Innovations

Examination of the Nexus between Six Sigma and Sustainability of Manufacturing Firms in South-East Nigeria

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Abstract: *The study investigated the nexus between Six Sigma and the sustainability of manufacturing companies in southeast Nigeria. The main goals were to analyse the correlation between cycle time management and customer satisfaction and ascertain the relationship between top management commitment and competitiveness of food and beverage manufacturing companies in South East Nigeria. From a population of 1675, a sample of 313 was selected using Freund and William's statistical technique. A well-structured questionnaire was used to elicit data from the respondents. The study instrument was validated through face and content validity. The instrument's reliability was established via the test-retest method and Cronbach's Alpha Statistic. The results indicated that all the values were over 70%. With SPSS version 26, the hypotheses were used in the regression analysis technique at a significance level of 5%. The results showed that cycle time management has a positive and significant impact on customer satisfaction in food and beverage manufacturing firms in Southeast Nigeria ($\beta = 0.943$; $p < 0.05$) and that top management commitment has a positive and significant effect on competitiveness ($\beta = 0.916$; $p < 0.05$).The study concludes a robust positive relationship between Six Sigma and the sustainability of manufacturing enterprises in South East Nigeria. Among others, the study recommends that businesses should enhance the dedication of their senior management to improve productivity, enhance employee involvement, cultivate an influential workplace culture, and ultimately enhance overall success.*

Key Concepts: *Six Sigma, Sustainability, Manufacturing companies, Cycle time, Competitiveness*

1.1 Introduction

Organizations continually strive to efficiently manage time, costs, processes, and products to optimize their operations in a constantly evolving market. Maintaining a competitive advantage is essential, prompting the development of various tools and techniques to evaluate product quality and functionality. To ensure customer satisfaction, organizations employ multiple methods, including Quality Inspection (QI), Quality Assurance (QA), Total Quality Management (TQM), Strategic Quality Management (SQM), Just-In-Time (JIT), and Six Sigma Manufacturing Methodology. Nonetheless, challenges arise due to market fluctuations, environmental conditions, and changing business characteristics (Ahmad, Othman & Lazim, 2014).

To address unresolved organizational issues, Six Sigma provides a data-driven project management methodology that uses a five-step process focused on statistical analysis to reduce defects and product variations (John, 2022). The success of Six Sigma implementation depends on employee involvement, leading to decreased cycle times and nearly flawless product or service delivery to clients. The Six Sigma manufacturing methodology aims to reduce process variation, improve performance, and enhance customer satisfaction (Mousli et al., 2023). Its advantages include a structured approach, data-driven decision-making, and a problem-solving focus (Sundram et al., 2023; Sukwadi et al., 2021).

Sustainability involves maintaining the fundamental health, resilience, and adaptability necessary for life (Wahl, 2021). More broadly, sustainability refers to the capacity of something to endure or sustain itself over time. In business and policy contexts, sustainability constraints are defined by physical and natural resources, environmental degradation, and social resources. In business, sustainability encompasses corporate responsibility towards various communities, necessitating efforts to mitigate negative business impacts (Baumgartner, 2014; Carpenter & White, 2004). Thus, businesses pursuing sustainable development must consider environmental and societal responsibilities alongside their organizational goals. Sustainable development offers significant challenges and opportunities for businesses. Companies that operate sustainably can improve their reputation, financial performance, and environmental impact, thereby gaining a competitive advantage (Porter & Kramer, 2006; Paulraj, 2011; Hollos et al., 2012; Longoni &Cagliano, 2015).

Sustainable Manufacturing incorporates sustainability principles into manufacturing processes to improve a company's efficiency and effectiveness (Utama et al., 2023). This concept includes economic, environmental, and social dimensions (Machado et

al., 2020). Sustainable Manufacturing aims to minimize negative environmental impacts, ensure job security, and create long-term economic benefits.

Six Sigma and sustainability transform manufacturing businesses from mere tools of operational efficiency into advocates of greener practices, highlighting the connection between process optimization and eco-friendly initiatives. This comprehensive methodology helps businesses reduce waste, improve resource utilization, and lower their carbon footprint. Six Sigma's influence on sustainability extends through every phase of a product's life cycle, assisting businesses in creating environmentally friendly products. By analyzing processes and materials, Six Sigma optimizes product development while reducing environmental impact, providing a holistic approach for companies committed to sustainable and circular practices.

This study explores the relationship between Six Sigma and sustainability in food and beverage manufacturing firms in South East Nigeria. It aims to understand how the lack of adoption of Six Sigma methodology and sustainability practices has impacted these firms' performance, preventing them from meeting international standards (Nnabuife & Ohue, 2021).

The manufacturing sector is crucial to Nigeria's economy, contributing about 10% to the annual GDP. However, it faces several challenges, such as outdated production tools and machinery, poor leadership, lack of skilled workers, infrastructure problems, and inadequate responsiveness to customer needs, leading to poor performance (Adebowale, 2022). The research also addresses the gap in recognizing the benefits of Six Sigma and sustainability among Nigerian manufacturing firms, resulting in outcomes below expectations. Factors such as poor cycle time management, inadequate leadership, lack of skilled workers, and infrastructure issues contribute to these shortcomings. The study aims to provide insights into the factors affecting customer satisfaction and competitiveness in the region's food and beverage manufacturing sector. Based on the preceding, we hypothesise as follows:

Ha: 1 Cycle time management significantly affects customer satisfaction of food and beverage manufacturing firms in South East Nigeria.

Ha: 2 Top management commitment significantly affects the competitiveness of food and beverage manufacturing firms in South East Nigeria.

By testing and analysing the two hypotheses, the study aims to enrich our understanding of "six sigma and sustainability" in the following ways: First, the

investigation into the relationship between cycle time management and customer satisfaction of food and beverage manufacturing firms in South East, Nigeria contributes to knowledge by offering insights into the specific dynamics that linkcycle time management to customer satisfaction. Understanding the relationship between top management commitment and competitiveness provides valuable knowledge for businesses aiming to enhance strategic decisions and the organisation's overall performance.

The study is organised as follows: First, following the introduction, which covered the general background, problem statement, and research hypotheses, the study analyses the literature and arguments surrounding "Six Sigma and sustainability." Next, the study describes the methodology used. Afterwards, the data analyses are presented. Then, the results and discussion of the findings are presented. Lastly, the study concludes and makes recommendations.

2.0 Literature Review

2.1 Six Sigma

Six Sigma is a methodology for process improvement that was first introduced by engineers Bill Smith and Mikel Harry at Motorola in 1986. It gained significant recognition when Jack Welch made it a central part of General Electric's business strategy in 1995. Since then, many companies globally have adopted Six Sigma as their standard operational practice (Barney, 2002). Six Sigma involves various methodologies and tools aimed at improving business processes by minimizing defects, errors, and variations, thereby enhancing quality and efficiency. The goal of Six Sigma is to achieve nearly perfect quality, with only 3.4 defects per million opportunities. The term "Six Sigma" represents a statistical measure of process deviation from perfection. It is a disciplined, data-driven approach extensively used in project management to foster process improvement and defect reduction. This involves streamlining processes, lowering defects, improving quality, and optimizing resources to deliver greater value with less effort (Pankaj, 2023). Six Sigma practitioners use statistics, financial analysis, and project management to enhance business functionality and superior quality control by identifying and correcting errors or defects in existing processes.

Advocates of Six Sigma claim that this business strategy can lead to benefits such as up to a 50% reduction in process costs, improvements in cycle time, reduced material waste, a better understanding of customer requirements, increased customer satisfaction, and more reliable products and services. The initial step in implementing Six Sigma within an organization is to effectively present the benefits of statistical tools like Six Sigma to garner stakeholder support. The Six Sigma

methodology focuses on limiting variations within business processes and managing process output quality through problem-solving statistical techniques (McLaughlin, 2023). In statistics, "sigma" is a Greek letter that represents the standard deviation from the mean, emphasizing quality in the Six Sigma concept.

Six Sigma offers a structured approach to problem-solving, centered around three methodologies: DMAIC, process management, and Design for Six Sigma (DFSS). DMAIC stands for Define, Measure, Analyze, Improve, and Control. Process management involves organizing business processes to achieve goals. Design for Six Sigma, also known as DMADV (Define, Measure, Analyze, Design, and Verify), is another approach. Six Sigma is a management tool aimed at eliminating defects and reducing variation, described as a systematic problem-solving approach focused on process improvement. One of its primary tools is the DMAIC methodology, a logical framework that facilitates planning process improvements to achieve near-perfect performance (Hessing, 2023). A Six Sigma project operates within the DMAIC improvement cycle (Steve, 2023). The benefits of DMAIC include a structured approach, data-driven decision-making, and a problem-focused strategy (Sundram et al., 2023; Sukwadi et al., 2021). DMAIC involves critical stages such as defining the problem, measuring the current process, analyzing data, improving the process, and controlling the new process to ensure long-term sustainability. Consequently, DMAIC is a valuable tool for businesses seeking to enhance their performance in sustainable manufacturing.

2.2 Sustainability

Sustainable development has become a key global discussion in the 21st century, making it essential to grasp its core principles. A widely accepted definition from the United Nations World Commission on Environment and Development describes sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission, 1987). This definition is based on two main concepts: "needs," referring to the essential needs of the world's poor, and "limitations," which are the constraints technology and socio-economic factors place on the environment's ability to meet current and future needs. Sustainable development encompasses three dimensions: Environmental Sustainability, Economic Sustainability, and Social Sustainability. Achieving sustainable development requires balancing these three aspects (Sonnemann et al., 2015).

Environmental Sustainability: This involves operating within the limits of natural resources. Genuine environmental sustainability requires the sustainable use of resources like materials, energy, land, and water, either through sustainable usage rates or circular practices. It considers issues such as material scarcity, environmental damage from resource extraction, and adherence to circular economy principles (Circular, 2020).

Economic Sustainability: This emphasizes the need for businesses or countries to use resources efficiently and responsibly to generate sustainable and consistent profits. Without operational profits, businesses cannot continue their activities. Efficient and responsible resource utilization is crucial for long-term operational sustainability.

Social Sustainability: This relates to the ability of a society or social system to maintain well-being over time. Achieving social sustainability ensures the lasting well-being of a country, organization, or community. In a business context, it involves understanding the impact of corporate activities on people and society (ADEC Innovations, 2020). Social sustainability is the most challenging to quantify among the three dimensions.

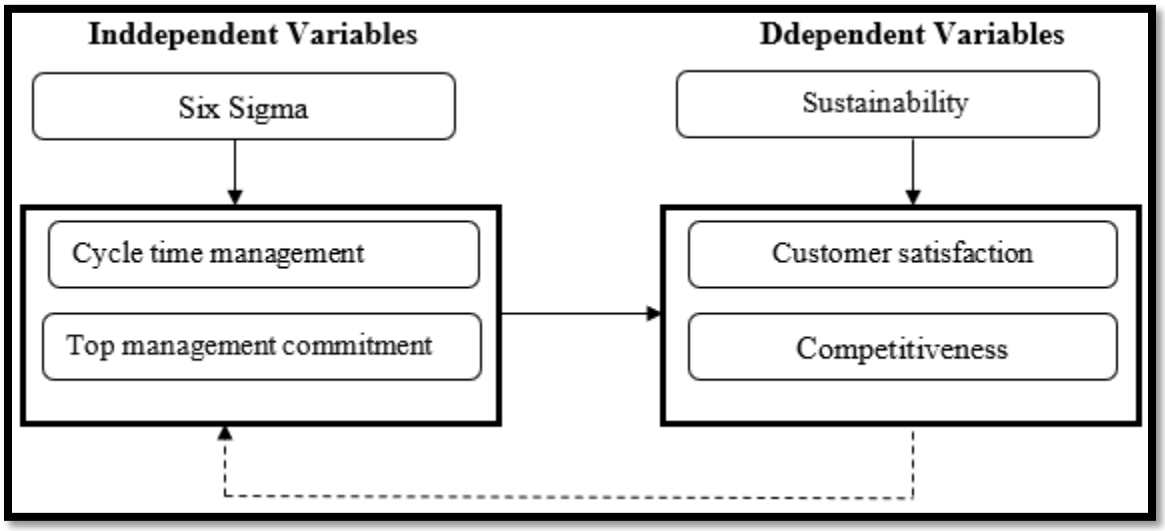

Figure 2.1: Conceptual Framework. Source: Authors Design,2024

2.3 Theoretical Framework

Business Process Change (BPC) Theory

The Business Process Change (BPC) Theory developed by Kettinger and Grover in 1995 guided the study. According to Kettinger and Grover (1995), any significant change in business processes requires a strategic initiative led by top managers. This initiative involves defining and communicating a vision for change, fostering an environment conducive to learning, cultivating a receptive culture, maintaining balanced network relationships, ensuring technological adaptability, promoting knowledge sharing, and implementing established process management and change management practices. The utilisation of process and change management techniques and adaptability to changing environments facilitate the enhancement of business operations and workplace conditions. These enhancements are essential for achieving customer success and attaining measurable and sustainable competitive performance improvements (Drago & Geisler, 1997). The components of this framework form the basis for the researcher's examination of the extent to which Six Sigma influences sustainability.

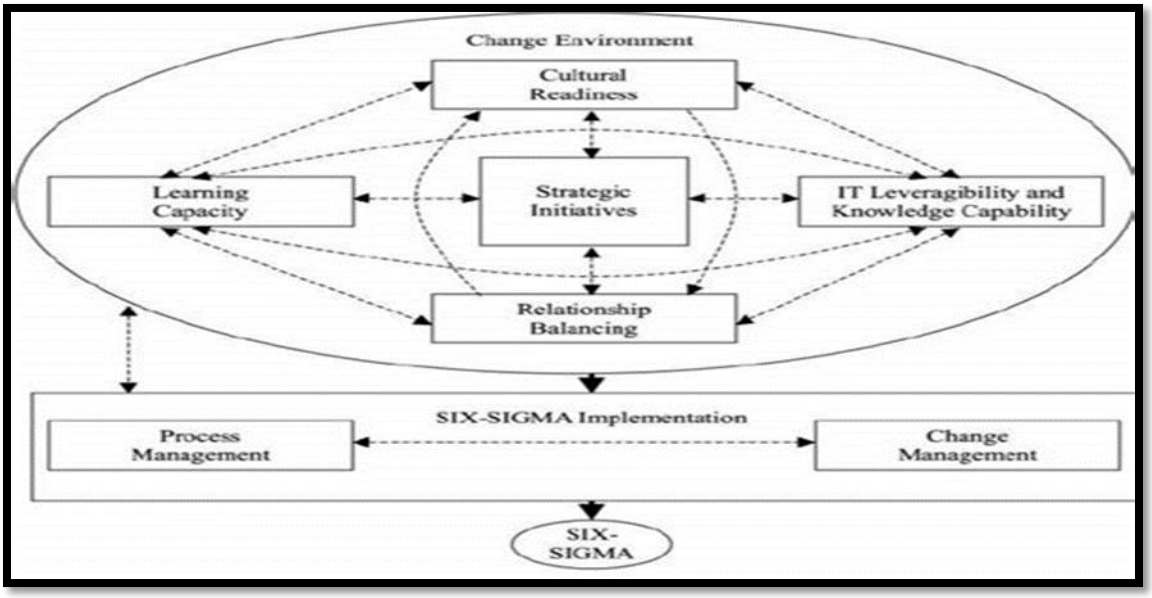

Figure 2.2: Business Process Change (BPC)Theory.
Source: Kettinger and Grover's model of BPC management (1995)

According to Kotter (1995), process transformation often commences with strategic objectives the senior management team sets, frequently incorporated into the company's strategic plan. These objectives might aim to capitalise on potential opportunities or proactively address needs, such as inadequate customer service (Earl, 1994). Moreover, evidence suggests that rather than being revolutionary and

dramatic, strategy change, and perhaps process change, often occurs gradually, informally, and emergently and relies on learning through small victories (Mintzberg & Waters, 1985).

2.4 Cycle Time Management and Customer Satisfaction

Lulagala, Mwelu, Watera and Makepu (2023) conducted a study on the impact of delivery cycle time on the performance of manufacturing firms. They found that relevant resources, operational efficiency, coordination, and adaptability predict delivery cycle time significantly. Lee & Lee (2023) highlighted the resilience of fast-food restaurants during the COVID-19 pandemic while advocating for innovative strategies. Titanic, Grigoroudis, and Chrysochou (2022) explored customer satisfaction in short-food supply chains, emphasising the importance of sales processes and producers. Wuanor and Eke (2022) revealed a positive correlation between service quality dimensions and customer satisfaction in the flour mill industry in Nigeria, suggesting employee training and service improvement. Nwulu and Nwokah (2018) investigated the relationship between customer service management and marketing performance of food and beverage manufacturing firms in Nigeria, affirming the significant contribution of customer service management to marketing performance. Igwe and Ntah (2018) explored the link between customer satisfaction and nation-building, recommending a focus on creating value for customers to foster national integration and patriotism. Hung and Sung (2011) delved into applying Six Sigma to manufacturing processes in the food industry, highlighting the DMAIC methodology's efficacy in reducing process variation and associated defects.

2.5 Top Management Commitment and Competitiveness

Makinde, Akinlabi, Adefulu and Vyas (2023) found that quality management practices positively impact the competitive advantage of food and beverage manufacturing firms in Lagos State, Nigeria. Eneh, Ogbuke and Okwor (2023) concluded that engaged employees and talent significantly influence the profitability and output of food and beverage manufacturing firms in Enugu State, Nigeria, recommending investment in learning and development. Adiele and Onuoha (2023) explored talent management's effect on competitiveness, suggesting training in people management to optimise intangible assets. Adudu and Torough (2023) investigated competitive intelligence's impact on competitiveness among quoted foods and beverages manufacturing firms in Nigeria, emphasising the critical role of competitive intelligence. Hotlan, Zeplin, and Sautma (2022) explored the role of top management commitment in enhancing competitive advantage through green innovation, supplier integration, and customer integration. Memon, Rasli, Dahri and Abas (2022) examined the importance of top management

commitment to environmental performance in Pakistani industries, supporting the role of top management in encouraging environmental performance and green training. Toong, Wong, and Vasudevan (2022) researched leadership styles in the Malaysian food and beverage service industry, finding significant influences on company performance. Nicholas, Raph and Sergius (2014) studied the effectiveness of change management and top management commitment in South Eastern Nigerian manufacturing firms, advocating for a conducive change management process.

3.0 Methodology

The study adopted a survey research design, targeting 1675 staff members from management, senior, and junior levels in selected manufacturing firms in Southeast Nigeria. The sample size of 313 respondents was determined using Freund and William's statistical formula, with 274 completed and returned copies of the questionnaire for the analyses. A stratified sampling technique was adopted to ensure representation across different strata. The study instrument was validated through face and content validity. The instrument's reliability was established through the test-retest method and Cronbach's Alpha statistic. The hypotheses were tested using the regression analysis technique at a 5% significance level. The software used was SPSS version 26.

4.0 Findings and Discussion of Results.

4.1 Findings

Implementing cycle time management in food and beverage manufacturing firms in Southeast Nigeria significantly positively affects customer satisfaction ($\beta = 0.943$; $p < 0.05$). This suggests that organisations that incorporate cycle time management into their operations will experience substantial customer satisfaction. The presence of firm commitment from top management has a significant effect on the competitiveness of the manufacturing firms, as indicated by a beta coefficient of 0.916 and a significance level of $p < 0.05$. This suggests that the effective attainment of organisational objectives relies heavily on the dedication demonstrated by top management.

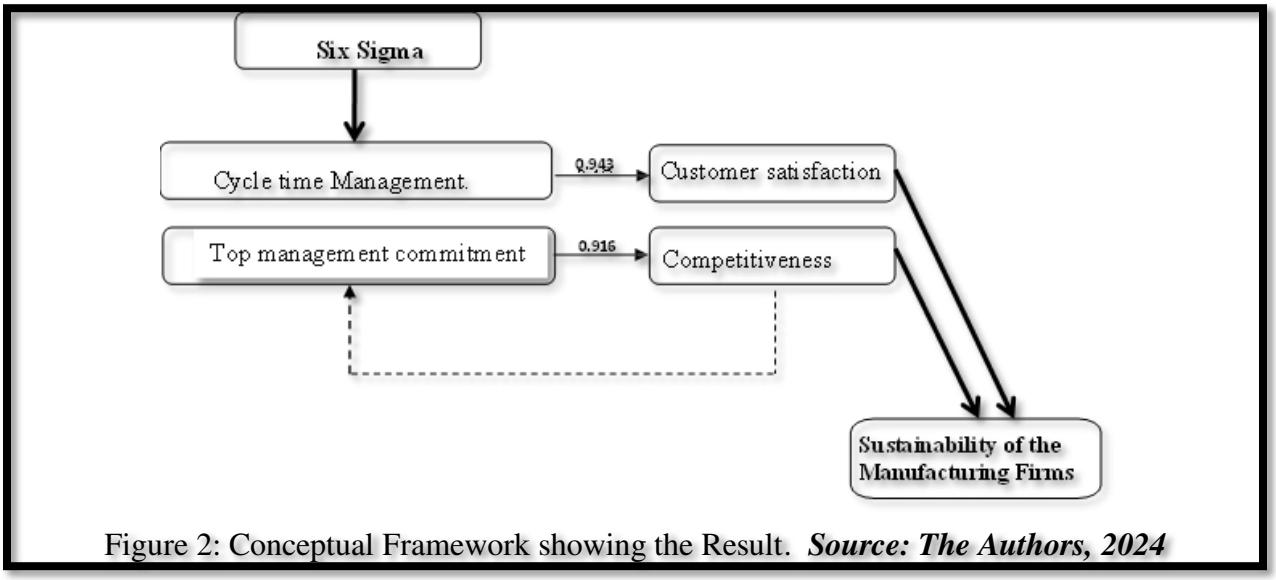

Figure 2: Conceptual Framework showing the Result. ***Source: The Authors, 2024***

4.2 Discussion of Results

(i) **Cycle Time Management and Customer Satisfaction**

The study results indicate a significant positive relationship between Cycle Time Management and Customer Satisfaction in beverage manufacturing enterprises in Southeast Nigeria ($\beta = 0.943$; $p < 0.05$), which is consistent with prior research findings. Lulagala, Mwelu, Watera and Makepu (2023) highlighted the significance of delivery cycle time on the performance of manufacturing firms, emphasising the impact of relevant resources, operational efficiency, operational coordination, and adaptability on delivery cycle time. Similarly, Lee and Lee's (2023) research on sustainable golf course management and Villanueva, Alejandro, and Gaan's (2023) study during the COVID-19 pandemic both underscored the positive effects of service quality and innovative strategies on customer satisfaction. Tiganis, Grigoroudis, and Chrysochou's (2022) study on customer satisfaction in short-food supply chains support this notion, suggesting that the sales process and producers play crucial roles in ensuring customer satisfaction. Additionally, Wuanor and Eke's (2022) investigation into the flour mill industry in Nigeria revealed a positive correlation between service quality dimensions and customer satisfaction. These studies contribute to a comprehensive understanding of manufacturing practices and innovations, highlighting the critical role of cycle time management in optimising production processes and ensuring product quality and customer satisfaction.

(ii) Top Management Commitment and Competitiveness

The results indicate a strong positive impact of Top Management Commitment on Competitiveness ($\beta = 0.916$; $p < 0.05$), which is consistent with and enhances earlier research findings. Makinde, Akinlabi, Adefulu and Vyas (2023) explored the relationship between quality management practices and competitive advantage in selected food and beverage manufacturing firms in Lagos State, Nigeria, supporting that quality management practices contribute to competitive advantage. Similarly, Adiele& Onuoha's (2023) study on Talent Management and Competitiveness of Food and beverage firms in Rivers State, Nigeria, found a positive and significant correlation between effective talent management and business outcomes. Furthermore, Adudu&Torough (2023) delved into Competitive Intelligence and Competitiveness among Quoted Foods and Beverages Manufacturing Firms in Nigeria, revealing that customer intelligence, marketing intelligence, competitor intelligence, and product intelligence all contribute to the competitive stance of firms in the industry. Additionally, Hotlan, Zeplin, and Sautma's (2022) exploration of the role of top management commitment in enhancing competitive advantage aligns with the notion that top management commitment plays a vital role in enhancing competitiveness.

Moreover, Memon, Rasli, Dahri, and Abas's (2022) study on the Importance of Top Management Commitment to Organizational Citizenship Behaviour towards the Environment in Pakistani Industries supported the idea that top management commitment encourages environmental performance and green training, leading to organisational citizenship behaviour towards the environment. Similarly, Toong, Wong, and Vasudevan's (2022) research on leadership styles in the Malaysian food and beverage service industry demonstrated the significant influence of leadership styles on company performance. These collective insights underscore the multifaceted relationship between top management commitment and competitiveness in the food and beverage sector, offering valuable considerations for businesses aiming to optimise operational efficiency and leadership development.

5.0 Conclusion and Recommendations

5.1 Conclusion

From the results, the study concludes that Six Sigma substantially benefits the long-term viability of food and beverage manufacturing companies in Southeast Nigeria.

5.2 Recommendations

Based on the conclusion, the following recommendations are made:

(i) Organisations should implement a culture of cycle time management in their processes and products to improve customer satisfaction. It is essential to continually evaluate and enhance operational processes, product quality, and customer experiences. This may be done by applying methodologies like Six Sigma, which helps identify areas for improvement, eliminate inefficiencies, and encourage innovation and sustainability. Devoting attention to cycle time management not only enhances client happiness but also aids an organisation in optimising and modifying its products and services.

(ii)Organisations should strengthen top management commitment to promote productivity, employee engagement, efficiency culture, and overall organisational performance. It is advisable to allocate resources towards cultivating leaders who can revolutionise the corporate landscape and make substantial financial savings while demonstrating expertise in strategic decision-making and creative problem-solving.

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Appendices

Appendix 1

Model Summary[b] for Hypothesis One					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.943[a]	.889	.888	.30623	.249
a. Predictors: (Constant), Cycle time management b. Dependent Variable: Customer satisfaction					

ANOVA[a] for Hypothesis One						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	203.602	1	203.602	2171.095	.000[b]
	Residual	25.508	272	.094		
	Total	229.109	273			
a. Dependent Variable: Customer satisfaction b. Predictors: (Constant), Cycle time management						

Coefficients[a] for Hypothesis One						
Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.303	.035		8.779	.000
	Cycle time management	.769	.016	.943	46.595	.000
a. Dependent Variable: Customer satisfaction						

Appendix 2

Model Summary[b] for Hypothesis Two					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.916[a]	.840	.839	.36330	.331
a. Predictors: (Constant), Top management commitment b. Dependent Variable: Competitiveness					

ANOVA[a]for Hypothesis Two						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	187.895	1	187.895	1423.595	.000[b]
	Residual	35.900	272	.132		
	Total	223.796	273			
a. Dependent Variable: Competitiveness b. Predictors: (Constant), Top management commitment						

Coefficients[a] for Hypothesis Two						
Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.250	.045		5.596	.000
	Top management commitment	.766	.020	.916	37.731	.000
a. Dependent Variable: Competitiveness						