

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Abstract: *The study examined the effect of Sustainable Lean Six Sigma on operational efficiency in Southeast Nigeria's food industry. The specific objectives were to; evaluate the effect of the continuous improvement process on the operational efficiency and identify the effect of eliminating waste on operational efficiency in Southeast Nigeria's food industry. A survey research design was selected for the investigation. A standardized questionnaire with a point Likert scale was used to collect data for the study. The data was analyzed using the mean, standard deviation, and fundamental percentages. (SPSS version 20, a program for descriptive statistics). The result review that Continuous improvement process has a significant positive effect on the operational efficiency with the calculated Z- value of 7.098 < 10.089 against the critical Z- value of .000. while Eliminating waste has a significant positive effect on operational efficiency with the calculated Z- value of 7.117 < 11.160 against the critical Z- value of .000 in Southeast Nigeria's food industry.*
Keywords: *Efficiency, Lean, Operational, Sigma, Six*

1.1 Introduction

In today's increasingly interconnected and environmentally conscious world, organizations face mounting pressure to optimize their operations while minimizing their environmental and social impact (Abubakar & Igbokwe, 2022; Uche, 2024). This dual challenge has spurred the rise of Sustainable Lean Six Sigma (SLSS). This powerful integrated methodology combines the process improvement principles of Lean Six Sigma with the goals of sustainability, providing effective solutions to those dual challenges organizations face. It is opined that Sustainable Lean Six Sigma provides a comprehensive approach to enhancing organizational performance, minimizing waste, and promoting environmental and social responsibility (Ajayi, 2023). To appreciate the significance of Sustainable Lean Six Sigma, it is essential to understand its constituent methodologies, which Originated from Toyota's production system, Lean focuses on eliminating waste ("muda" in Japanese) in all its forms,

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including defects, overproduction, waiting, non-utilized talent, transportation, inventory, motion, and extra processing. By streamlining processes and improving efficiency, Lean aims to deliver maximum value to customers with minimal resource consumption (Chinedu, 2023; Eze, 2023; Ndukwe, 2023).

In the context of business, sustainability encompasses environmental, social, and economic dimensions, often referred to as the "triple bottom line." It involves minimizing environmental impact through resource conservation, pollution prevention, and waste reduction; promoting social equity through fair labour practices, community engagement, and ethical sourcing; and ensuring long-term economic viability through efficient operations and responsible financial management (Chinedu, 2023; Eze, 2023).

Operational efficiency refers to the ability of an organization to deliver goods or services with minimal waste of resources, including time, materials, energy, and human effort (Okafor, 2022). In the context of SLSS, operational efficiency is not solely focused on cost reduction and output maximization but also on minimizing environmental impact and promoting social well-being (Nwankwo & Chukwu, 2024). This broader perspective requires a shift in mindset, where efficiency gains are evaluated in terms of their overall contribution to the "triple bottom line": economic, environmental, and social performance (Okwudili, 2024).

Southeast Nigeria's food industry is a critical sector for economic growth and development, contributing significantly to the region's GDP and employment. However, the industry grapples with inefficiencies, high levels of waste, and environmental degradation due to unsustainable practices (Obi, 2024). According to recent reports, the region's food supply chain is often characterized by inadequate infrastructure, poor logistics, and limited access to modern technologies, leading to high rates of spoilage and waste (Oko, 2023). These challenges necessitate innovative solutions to enhance operational efficiency and promote sustainability.

1.2 Statement of the Problem

The food industry in Southeast Nigeria is critical to the region's economic growth, yet it faces significant challenges related to operational inefficiency, high levels of waste, and sustainability concerns. Despite the potential benefits of Sustainable Lean Six Sigma (SLSS) in enhancing operational efficiency, many food manufacturers in this region have not fully adopted or implemented these practices. This gap results in suboptimal resource utilization, increased costs, and a negative environmental impact, ultimately hindering the industry's competitiveness and sustainability.

Specifically, the lack of streamlined processes and inadequate waste reduction strategies contributes to substantial food spoilage and inefficiencies throughout the supply chain. Additionally, cultural resistance to change and insufficient training further impede the adoption of SLSS methodologies. As a result, the operational efficiency of food manufacturers in Southeast Nigeria remains below potential, adversely affecting not only their profitability but also their ability to contribute to regional economic development and environmental sustainability.

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This study aims to investigate the effects of Sustainable Lean Six Sigma on operational efficiency within Southeast Nigeria's food industry, identifying barriers to implementation and proposing actionable strategies for enhancing both economic and environmental performance.

1.3 Objective of the study

The main objective of this study is to examine the effect of Sustainable Lean Six Sigma on operational efficiency in Southeast Nigeria's food industry. The specific objectives were to;

i. Evaluate the effect of the continuous improvement process on the operational efficiency in Southeast Nigeria's food industry.

ii. Identify the effect of eliminating waste on operational efficiency in Southeast Nigeria's food industry.

1.4 Hypotheses of the study

i. The Continuous improvement process has no significant effect on the operational efficiency in Southeast Nigeria's food industry.

ii. Eliminating waste has no significant effect on operational efficiency in Southeast Nigeria's food industry.

Literature Review

2.1 Conceptual Review

Sustainable Lean Six Sigma

In recent years, Lean Six Sigma (LSS) has drawn significant attention for its ability to improve environmental performance and encourage sustainable manufacturing practices (Zhang, Luo, & Skitmore, 2015; Ganjavi & Fazlollahtabar, 2021). LSS is an approach that reduces waste and errors in business processes by combining Six Sigma quality management with Lean manufacturing principles. However, by implementing strategies like energy efficiency, waste reduction, and the utilization of renewable resources, sustainable manufacturing practices seek to lessen the adverse effects of production on the environment (Antony, Snee, Hoerl, & Management, 2017). Analyzing the connection between LSS principles, data-driven decision-making, and environmental performance within the framework of sustainable manufacturing practices is the goal of this review of the literature. Relevant keywords and search terms, including "Lean Six Sigma," "sustainable manufacturing," "environmental performance," and "data-driven decision making," were used to search academic databases and other sources in order to obtain a wide range of literature on the subject (Huang et al, 2023).

The review will then synthesize and analyze the literature to determine the critical elements that support the effective application of LSS in advancing sustainable manufacturing practices and enhancing environmental performance. Through an analysis of the literature, the review seeks to offer insights and suggestions for manufacturing firms looking to enhance their environmental sustainability while preserving operational effectiveness and profitability (Huang et al, 2023). The body of research on LSS in sustainable manufacturing practices and its impact on environmental performance provides

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us with useful data and case studies. But additional research is required to understand the particular issues that arise when LSS is applied to sustainable production (Huang et al, 2023).

The advantages and effective applications of LSS for sustainable manufacturing have received more attention in the literature than the possible drawbacks and restrictions of this approach. Furthermore, not many studies look at the combination of data-driven methods and LSS concepts to enhance environmental performance. More research is required to determine how data-driven decision-making might improve LSS's ability to support environmentally friendly production methods and sustainable manufacturing practices, even if some studies have examined how data science fits into LSS and how it impacts various industries (Huang et al, 2023). Future studies could examine the particular issues that come up when using LSS in environmentally friendly production and how they might be resolved. It would be advantageous to investigate the ways in which LSS concepts and data-driven approaches complement one another to enhance environmental performance in various businesses. This would increase our understanding of the subject and provide industry professionals with the resources they need to advance sustainable manufacturing methods.

Continuous Improvement (CI)

Continuous Improvement (CI), also known as Kaizen (Japanese for "change for the better"), is a fundamental management philosophy that emphasizes ongoing efforts to enhance products, services, or processes (Bessant, & Maher, 2009, Suárez-Barraza et al 2012). It is not a one-time project but a sustained, incremental approach to improvement, involving all members of an organization (Liker, 2004, Jørgensen, et al 2003). The core idea is that small, consistent changes can lead to significant cumulative improvements over time (Bessant, & Maher, 2009, Suárez-Barraza et al 2012). Understanding and meeting customer needs and expectations is central to continuous improvement (Deming, 2000, Oakland, 2014). Improvements are driven by customer feedback and the desire to enhance customer satisfaction (Deming, 2000, Oakland, 2014). Continuous Improvement focuses on improving processes rather than individual performance (Bessant, & Maher, 2009, Suárez-Barraza et al 2012, Tortorella, & Fettermann, 2018). By analyzing and optimizing processes, organizations can eliminate waste, reduce errors, and improve efficiency (Bessant, & Maher, 2009, Suárez-Barraza et al 2012, Siriram, 2019).

Eliminating Waste

Waste elimination is a multifaceted concept gaining increasing importance across various sectors, driven by concerns about resource depletion, environmental degradation, and economic efficiency. This review explores the conceptual underpinnings of waste elimination, examining its evolution, diverse applications, and strategies for effective implementation. Waste, broadly defined as any resource that is not utilized optimally, presents a significant challenge to sustainability. Eliminating waste requires a shift towards circular economy models, emphasizing reduction, reuse, recycling, and recovery. The concept of waste elimination has evolved significantly over time. Initially rooted in manufacturing and

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operations management, the principles have expanded to encompass broader societal and environmental contexts. Taiichi Ohno's work at Toyota pioneered the concept of "Muda" or waste, categorizing it into seven types: overproduction, inventory, defects, motion, waiting, transportation, and over-processing. The Kaizen Institute emphasizes that sales teams should eliminate waste to focus on value-added activities, enhancing productivity and customer service.

Operational Efficiency

Operational efficiency is a critical concept for organizations across all sectors, focusing on maximizing output with minimal input. It involves streamlining processes, reducing waste, and optimizing resource utilization to achieve the best possible performance. In an increasingly competitive global landscape, enhancing operational efficiency is essential for achieving sustainable growth and maintaining a competitive advantage. Operational efficiency is often defined as the ratio between an organization's inputs and outputs. Inputs typically include resources such as time, labour, capital, and materials, while outputs encompass products, services, revenue, and customer satisfaction. The goal is to improve this ratio, either by reducing the inputs required for a given level of output or by increasing the output achieved with the same level of input. Operational efficiency is the organization's ability to decrease wastage of inputs and maximize resource utilization.

2.2 Theoretical Framework

John Elkington first proposed the idea of the Triple Bottom Line (TBL), sometimes referred to as the "three pillars" or "three Ps" of sustainability, in 1994. He founded the consulting firm Sustain Ability and is a British management consultant. According to the principle, businesses should prioritize three things: profit, people, and the environment. This entails taking into account a company's social and environmental effects in addition to its financial performance when assessing its success. Businesses used to function exclusively to support their bottom line. The triple bottom line (TBL) was first proposed in 1994 by author and businessman John Elkington in an effort to change the financial accounting-focused corporate system into a complete strategy that gauges success and effect. Some companies started to understand the link between social well-being, environmental health, and an organization's resilience and financial success as a result of the triple bottom line theory and its implementation. Organizations must completely account for all costs related to conducting business in order to obtain a comprehensive view of their operations that goes beyond what is shown in their profit and loss statements.

i. It is a transformation framework designed to assist companies and organizations in their transition to a more sustainable and regenerative future.

ii. TBL provides instruments to assist a company in measuring, comparing, establishing objectives, and ultimately moving toward more sustainable models and systems.

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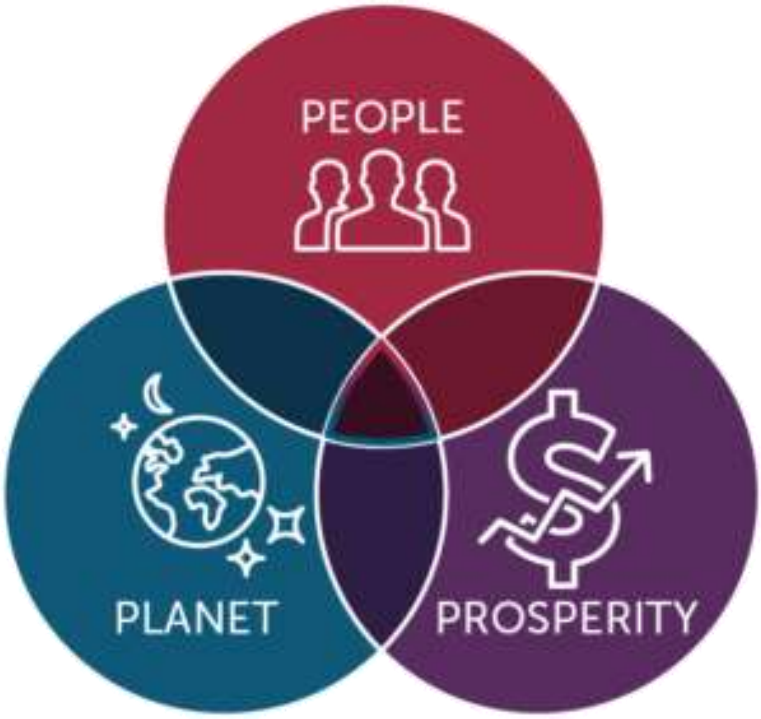
iii. It shows that a company cannot account for all of the costs associated with conducting business and will not prosper in the long run if it is solely concerned with making money while neglecting people and the environment.

By incorporating an organization's contributions to social well-being, environmental health, and a just economy, the triple bottom line hypothesis broadens the scope of traditional commercial success indicators. The three "P's"—people, planet, and prosperity—are frequently used to describe these bottom line categories. The triple bottom line is composed of three categories, however it's crucial to keep in mind that they are not distinct from one another. The three "P's" are all related when viewed through the perspective of systems theory. Since systems thinking is the cornerstone of sustainability, any endeavor that pertains to people, the planet, or prosperity will also have an effect on the others.



The triple bottom line, often referred to as the three "P's": people, planet, and prosperity.

People

Employees, the communities in which a business operates, people in the supply chain, future generations, and consumers are just a few of the stakeholders that people take into account (as opposed to merely shareholders). This part of the triple bottom line revolves around the relationship with corporate social responsibility (CSR). CSR is the duty of stakeholders to hold organizations accountable for their activities and the duty of organizations to satisfy the requirements of their stakeholders. Human rights advancement, poverty and hunger alleviation, diversity, equity, and inclusion, gender

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equity, maintaining a safe and healthy workplace, community involvement, and volunteerism are a few activities that a firm may think about include in its CSR objectives. Stakeholders benefit from CSR activities, but businesses also profit when they include CSR into their business plan. Businesses frequently share best practices with other companies and organizations as part of their dedication to advancing CSR initiatives.

Planet

Planet takes into account how a company or organization interacts with the environment and its ecological systems. Stakeholders may now hold companies more accountable for their activities because to a variety of factors, including public opinion, consumer purchasing power, the speed and transparency of information sharing on social media, and even industry-led activism (like Patagonia's 1 percent for the Planet campaign). This is demonstrated by stakeholders praising an organization for its beneficial effects and criticizing its negative ones. It is likely to have an effect on who customers choose to support and who they purchase from when that opinion becomes widely known.

In addition to the potential effects that corporate operations may have on the environment, society, and economy, stakeholders are becoming more conscious of the significance of global concerns like social justice and climate change. Actually, according to a 2020 Climate Change in the American Mind survey, "nearly six out of ten Americans, or roughly 58 percent, are now either 'Alarmed' or 'Concerned' about global warming." The percentage of people who were "alarmed" almost tripled between 2014 and 2019.Businesses have been implementing more environmentally friendly strategies over the last few decades. Large corporations such as AT&T, DELL, EASTON, Hewlett Packard, Kohler Co., Levi Strauss & Co., and Target, to mention a few, have advanced down the sustainability road in recent years by having a net-positive or regenerative effect on society and the environment.

Prosperity

Prosperity takes into account the economic metrics that a company or organization can control, such as providing livable salaries, using ethical suppliers, and ensuring worker health and safety. The triple bottom line theory's perspective on people, the environment, and prosperity makes it systemic. The Sustainable Development Goals (SDGs) were established by the United Nations (UN) to "ensure all human beings can enjoy prosperous and fulfilling lives and that economic, social, and technological progress occurs in harmony with nature" in light of this interconnectedness. Numerous UN SDGs seek to enhance a variety of aspects pertaining to people, the environment, and economic prospects. Providing decent work (safe working conditions, living pay, and compassionate leadership) and economic growth for people in particular areas is one of the many prosperity-focused agendas.

2.3 Empirical Review

Njoku (2021) conducted a study on Leadership and Continuous Improvement in the Nigerian Leadership and Continuous Improvement in the Nigerian. There is a high failure rate of continuous improvement (CI) initiatives in the beverage industry. Continuous improvement initiatives could help

beverage manufacturing managers improve product quality, efficiency, and overall performance. Grounded in the transformational leadership theory, the purpose of this quantitative co relational study was to examine the relationship between idealized influence, intellectual stimulation, and CI. Nigerian beverage industry managers (N = 160) who participated in the study completed the Multifactor Leadership Questionnaire Form 5X-Short, and the Plan, Do, Check, and Act (PDCA) cycle. The results of the multiple linear regression were statistically significant, $F(2, 157) = 16.428$, $p < 0.001$, $R2 = 0.173$. Idealized influence ($ß = 0.242$, $p = 0.000$) and intellectual stimulation ($ß = 0.278$, $p = 0.000$) were both significant predictors. The implications for positive social change include the potential to increase the opportunity for the growth and sustainability of the beverage industry

Ogbuke, Eneh, and Okwor (2023) conducted a study on Employee Performance Management and Performance of Food Beverage Manufacturing Firms of Enugu State The study evaluated the employee performance management practices and performance of food beverage manufacturing firms of Enugu State. The specific objectives were to: examine the relationship between engaged employees and the profitability and evaluate the relationship between identification of talent and output of food manufacturing firms of Enugu State. The area of the study was the SMEs in Enugu State. The study used the descriptive survey design approach. The primary source of data was the administration of questionnaire. A total population of 911 selected staff of the study organisations. The hypotheses were analysed using Pearson correlation coefficient (r). The findings indicated there was significant positive relationship between Engaged employees and the profitability r (95, n=228), = .453 < .985, P <. 05 and there was significant positive relationship between identification of talent and output of food manufacturing firms of Enugu State r (95, n=228), = .416 < .971, P <. 05. The study concluded that engaged employees and talent had significant positive relationship with the profitability and output of food beverage manufacturing firms of Enugu State.

Onoh, Chinasa, and Hubs, (2022) conducted a study on Development on the Waste Reduction of Food, Beverage and Tobacco Manufacturing Firms in Enugu State. The study evaluated the sustainability development on the waste reduction of food, beverage and tobacco manufacturing. The specific objectives were to: examine the effect of employee equal opportunity on the prevention of waste and evaluate the effect of maintenance skills on the standard costing of Food, Beverage and Tobacco Manufacturing firms in Enugu state. The study employed survey method research. Data was presented and analysed by mean score (3.0 and above agreed while below 3.0 disagreed) and Z-test was used to test the hypotheses. The findings indicated that Employee equal opportunity had positive effect on the prevention of waste, (7.530 < 8.532, p = < .05) and Maintenance of skills had positive effect on the standard costing of Food, Beverage and Tobacco Manufacturing firms in Enugu state, (4.965 < 6.654, p = < .05).The study concluded that Employee equal opportunity and Maintenance of skills had positive effect on the prevention of waste, standard costing and reusable products of Food, Beverage and Tobacco Manufacturing firms in Enugu state.

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Rolker, Eisler, Cardenas, Deeney, and Takahashi (2022) conducted a study on Food waste interventions in low-and-middle-income countries: A systematic literature. Reduction of food waste in low-and-middle-income countries (LMICs) can provide multi-layered benefits for their sustainable development, through improved food security, enhanced income as well as the creation of environmentally friendly secondary markets. Food systems, however, are often characterised by a complex network of actors across the value chain, where a parochial intervention at a local scale does not always achieve a globally optimal outcome. Here, we systematically reviewed 8318 studies for the current evidence associated with the impact of interventions pursuing food waste reduction in LMICs. We first classified interventions by the target stage within the value chain and by the mechanism of action, and then further based on whether they are primarily designed to prevent or mitigate (recycle, reuse, remanufacture, repurpose and recover) the wastage of the commodity. We found a near-complete disconnect between preventive and mitigative interventions amongst the studies, with the former only investigated at production, storage and transportation stages and the latter only at wholesale and consumption stages. No identified study employed preventive and mitigative measures together to explore the combined level of efficacy. We also identified a strong bias in favour of material-based interventions, with little attention given to knowledge-based alternatives or local capacity building.

3. Methodology

A survey research design was selected for the investigation. A standardized questionnaire with a point Likert scale was used to collect data for the study. The study's population consists of workers from the selected food producing enterprises in South-East Nigeria. The workforce was made up of both senior and junior employees from various divisions of food and beverage production enterprises. In this study, 3,565 employees were included in the sample. The sample size for the study consisted of 347 respondents. The sample size was calculated using Freund and William's statistical technique. The data was analyzed using the mean, standard deviation, and fundamental percentages. (SPSS version 20, a program for descriptive statistics).

4 Data Presentation and Analyses

4.1 Distribution and returned Questionnaire

The presentation and interpretation of data were based on the questionnaire administrated to the staff of the Southeast Nigeria's food industry.

Table 4.1 Distribution and Return of the Questionnaire

Firms	Distributed	No Returned	percent	No not Returned	Percent
1. Nigeria Breweries, Aba	50	49	14	2	1
2.M.O. Nnaji Bakeries, Aba	17	16	5	1	-
3.Tummy Tummy foods, Nnewi	37	35	10	2	1

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4.Nigeria Bottling Co. Ltd., Onitsha	44	42	12	2	1
5.Jaypee Enterprises, Uburu	24	23	7	1	-
6 Abakaliki Rice Cluster	46	42	12	4	1
7.Nigerian Breweries Plc, Enugu	37	35	10	2	1
8.Aqua Ralpha Investment, 9th Mile	42	36	10	6	2
9.Emmerald food, Owerri	38	37	11	1	-
10.Jacob Wine, Orlu	12	11	3	1	-
Total	**347**	**326**	**93.0**	**21**	**7.0**

Source: Field Survey, 2024

Table 4.1 shows that of the 347 distributed copies of the questionnaire, three hundred and twenty-six (326) were returned representing ninety-one (91) percent and used, while twenty-one (21) copies of the questionnaire representing seven (7) percent were not returned and were not used. This shows a high respondents' rate.

4.2 Bio Data

The bio-data shows the gender distribution, marital status of respondents, educational qualifications, and years of experience and age of the respondents under study.

Table 4.2.1 Gender Distribution

	Frequency	Percent	Valid Percent	Cumulative Percent
Male	183	56.1	56.1	56.1
Female	143	43.9	43.9	100.0
Total	**326**	**100.0**	**100.0**	

Source: Field Survey, 2024

From table 4.2.1 it was observed that 183 respondents out of 326 representing 56.1 percent were males whereas 143 respondents representing 43.9 percent were females. This indicated that male were more than the females.

Table 4.2.2 marital status of Respondents

	Frequency	Percent	Valid Percent	Cumulative Percent
Single	109	33.4	33.4	33.4
Married	191	58.6	58.6	92.0
Widowed	20	6.1	6.1	98.1

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Divorced	6	1.9	1.9	100.0
Total	**326**	**100.0**	**100.0**	

Source: Field Survey, 2024

Table 4.2.2 reveals that 109 respondents out of 326 representing 33.4 percent were single, 191 respondents representing 58.6 percent were married. 20 respondents representing 6.1 percent were widowed. 6 respondents representing 1.9 percent were divorced.

Table 4.2.3 Educational qualifications of the Respondents

	Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
WASC/GCE	88	27.0	27.0	27.0
OND/NCE	88	27.0	27.0	54.0
HND/B.Sc.	92	28.3	28.3	82.3
MBA/M.Sc.	37	11.3	11.3	93.6
PhD	21	6.4	6.4	100.0
Total	**326**	**100.0**	**100.0**	

Source: Field Survey, 2024

Table 4.2.3, reveals that 88 respondents out of 326 representing 27.0 percent were holders of WASC/GCE, 88 respondents representing 27.0 percent were holders of NCE/OND, 92 respondents representing 283 percent were holders of HND and BSC, 37 respondents representing 11.3 percent were holders of Masters degree and 21 respondents representing 6.4 percent were holders of PhD.

Table 4.2.4: Years of Experience

	Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
less than 1 - 2years	82	25.2	25.2	25.2
3-5years	208	63.8	63.8	89.0
6-10years	30	9.2	9.2	98.2
11 years and above	6	1.8	1.8	100.0
Total	**326**	**100.0**	**100.0**	

Source: Field Survey, 2024

Table 4.2.4, 82 respondents out of 326 representing 25.2 percent have less than 1 – 2 years experience, 208 respondents with 63.8 percent were within the years experience of 3 – 5 years, 30 respondents representing 9.2 percent were within the years' experience 6-10years, 6 respondents representing 1.8 percent were within the 11 years and above.

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Table 4.2.5 Age of the respondents

	Frequency	Percent	Valid Percent	Cumulative Percent
25-30years	53	16.3	16.3	16.3
31-35years	77	23.6	23.6	39.9
36-40years	89	27.3	27.3	67.2
45- 50years	19	5.8	5.8	73.0
51years and above	88	27.0	27.0	100.0
Total	**326**	**100.0**	**100.0**	

Source: Field Survey, 2024

Table 4.2.5, 53 respondents out of 326 representing 16.2 percent were within the age of 25 - 30years, 77 respondents with 23.6 percent were within the age bracket of 31-35, 89 respondents representing 27.3 percent were within the age bracket of 36 – 40years, 19 respondents representing 5.8 percent were within the age bracket of 45-50 years while 88 respondents representing 27.0 percent were within the age bracket of 51 years and above. This implies that greater proportion of the respondents fall within the ages of 36 - 40 years.

4.3 Data Presentation and Analyses

i. 4.3.1 The effect of continuous improvement process on operational efficiency in Southeast Nigeria's food industry.

iii. Table 4.3.1.1: Responses on the effect of continuous improvement process on operational efficiency in Southeast Nigeria's food industry.

		5 SA	4 A	3 N	2 DA	1 SD	∑FX	- X	SD	Decision
1	There is improvement to service which promotes best outcomes	900 180 55.2	140 35 10.7	129 43 13.2	84 42 12.9	26 26 8.0	1,279 326 100.0	3.92	1.385	Agree
2	Continuous improvement enables the organisations to make an ongoing	915 183 56.1	112 28 8.6	117 39 12.0	86 43 13.2	33 33 10.1	1263 326	3.87	1.453	Agree

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	commitment to change and apply better success						100.0			
3	The continuous, interactive improvement is linked with innovation which helps customers in getting better services.	640 128 39.3	112 28 8.6	279 93 28.5	66 33 10.1	44 44 13.5	1141 326 100.0	3.5	1.433	Agree
4	Small incremental changes add up to significant results that prevent damaged goods.	725 145 44.5	324 81 24.8	93 31 9.5	26 13 4.0	56 56 17.2	1224 326 100.0	3.75	1.481	Agree
5	Continuously reviewing results and adopting new measures ameliorate spoilt goods	975 195 59.8	188 47 14.4	60 20 6.1	76 38 11.7	26 26 8.0	1325 326 100.0	4.06	1.358	Agree
	Total Grand mean and standard deviation							**19.1**	**7.11**	

Source: Field Survey, 2024

Table 4.3.1.1., 215 respondents out of 326 representing 65.9 percent agreed that there is improvement to service which promotes best outcomes with mean score 3.92 and standard deviation of 1.385. 211 responden4ts representing 64.7 percent agreed that continuous improvement enables the organisations to make an ongoing commitment to change and apply better success with mean score of 3.87 and standard deviation of 1.453. 156 respondents representing 47.9 percent agreed that the continuous, interactive improvement is linked with innovation which helps customers in getting better services with mean score of 3.5 and standard deviation of 1.433. 226 respondents representing 69.3 percent agreed with that Small incremental change add up to significant results that prevent damaged goods Mean score of 3.75 and 1.481. 242 respondents representing 74.2 percent agreed that continuously reviewing results and adopting new measures ameliorate spoilt goods with a mean score of 4.06 and standard deviation 1.358.

Table 4.3.4.1 The effect of eliminating waste on operational efficiency in Southeast Nigeria's food industry.

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Table 4.3.4.1: Responses on the effect of eliminating waste on operational efficiency in Southeast Nigeria's food industry.

		5 SA	4 A	3 N	2 DA	1 SD	∑FX	- X	SD	Decision
1	The food and beverage firms reduce excess inventory to increase the profitability.	555 111 34.0	 396 99 30.4	45 15 4.6	20 4 68 20.9	33 33 10.1	1233 326 100.0	3.78	1.399	Agree
2	The organization converts raw materials into service to help increase cash flow	715 143 43.9	540 135 41.4	48 16 4.9	6 3 .9	29 29 8.9	1338 326 100.0	4.10	1.148	Agree
3	Adopting just- in – time services reduce expenses of the organization	960 192 59.8	376 94 28.8	45 15 4.6	36 18 5.5	7 7 2.1	1424 326 100.0	4.37	.957	Agree
4	Investing in efficiency improvements in the organisation attracts cash flow.	835 167 51.2	464 116 35.6	39 13 4.0	36 18 5.5	12 12 3.7	1386 326 100.0	4.25	1.022	Agree
5	Ordering exactly the right number of products drives income.	425 85 26.1	648 162 49.7	39 13 4.0	10 6 53 16.3	13 13 4.0	1231 326 100.0	5.22	1.124	Agree
	Total Grand mean and standard deviation							**21.72**	**5.65**	

Source: Field Survey, 2024

Table 4.3.4.1., 210 respondents out of 326 representing 64.4 percent agreed that the food firms reduces excess inventory to increase the operational efficiency with mean score 3.78 and standard deviation of 1.399. 278 respondents representing 85.3 percent agreed that the organization converts raw materials

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into service to help increase cash flow with mean score of 4.10 and standard deviation of 1.148. 286 respondents representing 88.6 percent agreed that adopting just- in – time services reduce expenses of the organization with mean score of 4.37 and standard deviation of .957. 283 respondents representing 86.8 percent agreed that investing in efficiency improvements in the organisation attracts cash flow with mean score of 4.25 and standard deviation of 1.022. 247 respondents representing 75.8 percent agreed that ordering exactly the right number of products drives income with a mean score of 5.22 and standard deviation 1.124.

4.4 Test of Hypotheses

4.4.1 Hypothesis One: Continuous improvement process has significant effect on the operational efficiency in Southeast Nigeria's food industry.

One-Sample Kolmogorov-Smirnov Test

		There is improvement to service which promotes better outcomes.	Continuous improvement enables the organisations to make an ongoing commitment to change and apply better success.	The continuous, interactive improvement is linked with innovation which helps customers in getting better services.	Small incremental changes add up to significant results that prevent damaged goods	Continuously reviewing results and adopting new measures ameliorate spoilt goods
N		326	326	326	326	326
Uniform Parameters[a,b]	Minimum	1	1	1	1	1
	Maximum	5	5	5	5	5
Most Extreme Differences	Absolute	.552	.561	.393	.445	.598
	Positive	.080	.101	.135	.172	.080
	Negative	-.552	-.561	-.393	-.445	-.598
Kolmogorov-Smirnov Z		9.969	10.135	7.089	8.031	10.800
Asymp. Sig. (2-tailed)		.000	.000	.000	.000	.000

a. Test distribution is Uniform.

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b. Calculated from data.

Decision Rule

If the calculated Z-value is greater than the critical Z-value (i.e. Z_{cal} > Zcritical), reject the null hypothesis and accept the alternative hypothesis accordingly.

Result

With Kolmogorov-Smirnon Z – value of 7.098 < 10.089 and on Asymp. Significance of 0.000, the responses from the respondents as display in the table is normally distributed. This affirms the assertion of the most of the respondents that continuous improvement process had significant positive effect on the operational efficiency in Southeast Nigeria's food industry.

Decision

Furthermore, comparing the calculated Z- value of 7.098 < 10.089 against the critical Z- value of .000 (2-tailed test at 97percent level of confidence) the null hypothesis was rejected. Thus, the alternative hypothesis was accepted which states that continuous improvement process had significant positive effect on the operational efficiency in Southeast Nigeria's food industry.

4.4.2 Hypothesis two: Eliminating waste has significant effect on operational efficiency in Southeast Nigeria's food industry.

One-Sample Kolmogorov-Smirnov Test

		The food and beverage firms reduce excess inventory to increase the profitability	The organization converts raw materials into service to help increase cash flow.	Adopting just- in –time services reduce expenses of the organization	Investing in efficiency improvements in the organisation attracts cash flow.	Ordering exactly the right number of products drives income.
N		326	326	326	326	326
Uniform Parameters[a,b]	Minimum	1	1	1	1	1
	Maximum	5	5	5	5	5
Most Extreme Differences	Absolute	.394	.603	.627	.618	.508
	Positive	.101	.089	.021	.037	.040
	Negative	-.394	-.603	-.627	-.618	-.508
Kolmogorov-Smirnov Z		7.117	10.883	11.326	11.160	9.166
Asymp. Sig. (2-tailed)		.000	.000	.000	.000	.000

a. Test distribution is Uniform.

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b. Calculated from data.

Decision Rule

If the calculated Z-value is greater than the critical Z-value (i.e. $Z_{cal} > Z_{critical}$), reject the null hypothesis and accept the alternative hypothesis accordingly.

Result

With Kolmogorov-Smirnon Z – value of 7.117 < 11.160 and on Asymp. Significance of 0.000, the responses from the respondents as display in the table is normally distributed. This affirms the assertion of the most of the respondents that eliminating waste had significant positive effect on operational efficiency in Southeast Nigeria's food industry.

Decision

Furthermore, comparing the calculated Z- value of 7.117 < 11.160 against the critical Z- value of .000 (2-tailed test at 97percent level of confidence) the null hypothesis was rejected. Thus, the alternative hypothesis was accepted which states that eliminating waste had significant positive effect on operational efficiency in Southeast Nigeria's food industry.

From the result of the hypothesis one, the calculated Z- value of 7.098 < 10.089 against the critical Z-value of .000 which implies that Continuous improvement process had significant positive effect on the operational efficiency in Southeast Nigeria's food industry.

The hypothesis two, the calculated Z- value of 7.117 < 11.160 against the critical Z- value of .000 which implies that eliminating waste had significant positive effect on operational efficiency in Southeast Nigeria's food industry.

5 Conclusion

In conclusion, the application of Sustainable Lean Six Sigma in Southeast Nigeria's food industry has demonstrated a significant positive effect on operational efficiency. The continuous improvement process has led to enhanced performance by fostering a culture of ongoing refinement and adaptation. Additionally, the focus on eliminating waste has resulted in more streamlined operations, reducing costs and increasing productivity. These findings indicate that the integration of Sustainable Lean Six Sigma principles can effectively address the unique challenges faced in this sector, ultimately driving improvements in efficiency and competitiveness. Moving forward, stakeholders should continue to leverage these methodologies to sustain growth and enhance operational capabilities within the industry.

Recommendation

To maximize the benefits of Sustainable Lean Six Sigma in Southeast Nigeria's food industry, the following recommendations are proposed:

i. Organizations should invest in comprehensive training for employees at all levels to deepen their understanding of continuous improvement processes. This will empower staff to identify inefficiencies and contribute to ongoing enhancement efforts.

ii. Companies should adopt specific strategies focused on waste elimination, such as value stream mapping and root cause analysis. Regular assessments should be conducted to identify areas for improvement and track progress.

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