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Effect of Returned Packaging Inspection Process on Production Line Efficiency in Rwanda. A case of SKOL Brewery Ltd

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Abstract: *This study examined the effect of the returned packaging inspection process on production line efficiency at SKOL Brewery Ltd. Specifically, it assessed the effect of the degree of automation of inspection on production line efficiency. The study employed descriptive and explanatory research design using quantitative and qualitative approaches. The target population comprised 167 employees, while 160 questionnaires were administered and 144 were fully completed and returned, representing a response rate of 90%. Data were collected using structured questionnaires and interview guides and analyzed using SPSS. Descriptive statistics, Pearson correlation analysis, and thematic analysis were used to analyze the data. The correlation analysis revealed a strong positive and statistically significant relationship between the degree of automation of inspection and production line efficiency (r = 0.866, p = 0.000). The findings indicated that automated inspection contributes to improved inspection speed, accuracy, consistency, and reliability while reducing inspection-related delays and production interruptions. The study concluded that the degree of automation of inspection is an important factor in improving production line efficiency at SKOL Brewery Ltd. The study recommended increasing the use of automated inspection systems, establishing regular maintenance and calibration of inspection equipment, and providing practical training to employees operating automated inspection systems.*

Keywords: *Degree of automation of inspection; Production line efficiency; Returned packaging inspection; Automated inspection; Quality control; SKOL Brewery Ltd.; Rwanda*

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1. Introduction

Returned packaging inspection has become an essential component of modern manufacturing systems, particularly in the beverage industry where reusable containers such as glass bottles are widely used. These containers must undergo rigorous inspection processes to ensure they meet hygiene, safety, and quality standards before being reintroduced into the production cycle. Ineffective inspection processes can result in contaminated or defective packaging entering the production line, leading to product recalls, increased waste, and operational inefficiencies. According to Montgomery (2020), quality control and inspection systems are fundamental in ensuring consistency in production processes and minimizing defects, thereby improving overall production line efficiency.

Globally, manufacturing industries have increasingly adopted advanced technologies to enhance inspection processes and optimize production performance. The World Bank (2020) emphasizes that efficient production systems are critical for industrial growth, competitiveness, and sustainability. Technologies such as automated bottle inspection systems, machine vision, and sensor-based detection are widely used to improve accuracy and speed in identifying defective packaging. These innovations not only reduce human error but also enhance production line

efficiency by minimizing downtime and ensuring a continuous production flow (Kumar & Singh, 2021).

In developed countries such as the United States, Germany, and the United Kingdom, returned packaging inspection processes are highly automated and integrated into production lines. These countries utilize advanced inspection technologies, including high-speed cameras and artificial intelligence systems, to detect defects such as cracks, contamination, and improper shapes in returned bottles. According to OECD (2021), such technologies have significantly improved operational efficiency by reducing production stoppages and increasing output levels. The integration of inspection systems into automated production lines ensures that only high-quality packaging materials are used, thereby maintaining product standards and reducing operational costs.

In Africa, manufacturing industries are progressively adopting improved inspection processes to enhance efficiency and product quality. However, challenges such as limited access to advanced technology, high costs of automation, and inadequate technical expertise continue to hinder the effectiveness of inspection systems. The African Development Bank (2022) notes that improving quality control mechanisms, including packaging inspection, is essential for strengthening industrial productivity across the continent. Despite these challenges, several African countries are investing in modernization initiatives aimed at improving manufacturing processes and reducing inefficiencies associated with defective packaging.

In East Africa, the manufacturing sector has experienced steady growth, driven by regional integration and industrial development policies. The East African Community (2021) reports that member states are increasingly focusing on improving production efficiency and quality assurance systems to enhance competitiveness in both regional and international markets. However, inefficiencies in returned packaging inspection processes, such as delays, manual errors, and inconsistent inspection standards, continue to affect production line performance in many industries. Addressing these challenges is critical for improving operational efficiency and achieving sustainable industrial growth in the region.

In Rwanda, the manufacturing sector, particularly the beverage industry, has expanded significantly in recent years. Companies such as SKOL Brewery Ltd rely heavily on returnable glass bottles as part of their production processes. According to Rwanda Development Board (2023), the use of reusable packaging contributes to cost reduction and environmental sustainability. However, it also requires efficient inspection systems to ensure that only safe and high-quality packaging is reused. Challenges such as slow inspection processes, equipment limitations, and inadequate detection of defective bottles can lead to production delays, increased downtime, and reduced efficiency.

Specifically, at SKOL Brewery Ltd, returned packaging inspection is a critical stage in the production process, as it directly influences the flow and efficiency of the production line. Inefficient inspection processes may result in bottlenecks, increased rejection rates, and interruptions in production. According to Niyonzima (2022), ineffective quality control systems in manufacturing industries can significantly reduce productivity and increase operational costs. Therefore, understanding the effect of returned packaging inspection processes on production line efficiency is essential for improving performance, reducing waste, and enhancing competitiveness in Rwanda's beverage manufacturing sector.

1.2 Statement of the Problem

Returned packaging inspection processes play a critical role in ensuring production line efficiency in beverage manufacturing industries, particularly where reusable containers such as glass bottles are used. These processes involve identifying and removing defective, contaminated, or damaged packaging before it re-enters the production cycle. Effective inspection systems help maintain product quality, reduce waste, and ensure smooth production flow. According to Montgomery (2020), quality inspection is essential in minimizing defects and improving operational efficiency in manufacturing systems. Similarly, the World Bank (2020) emphasizes that efficient quality control mechanisms are fundamental to achieving high productivity and competitiveness in industrial operations.

Despite the importance of returned packaging inspection processes, many manufacturing firms continue to experience inefficiencies related to inspection activities. Inadequate inspection systems, reliance on manual processes, and delays in detecting defective packaging often lead to production interruptions, increased downtime, and reduced output. In beverage industries, these inefficiencies can result in contamination risks, increased rejection rates, and higher operational costs. In Rwanda, companies such as SKOL Brewery Ltd face challenges including slow inspection processes, equipment limitations, and inconsistent quality control practices (Rwanda Development Board, 2023). These issues create bottlenecks within production lines, negatively affecting overall efficiency and organizational performance.

Several studies have examined factors influencing production efficiency and quality control in manufacturing

industries. For instance, Kumar and Singh (2021) found that automated inspection systems significantly improve production efficiency by reducing human error and inspection time. Similarly, Ndayisaba (2022) established that quality control practices positively influence manufacturing performance in Rwanda, although the study did not specifically focus on packaging inspection. A study by Brown (2021) revealed that effective inspection processes reduce production downtime and enhance operational performance in beverage industries. Additionally, African Development Bank (2022) reported that improving quality assurance systems, including inspection processes, is essential for enhancing industrial productivity in developing countries. However, these studies largely focus on general quality control systems rather than specifically examining returned packaging inspection processes.

Although previous studies provide valuable insights into production efficiency and quality control, limited empirical evidence exists on the specific effect of returned packaging inspection processes on production line efficiency, particularly in Rwanda's beverage manufacturing sector. This gap limits the ability of firms to implement targeted improvements in inspection systems. Therefore, this study seeks to bridge this gap by assessing the effect of returned packaging inspection processes on production line efficiency, using SKOL Brewery Ltd as a case study. The findings will provide evidence-based recommendations for improving inspection processes, enhancing efficiency, and strengthening manufacturing performance in Rwanda.

1.3 Research Objectives

The objectives of this study were presented in terms of the general objective and specific objectives

1.3.1 Objectives of the Study

The main purpose of this study is to assess the effect of returned packaging inspection process on production line efficiency at SKOL Brewery Ltd.

1.3.2 Specific objectives of the Study

This study was guided by the following research objectives:

To assess the effect of the degree of automation of the inspection on production line efficiency at SKOL Brewery Ltd.

2. Literature Review

This section review focuses on the key concepts derived directly from the specific objective of the study. These include the degree of automation of inspection as components of the returned packaging inspection process, as well as production line efficiency as the outcome variable. The section explains each concept and how it relates to production performance in manufacturing firms such as SKOL Brewery Ltd.

2.1.1 Returned Packaging Inspection Process

Returned packaging inspection process refers to the systematic, structured, and continuous evaluation of reusable packaging materials such as glass bottles, crates, and containers to determine their suitability for reuse in the production process (Fergison, 2024). In manufacturing industries, particularly in beverage production, this process is essential because packaging materials are repeatedly returned, cleaned, inspected, and reintroduced into the production line. The inspection process involves identifying defects such as cracks, chips, contamination, deformation, or any structural weaknesses that could compromise product quality or disrupt production operations. According to Evans and Lindsay (2020), effective inspection systems play a preventive role by ensuring that defective inputs are identified and removed before they enter the production process, thereby reducing the likelihood of downstream production failures.

The effectiveness of the returned packaging inspection process largely depends on how well it is integrated into the production system and how efficiently it operates relative to production speed(Kariako, 2023) In high-volume manufacturing environments, inspection must be fast, accurate, and consistent to avoid creating bottlenecks. Efficient inspection processes ensure that only acceptable packaging materials are supplied to the production line, thereby supporting continuous workflow and minimizing interruptions. Conversely, inefficient inspection processes characterized by delays, inconsistencies, or errors can lead to production stoppages, increased rejection rates, and reduced productivity. According to Heizer, Render, and Munson (2020), operational processes that are well-aligned with production flow significantly improve efficiency and reduce process variability.

Furthermore, the returned packaging inspection process is influenced by several key factors that determine its effectiveness and impact on production line efficiency (Terry, 2020). These include the degree of automation of inspection, which enhances speed and accuracy; the stringency of acceptance criteria, which determines the quality standards applied during inspection; and the training level of inspection personnel, which influences consistency and reliability in inspection decisions. In manufacturing firms such as SKOL Brewery Ltd, the

performance of the inspection process directly affects production efficiency. An effective inspection system minimizes disruptions, reduces waste, and improves product quality, while an ineffective system can create bottlenecks and negatively impact overall production performance.

2.1.2 Degree of Automation of Inspection

The degree of automation of inspection refers to the extent to which inspection activities within the production process are performed using automated technologies rather than manual human effort (Gaine, 2023). In modern manufacturing environments, automation involves the use of advanced systems such as sensors, machine vision, artificial intelligence, and computerized control systems to detect defects, measure quality parameters, and make real-time decisions. Automation reduces dependence on human judgment, increases consistency in inspection outcomes, and enhances the speed at which inspection processes are carried out. According to Evans and Lindsay (2020), automated inspection systems improve accuracy and reliability in quality control by minimizing human error and ensuring consistent application of standards.

The level of automation in inspection processes plays a significant role in determining production line efficiency (Raul, 2023). Highly automated inspection systems are capable of processing large volumes of materials quickly and accurately, which supports continuous production flow and reduces delays. Automation enables real-time monitoring and immediate detection of defects, allowing corrective actions to be taken promptly without interrupting production. On the other hand, low levels of automation, which rely heavily on manual inspection, are often associated with slower processing times, inconsistencies in defect detection, and increased likelihood of errors. As noted by Heizer, Render, and Munson (2020), integrating automation into operational processes enhances efficiency by reducing variability and improving process speed.

Furthermore, the degree of automation of inspection influences other aspects of production performance, including product quality, cost efficiency, and resource utilization. Automated systems reduce labor costs associated with manual inspection and minimize waste by ensuring that defective materials are identified early in the production process. However, the implementation of automation requires significant investment in technology and skilled personnel to operate and maintain the systems. In manufacturing firms such as SKOL Brewery Ltd, increasing the level of automation in returned packaging inspection is expected to improve production line efficiency by enhancing accuracy, reducing inspection time, and ensuring smooth workflow throughout the production process.

2.2 Theoretical Review

The theoretical review provides a foundation for understanding the relationship between the degree of automation of inspection and production line efficiency at SKOL Brewery Ltd. This study is guided by the Resource-Based View (RBV) Theory, which explains how organizations can achieve improved performance through the effective utilization of valuable internal resources and capabilities. The theory was formally developed by Barney (1991), building on earlier work by Penrose (1959), and argues that organizations can achieve superior performance when they possess and effectively utilize resources that are valuable, rare, difficult to imitate, and appropriately organized. Such resources include physical assets, technological systems, human skills, knowledge, and organizational capabilities. In this study, inspection technology is considered an important technological resource that can influence the effectiveness and efficiency of production operations (White, 2024).

The degree of automation of inspection represents the extent to which inspection activities are performed using automated technologies rather than relying entirely on manual inspection. From the RBV perspective, automated inspection systems constitute technological resources that can improve organizational performance when they are effectively acquired, implemented, and utilized. Automated inspection can enhance the speed and accuracy of identifying defective returned packaging, reduce human errors, improve consistency, and provide timely inspection decisions. Evans and Lindsay (2020) emphasize the importance of technological resources in improving process performance, while Heizer, Render, and Munson (2020) highlight the contribution of appropriate technology to productivity and operational efficiency in manufacturing systems. Therefore, the effective utilization of automated inspection technology can enable SKOL Brewery Ltd to process returned packaging more efficiently and reduce inspection-related delays and disruptions.

The RBV Theory is highly relevant to this study because it provides a theoretical explanation of how technological resources can influence production line efficiency. At SKOL Brewery Ltd, the degree of automation of returned packaging inspection can contribute to improved production performance by increasing inspection speed, improving the accuracy of defect identification, reducing errors, and minimizing interruptions in production activities. When automated inspection resources are effectively integrated into the production process, they can support smoother workflow, better utilization of

production resources, and improved operational efficiency. Therefore, the Resource-Based View Theory provides an appropriate theoretical foundation for assessing the effect of the degree of automation of inspection on production line efficiency at SKOL Brewery Ltd (Ghania, 2024).

2.3 Empirical Literature

Globally, the degree of automation of inspection has become a central determinant of production line efficiency in modern manufacturing systems. García and López (2022) conducted a comprehensive cross-industry study across Europe and Asia and found that the integration of automated inspection technologies such as machine vision systems, sensors, and artificial intelligence significantly improves efficiency by reducing inspection time, minimizing human error, and enhancing the precision of defect detection. The study reported a strong positive correlation between automation and production line efficiency ($r = 0.74$), indicating a robust relationship between increased automation and improved operational outcomes. Regression analysis further revealed a significant positive effect ($\beta = 0.70$, $p < 0.05$), while the model summary showed that automation explained a substantial proportion of variance in production efficiency ($R^2 = 0.55$). The ANOVA results confirmed that the model was statistically significant ($F = 36.8$, $p < 0.05$). Despite these strong findings, the study primarily focused on large multinational firms with advanced technological capabilities, leaving a gap in understanding how automation performs in developing countries with limited infrastructure and financial resources.

In developed countries, automation is widely adopted as a strategic tool for enhancing production performance and maintaining competitive advantage. Müller and Schmidt (2021), in a study conducted in Germany's manufacturing sector, found that firms implementing fully automated inspection systems experienced significant improvements in productivity, reduced machine downtime, and enhanced product quality. The study highlighted that automation enables real-time monitoring and consistent application of quality standards, thereby improving process reliability and efficiency. The findings revealed a strong positive correlation ($r = 0.78$) and a significant regression effect ($\beta = 0.73$, $p < 0.05$), with a high level of explanatory power ($R^2 = 0.60$). The ANOVA results confirmed statistical significance ($F = 42.5$, $p < 0.05$). However, the study was conducted in highly industrialized settings with well-established technological systems, and it did not address the feasibility of implementing such advanced systems in developing economies, creating a contextual gap.

In Africa, the adoption of automated inspection systems is gradually increasing, although it remains limited compared to developed regions. Adebayo et al. (2023), in a study conducted in Nigeria's manufacturing sector, found that low levels of automation in inspection processes contributed to inefficiencies such as longer inspection times, increased defect rates, and inconsistent quality outcomes. The study reported a moderate positive correlation between automation and production efficiency ($r = 0.61$), suggesting that improvements in automation can significantly enhance operational performance. Regression results showed a significant positive effect ($\beta = 0.57$, $p < 0.05$), while the model summary indicated moderate explanatory power ($R^2 = 0.37$). The ANOVA results confirmed that the model was statistically significant ($F = 20.9$, $p < 0.05$). However, the study did not examine how automation interacts with other factors such as employee training and acceptance criteria, leaving a gap for further research.

In East Africa, efforts to integrate automation into manufacturing processes have yielded encouraging but still limited results. Tesfaye (2022), in a study conducted in Ethiopia, examined the use of semi-automated inspection systems in food and beverage industries and found that automation improved production efficiency by reducing inspection time, increasing accuracy, and enhancing workflow continuity. The study established a positive correlation ($r = 0.65$) and a significant regression effect ($\beta = 0.62$, $p < 0.05$), with the model explaining a considerable proportion of efficiency variation ($R^2 = 0.42$). The ANOVA results confirmed statistical significance ($F = 26.7$, $p < 0.05$). However, the study was limited in scope and did not assess the long-term sustainability, cost implications, or scalability of automation technologies, creating a gap for future studies.

In Rwanda, empirical evidence on the degree of automation of inspection remains limited, particularly in relation to returned packaging systems in the beverage industry. Habimana (2021), in a study conducted among manufacturing firms in Kigali, found that low levels of automation in inspection processes contributed to inefficiencies such as production delays, inconsistent inspection results, and reduced productivity. The study reported a moderate positive correlation ($r = 0.57$) and a significant regression effect ($\beta = 0.54$, $p < 0.05$), with model summary results indicating moderate explanatory power ($R^2 = 0.32$). The ANOVA results confirmed that the model was statistically significant ($F = 16.8$, $p < 0.05$). However, the study did not specifically focus on returned packaging inspection processes in beverage manufacturing. Therefore, this study seeks to fill this gap by examining the effect of the degree of automation of inspection on production line efficiency at SKOL Brewery Ltd.

3. Methodology

The study assessed the effect of the degree of automation of inspection on production line efficiency at SKOL Brewery Ltd. The research used a descriptive and explanatory research design to describe the existing level of automation in returned packaging inspection and determine its effect on production line efficiency. The degree of automation of inspection was treated as the independent variable, while production line efficiency was treated as the dependent variable. The study focused on how the use of automated inspection systems was associated with production outcomes at SKOL Brewery Ltd. The explanatory research design enabled the researcher to determine the statistical effect of the degree of automation of inspection on production line efficiency.

The study population consisted of 167 employees involved in production, packaging, quality assurance, maintenance, and returned packaging activities at SKOL Brewery Ltd. These employees included 7 production managers, 43 quality control inspectors, 58 machine operators, 24 maintenance technicians, and 35 warehouse staff. The census sampling technique was used, whereby all 167 employees were included in the study. This approach allowed the researcher to obtain information from the entire identified population rather than selecting a smaller sample. The inclusion of employees from different categories provided information on the use of automated inspection systems and their relationship with production line efficiency from different operational perspectives.

Data on the degree of automation of inspection were collected using a structured questionnaire administered to the 167 employees. The questionnaire used closed-ended statements measured on a five-point Likert scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree. The items focused specifically on the extent to which automated technologies were used in returned packaging inspection, the speed of automated inspection, accuracy and consistency of automated inspection, reduction of manual inspection activities, and the contribution of automation to timely identification of defective packaging. These indicators enabled the researcher to obtain standardized responses concerning the degree of automation of returned packaging inspection at SKOL Brewery Ltd. The use of standardized responses also allowed the collected information to be coded and subjected to statistical analysis.

Production line efficiency was measured as the dependent variable. It was assessed using indicators relating to output rate, downtime, product quality, and production speed. Output rate focused on the quantity of products produced within a given production period, while downtime concerned interruptions or periods when production activities were stopped. Product quality focused on the ability of the production process to maintain the required quality standards, while production speed concerned the time and efficiency with which production activities were completed. These indicators provided the basis for assessing whether the degree of automation of inspection contributed to improved production line efficiency at SKOL Brewery Ltd.

The study also used a semi-structured interview guide to complement the questionnaire data. Key informant interviews were conducted with selected production managers, supervisors, and quality control personnel who had direct knowledge of returned packaging inspection and production operations. The interviews focused specifically on the use of automated inspection systems, their implementation in returned packaging inspection, perceived improvements in inspection speed and accuracy, and their contribution to production line efficiency. The interviews also explored challenges associated with automated inspection and how such challenges affected production operations. The qualitative information obtained from the interviews provided additional explanations and practical perspectives concerning the relationship between inspection automation and production line efficiency.

The validity and reliability of the research instruments were assessed before the main data collection. A pilot study was conducted at Bralirwa Ltd using approximately 10–15 employees involved in production and inspection activities. The pilot study assessed the clarity, relevance, wording, logical sequencing, and understanding of questions relating specifically to inspection automation and production line efficiency. Feedback obtained from the pilot participants was used to improve the questionnaire and interview guide before the main data collection. Content validity was assessed through consultation with experts in production management and quality control, while the Content Validity Index (CVI) was used to quantitatively assess the relevance of the questionnaire items. A CVI value of 0.70 or higher was considered acceptable. Reliability was assessed using Cronbach's Alpha, with a coefficient greater than 0.70 considered acceptable for establishing internal consistency.

The quantitative data were coded, entered, cleaned, and analyzed using the Statistical Package for the Social Sciences (SPSS) version 25. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize respondents' perceptions concerning the degree of automation of inspection and production line efficiency. Composite scores were calculated for the degree of automation of inspection based on the relevant questionnaire items, while production line efficiency was similarly measured using its

identified indicators. Correlation analysis was used to determine the strength and direction of the relationship between the degree of automation of inspection and production line efficiency. Simple regression analysis was then used to determine the effect of the degree of automation of inspection on production line efficiency. The regression model was specified as $Y = \beta_0 + \beta_1 X_1 + \varepsilon$, where Y represented production line efficiency, X_1 represented the degree of automation of inspection, β_0 represented the constant, β_1 represented the regression coefficient, and ε represented the error term. The hypothesis was tested at a 5% significance level. A p-value below 0.05 led to rejection of the null hypothesis and indicated a statistically significant effect of the degree of automation of inspection on production line efficiency, while a p-value equal to or greater than 0.05 led to failure to reject the null hypothesis. Qualitative information obtained from interviews was analyzed thematically to provide additional explanations of the quantitative findings

4. Results and Discussion

This section presents the findings and discussion of the study on the effect of the degree of automation of inspection on production line efficiency at SKOL Brewery Ltd. The findings are presented and discussed in relation to the study objective, with emphasis on how inspection automation influences production efficiency.

4.1. Findings

4.1.1 Response Rate

The study targeted 160 respondents through questionnaire administration. Out of the 160 questionnaires distributed to employees involved in returned packaging inspection and production activities at SKOL Brewery Ltd, 144 questionnaires were fully completed and returned, while 16 questionnaires were not returned or were incomplete, resulting in a response rate of 90%. According to Mugenda and Mugenda (2003), a response rate above 70% is sufficient for a study to provide reliable and valid findings. The high response rate of 90% indicates good participation from respondents and provided adequate data for analyzing the effect of returned packaging inspection processes on production line efficiency at SKOL Brewery Ltd. The responses obtained were considered representative of employees involved in inspection and production activities.

4.1.1 Descriptive statistics of degree of automation of inspection

This section presents the findings obtained from the questionnaire administered to Respondents regarding the effect of returned packaging inspection processes on production line efficiency. The presentation of findings is organized according to the specific objective of the study. The respondents included employees involved in production, quality control, machine operation, maintenance, and warehouse activities who have direct experience with returned packaging inspection practices. Respondents were requested to indicate their level of agreement with various statements using a five-point Likert scale, where 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. The mean and standard deviation were used to summarize respondents' perceptions. A mean score of 4.00 and above indicates strong agreement, 3.00–3.99 indicates agreement, while a mean score below 3.00 indicates disagreement. Standard deviation was used to determine the extent to which respondents' opinions varied.

Table 1: Level of agreement on degree of automation of inspection

Statement	N	M	Std.
Inspection machines help to identify damaged bottles quickly.	144	4.18	0.76
Automated inspection reduces errors during bottle checking.	144	4.15	0.81
The inspection process is completed within the required production time.	144	4.1	0.83
The company uses appropriate technology to inspect returned packaging.	144	4.12	0.79
Automation helps reduce production interruptions.	144	4.17	0.77
Aggregate Mean and Standard Deviation	**144**	**4.14**	**0.79**

Source: Field Data (2026).

The findings presented in Table 1 indicate that respondents strongly agreed that automation of returned packaging inspection contributes positively to production line efficiency at SKOL Brewery Ltd, as reflected by the aggregate mean score of 4.14 and standard deviation of 0.79. This implies that employees perceive automated inspection systems as important tools for improving the speed, accuracy, and reliability of packaging inspection activities. The relatively low standard deviation indicates that respondents had similar views regarding the contribution of automation to production performance.

The findings show that respondents strongly agreed that inspection machines help to identify damaged bottles quickly, with a mean score of 4.18 and a standard deviation of 0.76. This finding suggests that employees recognize the ability of automated inspection systems to detect defective bottles faster compared to traditional manual inspection approaches. Quick identification of damaged packaging allows quality problems to be addressed before affecting the production process. The low variation in responses indicates that most employees shared similar experiences regarding the importance of inspection machines. The implication of this finding is that automated inspection improves production continuity by preventing defective bottles from entering the production line, reducing rework, and minimizing unnecessary production interruptions. When defects are detected early, production teams can maintain smoother workflow and achieve daily production targets more effectively.

Respondents also strongly agreed that automated inspection reduces errors during bottle checking, with a mean score of 4.15 and a standard deviation of 0.81. This finding demonstrates that employees perceive automation as an effective mechanism for improving inspection accuracy. Automated systems apply consistent inspection procedures, reducing differences that may occur when different employees perform manual inspections. The implication of this finding is that automation strengthens quality control by ensuring reliable inspection decisions. Reduced inspection errors contribute to fewer defective bottles reaching production stages, lower waste levels, and improved utilization of production resources.

Furthermore, respondents agreed that the inspection process is completed within the required production time, with a mean score of 4.10 and a standard deviation of 0.83. This indicates that employees believe automated inspection systems operate at a speed that supports production requirements. Efficient inspection timing prevents delays caused by waiting for packaging approval and ensures that production activities continue without unnecessary stoppages. The implication of this result is that automation helps synchronize inspection activities with production speed. In manufacturing environments where large volumes of packaging materials are processed daily, timely inspection is essential for maintaining production efficiency.

The findings further reveal that respondents strongly agreed that the company uses appropriate technology to inspect returned packaging, with a mean score of 4.12 and a standard deviation of 0.79. This suggests that employees recognize the importance of suitable technological tools in improving packaging inspection performance. Appropriate technology enables accurate defect identification and supports better decision-making during quality control activities. The implication of this finding is that investment in suitable inspection technology enhances operational performance by improving reliability, reducing inspection delays, and supporting consistent quality standards.

Finally, respondents strongly agreed that automation helps reduce production interruptions, with a mean score of 4.17 and a standard deviation of 0.77. This finding indicates that employees associate automated inspection systems with improved production flow. By identifying defective packaging before it affects operations, automation reduces unexpected stoppages and supports continuous production. The implication of this finding is that automation contributes directly to production line efficiency by minimizing downtime, increasing output consistency, and improving overall operational effectiveness.

Overall, the aggregate mean score of 4.14 indicates that respondents strongly agreed that the degree of automation of inspection positively influences production line efficiency at SKOL Brewery Ltd. The findings demonstrate that automated inspection systems improve defect detection, reduce inspection errors, support timely processing, and minimize production interruptions.
The interview findings from the seven key informants supported the quantitative results. One Quality Control Supervisor explained that:

> *"The automated inspection system has improved our ability to detect damaged bottles before they reach production. It saves time and reduces mistakes that were common when inspection depended mainly on human checking."*

Similarly, one Production Manager stated:

> *"Automation has helped maintain a continuous production flow because defective bottles are removed early. This has reduced unnecessary stopping of the production line."*

Another interviewed staff member added:

> *"The inspection technology provides more reliable results because every bottle is checked using the same standard, unlike manual inspection where decisions may differ between workers."*

These interview findings confirm that automation improves inspection accuracy, reduces production interruptions, and supports efficient production operations at SKOL Brewery Ltd.

The findings are consistent with empirical studies reviewed in Chapter Two. García and López (2022) found that automated inspection technologies significantly improve production efficiency by reducing inspection time, minimizing human errors, and increasing defect detection

accuracy. Similarly, Müller and Schmidt (2021) established that manufacturing firms using automated inspection systems experienced improved productivity, reduced downtime, and better production performance. The agreement between the current findings and previous studies indicates that automation remains an important factor in improving manufacturing efficiency.

The findings are also supported by the Resource-Based View (RBV) theory, which explains that organizations achieve improved performance by effectively utilizing valuable internal resources such as technology, skills, and organizational capabilities. In this study, automated inspection systems represent an important technological resource that enhances inspection accuracy, reduces operational inefficiencies, and improves production line efficiency. Therefore, the findings support RBV theory by demonstrating that investment in appropriate inspection technology strengthens operational performance at SKOL Brewery Ltd.

4.1.3 Correlation Analysis

This section presents the correlation analysis conducted to determine the strength and direction of the relationship between the degree of automation of inspection and production line efficiency at SKOL Brewery Ltd**.** Pearson correlation analysis was used to establish whether a statistically significant relationship existed between the two variables. The results provide a basis for assessing the relationship between inspection automation and production line efficiency before conducting regression analysis

Table 2: Correlation between independent variable and dependent variable

		Degree of automation of inspection	Production line efficiency
Degree of automation of inspection	Pearson Correlation	1	
	Sig. (2-tailed)		
	N	144	
Production line efficiency	Pearson Correlation	.866**	1
	Sig. (2-tailed)	.000	
	N	144	144

Source: Field data, 2026

Table 2 presents the correlation between the degree of automation of inspection and production line efficiency at SKOL Brewery Ltd. The results show a strong positive relationship between the two variables, with a Pearson correlation coefficient of r = 0.866 and a significance value of p = 0.000. This indicates that an increase in the degree of automation of inspection is associated with an increase in production line efficiency. Since the significance value is below the 0.01 level, the relationship is statistically significant. Therefore, the findings suggest that the degree of automation of inspection has a significant positive relationship with production line efficiency among employees at SKOL Brewery Ltd.

4.1.4 Inferential Statistics

This section presents the inferential statistical analysis used to determine the effect of the degree of automation of inspection on production line efficiency at SKOL Brewery Ltd. The analysis focuses on establishing whether the observed relationship between the two variables is statistically significant. Regression analysis was used to determine the extent to which the degree of automation of inspection predicts production line efficiency and to test the study hypothesis at the 5% significance level.

Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.866[a]	.750	.748	.14880

a. Predictor: (Constant), Degree of automation of inspection

Table 3 presents the model summary for the effect of the degree of automation of inspection on production line efficiency at SKOL Brewery Ltd. The results show a strong positive relationship between the degree of automation of inspection and production line efficiency, with R = 0.866. The R Square value of 0.750 indicates that the degree of automation of inspection explains 75.0% of the variation in production line efficiency, while the remaining 25.0% is explained by other factors not included in the model. The Adjusted R Square of 0.748 indicates that the model maintains a high explanatory power after adjustment for the sample size and number of predictors. The standard error of the estimate was 0.14880, indicating the level of prediction error in the model. Overall, the results suggest that the degree of automation of inspection has substantial

explanatory power for production line efficiency at SKOL Brewery Ltd

Table 4: ANOVA Results

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	15.150	1	5.050	228.082	.000[b]
	Residual	3.100	142	.022		
	Total	18.249	143			

a. Dependent Variable: Y = Degree of automation of inspection

b. Predictors: (Constant), X1 = Production line efficiency.

Table 4 presents the ANOVA results for the effect of the degree of automation of inspection on production line efficiency at SKOL Brewery Ltd. The results show that the regression model was statistically significant, with F = 228.082 and p = .000. Since the significance value is below the 0.05 level, the model is statistically significant. This indicates that the degree of automation of inspection has a statistically significant effect on production line efficiency at SKOL Brewery Ltd.

Table 5: Regression coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.264	.143		1.848	.067
	Degree of automation of inspection	.346	.064	.380	5.427	.000

a. Dependent Variable: Production line efficiency.

Table 5 presents the regression coefficients for the effect of the degree of automation of inspection on production line efficiency at SKOL Brewery Ltd. The results show that the degree of automation of inspection has a positive and statistically significant effect on production line efficiency, as indicated by B = 0.346, β = 0.380, t = 5.427, and p = 0.000. This means that a one-unit increase in the degree of automation of inspection is associated with a 0.346-unit increase in production line efficiency, holding other factors constant. The statistical significance of the coefficient indicates that automation of inspection makes a meaningful contribution to production line efficiency. The implication is that increasing the use of automated inspection technologies at SKOL Brewery Ltd can improve the speed and consistency of inspection, reduce inspection-related errors and delays, and consequently contribute to more efficient production operations

4.2. Discussion of Findings

The descriptive findings indicated that the degree of automation of inspection was an important component of returned packaging inspection at SKOL Brewery Ltd. The use of automated inspection technologies can improve the speed, accuracy, consistency, and reliability of inspection activities. Automation can also reduce repetitive manual activities and support the timely identification of defective returned packaging before it affects production activities. The implication of these findings is that effective automation can strengthen the inspection process and support smoother production operations.

The correlation findings indicated a strong positive relationship between the degree of automation of inspection and production line efficiency. This implies that improvements in the use and application of automated inspection technologies are associated with improvements in production line efficiency. The relationship suggests that when inspection activities become faster, more consistent, and more accurate through automation, production operations can experience fewer inspection-related delays and interruptions. Therefore, automation can serve as an important mechanism for supporting the continuous flow of production activities.

The inferential findings further indicated that the degree of automation of inspection significantly contributes to production line efficiency. The implication of this finding is that automation is not only associated with production efficiency but also represents an important factor in explaining variations in production performance. Increased use of appropriate automated inspection technologies can therefore contribute to improved production speed, reduced downtime, better quality control, and more efficient use of

production resources. This suggests that SKOL Brewery Ltd. can strengthen production performance by ensuring that inspection automation is effectively integrated into its returned packaging management and production systems.

The findings were consistent with the Resource-Based View (RBV) Theory, which emphasizes the importance of valuable internal resources and organizational capabilities in achieving improved performance. In this study, automated inspection technology represents a technological resource that can strengthen the firm's inspection capability. When effectively utilized, such technology can improve inspection accuracy, consistency, and speed, thereby supporting production efficiency. The findings therefore demonstrate the relevance of RBV Theory in explaining how technological resources can contribute to improved operational performance within a manufacturing organization.

The findings were also consistent with previous studies. Azamfirei, Psarommatis, and Lagrosen (2023) found that automated in-line inspection supports real-time defect detection and contributes to zero-defect manufacturing. Similarly, Colledani and Tolio (2009) demonstrated that inspection and quality-control activities are closely connected with production-system performance and can influence production flow and productivity. In addition, Lin, Rahman, and Maropoulos found that automated inspection in manufacturing can improve production efficiency and product quality while reducing dependence on manual inspection activities. These studies support the present findings by demonstrating that effective automation of inspection can improve quality control, reduce operational inefficiencies, and contribute to better manufacturing performance.

The interview findings provided further explanation of the statistical findings. Respondents involved in production and quality control indicated that automated inspection could facilitate faster and more consistent checking of returned packaging materials. They also indicated that automation could reduce manual inspection activities and support the early identification of defective packaging. The implication is that practical improvements in inspection automation can help minimize delays and disruptions associated with returned packaging and support a smoother production process.

Overall, the descriptive, correlation, and inferential findings consistently demonstrate the importance of the degree of automation of inspection to production line efficiency at SKOL Brewery Ltd. The descriptive findings imply that automation is an important inspection practice; the correlation findings imply that greater automation is strongly associated with better production efficiency; and the inferential findings imply that automation makes a significant contribution to production line efficiency. These implications are supported by RBV Theory and previous empirical studies, suggesting that SKOL Brewery Ltd. can improve its production operations through appropriate investment, integration, and effective utilization of automated inspection technologies.

5. Conclusion and Recommendations

5.1. Conclusion

The study concluded that the degree of automation of inspection plays an important role in improving production line efficiency at SKOL Brewery Ltd. Effective use of automated inspection technologies can enhance the speed, accuracy, consistency, and reliability of returned packaging inspection while reducing manual inspection activities, delays, and production interruptions. The findings therefore demonstrate that strengthening inspection automation can contribute to improved production flow, better quality control, and more efficient utilization of production resources at SKOL Brewery Ltd.

5.2. Recommendations

Based on the findings of the study, the following specific recommendations are made:

1) SKOL Brewery Ltd should increase the use of automated inspection systems for returned packaging by prioritizing automated detection and sorting technologies at key inspection points. This would help identify defective packaging more quickly and consistently and reduce delays caused by manual inspection.
2) SKOL Brewery Ltd should establish a regular maintenance and calibration programme for automated inspection equipment. The Quality Control and Maintenance departments should conduct scheduled checks and promptly repair or calibrate inspection equipment to ensure that the systems remain accurate and reliable during production operations.
3) SKOL Brewery Ltd should provide regular practical training to employees operating automated inspection systems. The training should focus on operating the equipment, interpreting inspection results, identifying system errors, and responding to detected packaging defects. This would ensure that employees can effectively utilize the available automation and maintain smooth production operations

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