International Journal of Organizational Intelligence and Systems | ISSN 3087-4440
Published by BIRPUB https://birpub.org/ijois
Imp. Factor: 5.317

# Technological Innovation and Risk Management Efficiency of Food and Beverage Firms of Enugu State

**Onyeka-Udeh Virginia [1] Bill-Uchegbue Susan Ekelechi [2] & Abiakwe Joseph Uzoma [3]**

## Abstract

*The study evaluated the technological innovation and risk management efficiency of food and beverage firms in Enugu State. The specific objectives were to examine the effect of automation on the incidence of stockouts and to evaluate the effect of blockchain tracking on the frequency of fraud in food and beverage firms in Enugu State. The study adopted a descriptive survey design, and primary data were collected through the administration of a questionnaire. The total population of the study comprised 1,282 employees of the selected firms. A sample size of 297 was determined using the Ferund and Williams formula. A total of 284 questionnaires were returned and correctly completed. Data were presented and analyzed, and the hypotheses were tested using the Z-test. The findings indicated that automation had a significant positive effect on the incidence of stockouts ($Z = 9.672$, $p = .05$), and blockchain tracking had a significant positive effect on the frequency of fraud in food and beverage firms in Enugu State ($Z = 11.452$, $p = .05$). The study concluded that automation and blockchain tracking significantly improved the management of stockouts and fraud within the industry. It recommended, among other things, that food and beverage firms in Enugu State should invest in automation technologies to enhance inventory management, reduce the incidence of stockouts, and promote consistent product availability and customer satisfaction.*

***Keywords:*** *Automation, Blockchain Tracking, Efficiency, Innovation, Risk Management & Enugu State.*

***Cite:*** Onyeka-Udeh, V., Bill-Uchegbue, S. E. & Abiakwe, J. U. (2025). Technological Innovation and Risk Management Efficiency of Food and Beverage Firms of Enugu State. *International Journal of Organizational Intelligence and Systems, 3* (1), 17-29.



| Authors | Affiliation |
|---|---|
| **1** | Department of Business Administration, Enugu state University of Science and Technology, Enugu State |
| **2** | Department of Business Administration, Enugu state University of Science and Technology, Enugu State |
| **3** | Department of Business Administration, Enugu state University of Science and Technology, Enugu State |

**Introduction**

Technological innovation and risk management have become central themes in the study of business efficiency and growth in modern economies. Historically, technological advancements have been the primary drivers of progress in industries worldwide, including the food and beverage sector. The global food industry, for instance, has continuously evolved, incorporating new technologies such as automation, artificial intelligence, and advanced data analytics, to improve production efficiency and product quality (Porter & Heppelmann, 2014). These technological shifts are not only transforming how food and beverage firms operate but also reshaping the way they address risks associated with production, distribution, and consumer behavior.

From a historical perspective, the food and beverage industry has undergone significant changes, starting from basic manual labor and simple machinery in the early 20th century to the current digital age where automation, artificial intelligence, and biotechnology dominate. In the 21st century, the introduction of technologies such as predictive analytics and supply chain management software has been pivotal in identifying potential risks and providing firms with the tools necessary to mitigate them (Bichou, 2020). Risk management, traditionally focused on physical and financial risks, has expanded to include the management of technological, environmental, and regulatory risks as companies are increasingly affected by global challenges like climate change and the volatility of international trade (Schwab, 2016).

Globally, the role of technological innovation in risk management has gained prominence, with countries such as the United States, Germany, and China leading the way in adopting cutting-edge technologies to enhance operational efficiency. For instance, firms like Nestlé and Unilever have invested heavily in data analytics and AI-driven tools to streamline production processes, manage risks related to supply chain disruptions, and enhance product traceability (Goh, 2020). These firms have not only improved their operational efficiency but also positioned themselves to better adapt to emerging challenges in the global food market.

On a national level, Nigeria has witnessed significant transformations within its food and beverage industry, although it lags behind other developed nations in terms of technological adoption. In recent years, however, there has been a growing recognition of the importance of technological innovation in enhancing productivity and mitigating risks, particularly within the Nigerian food and beverage sector. Authors like Oloruntoba and Oloke (2019) emphasize the critical role of technological innovation in improving food safety, quality control, and compliance with international standards. Despite the challenges of infrastructure and resource limitations, Nigerian firms are increasingly adopting technologies such as enterprise resource planning (ERP) systems, automated inventory management, and mobile-based platforms to respond to the dynamic nature of food production and distribution.

Focusing on Enugu State, a key hub for food and beverage production in southeastern Nigeria, technological innovation and risk management strategies have become essential to the survival and competitiveness of local firms. The state has witnessed a rise in small and medium-sized enterprises (SMEs) in the food processing and beverage sectors, many of which are struggling to balance the need for innovation with the risks associated with inadequate infrastructure and limited access to advanced technology (Iwuoha, 2021). Additionally, the rise of local and global market competition, coupled with environmental challenges like climate change and food safety concerns, has intensified the need for effective risk management strategies within this industry. Firms in Enugu State are increasingly turning to technological solutions to enhance their resilience against market and operational risks, improve supply chain efficiency, and meet the growing demand for high-quality products.

In light of these global, national, and local developments, the study of technological innovation and risk management efficiency in the food and beverage firms in Enugu State becomes crucial. It will contribute to a deeper understanding of how technological tools can be leveraged to enhance the performance of firms in the face of operational, financial, and environmental challenges.

**Statement of the Problem**

The food and beverage industry in Enugu State, Nigeria, like many others worldwide, is facing an era of rapid technological change and increasing market volatility. Technological innovation has become a critical driver of growth and efficiency in the sector, enabling firms to improve production processes, manage resources more effectively, and minimize risks associated with supply chain disruptions, food safety, and market fluctuations. In an ideal scenario, food and beverage firms in Enugu would fully embrace advanced technologies such as automation, artificial intelligence, and predictive analytics to streamline operations, enhance product quality, and ensure greater

risk resilience. These technological tools would help firms anticipate potential challenges and mitigate them proactively, reducing operational costs and improving overall business performance.

However, several problems hinder the achievement of this ideal. Limited access to advanced technology, inadequate risk management frameworks, poor infrastructure, financial constraints, and a lack of skilled workforce are key barriers faced by local firms. The high cost of implementing modern technologies and the underdeveloped infrastructure in Enugu further exacerbate these issues, preventing firms from adopting the innovations that could boost their competitiveness. Additionally, many firms lack structured risk management strategies, making them vulnerable to disruptions in the global supply chain, regulatory changes, and environmental challenges.

If these problems are addressed, the food and beverage firms in Enugu would experience significant improvements in efficiency and profitability. Enhanced risk management frameworks and the integration of modern technologies would enable firms to reduce waste, improve product quality, and meet international standards, opening new market opportunities. Furthermore, addressing these challenges would lead to increased economic growth, job creation, and sustainability in the region. Ultimately, the successful adoption of technological innovation and risk management practices would strengthen the competitiveness of Enugu's food and beverage sector, benefiting both local businesses and the broader economy.

**Objectives of the Study**

The main objective of the study was to examine Technological Innovation and Risk Management Efficiency of Food and Beverage Firms of Enugu State. The specific objectives were to:

i. Examine the effect of Automation on incidence of stockouts in food and beverage firms in Enugu State.
ii. Evaluate the effect of Blockchain tracking on the frequency of fraud of food and beverage firms in Enugu State.

**Research Questions**

i. What is the effect of Automation on incidence of stockouts in food and beverage firms in Enugu State?
ii. What is the effect of Blockchain tracking on the frequency of fraud of food and beverage firms in Enugu State?

**Statement of the Hypotheses**

i. Automation has significant effect on incidence of stockouts in food and beverage firms in Enugu State.
ii. Blockchain tracking significant effect on the frequency of fraud of food and beverage firms in Enugu State.

**Significance of the study**

This study is significant as it addresses two critical pillars of business sustainability and competitiveness technological innovation and risk management efficiency within the context of food and beverage firms in Enugu State, Nigeria. The relevance of this research lies in its potential to offer practical, economic, and policy-level insights that can support the transformation of the local food and beverage industry in an increasingly competitive and uncertain business environment.

**Scope of the study**

The scope of this study outlines the boundaries within which the research is conducted, ensuring focus and clarity. The study is geographically limited to Enugu State, located in southeastern Nigeria. Enugu is selected due to its growing number of food and beverage firms, particularly small and medium-sized enterprises (SMEs), which play a critical role in the state's economic development. The findings will reflect the local economic, infrastructural, and technological

**Review of Related Literature**

**Conceptual Review**

**Technological Innovation**

Technological innovation refers to the development, adoption, and implementation of new or significantly improved technologies, systems, and processes that enhance productivity, efficiency, and competitiveness in business operations. According to Schumpeter (2019), innovation is the engine of economic growth and includes the introduction of new products, new methods of production, new markets, or new forms of organization. In the context of food and beverage firms, technological innovation may include: Automation of production processes; Use of artificial intelligence (AI) for demand forecasting and quality control; Enterprise Resource Planning (ERP) systems for resource management; Blockchain technology for product traceability and Digital platforms for sales, customer service, and inventory management These innovations reduce manual labor, minimize errors, increase production speed, and enable firms to respond more quickly to market changes. Porter and Heppelmann (2014) highlight that smart, connected technologies are reshaping competition across industries, especially in manufacturing and consumer goods sectors like food and beverage.

**Automation**

Automation in food and beverage (F&B) firms refers to the use of machines, software, control systems, and robotics to perform tasks that would otherwise require significant human effort. These tasks may occur in processing, packaging, quality control, supply chain logistics, or customer service, and automation aims to execute them with greater speed, higher consistency, and minimal human intervention.

Automation includes not only physical machinery such as robotic arms and autonomous vehicles but also digital tools—sensors, computer vision, artificial intelligence, and data analytics—that monitor, control, and optimize processes.

Automation in F&B firms can be understood as:

i. The integration of mechanical, robotic, and digital technologies to automate activities across the production and supply chain, from raw material handling and processing to packaging, logistics, and service.

ii. The design of operations to reduce reliance on manual labour for repetitive, hazardous, or highly precise tasks.

iii. The use of feedback systems (e.g., sensors, vision systems, AI) to monitor operations, make adjustments, and ensure consistent product quality, safety, and regulatory compliance.

iv. A strategic enabler that allows firms to scale production, respond to fluctuating demand, meet regulatory standards, improve hygiene and traceability, and reduce waste. (Singh, 2023; Caldwell, 2023; Colyer, 2023; Güngör & Güngör, 2024).

**Blockchain tracking**

Blockchain technology has emerged as a transformative tool in the food and beverage (F&B) industry, primarily for enhancing traceability**,** transparency**,** and accountability within supply chains. By providing an immutable, decentralized ledger, blockchain enables stakeholders—from farmers to consumers—to access real-time, verifiable information about a product's journey, ensuring food safety and authenticity. Blockchain allows for the recording of every transaction and movement of food products, creating a transparent and auditable trail. This capability is crucial in managing complex supply chains and ensuring that all parties have access to accurate and timely information (Ellahi, Wood & Bekhit, 2023). By tracking products at each stage from farm to table blockchain helps in identifying and addressing potential issues promptly. This proactive approach aids in maintaining high standards of food safety and quality, (Rajput, More, Adhikari & Arya, 2025). Blockchain technology offers promising solutions to the challenges faced by the food and beverage industry, particularly in enhancing traceability, transparency, and efficiency. However, its successful implementation requires addressing integration, standardization, and regulatory

challenges. As the industry continues to evolve, blockchain is poised to play a pivotal role in shaping the future of food safety and supply chain management.

Risk management is the process of identifying, assessing, mitigating, and monitoring potential events or conditions that may negatively affect an organization's operations, finances, or reputation (ISO 31000, 2018). In a volatile business environment, especially in developing economies like Nigeria, effective risk management is critical to survival and growth. Types of risks relevant to food and beverage firms include: Operational risks (machine breakdown, supply shortages); Health and safety risks (food contamination, product recalls); Market risks (price volatility, competition); Regulatory risks (compliance with food safety laws); Environmental risks (climate impact on raw materials) and Financial risks (cost fluctuations, currency devaluation). Effective risk management involves not only identifying these risks but also developing systems and policies to minimize their impact on business continuity.

**Risk Management Efficiency**

Risk management efficiency refers to the ability of a firm to effectively identify, assess, and respond to risks in a manner that minimizes losses and maximizes resilience. Efficient risk management is proactive, data-driven, and often supported by technology. Bichou (2020), efficient risk management in supply chains and production processes is increasingly dependent on real-time data, predictive analytics, and integrated decision-making systems. When technology is used to support risk management, it leads to quicker identification of potential disruptions, better decision-making, and improved crisis response. In food and beverage firms, efficiency in risk management means: Rapid detection of product defects; Timely response to supply chain interruptions; Accurate regulatory compliance tracking and Improved customer satisfaction through consistent product quality

**Incidence of Stockouts**

A stockout, also known as an out-of-stock (OOS) event, is a situation where inventory is depleted, preventing the fulfillment of customer orders. In the F&B industry, stockouts can arise due to various factors, including inaccurate demand forecasting, supply chain disruptions, or inadequate inventory management practices,( Encyclopedia of Production and Manufacturing Management, (2024). Stockouts in the food and beverage industry pose significant challenges, impacting sales, customer satisfaction, and operational efficiency. By understanding the causes and consequences of stockouts and implementing proactive strategies such as improved demand forecasting, advanced inventory management systems, strong supplier relationships, and safety stock maintenance, businesses can minimize the occurrence of stockouts. Ensuring product availability is essential for maintaining customer trust and sustaining long-term success in the competitive F&B market.

**Frequency of Food Fraud in Food and Beverage Firms: An Overview**

Food fraud remains a significant concern within the global food and beverage (F&B) industry, involving deliberate acts such as adulteration, mislabeling, and substitution. These fraudulent practices not only endanger consumer health but also undermine industry integrity and economic stability. This essay provides an overview of the prevalence and impact of food fraud in F&B firms, drawing on recent studies and reports.

Recent data indicate a concerning rise in food fraud incidents. In 2023, a total of 419 cases were reported across 66 countries, with Europe, South America, Africa, North-Central America, and Australia identified as the most affected regions. Notably, Pakistan, Italy, Brazil, Nigeria, the Dominican Republic, and Australia recorded the highest number of cases (Psomiadis, 2023). The most commonly adulterated products include alcoholic beverages (18.13% of total cases), meat and meat products (15.03%), fish and seafood (13.60%), and grain-based foods, cereals, and bakery products (11.69%).

The growing frequency of food fraud in the food and beverage industry highlights the urgent need for stringent monitoring, robust regulatory frameworks, and heightened industry vigilance. Addressing this issue is essential to ensure consumer safety, uphold industry standards, and maintain public confidence in food products.

**Theoretical Framework**

The study was guided by Technology-Organization-Environment (TOE) Framework (Tornatzky, L.G., & Fleischer, M. 1990).

The TOE framework posits that three critical elements influence the adoption and implementation of technological innovations within an organization:

i. **Technology**: This refers to the existing technologies within the firm and the new technologies being considered for adoption. It encompasses the technical infrastructure, tools, and systems that support operations.
ii. **Organization**: This element includes the internal characteristics of the firm, such as its size, structure, human resources, and management practices. Organizational culture and readiness for change also fall under this category.
iii. **Environment**: This encompasses the external factors affecting the firm, including industry trends, regulatory requirements, market dynamics, and competitive pressures.

**Application of TOE in Food and Beverage Firms in Enugu State**

In the context of food and beverage firms in Enugu State, the TOE framework can be utilized to assess how these firms adopt technological innovations and how such adoptions impact their risk management efficiency.

**Technology**: Adopting advanced technologies can enhance production processes, improve product quality, and streamline operations. For instance, the adoption of automation and digital tools can reduce human errors and operational risks.

**Organization**: The firm's internal capabilities, such as skilled workforce and management support, play a crucial role in effectively implementing new technologies. A culture that encourages innovation and continuous improvement can facilitate smoother transitions and better risk management.

**Environment**: External factors like regulatory changes, market demands, and technological advancements in the industry can drive firms to adopt new technologies. Staying abreast of these changes helps firms mitigate risks associated with non-compliance and market obsolescence.

By examining these three elements, the TOE framework helps in understanding how technological innovations can be leveraged to enhance risk management practices in food and beverage firms in Enugu State. This holistic approach ensures that firms not only adopt new technologies but also align them with their organizational capabilities and external environment to effectively manage risks.

The TOE framework offers a structured approach to analyzing the interplay between technological innovation and risk management efficiency. For food and beverage firms in Enugu State, adopting this framework can lead to more informed decisions, better risk mitigation strategies, and improved overall performance.

**Empirical Review**

Oloruntoba & Oloke (2019) conducted a study on food and beverage firms in southwestern Nigeria and found that firms that adopted automation, ERP systems, and real-time monitoring technologies experienced significant improvements in production speed, product consistency, and regulatory compliance. The study concluded that technological innovation plays a crucial role in enhancing operational efficiency and customer satisfaction.

Eze & Okonkwo (2020) examined how innovation influences risk management strategies in medium-sized enterprises in southeastern Nigeria. The study used regression analysis and found a statistically significant relationship between the level of technology adoption and the firm's ability to manage supply chain, financial, and reputational risks. Firms that integrated ERP systems and business intelligence software were better at risk detection and response.

Bichou (2020), in a cross-industry study of global manufacturing firms, found that companies that implemented predictive analytics and AI in their supply chains reduced operational disruptions by up to 40%. These technologies helped firms anticipate risks, such as supplier delays or demand fluctuations, and allowed for quicker responses

Ogbu & Nweze (2021) analyzed the extent of digital technology adoption among SMEs in Enugu and Anambra States. Their findings revealed that firms using mobile-based inventory systems and digital accounting tools saw a 20–30% improvement in inventory control and financial reporting accuracy. However, the study also highlighted barriers such as high cost, poor infrastructure, and limited digital literacy

In the Nigerian context, Iwuoha (2021) studied SMEs in Enugu State and found that most lacked formal risk management frameworks. However, firms that utilized technology-driven solutions such as cloud storage, automated alerts, and mobile banking platforms were more resilient during economic shocks and supply chain disruptions. The study recommended increased investment in digital tools and risk awareness training for SME operators.

**Summary of Empirical Reviewed literature**

The few studies done were carried outside Technological Innovation and Risk Management Efficiency of Food and Beverage Firms of Enugu State and did not focus to best of our knowledge on the Automation on incidence of stockouts; of Block chain tracking on the frequency of fraud of food and beverage firms in Enugu State. Most of the studies reviewed analyzed their data through A purposeful sampling technique, Descriptive statistics and appropriate inferential statistics, Purposive Sampling technique, Pearson Moment Correlation Coefficient, Multiple sampling technique, Partial Least Square Structural Equation Modeling (PLS-SEM), Multiple Regression Analysis (MRA) method, Simple linear regression and Pearson correlation coefficient (r) while the present study made use of Z- test to test the hypotheses. Therefore, the study aimed at filling this research gap by evaluating the Technological Innovation and Risk Management Efficiency of Food and Beverage Firms of Enugu State.

**Methodology**

The area of the study was Enugu Metropolis, One thousand, two hundred and eighty two (1282) employees were selected for the study. 297 sample size using Ferund and Williams statistical formula. The study used the descriptive survey design approach. The primary source of data was the administration of questionnaire. Two hundred and eighty four (284) employees returned their questionnaire and accurately filled. That gave 96 percent response rate. The validity of the instrument was tested using content analysis and the result was good. The reliability was tested using the Pearson correlation coefficient (r). It gave a reliability co-efficient of 0.71 which was also good. Data was presented and analyzed by mean score and standard deviation. The hypotheses were analyzed using Z - test statistic tool.

**Data Presentation**

**Effect of Automation on incidence of stockouts in food and beverage firms in Enugu State.**

**Table 1: Responses on the effect of Automation on incidence of stockouts in food and beverage firms in Enugu State**

| | | 5 SA | 4 A | 3 N | 2 DA | 1 SD | ∑FX | - X | SD | Decision |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Automation significantly reduces the incidence of stockouts by improving inventory tracking accuracy in food and beverage firms in Enugu State. | 575<br>115<br>40.5 | 184<br>46<br>16.2 | 252<br>84<br>29.6 | 40<br>20<br>7.0 | 19<br>19<br>6.7 | 1071<br>284<br>100% | 3.77 | 1.239 | Agree |
| 2 | With automation, firms can efficiently monitor stock levels in real-time, preventing unexpected shortages and ensuring continuous product availability. | 795<br>159<br>56.0 | 184<br>46<br>16.2 | 60<br>20<br>7.0 | 34<br>17<br>6.0 | 42<br>42<br>14.8 | 1115<br>284<br>100% | 3.93 | 1.484 | Agree |
| 3 | Automated systems enable food and beverage firms in Enugu State to optimize their supply chain management, minimizing stockouts and enhancing customer satisfaction. | 640<br>128<br>45.1 | 184<br>46<br>16.2 | 204<br>68<br>23.9 | 34<br>17<br>6.0 | 25<br>25<br>8.8 | 1087<br>284<br>100% | 3.83 | 1.303 | Agree |
| 4 | The implementation of automation streamlines order processing and replenishment, reducing delays and the risk of stockouts in these firms. | 675<br>135<br>47.5 | 352<br>88<br>31.0 | 60<br>20<br>7.0 | 18<br>9<br>3.2 | 32<br>32<br>11.3 | 1137<br>284<br>100% | 4.00 | 1.301 | Agree |
| 5 | Automation enhances forecasting and demand planning, allowing food and beverage firms in Enugu State to maintain adequate stock levels and avoid stockouts effectively. | 815<br>163<br>57.4 | 216<br>54<br>19.0 | 36<br>12<br>4.2 | 20<br>10<br>3.5 | 45<br>45<br>15.8 | 1132<br>262<br>100% | 3.99 | 1.480 | Agree |
| | **Total Grand mean and standard deviation** | | | | | | | **3.904** | **1.3614** | |

***Source: Field Survey, 2025***

Table 1, 161 respondents out of 284 representing 56.7 Automation significantly reduces the incidence of stockouts by improving inventory tracking accuracy in food and beverage firms in Enugu State with mean score of 3.77 and standard deviation of 1.239. With automation, firms can efficiently monitor stock levels in real-time, preventing unexpected shortages and ensuring continuous product availability. 205 respondents representing 72.2 percent agreed with mean score of 3.93 and standard deviation of 1.484. Automated systems enable food and beverage firms in Enugu State to optimize their supply chain management, minimizing stockouts and enhancing customer satisfaction. 174 respondents representing 61.2 percent agreed with mean score of 3.83 and standard deviation of 1.303. The implementation of automation streamlines order processing and replenishment, reducing delays and the risk of stockouts in these firms. 223 respondents representing 78.5 percent agreed with mean score of 4.00 and 1.301. Automation enhances forecasting and demand planning, allowing food and beverage firms in Enugu State to maintain adequate stock levels and avoid stockouts effectively. 217 respondents representing 76.4 percent agreed with a mean score of 3.99 and standard deviation 1.480.

**The effect of Blockchain tracking on the frequency of fraud of food and beverage firms in Enugu State**

**Table 2: Responses on the effect of Blockchain tracking on the frequency of fraud of food and beverage firms in Enugu State**

| | | 5 SA | 4 A | 3 N | 2 DA | 1 SD | ∑FX | - X | SD | Decision |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Blockchain tracking greatly reduces the frequency of fraud by providing transparent and tamper-proof records in food and beverage firms in Enugu State. | 450<br>92<br>32.4 | 384<br>96<br>33.8 | 36<br>12<br>4.2 | 80<br>40<br>14.1 | 44<br>44<br>15.5 | 994<br>284<br>100% | 3.54 | 1.454 | Agree |
| 2 | The use of blockchain technology enhances traceability, making it easier to identify and prevent fraudulent activities within the supply chain. | 545<br>109<br>38.4 | 424<br>106<br>37.3 | 36<br>12<br>4.2 | 12<br>6<br>2.1 | 51<br>51<br>18.0 | 1068<br>284<br>100% | 3.76 | 1.441 | Agree |
| 3 | Blockchain's secure and decentralized ledger system increases trust among stakeholders, significantly lowering the risk of fraud in these firms. | 705<br>141<br>49.6 | 472<br>118<br>41.5 | 36<br>12<br>4.2 | 8<br>4<br>1.4 | 9<br>9<br>3.2 | 1230<br>284<br>100% | 4.33 | .879 | Agree |
| 4 | By implementing blockchain tracking, food and beverage firms in Enugu State can quickly verify product authenticity, thereby minimizing fraudulent transactions. | 615<br>123<br>43.3 | 564<br>141<br>49.6 | 21<br>7<br>2.5 | 20<br>10<br>3.5 | 3<br>3<br>1.1 | 1223<br>284<br>100% | 4.31 | .776 | Agree |
| 5 | Blockchain technology strengthens accountability and oversight, leading to a marked decrease in fraud occurrences in the food and beverage industry in Enugu State | 480<br>96<br>33.8 | 516<br>129<br>45.4 | 21<br>7<br>2.5 | 74<br>37<br>13.0 | 15<br>15<br>5.3 | 1053<br>284<br>100% | 3.89 | 1.163 | Agree |
| | **Total Grand mean and standard deviation** | | | | | | | **3.966** | **1.1426** | |

***Source: Field Survey, 2025***

Table 2, 188 respondents out of 284 representing 66.2 Blockchain tracking greatly reduces the frequency of fraud by providing transparent and tamper-proof records in food and beverage firms in Enugu State with mean score of 3.54 and standard deviation of 1.454. The use of blockchain technology enhances traceability, making it easier to identify and prevent fraudulent activities within the supply chain 215 respondents representing 75.7 percent agreed with mean score of 3.76 and standard deviation of 1.441. Blockchain's secure and decentralized ledger system increases trust among stakeholders, significantly lowering the risk of fraud in these firms. 259 respondents representing 91.1 percent agreed with mean score of 4.33 and standard deviation of .879. By implementing blockchain tracking, food and beverage firms in Enugu State can quickly verify product authenticity, thereby minimizing fraudulent transactions 264 respondents representing 92.9 percent agreed with mean score of 4.31 and .776. Blockchain technology strengthens accountability and oversight, leading to a marked decrease in fraud occurrences in the food and beverage industry in Enugu State 225 respondents representing 79.2 percent agreed with a mean score of 3.89 and standard deviation 1.163.

**Test of Hypotheses**

**Test of hypothesis one: Automation has significant effect on incidence of stockouts in food and beverage firms in Enugu State.**

**Table 3: One-Sample Kolmogorov-Smirnov Test**

| | | Automation significantly reduces the incidence of stockouts by improving inventory tracking accuracy in food and beverage firms in Enugu State. | With automation, firms can efficiently monitor stock levels in real-time, preventing unexpected shortages and ensuring continuous product availability | Automated systems enable food and beverage firms in Enugu State to optimize their supply chain management, minimizing stockouts and enhancing customer satisfaction. | The implementation of automation streamlines order processing and replenishment, reducing delays and the risk of stockouts in these firms. . | Automation enhances forecasting and demand planning, allowing food and beverage firms in Enugu State to maintain adequate stock levels and avoid stockouts effectively . |
|---|---|---|---|---|---|---|
| N | | 284 | 284 | 284 | 284 | 284 |
| Uniform Parameters[a,b] | Minimum | 1 | 1 | 1 | 1 | 1 |
| | Maximum | 5 | 5 | 5 | 5 | 5 |
| Most Extreme Differences | Absolute | .405 | .560 | .451 | .535 | .574 |
| | Positive | .067 | .148 | .088 | .113 | .158 |
| | Negative | -.405 | -.560 | -.451 | -.535 | -.574 |
| Kolmogorov-Smirnov Z | | 6.824 | 9.435 | 7.595 | 9.020 | 9.672 |
| Asymp. Sig. (2-tailed) | | .000 | .000 | .000 | .000 | .000 |

a. Test distribution is Uniform.

b. Calculated from data.

***Source: Researchers' computation from Field Survey Data, 2025***

**Decision Rule**

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

**Result**

With Kolmogorov-Smirnon Z – value ranges from 6.824 < 9.672 and on Asymp. Significance of 0.000, the responses from the respondents as display in the table is normally distributed. This affirms the assertion of the most of the respondents that Automation had significant positive effect on incidence of stockouts in food and beverage firms in Enugu State.

**Decision**

Furthermore, comparing the calculated Z- value ranges from 6.824 < 9.672 against the critical Z- value of .000(2-tailed test at 95 percent level of confidence) the null hypothesis were rejected. Thus the alternative hypothesis was accepted which states that that Automation had significant positive effect on incidence of stockouts in food and beverage firms in Enugu State**.**

**Test of hypothesis Two: Blockchain tracking significant effect on the frequency of fraud of food and beverage firms in Enugu State.**

**Table 4: One-Sample Kolmogorov-Smirnov Test**

| | | Blockchain tracking greatly reduces the frequency of fraud by providing transparent and tamper-proof records in food and beverage firms in Enugu State. | The use of blockchain technology enhances traceability, making it easier to identify and prevent fraudulent activities within the supply chain. | Blockchain's secure and decentralized ledger system increases trust among stakeholders, significantly lowering the risk of fraud in these firms. | By implementing blockchain tracking, food and beverage firms in Enugu State can quickly verify product authenticity, thereby minimizing fraudulent transactions. | Blockchain technology strengthens accountability and oversight, leading to a marked decrease in fraud occurrences in the food and beverage industry in Enugu State |
|---|---|---|---|---|---|---|
| N | | 284 | 284 | 284 | 284 | 284 |
| Uniform Parameters[a,b] | Minimum | 1 | 1 | 1 | 1 | 1 |
| | Maximum | 5 | 5 | 5 | 5 | 5 |
| Most Extreme Differences | Absolute | .412 | .507 | .662 | .680 | .542 |
| | Positive | .155 | .180 | .032 | .011 | .053 |
| | Negative | -.412 | -.507 | -.662 | -.680 | -.542 |
| Kolmogorov-Smirnov Z | | 6.943 | 8.545 | 11.156 | 11.452 | 9.138 |
| Asymp. Sig. (2-tailed) | | .000 | .000 | .000 | .000 | .000 |

a. Test distribution is Uniform.

b. Calculated from data.

***Source: Researchers' computation from Field Survey Data, 2025***

**Decision Rule**

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

**Result**

With Kolmogorov-Smirnon Z – value ranges from 6.943 < 11.452 and on Asymp. Significance of 0.000, the responses from the respondents as display in the table is normally distributed. This affirms the assertion of the most of the respondents that Blockchain tracking had significant positive effect on the frequency of fraud of food and beverage firms in Enugu State**.**

**Decision**

Furthermore, comparing the calculated Z- value ranges from 6.943 < 11.452 against the critical Z- value of .000(2-tailed test at 95 percent level of confidence) the null hypothesis were rejected. Thus the alternative hypothesis was accepted which states that that Blockchain tracking had significant positive effect on the frequency of fraud of food and beverage firms in Enugu State.

**Discussion of Findings**

From the result of hypotheses one, the calculated Z- value ranges from 6.824 < 9.672 against the critical Z- value of .000 which implies that that Automation had significant positive effect on incidence of stockouts in food and beverage firms in Enugu State. In support of the result in the literature review, Oloruntoba and Oloke (2019) conducted a study on food and beverage firms in southwestern Nigeria and found that firms that adopted automation, ERP systems, and real-time monitoring technologies experienced significant improvements in production speed, product consistency, and regulatory compliance. Eze and Okonkwo (2020) examined how innovation influences risk management strategies in medium-sized enterprises in southeastern Nigeria. The study used regression analysis and found a statistically significant relationship between the level of technology adoption and the firm's ability to manage supply chain, financial, and reputational risks. Firms that integrated ERP systems and business intelligence software were better at risk detection and responses

From the result of hypotheses two, the calculated Z- value ranges from 6.943 < 11.452 against the critical Z- value of .000, which implies that that Blockchain tracking had significant positive effect on the frequency of fraud of food and beverage firms in Enugu State. . In support of the result in the literature review**,** Bichou (2020), in a cross-industry study of global manufacturing firms, found that companies that implemented predictive analytics and AI in their supply chains reduced operational disruptions by up to 40%. In the Nigerian context, Iwuoha (2021) studied SMEs in Enugu State and found that most lacked formal risk management frameworks. However, firms that utilized technology-driven solutions such as cloud storage, automated alerts, and mobile banking platforms were more resilient during economic shocks and supply chain disruptions.

**Summary of Findings, Conclusion and Recommendations**

**Summary of Findings**

i. Automation had significant positive effect on incidence of stockouts in food and beverage firms in Enugu State, Z(9.672 , P. = .05)
ii. Blockchain tracking had significant positive effect on the frequency of fraud of food and beverage firms in Enugu State, Z(11.452, P. = .05)

**Conclusion**

The study concluded that Automation and Blockchain tracking had significant positive effect on incidence of stockouts and the frequency of fraud in food and beverage firms in Enugu State., technological innovation plays a crucial role in enhancing the risk management efficiency of food and beverage firms in Enugu State. By adopting advanced technologies such as automation and blockchain tracking, these firms are better equipped to mitigate operational risks, reduce incidences like stockouts and fraud, and improve overall supply chain transparency. The integration of technology not only streamlines processes but also strengthens the firms' ability to respond proactively to challenges within the dynamic business environment. As a result, embracing technological innovation is essential for food and beverage firms in Enugu State to sustain competitive advantage, ensure product quality, and safeguard their long-term growth and resilience.

**Recommendations**

Based on the findings, the following recommendations were proffered:

i. Food and beverage firms in Enugu State should invest in automation technologies to improve inventory management and reduce the incidence of stockouts, ensuring consistent product availability and customer satisfaction.
ii. Food and beverage firms in Enugu State should implement blockchain tracking to enhance transparency and significantly reduce the frequency of fraud within their supply chains.

**References**

Bichou, K. (2020). Technological innovation and risk management in global supply chains. *Journal of Business Research, 104*(3), 345–358.

Caldwell, D. G. (2023). *Automation in food manufacturing and processing*. Springer. https://www.researchgate.net

Colyer, D. (2023, May). *Automation trends in food and beverage*. Automation World. https://www.automationworld.com

Ellahi, R. M., Wood, L. C., & Bekhit, A. E.-D. A. (2023). Blockchain-based frameworks for food traceability: A systematic review. *Foods, 12*(16), 3026. https://doi.org/10.3390/foods12163026

Encyclopedia of Production and Manufacturing Management. (2024). Stockouts. SpringerLink. https://link.springer.com/referenceworkentry/10.1007/1-4020-0612-8_925

Eze, T. C., & Okonkwo, O. (2020). Innovation strategies and risk management in medium enterprises. *Journal of Business and Technology, 12*(2), 55–68.

Goh, M. (2020). Advancements in supply chain technology and their implications for the food and beverage industry. *Food Technology, 74*(4), 45–50.

Güngör, A., & Güngör, B. (2024). Automation in gastronomy: Use of smart cooking systems in industrial kitchens. *Worldwide Hospitality and Tourism Themes*. https://www.emerald.com/insight

ISO. (2018). *ISO 31000: Risk management – Guidelines*. International Organization for Standardization.

Iwuoha, D. (2021). Challenges of SMEs in the food and beverage industry: The case of Enugu State. *Journal of Business Development, 15*(2), 210–225.

Iwuoha, D. (2021). Technological resilience among SMEs in Enugu State. *Journal of SME Development, 18*(1), 112–128.

Ogbu, J., & Nweze, N. (2021). Digital transformation and performance of SMEs in southeastern Nigeria. *International Journal of Business Innovation, 6*(3), 34–50.

Oloruntoba, R., & Oloke, D. (2019). Food processing firms and technology adoption in Nigeria. *African Journal of Industrial Management, 10*(1), 77–89.

Oloruntoba, R., & Oloke, D. (2019). Food safety and quality control in Nigerian food and beverage firms: A technological perspective. *International Journal of Food Science, 60*(5), 500–514.

Porter, M. E., & Heppelmann, J. E. (2014). How smart, connected products are transforming competition. *Harvard Business Review, 92*(11), 64–88.

Psomiadis, D. (2023). Adulteration in food industry in 2023: Overview. https://www.researchgate.net/publication

Rajput, D. V., More, P. R., Adhikari, P. A., & Arya, S. S. (2025). Blockchain technology in the food supply chain: A way towards circular economy and sustainability. *Sustainable Food Technology, 3*, 930–946. https://doi.org/10.1039/D5FB00065C

Schumpeter, J. A. (2019). *The theory of economic development*. Harvard University Press.

Singh, P. (2023). Role of automation and robotics in transforming the food industry. *Veterinaria*. https://veterinaria.org/index.php/REDVET/article/view/809