

Poka-Yoke Manufacturing Methodology and Performance of Beverage Firms in Edo State, Nigeria

Dr. Ohue Paul Itua

*Department of Business Administration,
Ambrose Alli University Ekpoma,
Edo State, Nigeria*

Prince Godswill Akhimien

*Department of Business Administration,
Ambrose Alli University Ekpoma,
Edo State, Nigeria
ORCID No: 000-0002-4730-5827*

ABSTRACT

A field survey by the researchers revealed the failure of managers of most Nigerian manufacturing firms to regularly update their manufacturing methodologies. This attitude could negatively impact the performance level of these firms. The broad objective of this study is to examine the relationship between Poka-Yoke Manufacturing Methodology and Performance of beverage firms in Edo State. Survey research design was used, questionnaire was the data collection instrument employed, a sample size of two hundred and six (206) was obtained using Krejcie and Morgan (1970) formula. The analysis of collected data was done using Pearson Product Moment Correlation. Findings obtained from a test of the formulated hypothesis revealed that there is a strong significant positive relationship between preventive poka-yoke and competitiveness of the studied firms. Based on the finding of the study, the researchers concluded that there is a strong significant positive relationship between Poka-Yoke Manufacturing Methodology and Performance of the studied beverage firms. The researchers recommended that the studied beverage firms should enact mechanisms that could aid early detection of errors in the manufacturing process so as to positively impact its competitive position.

Keywords: *Poka-Yoke Manufacturing Methodology, Preventive Poka-Yoke, Organizational Performance, Firm Competitiveness*

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I. Introduction

The origin of the poka-yoke manufacturing methodology can be traced back to the Toyota Production System (TPS) in Japan, where it was developed by Shigeo Shingo, an influential industrial engineer renowned for his contributions to lean manufacturing principles (Hutchins, 2023). Shingo introduced the concept of poka-yoke as part of TPS in the 1960s to address the challenge of human errors in production processes. The term "poka-yoke" itself translates to "mistake-proofing" or "error-proofing" in Japanese, reflecting its fundamental purpose of preventing errors or defects before they occur. As Toyota and other Japanese firms embraced poka-yoke techniques, the methodology gradually gained prominence in other business organizations as a result of its effectiveness in improving product quality, reducing waste, and enhancing overall operational efficiency (Li & Wang, 2022). Over time, poka-yoke became an integral part of lean manufacturing practices and was widely adopted by companies worldwide seeking to optimize their production processes and deliver superior quality products to customers. In recent years, the emergence of poka-yoke manufacturing methodology has also made significant inroads into the Nigerian manufacturing sector. With the Nigerian economy experiencing rapid growth and industrialization, manufacturing companies in sectors such as food and beverage are increasingly focusing on enhancing their competitiveness and meeting evolving consumer demands (Okafor & Adeniyi, 2023). In this context, the adoption of poka-yoke techniques offers a strategic approach for Nigerian manufacturers to improve product quality, reduce production costs, and gain a competitive edge in the market. In today's highly competitive business landscape, manufacturing companies worldwide continuously seek strategies to enhance operational efficiency, improve product quality, and maintain market leadership. One such strategy that has gained significant attention in recent years is the adoption of advanced manufacturing methodologies aimed at optimizing production processes (Chen, & Choi, 2019). Among these methodologies, the poka-yoke manufacturing approach stands out as a powerful tool for error prevention and quality improvement. Poka-yoke, a Japanese term meaning "mistake-

proofing" or "error-proofing," originated from the Toyota Production System (TPS) and was popularized by Shigeo Shingo, a renowned Japanese industrial engineer. The methodology emphasizes the implementation of a mechanism aimed at preventing errors or defects from occurring during the manufacturing process. By incorporating simple yet effective design modifications, poka-yoke aims to eliminate human errors, minimize waste, and enhance overall process reliability. Recent studies have highlighted the relevance and applicability of poka-yoke methodologies in the Nigerian manufacturing context (Adeyemi, 2024). For example, research by Adedokun (2021) explored the implementation of poka-yoke techniques in Nigerian manufacturing firms and identified significant improvements in process efficiency and product quality. Similarly, a study by Olugbade (2020) investigated the impact of poka-yoke on the performance of Nigerian small and medium-sized enterprises (SMEs), revealing positive outcomes in terms of cost reduction and customer satisfaction. By embracing poka-yoke manufacturing methodology, Nigerian businesses can capitalize on its proven benefits to enhance operational excellence and drive sustainable growth (Rahman, 2023). Through the systematic integration of preventive, detective, and warning poka-yoke techniques, Nigerian manufacturers can mitigate production errors, minimize waste, and optimize resource utilization, thereby improving their competitiveness and market positioning in the dynamic business environment.

Despite the recognized benefits of poka-yoke manufacturing methodologies in enhancing operational efficiency and product quality, several challenges persist in their implementation within Nigerian manufacturing businesses, including Nigerian Bottling Company and Seven Up Bottling Company. These challenges necessitate further investigation to comprehensively understand the barriers hindering the effective adoption and utilization of poka-yoke techniques in improving organizational performance (Adeyemi, 2024).

The broad objective of this study is to examine the relationship between poka-yoke manufacturing methodology and performance of beverage firms in Edo State. Specifically, this study seeks to ascertain the relationship between preventive poka-yoke and firm competitiveness.

II. Review of Related Literature

Conceptual Review

Poka-Yoke Manufacturing Methodology

Poka-yoke, a term originating from the Toyota Production System (TPS), represents a fundamental concept in lean manufacturing aimed at error prevention or mistake-proofing within production processes. Developed by Shigeo Shingo in the 1960s, poka-yoke methodologies emphasize the implementation of mechanisms geared towards eliminating errors or defects before they occur, thereby enhancing product quality and operational efficiency (Kumar, & Suresh 2018). The term "poka-yoke" itself translates to "mistake-proofing" or "error-proofing" in Japanese, reflecting its core objective of preventing mistakes in manufacturing processes. Over the years, poka-yoke has gained widespread recognition and adoption across industries worldwide as an effective approach to improving process reliability and reducing waste. The poka-yoke techniques available to manufacturing firms are preventive, detective, and warning poka-yoke techniques (Srivastava, & Srivastava, 2020). In a nut shell, poka-yoke manufacturing methodology emphasizes early detection of error in the manufacturing process. The emphasis of this study is preventive poka-yoke manufacturing methodology. As manufacturing industries continue to evolve, the adoption of poka-yoke techniques remains essential for achieving excellence in quality and operational performance.

Preventive Poka-Yoke

Preventive poka-yoke represents a cornerstone of poka-yoke methodology, focusing on proactively designing processes or systems to eliminate the possibility of errors occurring in the first place (Ribeiro, & Almeida, 2017). This preventive approach aims to build error-proofing mechanisms into the production process, thereby reducing the likelihood of defects and improving overall product quality. Preventive poka-yoke techniques encompass a wide range of strategies, including design simplification, error-proofing devices, and standardized work procedures. One common preventive poka-yoke technique is the design simplification of products or processes to minimize the potential for errors (Jiang, 2020). By simplifying product designs or streamlining production processes, manufacturers can reduce complexity and variability, making it easier for operators to perform tasks correctly and consistently. For example, in automotive manufacturing, Toyota famously redesigned the fuel cap and fuel filler neck assembly to prevent misalignment and ensure proper sealing, thereby eliminating the risk of fuel leaks and associated safety hazards (Gupta, 2021). This simple design modification effectively prevented potential errors and enhanced product reliability.

Another preventive poka-yoke strategy involves the use of error-proofing devices or mechanisms to prevent errors from occurring during assembly or production (Adedokun, 2021). These devices are designed to detect and prevent common types of errors, such as misalignments, incorrect part orientations, or missing components. For instance, in semiconductor manufacturing, automated vision systems are used to inspect and verify the orientation of semiconductor wafers before processing, ensuring that they are correctly aligned and

positioned (Tapping, & Shuker, 2015). By integrating error-proofing devices into production equipment or assembly lines, manufacturers can detect and correct errors in real-time, minimizing the risk of defects and rework. Standardized work procedures represent another key aspect of preventive poka-yoke, ensuring that operators follow consistent and standardized processes to minimize errors (Adeyemi, 2024). Standardized work instructions provide clear guidance to operators on how to perform tasks correctly and efficiently, reducing the likelihood of deviations or mistakes. For example, in food processing plants, standard operating procedures (SOPs) outline precise steps for handling and preparing ingredients, minimizing the risk of contamination or cross-contamination (Olugbade, 2020). By establishing standardized work procedures and providing adequate training to operators as emphasized by preventive poka-yoke manufacturing methodology, manufacturers can create a culture of quality and reliability, driving continuous improvement and error prevention.

Organizational Performance

Organizational performance is a multidimensional concept that encompasses various aspects of an organization's effectiveness, efficiency, and competitiveness in achieving its strategic objectives and goals (Rahman, 2022). It serves as a crucial indicator of an organization's overall health, sustainability, and success in the marketplace. Organizational performance metrics typically include financial indicators as well as non-financial indicators (Gupta, 2021). Financial performance metrics include measures such as revenue growth, profit margins, return on investment (ROI), and cash flow. A financially healthy organization is able to generate sustainable profits, reinvest in business growth, and reward shareholders with dividends or capital appreciation. High financial performance is essential for ensuring the long-term viability and competitiveness of an organization in the marketplace. Non-financial performance indicators include firm competitiveness, market leadership, market share, customer satisfaction, turnover intention (Jiang, 2020). For this study, firm competitiveness a non-financial performance indicator was used.

Firm Competitiveness

Firm competitiveness refers to an organization's ability to compete effectively in the market by offering superior products or services compared to competitors (Rahman, 2022). It encompasses various factors that contribute to the organization's market position, differentiation, and perceived value proposition. Firm competitiveness is essential for sustaining customer loyalty, attracting new customers, and achieving long-term success in competitive markets. Product quality represents a critical dimension of firm competitiveness, as high-quality products are more likely to meet customer needs and expectations, leading to increased customer satisfaction and loyalty (Gupta, 2021). Organizations that consistently deliver superior-quality products can differentiate themselves from competitors, command premium prices, and gain a competitive advantage in the marketplace. Quality certifications such as ISO 9001 and Six Sigma demonstrate a commitment to quality excellence and can enhance an organization's reputation and market credibility. Innovation capability is another key driver of firm competitiveness, as organizations that innovate are better positioned to meet changing customer needs, disrupt existing markets, and create new market opportunities (Jiang, 2020). Innovation can take various forms, including product innovation, process innovation, business model innovation, and technological innovation. Organizations that invest in research and development (R&D), foster a culture of creativity and experimentation, and collaborate with external partners can generate breakthrough innovations that differentiate them from competitors and drive growth.

Customer focus and market orientation are essential for firm competitiveness, as organizations that understand their customers' needs, preferences, and buying behavior can develop products and services that resonate with target audiences (Adedokun, 2021). Customer-centric organizations gather customer feedback, conduct market research, and segment their target markets to tailor their offerings and marketing strategies accordingly. By providing personalized experiences, anticipating customer needs, and delivering exceptional customer service, organizations can build strong customer relationships and gain a competitive edge in the marketplace. Cost leadership is a strategic approach to firm competitiveness, focusing on achieving lower costs than competitors while maintaining acceptable levels of quality and value (Tong, & Suresh, 2018). Staying competitive is all about developing strategies that could help an organization meet up with the ever changing demands of customers in the business environment.

Theoretical Framework

This study is fastened on Dynamic Capability Theory, pioneered by Teece, Pisano, and Shuen in 1997. At its core, Dynamic Capability Theory posits that organizations must continuously adapt and evolve their capabilities to respond effectively to changes in the business environment (Teece, Pisano, & Shuen, 1997). This theory aligns closely with the essence of poka-yoke methodology, which emphasizes the need for organizations to implement error-proofing techniques and continually improve their processes to prevent errors, reduce waste, and enhance operational efficiency. In the context of poka-yoke manufacturing, dynamic capabilities play a crucial

role in enabling organizations to innovate and adapt their production processes in response to evolving customer needs, technological advancements, and competitive pressures. By embracing dynamic capabilities, organizations can identify opportunities for process improvement, experiment with new techniques or technologies, and reconfigure their resources to optimize their manufacturing operations. In summary, Dynamic Capability Theory provides a valuable framework for understanding how organizations can leverage poka-yoke manufacturing methodology to enhance their performance and competitiveness. By cultivating dynamic capabilities, organizations can effectively adapt to changing circumstances, innovate their production processes, and sustain long-term success in dynamic and competitive business environments.

Empirical Review

Tzortzopoulos, & Chan, (2019), conducted a study in India, examining the impact of poka-yoke implementation on manufacturing firms' competitiveness. The research utilized a survey research design with a sample size of 200 respondents. Data was collected through questionnaire and analyzed using regression analysis. The findings revealed a positive relationship between poka-yoke implementation and firm competitiveness, highlighting the significance of error-proofing techniques in enhancing organizational performance.

Wu, & Kao, (2020), investigated the effect of poka-yoke techniques on operational efficiency and customer satisfaction in the manufacturing sector in Bangladesh. The study employed a mixed-methods approach, combining surveys and interviews with 50 manufacturing firms. Data analysis involved thematic analysis and statistical techniques. The results indicated that organizations implementing poka-yoke methodologies experienced improved operational efficiency and higher levels of customer satisfaction, underscoring the importance of error prevention in enhancing organizational performance.

Adedokun (2021), conducted a study in Nigeria to explore the adoption and impact of poka-yoke techniques in small and medium-sized enterprises (SMEs). The research employed a qualitative research design, including interviews and focus group discussions with 15 SME owners and managers. Thematic analysis was used to analyze the data. The findings revealed that SMEs implementing poka-yoke techniques reported reduced errors, improved product quality, and enhanced customer satisfaction, highlighting the relevance of error-proofing strategies in enhancing SME performance.

Li and Wang (2021), conducted a study in China to investigate the effectiveness of preventive poka-yoke techniques in the automotive manufacturing industry. The research utilized a quantitative research design with a sample size of 300 production line workers. Data was collected through structured surveys and analyzed using descriptive and inferential statistical methods. The findings demonstrated that the implementation of preventive poka-yoke techniques resulted in a significant reduction in defects and improved product quality, emphasizing the importance of error prevention in manufacturing processes.

Okafor and Adeniyi (2023), examined the application of poka-yoke methodologies in the food processing industry in Nigeria. The study employed a case study approach, focusing on three food processing companies in different regions of Nigeria. Data was collected through interviews, observations, and document analysis. Thematic analysis was used to analyze the qualitative data. The findings revealed that organizations adopting poka-yoke techniques experienced reduced waste, improved process efficiency, and enhanced product quality, highlighting the relevance of error-proofing strategies in the Nigerian food processing sector.

Jiang (2020), investigated the impact of detective poka-yoke techniques on production efficiency and cost reduction in electronic manufacturing firms in South Korea. The research utilized a quantitative research design with a sample size of 150 production line workers. Data was collected through structured surveys and analyzed using regression analysis. The results indicated that the integration of detective poka-yoke devices into assembly processes led to increased production efficiency, decreased rework costs, and improved overall process reliability, demonstrating the effectiveness of error detection mechanisms in enhancing organizational performance.

Gap in Knowledge

Despite the wealth of literature on poka-yoke manufacturing methodology and its impact on organizational performance, there remains a notable gap in knowledge regarding its application and effectiveness in specific contexts, such as developing countries or emerging industries. Base on that, this study seeks to fill this gap by x-raying the effect of poka-yoke manufacturing methodology on performance of beverage firms in Edo State.

III. Methodology

Research Design

This study employed a survey research design. The survey research design was chosen because it enables the researcher to describe and explain the relationship between Poka-yoke Manufacturing Methodology and performance of beverage firms in Edo state.

Area of Study

The study is centered on Nigerian Bottling Company, Benin plant, located at Benin Auchu Rd, Eyaen, Benin City, Edo State and Seven Up Bottling Company located at Iguosa, Benin City, Edo State.

Population of Study

The population of the study is the entire workforce of Nigerian Bottling Company and Seven Up Bottling Company Benin plant, Edo state. Nigerian Bottling Company, Benin plant has a total workforce of two hundred and sixty one (265) employees while Seven Up Bottling Company Benin plant has a total workforce of one hundred and seventy five (182). This gives a total of four hundred and thirty six (447).

Sample Size and Sampling

The Krejcie and Morgan (1970) sampling technique was used for this study. The formular is denoted below:

$$S = \frac{x^2NP(1-P)}{d^2(N-1) + x^2P(1-P)}$$

The Krejcie and Morgan (1970) sampling technique was used for this study. The formular is denoted below:

Where S= Sample Size

X²= Table value of chi-square for 1 degree of freedom 0.05 confidence level (3.84)

N= population Size (447)

P= Population proportion (0.5)

d²= Degree of accuracy (0.05)

S= 3.84 (447) (0.5) (1-0.5)

$$S = \frac{(3.84)^2 (447-1) + (3.84) (0.5) (1-0.5)}{0.05^2}$$

$$S = \frac{1.12+0.96}{0.0025}$$

$$S = \frac{2.08}{0.0025}$$

$$S = 206.3 = 206$$

Based on the foregoing, 206 copies of the questionnaire were randomly administered to respondents of the focused beverage firms.

Instrument of Data Collection

The data collection tool employed by the researcher was the questionnaire. It was designed on a five point Likert Scale. Strongly Agree (SA), Agree (A), Undecided (U), Strongly Disagree (SD), and Disagree (D).

Validity of the Instrument

Validity is the extent to which an instrument measures what it intends to measure. The content and face validity test was used by the researchers.

Reliability of the Instrument

Reliability test is a measure of the consistency of a particular instrument employed by a researcher. The Cronbach’s Alpha reliability test was used for the study. Suwannoppharat and Kaews, (2015) assert that a reliability coefficient of 0.696 and above is acceptable. Therefore, a benchmark of 0.696 was used for the study.

Table 1: Scale: Reliability Statistics for Preventive Poka-Yoke

Reliability Statistics	
Cronbach's Alpha	N of Items
.813	5

Source: Field Survey 2024

Since the Cronbach’s Alpha score of the reliability statistics for preventive poka-yoke 0.81 is greater than 0.696, it shows that the instrument is reliable.

Table 2: Scale: Reliability Statistics for Firm Competitiveness

Reliability Statistics	
Cronbach's Alpha	N of Items
.842	5

Source: Field Survey 2024

Since the Cronbach's Alpha score of the reliability statistics for firm competitiveness 0.84 is greater than 0.696, it shows that the instrument is reliable. The results of the reliability test were indications of the internal consistency of the instrument.

Techniques of Data Analysis

Mean was used to analyze the research question using while Pearson Product Moment Correlation was used to test the hypotheses. This was done using SPSS version 26.

Data Presentation, Analysis and Interpretation

Table 3: Analysis of Returned and Unreturned Questionnaire

Items	No. of Respondents	Percentage (%)
Returned	184	89.32%
Unreturned	22	10.68%
Total	206	100%

Source: Field Survey (2024)

From Table 3, 184 respondents representing 89.32% completely filled and “returned” while 22 respondents representing 10.68% did not return copies of the questionnaire given to them. Base on that, one hundred and eighty four (184) copies of the questionnaire was used for the analysis.

What is the relationship between preventive poka-yoke and competitiveness of beverage firms in Edo State?

Table 4: Descriptive Statistics for Preventive Poka-Yoke

	N	Minimum	Maximum	Mean
Q1	184	1.00	5.00	2.61
Q2	184	1.00	5.00	2.75
Q3	184	1.00	5.00	3.23
Q4	184	1.00	5.00	3.41
Q5	184	1.00	5.00	2.82
Valid N (listwise)	184			

Source: Field Survey, 2024.

The mean scores from the questionnaire responses on questions relating to preventive poka-yoke are >2.5. This makes the responses acceptable.

Table 5 Descriptive Statistics for Firm Competitiveness

	N	Minimum	Maximum	Mean
Q1	184	1.00	5.00	2.86
Q2	184	1.00	5.00	3.70
Q3	184	1.00	5.00	3.21
Q4	184	1.00	5.00	3.62
Q5	184	1.00	5.00	2.53
Valid N (listwise)	184			

Source: Field Survey, 2024.

The mean scores from the questionnaire responses on questions relating to firm competitiveness are >2.5. This makes the responses acceptable.

Test of Hypothesis

Hypothesis

Ho: There is no significant positive relationship between preventive poka-yoke and firm competitiveness

Correlation

		PRE_POK_YOK	FIR_COMP
PRE_POK_YOK	Pearson Correlation	1	.852*
	Sig. (2-tailed)		.000
	N	184	184
FIR_COMP	Pearson Correlation	.852*	1
	Sig. (2-tailed)	.000	
	N	184	184

** . Correlation is significant at the 0.01 level (2-tailed).

Since $r = 0.852$ (85%), it shows that there is a strong positive relationship between preventive poka-yoke and firm competitiveness. Since the p value $0.00 < 0.001$, it shows that the result is statistically significant at 0.05 (5%) level of significance

IV. Discussion of Findings

The result obtained from a test of the hypothesis reveals that there is a significant positive relationship between preventive poka-yoke techniques and firm competitiveness. This finding is consistent with Jiang (2020), who emphasized that preventive poka-yoke aims to integrate error-proofing mechanisms into the production process. By doing so, it effectively lowers the occurrence of defects and enhances overall product quality. Preventive poka-yoke strategies encompass diverse approaches such as design simplification, implementation of error-proofing devices, and establishment of standardized work procedures. A particularly notable technique involves streamlining product designs or processes to mitigate error potentials effectively.

Findings obtained from a test of the hypothesis also aligns with the study of Jiang (2020). Findings of his study reveals that preventive poka-yoke techniques contribute to sustainable competitive advantage by fostering a culture of continuous improvement and operational excellence. This approach not only reduces rework and waste but also enhances customer satisfaction through consistently high-quality products.

V. Summary, Conclusion and Recommendation

Summary

Findings revealed that there is a strong significant positive relationship between Poka-Yoke Manufacturing Methodology and Performance of beverage firms in Edo State since $r = 0.85$ (85%) and p value $0.00 < 0.001$.

Conclusion

The findings obtained from this study underscore a robust positive relationship between the Poka-Yoke Manufacturing Methodology and organizational performance. Specifically, the research demonstrates a significant positive correlation between the implementation of preventive poka-yoke techniques and firm competitiveness. This aligns with contemporary literature, which emphasizes how preventive poka-yoke contributes to enhancing operational efficiency, reducing defects, and improving overall product quality. The integration of error-proofing mechanisms, such as design simplification and standardized procedures, plays a pivotal role in achieving these outcomes.

Recommendation

The researchers recommended that the studied beverage firms should enact mechanisms that could aid early detection of errors in the manufacturing process so as to positively impact its competitive position.

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