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MEASUREMENT TRACEABILITY AND PERFORMANCE OF FOOD AND BEVERAGE MANUFACTURING FIRMS IN TANZANIA.

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ABSTRACT

The study aimed to ascertain the effect of measurement traceability on performance of food and beverage manufacturing firms in Tanzania. The study was anchored in institutional theory and the knowledge-based view theory. It employed a cross-sectional survey design, collecting data from food and beverage manufacturing firms throughout mainland Tanzania. The target population included 480 respondents from 120 registered food and beverage manufacturers. The overall sample size for this study was determined using a formula developed by Miller and Brewer. Consequently, applying this formula, the sample size was 218 respondents from 55 food and beverage firms in Tanzania. The research utilised a questionnaire to gather primary data. The data were analysed using descriptive and inferential statistics using the Statistical Package for the Social Sciences (SPSS version 27). The findings revealed that measurement traceability positively influences firm performance, supporting the hypothesis that enhanced measurement traceability leads to improved firm performance. The study concludes that companies in the manufacturing sector can create a collaborative environment where compliance and innovation thrive together by aligning goals across departments like quality assurance and research and development. Furthermore, leveraging technology such as automation tools or data analytics platforms can streamline both measurement processes and innovation efforts. This allows firms to maintain high levels of accuracy while reallocating resources towards creative projects.

Keywords: Measurement traceability, Firm performance, Food and beverage manufacturing firms.

Background of the Study

Food and beverage manufacturing is crucial to Tanzania's economy, significantly contributing to growth, job creation, and food safety (Lugina et al., 2022). In a highly competitive marketplace, businesses face pressure to provide consistently high-quality products while adhering to stringent regulatory standards and evolving consumer expectations (Tran, 2018). Measurement traceability is the ability to connect measurements to national or international standards, which is vital for ensuring product quality and safety (Schuitemaker & Xu, 2020). Traceability in measurements is crucial for organizations involved in manufacturing, supply, transportation, and services. The manufacturing sector focuses on the mass production of both consumable and non-consumable goods, regardless of quantity (Maganga & Taifa, 2023b). Consequently, numerous measurement activities are carried out throughout the manufacturing process, such as testing, inspecting, and analyzing samples prior to, during, and following production (Nzumile et al., 2024). As consumer awareness and regulatory oversight increase, guaranteeing product safety and quality becomes critical, with measurement traceability being key to achieving consistent quality (Sun et al., 2017). For instance, organizations like the International Organization for Standards (ISO) offer standardized guidelines for evaluating quality, safety, and environmental performance. Additionally, certification ensures that measurements can be traced to recognized standards, fostering trust among consumers by providing transparent information about product quality and safety (Haleem et al., 2019). Consequently, product certification enhances measurement traceability by setting defined and standardized measurement benchmarks, acting as a quality assurance mechanism within the food and beverage supply chain (Sun & Wang, 2019).

Nonetheless, while measurement traceability is broadly acknowledged as essential for ensuring product quality and operational efficiency globally, its specific effects on the performance of food and beverage manufacturing companies in Tanzania are still not well examined (Maganga & Taifa, 2023b). Manufacturers in Tanzania encounter ongoing challenges, including unpredictable product quality, inefficient processes, and obstacles in meeting international food safety standards (Nzumile et al., 2024). These challenges stem in part from inefficient traceability systems that do not adequately capture and convey essential traceability information relevant to Tanzania. Moreover, research demonstrates that measurement traceability can enhance product quality by supplying dependable data that underpins decision-making within manufacturing operations (Andonov & Cundeva-Blajer, 2018). For example, studies across various sectors reveal that companies with strong traceability systems experience reduced product recalls and increased customer confidence (Kumar et al., 2022). In the context of food safety, traceability is crucial for quickly and effectively identifying sources of contamination (Bai et al., 2020).

The government can focus on implementing traceability as a key regulatory approach in developing countries, which can significantly improve public health and safety (Tran, 2018). Policies from the government affect the supply chain performance of specific food products in various ways, including taxes, regulations, and subsidies that impact production costs. In Tanzania, regulatory bodies such as the Tanzania Bureau of Standards (TBS) and the Tanzania Medicines and Medical Devices Authority (TMDA) oversee food standards. Moreover, these regulatory frameworks can influence the food supply chain by limiting harmful products and ensuring the registration and traceability of medicines and medical devices. Existing studies indicate that many local companies face challenges in establishing effective measurement systems due to inadequate infrastructure, a shortage of trained personnel, and insufficient investment in technology (Maganga & Taifa, 2023 and, Nzumile et al., 2024). These obstacles prevent them from achieving optimal performance levels compared to businesses in more developed markets. Therefore, this study aims to ascertain the effect of measurement traceability on performance of Tanzania’s food and beverage manufacturers.

Statement of the Problem

Although measurement traceability is increasingly recognized worldwide as essential for enhancing supply chain transparency and operational effectiveness, its application and implementation in Tanzania's food and beverage manufacturing sector remain inconsistent. According to the Tanzania Bureau of Standards inspection reports, the compliance rate for food and beverage manufacturing firms in 2022 was found to be approximately 65% to 70%. This compliance addresses key elements, including hygiene, accurate labelling, and following basic production protocols. Numerous companies in this field stand to gain advantages such as improved quality control, better regulatory compliance and heightened operational efficiency with effective traceability systems (Nzumile et al., 2024). However, a lack of comprehensive traceability practices often leads to inconsistent product quality, increased production costs, and significant risks of failing to meet regulations (Zhou et al., 2022).

Likewise, firms struggle to quickly identify and resolve quality issues without a robust framework to track critical process metrics, resulting in inefficiencies that negatively impact overall performance (Martins et al., 2020). Research by Zorn et al., (2013) and Zanoli et al., (2014) indicates that the costs of compliance may drive some individuals to take compliance risks rather than contend with higher production expenses, potentially undermining short-term profits. This situation creates vulnerabilities in the food and beverage supply chain, jeopardizing immediate earnings and, more importantly, affecting product quality and safety (da Silva et al., 2019). Consequently, the risk of non-compliance, or the likelihood that a product or service does not meet established standards, is prevalent across various food sectors and the food supply chain. Additionally, this risk poses operational, financial, and reputational threats throughout the entire "farm-to-fork" process (Bailey, 2015). While measurement traceability is recognized as crucial for ensuring quality and mitigating risks, there remains a lack of understanding regarding how its implementation can deter non-compliance incentives. Specifically, empirical research is needed to evaluate the impact of measurement traceability on the performance of food and beverage manufacturers in Tanzania.

Objectives of the Study

The study was guided by the following objectives;

i. To ascertain the effect of measurement traceability on performance of food and beverage manufacturing firms in Tanzania.
ii. To determine the moderating effect of innovation strategies on the relationship between measurement traceability and performance of food and beverage manufacturing firms in Tanzania.

Research Hypotheses

H_{01}: Measurement traceability has no significant effect on performance of food and beverage manufacturing firms in Tanzania.

H_{02}: Innovation strategies have no significant moderating effect on the relationship between measurement traceability and performance of food and beverage manufacturing firms in Tanzania.

Theoretical Framework

Institutional Theory

Institutional theory aids in the examination of how firms respond to external pressures. The primary prediction of the theory is that a company becomes entrenched in and swayed by institutions and their norms and practices, to which firms ultimately adapt (Hirsch, 1975). The central issue of institutional theory is that firms, through isomorphic pressures that are coercive, normative, and mimetic, ultimately implement similar approaches (DiMaggio & Powell, 1983).

Thus, institutional theory serves as a comprehensive method to recognise the external pressures, or factors influencing organisational practices (Scott, 2014).

Coercive isomorphism arises from political influences in the form of monitoring bodies, rules, guidelines, and certification procedures (Caplan & boyd, 2018). Because this theory is quite broad for this study, coercive isomorphism is particularly relevant as it assumes political influence and the issue of legitimacy (Nelson et al., 2014). The theory supports the objective of measurement traceability, which focuses on ensuring industry compliance with standards, rules, and regulations enforced by the government in the manufacturing of food and beverages (Scott, 2014). The nature of coercion facilitates companies' introduction of new technologies into their operations to meet national and international standards (Kumar & Sharma, 2015). Similarly, many industries have established standards for measurement accuracy, and firms are expected to meet these standards to maintain their legitimacy and credibility. Measurement traceability can assist firms in demonstrating compliance with standards and regulations, as well as ensuring quality control by providing a transparent and auditable record of the measurement results.

Therefore, institutional theory is governed by regulatory authorities dealing with food and beverages to ensure compliance with quality and safety standards (Scott, 2014). It can be observed that institutional pressure encourages the development of necessary competencies in a supply chain (Zhao et al., 2018); that is, institutional theory can lead organisations to adopt certain capabilities (Adebanjo et al., 2018), such as the utilisation of supply chain traceability. The theory can also be employed as a complementary approach to identify the dynamics of cutting-edge technologies within production systems (Dubey et al., 2019). In addition, institutional theory can be used to analyse the reasons why companies adopt innovative technologies to enhance compliance with government laws and regulations (Sodero et al., 2013). Thus, institutional theory supports measurement traceability by enabling firms to maintain legitimacy in the institutional environment in which they operate.

Knowledge-Based View Theory

The Knowledge-Based View (KBV) theory arose as organizations shifted their focus from tangible assets to intangible resources, enhancing productivity (Nonaka, 1994). This theory highlights the importance of modern technology, economic globalization, and robust knowledge sharing among partners to innovate new products and enhance existing ones, contributing to the long-term success of the company (Díaz-Díaz et al., 2008). KBV clarifies the connections between a core firm and its suppliers, allowing the firm to leverage skills and expertise from suppliers while also understanding customer needs to create competitive products that align with expectations (Oke et al., 2013).

Moreover, researchers indicate that an innovation strategy is vital for companies that seek a competitive advantage and can affect organizational performance (Lee et al., 2018). In the same vein, innovative strategies have played a crucial role in the integration of supply chain traceability systems (Yang & Wang, 2023). Consequently, scholars assert that an effective innovation strategy is essential for firms aiming to achieve a competitive edge and influence organizational performance (Lee et al., 2018). Similarly, innovative strategies have aided in the adoption of supply chain traceability systems (Yang & Wang, 2023). Thus, research suggests that innovation strategies are shaped by contextual elements, including collaboration among supply chain partners, knowledge sharing, commitment from senior management, and the organizational culture.

Conceptual Framework

A conceptual framework acts as an analytical tool that spans different contexts and adaptations. It demonstrates the connections among independent, moderating, and dependent variables.

Measurement traceability is the independent variable, innovation strategies is the moderating variable, and the performance of food and beverage manufacturing firms in Tanzania constitutes the dependent variable.

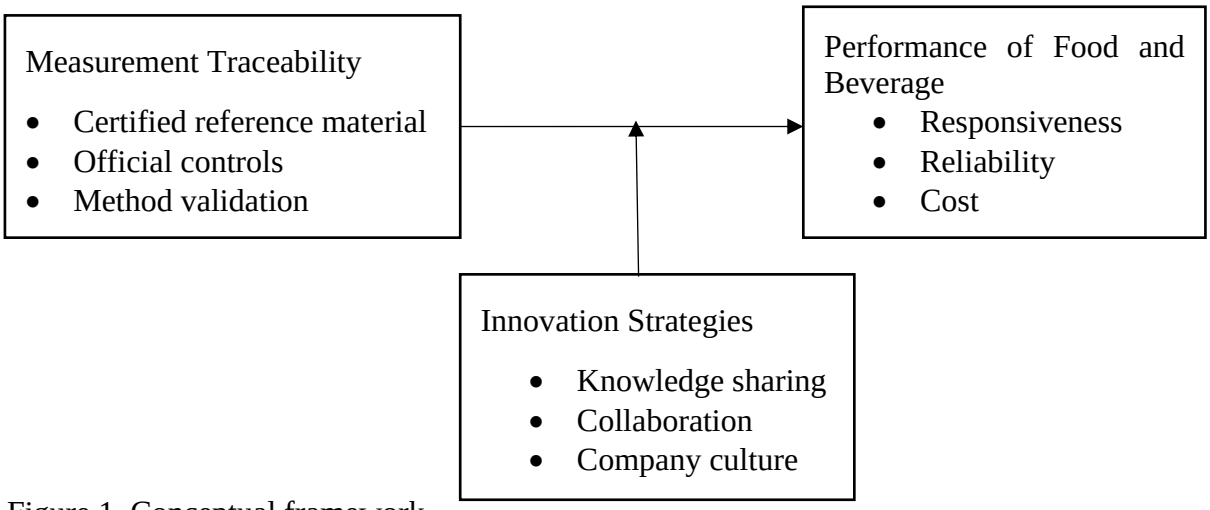

Figure 1. Conceptual framework

Measurement Traceability

Traceability of measurements refers to individual measurement outcomes of the produced products regarding required standards (Schuitemaker & Xu, 2020). Measurement traceability is crucial for ensuring measurement data's accuracy and reliability. It involves comparing measurement results to established standards and maintaining documentation and calibration records to ensure that measurements can be traced back to a known and reliable reference (Schuitemaker & Xu, 2020). To achieve this, measuring and testing equipment, as well as measuring standards, are calibrated with the aid of acceptable standard goods which are certified to local or global standards (Sun & Wang, 2019). Due to safety and quality concerns, rules and regulations have been introduced for the effective functioning of the traceability system in the food and beverage supply chain. To ensure compliance in the supply chain, the regulatory framework can intervene in and influence the performance of the food and beverage supply chain by using payments to encourage the production of goods and services it deems necessary for consumers, while subsidies lead to a rightward shift in the supply chain, lowering the equilibrium price and increasing the equilibrium quantity (Mollenkopf et al., 2020). Therefore, compliance products with specific standards and regulations can enhance measurement traceability by ensuring that measurements are accurate, reliable, and consistent across different industries (Khan et al., 2018). As it helps to reduce measurement errors and inconsistencies and improve the overall quality and reliability of the product. In addition, it requires the use of specific measurement data management systems to enable compliance with these standards ensuring that measurement data is properly recorded, stored, and maintained (Sun & Wang, 2019). This helps to ensure that measurements are traceable and they meet the required quality and safety. Hence, the literature also identifies aspects of regulation in the execution of traceability in the food SC that is a requirement in many countries (Haleem et al., 2019).

Innovation Strategies

Innovation strategies enable businesses to stay competitive by continuously enhancing their products, services, and processes. They provide critical competitive advantages, now viewed as essential rather than optional for success (Liao et al., 2020). Therefore, a company must leverage skills and knowledge both internally and externally to boost performance and cultivate internal capabilities that support supply chain traceability (Grissemann et al., 2013). In

addition, innovation improves learning abilities and helps companies effectively identify and nurture cutting-edge ideas that lead to more efficient manufacturing methods (Ioniță, 2022). Collaborating with key supply chain partners for innovative objectives allows a firm to stay actively engaged with these partners' advanced activities, learning from them and adapting its innovation strategies accordingly (Oke et al., 2013). Suppliers can also contribute innovative ideas and recognize the value of these concepts, along with new technologies, in implementing traceability systems (Liao et al., 2020). An organization that fosters innovation gains a competitive advantage as it adapts to market changes (Chege et al., 2020). This innovative culture also motivates employees, allocates resources effectively, and cultivates an environment that nurtures new ideas and approaches (Shin et al., 2022). Furthermore, the organization ensures the availability of resources for innovation by financing research and development, investing in new technologies and equipment, and supporting training initiatives (Lin et al., 2019). This approach promotes collaboration across departments and teams, which encourages the exchange of knowledge and expertise that drives innovation. In conclusion, adopting an innovation-oriented culture helps a company strategize around innovative technologies, leading to a wider range of applications and more innovative and traceable products (Ioniță, 2022).

Performance of the Food and Beverage Manufacturing Firms

An organization's performance reflects its efforts and success in achieving set goals (Al-Matari et al., 2014). To assess a company's performance, key performance indicators (KPIs) specific to the business are utilized. This performance dimension is crucial for management assessments, progress reporting, and improved incentives (Waggoner et al., 1999). Performance measurement is essential for effective corporate management, enhancing both the company's image and its organizational control capabilities (Taouab & Issor, 2019). Additionally, evaluating supply chain performance in manufacturing requires organizations to incorporate criteria about operational efficiency and service effectiveness to create a cohesive framework (Gupta & Gupta, 2019). The Supply Chain Operations Reference (SCOR) model acts as a comprehensive framework for assessing and improving supply chain performance, providing a standardized approach to analyse, measure, and optimize supply chain activities. Developed by the Supply Chain Council, the SCOR model integrates business process re-engineering, benchmarking, and best practices into one cohesive framework (Fauziyah et al., 2020). It revolves around five key processes: Plan, Source, Make, Deliver, and Return. The SCOR model pinpoints essential performance indicators vital for evaluating supply chain efficiency, which includes measures of reliability, responsiveness, agility, cost, and asset management (Prasetyaningsih et al., 2020). Therefore, employing the SCOR model allows manufacturing firms to uncover performance gaps, enact targeted enhancements, and continuously monitor and optimize supply chain processes, thus improving overall performance (Ashok Chopra, 2022). This research focuses on the performance of food and beverage manufacturing companies by analysing the KPIs utilized to measure supply chain efficiency, specifically looking at responsiveness, reliability, and cost.

Empirical Review

Measurement Traceability and Performance of the Firm

A study by Sun & Wang, (2019) on promoting traceability in the food supply chain through certification. The research showed that both buyers and suppliers need to invest in a food traceability system to meet regulatory requirements. Additionally, the study highlighted that certification is vital for enhancing regulatory traceability in the food and beverage supply chain. Certifying products through recognized organizations assures consumers and enhances the safety and quality of food items, thereby increasing consumer trust. A robust traceability system significantly contributes to improved food safety standards. As such, a well-designed

traceability system not only reduces the number of recalls but also lowers the chances of food safety incidents. In the food and beverage industry, certification has been employed to ensure traceability throughout the supply chain and to attract customers (Bai et al., 2013).

A study by Tran, (2018) on critical factors and conditions for food quality and safety compliance in the Vietnamese seafood supply chain. The research indicated that food safety regulations and standards are mainly enforced by governments or third-party organizations in importing nations. While most regulations benefit all parties involved—from consumers to producers—they also present various challenges and potential compliance risks for food businesses. Increasing awareness of the compliance risk management framework can be achieved through information sharing, guidance, and support from key influencers. Additionally, risk-based compliance management systems are effective tools for minimizing instances of non-compliance. Moreover, following food quality and safety regulations, along with import market standards, is a costly and long-term endeavour for developing nations.

A study by Zhou *et al.,* (2022), on the effects of regulatory policy mixes on traceability adoption in wholesale markets: Food safety inspection and information disclosure. The study found that food safety regulation in China is ineffective and needs improvement. Additionally, it's important to evaluate how regulatory practices influence the implementation of strategies designed to minimize food safety risks. Factors like sample inspections, penalties for failures, and information sharing serve as essential motivators for food manufacturers and suppliers to implement traceability systems. Moreover, the research demonstrated that both the rigor of sampling and information sharing significantly enhance the adoption of traceability by sellers. This study also has important implications for developing economies, where many small-scale farmers operate and where transparency in the supply chain is often lacking.

Innovation Strategies and Performance of the Firm

A study by Gupta & Gupta, (2019) on innovation and culture as dynamic capabilities for firm performance: a study from emerging markets. The authors used firm size as a moderating variable to analyse the influence of different types of innovation (process, product, and culture) on firm performance. The findings revealed that innovation culture had a significant positive effect on larger firms, while it did not for smaller ones. Therefore, company size plays a moderating role in this relationship, and, akin to product innovation, it did not show statistical significance for the performance of either group. As a result, no additional statistical analysis was conducted in this study. On the other hand, process innovation demonstrated a significant and positive effect on business performance across both groups. The research further evaluated the two groups and concluded that firm size moderates the effect of process innovation on performance.

Oke et al. (2013) demonstrate that for a firm to achieve safety and quality in product production, it is crucial to form strategic relationships and collaborate with skilled suppliers. This can be accomplished through investments in advanced technologies, such as supply chain traceability systems. Their research shows that innovative strategies boost organizational learning and the capacity to absorb new knowledge from supply chain partners, ultimately enhancing organizational performance. In fact, supply chain traceability innovation is essential for both organizational success and individual creativity (Shanker et al., 2017). Additionally, other studies reveal that having administrative knowledge allows a firm to cultivate innovative concepts that enhance productivity and profitability (Lee et al., 2018). Thus, to secure a competitive advantage in a tough market, implementing innovation strategies is vital. As a result, developing transformative capabilities in supply chain traceability becomes imperative due to significant shifts in consumer demand, especially concerning the safety and quality of products.

Research Methodology

Research Design

Research design serves as a detailed blueprint that guides researchers throughout the research process (Siedlecki, 2020). In this study, a cross-sectional design was utilized. Additionally, researchers chose a cross-sectional survey because it facilitates data collection at a specific moment, shows reliability in assessing effect relationships, and can be applied to the general population (Yan et al., 2019). Similarly, the researcher implemented a selective survey design targeting the food and beverage manufacturing sectors in several regions of mainland Tanzania, including Arusha, Kilimanjaro, Tanga, Mwanza, Mbeya, Morogoro, Coast, and Dar es Salaam.

Research Philosophy

This study was based on the positivist research philosophy, as the researcher intended to utilize existing theories to identify and develop variables while formulating hypotheses that can be verified, confirmed, or disproven entirely or partially. This process leads to the advancement of theories that future studies can validate. According to (Park et al., 2020), any scientific investigation taking a positivist approach must prioritize evidence over mere impressions. Positivism implies that one can observe real and factual occurrences (Aliyu et al., 2014). Additionally, this method adheres to its standard protocol, which consists of articulating a hypothesis to characterize the event being studied, followed by collecting data to quantitatively assess the proposed hypothesis using the gathered information.

Target Population

The target population for an investigation represents the components from which study data are drawn to reach conclusions (Stratton, 2021). For this research, the target population included 480 respondents from 120 food and beverage manufacturing firms in mainland Tanzania, consisting of managers in procurement, inspection, quality, and production departments. The participating companies were identified through the Business Registrations and Licensing Agency (BRELA) of the Ministry of Industry, Trade and Investment. Consequently, this study's primary unit of analysis is the food and beverage manufacturing firm, with observations focused on managers from the mentioned departments. The selection of managers from these four areas was influenced by the study's focus and the relevance of the questions, as these individuals held the necessary information for the investigation.

Sample size and sampling technique

The sample size governs the arithmetic precision of the results (Lakens, 2022). A representative sample size is crucial in research as it facilitates the generalisation of study findings to the broader population. The total sample size is determined using the formula provided by Miller and Brewer (2006), as shown below (Saunders et al. 2009).

$$n = \frac{N}{1+N(e^2)}$$

Where n represents sample size, N is the population size and e is the desired marginal error this study intends to use a 95% confidence interval. Therefore, the determined sample size is;

$$n = \frac{480}{1+480(0.05^2)} = 218$$

Hence, the sample size for this study included 218 respondents from 55 food and beverage manufacturing firms in Tanzania mainland.

The sampling method utilized was stratified random sampling, ensuring that each subgroup within the population was sufficiently represented in the sample. The sampling frame identified six subgroups/strata: soft drinks and juices, dairy products, processed meats, seafood, cereal and grain products, and vegetable oil. Following this, simple random sampling

was employed to proportionately select sample sizes from each stratum. This approach ensured that every stratum was well represented in the sample, enhancing accuracy in reflecting population characteristics since a random sample was drawn from each stratum (Kothari & Garg, 2014). This sampling method effectively reduces sampling bias error.

Data Collection Instruments

This study collected data using a mix of closed-ended and open-ended questions. Closed-ended questions required respondents to provide straightforward answers without additional details, while open-ended questions sought to understand respondents' views on the variables under investigation. Kamanga (2024) and Munyi (2024) adapted the semi-structured questionnaire in their studies.

Pilot Study

Before launching a full-scale research project, a pilot test was conducted as a small-scale preliminary study to evaluate the feasibility and practicality of the research design, methods, and procedures (Madden et al., 2020). The goal was to improve the quality and efficiency of the main study while minimizing errors, bias, and resource waste. A pilot study of the data collection instruments was conducted to confirm that the questionnaire items were clearly articulated and interpreted consistently by target respondents and to gauge the time needed for questionnaire completion. Kothari (2017) suggests that the sample size for pilot tests can vary from 1% to 10% of the target population. In this instance, the pilot study purposefully selected 6 firms from a pool of 22 respondents, amounting to 10% of the total. The pilot study outcomes are commonly used to refine the research design or methodology before proceeding to the main study. Questions that had errors, omissions, ambiguities, or were irrelevant were revised, and the questionnaire's content, structure, and sequence were adjusted to enhance content validity and reliability. These enhancements ensured that the data collection instruments were accurate.

Data Analysis and Presentation

The researcher gathered the questionnaires, assigned codes to them, and entered the data into the Statistical Package for the Social Sciences (SPSS version 26) for analysis. Initially, the sort function was utilized for screening. The data was gathered in alignment with the study's objectives and hypotheses. Descriptive statistical methods, such as frequency, mean, and standard deviation, were used to analyze the quantitative data collected. Results were presented in frequency distribution tables, which documented how often each score or response appeared. The research also employed inferential statistics, including regression and correlation analyses. Hierarchical multiple regression was used to examine the moderating effect of innovation strategies.

Research Findings and Discussion

Descriptive Analysis of the Study Variables

This section discusses the findings from Likert scale questions, where participants indicated their agreement levels with statements concerning the link between measurement traceability and the performance of food and beverage manufacturing firms in Tanzania. A 5-point Likert scale was utilized, with 1 representing strongly disagree, 2 disagree, 3 neutral, 4 agree, and 5 strongly agree. Mean values and standard deviations were used for interpretation; a mean score of 1-1.4 reflected strong disagreement, 1.5-2.4 disagreement, 2.5-3.4 neutrality, 3.5-4.4 agreement, and 4.5-5 strong agreement. A standard deviation over 2 indicated a large spread, suggesting responses were widely dispersed rather than clustered around the mean, which implies significant variability in responses. This variability may indicate different participant interpretations or perceptions of the posed questions. Moreover, open-ended questions

followed the Likert scale, capturing insights not expressed through the scale. This qualitative data was analysed with content analysis and presented in prose format.

Measurement Traceability

The study's objective was to ascertain the effect of measurement traceability on the performance of food and beverage manufacturing firms in Tanzania. Respondents were, therefore, requested to indicate their level of agreement with statements on measurement traceability and performance of food and beverage manufacturing firms in Tanzania. Table 1 presents a summary of the findings obtained.

Participants were asked to express their agreement with the claim that the firm maintains laboratory reports and certificates for microbial counts to ensure easy traceability. Results showed that 51.6% (80) agreed, while 28.4% (44) strongly agreed. Meanwhile, 14.8% (23) were neutral, 3.9% (6) disagreed, and a small minority of 1.3% (2) strongly disagreed. The mean response was (M= 4.02) and the standard deviation was (SD= 0.841). Next, participants were questioned about their agreement with the firm keeping laboratory reports and certificates concerning specific pathogens for traceability; 49.7% (77) strongly agreed, followed by 21.9% (34) who agreed, and 19.4% (30) who were neutral. In contrast, 3.9% (6) disagreed, and 1.3% (2) strongly disagreed. The mean was calculated as (M= 4.12) with a standard deviation of (SD= 1.038). Additionally, respondents were asked to share their agreement with the statement that the company's products are certified and tested by accredited laboratories, ensuring safety and reliability in measurements, thus aiding traceability. Here, 43.2% (67) agreed, 31.6% (49) strongly agreed, while 17.4% (27) were neutral. Meanwhile, 4.5% (7) disagreed, and 3.2% (5) strongly disagreed. The mean was (M= 3.95) with a standard deviation of (SD= 0.983).

Additionally, participants were asked to express their agreement with the statement that the firm’s products are assured for safety due to rigorous testing, with measurements traceable to recognized standards. A small 1.9% (3) of respondents strongly disagreed, 6.5% (10) disagreed, and 17.4% (27) remained neutral. The majority, 45.2% (70), strongly agreed, while 29% (45) agreed. The mean for this question was 4.09 with a standard deviation of 1.028. Similarly, participants indicated their level of agreement with the statement that the firm keeps records of instrument calibration and verification activities, such as calibration results, to ensure accuracy and reliability. Here, 43.2% (67) strongly agreed, followed by 32.9% (51) who agreed, while 16.1% (25) remained neutral, 7.1% (11) disagreed, and 0.6% (1) strongly disagreed. The mean was 4.11 with a standard deviation of 0.964. Finally, respondents were asked about their agreement with the assertion that the firm’s products are tested and certified by accredited laboratories, ensuring the safety and reliability of the measurements and their traceability. The results revealed that 54.8% (85) strongly agreed, followed by 23.2% (36) who agreed, with 16.8% (26) neutral, 4.5% (7) disagreeing, and only 0.6% (1) strongly disagreeing. The mean was 4.27 with a standard deviation of 0.942. Overall, these responses produced a mean value of 4.05 and a standard deviation of 0.824. This research outcome is consistent with the findings of (Martins, 2020).

In the section regarding official controls, participants were asked to indicate their level of agreement on whether the firm performs internal audits and inspections to assess compliance with official controls, standard operating procedures, and quality control standards. A small 1.9% (3) of the respondents strongly disagreed, while 5.2% (8) disagreed, and 14.2% (22) remained neutral. The majority, 54.2% (84), strongly agreed, and 24.5% (38) agreed. The mean response was 4.24 with a standard deviation of 1.007. Additionally, respondents were queried about whether their firms maintain evidence of successful audits and assessments, including audit reports, accreditation certificates, and corrective actions taken in response to audit findings. The results showed that 45.8% (71) of participants strongly agreed with this assertion,

followed by 32.3% (50) who agreed. Moreover, 15.5% (24) remained neutral, 5.8% (9) disagreed, and only 0.6% (1) strongly disagreed. The mean for this question was 4.17 with a standard deviation of 0.938. Likewise, participants were asked to express their agreement with the statement that their firm keeps records to confirm that personnel are sufficiently trained in the proper use of measurement equipment methods and procedures. A small 1.3% (2) of respondents strongly disagreed, 5.8% (9) disagreed, and 17.4% (27) were neutral. The largest group, 43.9% (68), strongly agreed, followed by 31.6% (49) who agreed. The mean for this question was 4.11 with a standard deviation of 0.977.

Furthermore, participants were asked to express their agreement regarding the audit of firm products to ensure consistent adherence to regulatory processes and established national standards. Results revealed that a majority—38.7% (60)—strongly agreed, while 38.1% (59) agreed, 16.8% (26) were neutral, and 5.2% (8) disagreed, with a minority of 1.3% (2) strongly disagreeing. The mean (M) was 4.08, and the standard deviation (SD) was 0.937. Similarly, when asked about their agreement on whether the firm complies with legal and regulatory standards to guarantee products meet safety and quality requirements defined by regulatory bodies, the results demonstrated that 47.1% (73) strongly agreed, followed by 29% (45) who agreed, 18.1% (18) remaining neutral, 5.2% (8) in disagreement, and only 0.6% (1) who strongly disagreed. These responses resulted in a mean value of M=4.17 and a standard deviation of SD=0.945. Lastly, participants were invited to state their agreement with the assertion that the firm meets the standards of calibration laboratories and verification bodies to ensure quality and safety for consumers. The data indicated that 40.6% (63) of respondents agreed, with an additional 38.7% (60) strongly agreeing, while 14.2% (22) were neutral, 4.5% (7) dissented, and a small portion, 1.9% (3), strongly disagreed. This yielded a mean value (M) of 4.10 and a standard deviation (SD) of 0.938. This research aligns with the findings of Zhou et al. (2022).

Regarding method validation, participants were asked to express their agreement on whether the firm maintains records of discrepancies between actual measurement results and standard measurements. The results showed that most respondents, 40.6% (63), agreed, while 38.7% (60) strongly agreed. A neutral stance was taken by 14.2% (22), and 5.2% (8) disagreed, with a small minority of 1.3% (2) strongly disagreeing. The Mean (M) was calculated at 4.10, with a Standard Deviation (SD) of 0.920. Similarly, participants were asked if they believed that the firm consistently follows standard operating procedures to ensure the reliability of the robust assessment. Here, 51.6% (80) strongly agreed, followed by 27.1% (42) who agreed. Meanwhile, 15.5% (24) were neutral, 4.5% (7) expressed disagreement, and 1.3% (2) strongly disagreed, leading to a mean of (M= 4.23) and a standard deviation (SD= 0.959). Additionally, when asked about the firm's practice of recording any deviations from planned experimental settings during robustness assessments and explaining these deviations, 49% (76) agreed. This was supported by 28.4% (44) who strongly agreed, while 14.8% (23) remained neutral, 5.8% (9) disagreed, and 1.9% (3) strongly disagreed. These responses resulted in a mean value of (M= 3.96) and a standard deviation of (SD= 0.918).

Additionally, participants were asked to express their agreement with the statement that their firm engages in proficiency testing programs organized by regulatory agencies to validate the reliability of the firm's measurements. Only 1.3% (2) of respondents strongly disagreed, while 4.5% (7) disagreed, and 16.8% (26) remained neutral. A majority, representing 40% (62), strongly agreed, followed by 37.4% (58) who agreed. The average response for this question was 4.10, with a standard deviation of 0.927. Participants were then asked about their agreement regarding the firm's regular verification of measurement instrument performance using certified reference materials, standards, or internal quality control samples. Here, 43.2% (67) strongly agreed, 34.2% (53) agreed, and 15.5% (24) were neutral. In contrast, 6.5% (10) disagreed, while 0.6% (1) strongly disagreed, leading to a mean of 4.13 and a standard

deviation of 0.945. Finally, respondents were inquired about their agreement regarding their firm's documentation of accuracy studies, recovery studies, inter-laboratory comparisons, and proficiency testing results in validation reports about measurement accuracy. In this case, 1.3% (2) strongly disagreed, 4.5% (7) disagreed, and 14.2% (22) remained neutral. The majority, 45.2% (70), agreed, with 33.5% (52) strongly agreeing, resulting in a mean of 4.05 and a standard deviation of 0.889. These findings align with the research of Tran (2018).

Table 1: Descriptive Statistics on Measurement Traceability

Statement	1	2	3	4	5	Mean	Std. Dev.
Certified reference materials							
The firm keeps laboratory reports and certificates on microbial counts for easy traceability.	1.3%	3.9%	14.8%	51.6%	28.4%	4.02	.841
The firm keeps laboratory reports and certificates on the presence/absence of specific pathogens for easy traceability.	0.6%	8.4%	19.4%	21.9%	49.7%	4.12	1.038
The firm's products are certified and tested by accredited laboratories to ensure the safety, accuracy, and reliability of the measurements and thus can easily be traced.	3.2%	4.5%	17.4%	43.2%	31.6%	3.95	0.983
The firm products are safety assured as they undergo rigorous testing in which their measurements can be traced back to recognized measurement standards.	1.9%	6.5%	17.4%	29%	45.2%	4.09	1.028
The firm maintains records of instrument calibration and verification activities like calibration logs, calibration certificates, and verification results to ensure accuracy and reliability.	0.6%	7.1%	16.1%	32.9%	43.2%	4.11	0.964
The firm products are certified and tested by accredited laboratories to ensure the safety, accuracy, and reliability of the measurements and thus can easily be traced.	0.6%	4.5%	16.8%	23.2%	54.8%	4.27	0.942
Official controls							
The firm conducts internal audits and inspections, compliance controls, Standard Procedures, and control standards.	1.9%	5.2%	14.2%	24.5%	54.2%	4.24	1.007
The firm keeps evidence of successful audits and assessments including audit reports, accreditation certificates, and any corrective action implemented in response to audit findings.	0.6%	5.8%	15.5%	32.3%	45.8%	4.17	0.938
The firm keeps evidence to prove that personnel are adequately trained in the use of measurement equipment, methods, and procedures.	1.3%	5.8%	17.4%	31.6%	43.9%	4.11	0.977
The firm products are audited to ensure that regulatory processes and practices are consistently followed and conform to established national standards.	1.3%	5.8%	16.8%	38.1%	38.7%	4.08	0.937
The firm adheres to legal and regulatory standards to ensure products meet safety and quality requirements set by the regulatory bodies.	0.6%	5.2%	18.1%	29%	47.1%	4.17	0.945

The firm adheres to the requirements of calibration laboratories, and verification bodies to ensure quality and safety to consumers.	1.9%	4.5%	14.2%	40.6%	38.7%	4.10	0.938
Method Validation							
The firm keeps records of variations between measurements results obtained and standard measurements.	1.3%	5.2%	14.2%	40.6%	38.7%	4.10	0.920
The firm consistently adheres to standard procedures to enhance the credibility of the robust assessment.	1.3%	4.5%	15.5%	27.1%	51.6%	4.23	0.959
The firm keeps records of any deviations from the planned experimental settings/conditions during robustness assessment and provides explanations for deviations.	1.9%	5.8%	14.8%	49%	28.4%	3.96	0.918
The firm participates in proficiency testing programs organized by regulatory agencies to verify the robustness of our measurements.	1.3%	4.5%	16.8%	37.4%	40%	4.10	0.927
The firm regularly verifies the performance of measurement instruments using certified reference materials, performance verification standards, or internal quality control samples.	0.6%	6.5%	15.5%	34.2%	43.2%	4.13	0.945
The firm documents the results of accuracy studies, recovery studies, inter-laboratory comparisons, and validation reports regarding the accuracy of measurements.	1.3%	4.5%	15.5%	45.2%	33.5%	4.05	0.889
Aggregate mean						**4.11**	**0.949**

Strongly Disagree =1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree = 5

Innovation Strategies

The moderating objective of the study was to determine the effect of innovation strategies on the relationship between measurement traceability and the performance of food and beverage manufacturing firms in Tanzania. Respondents expressed their agreement with statements on innovation strategies for the performance of food and beverage manufacturing firms in Tanzania. Table 2 below presents a summary of the findings obtained.

On knowledge sharing, the respondents were called upon to indicate their agreement regarding the firm's encouragement of a learning culture that encourages organizations to explore new ideas to support innovation. A majority of 42.6% (66) of the respondents concurred, followed by 39.4% (61) who strongly agreed, with an additional 12.3% (19) remaining neutral, while 4.5% (7) were in disagreement and a small percentage of 1.3% (2) who strongly disagreed, resulting in a mean (M= 4.14) and standard deviation (SD= 0.893). Similarly, when questioned to show their level of agreement with the firm encouraging a collective knowledge repository that captures the expertise and insights of its staff, the majority, 43.9% (68) of respondents strongly agreed, 36.8% (57) concurred, with 14.2% (22) remained neutral, whereas 3.9% (6) disagreed and a minority 1.3% (2) strongly disagreed, resulting in a mean (M= 4.18) and standard deviation (SD= 0.908). These findings align with (Rajab, 2024) research.

Moreover, participants were requested to indicate their agreement with the statement asserting that their firm encourages mentoring and coaching programs to share expertise to facilitate the development of skills and competencies. A small percentage of 1.9% (3) of the respondents strongly dissented, with 5.2% (7) disagreed, while 12.3% (19) remained neutral. The majority,

comprising 51.6% (80) of the respondents, agreed, followed by 29% (45) who strongly agreed. The mean for this question was 4.01, with a standard deviation of 0.894. Subsequently, the researcher also inquired about their level of agreement as to whether the firm has platforms with their supply chain partners to share knowledge and exchange ideas related to their product's supply chains. A significant majority of 41.3% (64) concurred, 40.6% (63) strongly agreed, 11.6% (18) were neutral, while 4.5% (7) disagreed, and a small fraction of 1.9% (3) strongly disagreed, resulting in a mean (M= 4.14) and standard deviation (SD= 0.929). Finally, respondents were asked to indicate their agreement regarding whether their firm motivates employees who bring creative ideas and knowledge to improve performance. A small percentage of 1.3% (2) strongly disagreed, followed by 4.5% (7) in disagreement, 13.5% (21) were neutral, while a majority of 42.6% (66) concurred, and 38.1% (59) strongly agreed, resulting in a mean of 4.12 and a standard deviation of 0.897. These findings are consistent with Sun *et al.,* (2020) research.

With collaboration, participants were called upon to indicate their concurrence regarding the assertion that the firm has access to diverse expertise through collaborations, thus allowing for a comprehensive understanding of opportunities. A small percentage of 1.3% (2) of the participants strongly disagreed, 5.8% (9) disagreed, 12.9% (20) remained neutral, whereas the majority, comprising 41.9% (65) of the respondents, strongly agreed, and 38.1% (59) simply agreed. The mean was calculated at 4.14 with a Standard Deviation of 0.940. Likewise, the respondents were requested to show a level of agreement with the statement that the firm jointly solves its problems with supply chain partners through the exchange of ideas and brainstorming, leading to novel ideas. A significant majority of 52.3% (81) concurred, 25.3% (40) strongly agreed, 14.2% (22) were neutral, while 6.5% (10) disagreed, and a small fraction of 1.3% (2) strongly disagreed, resulting in a mean (M= 3.95) and standard deviation (SD= 0.881). Additionally, respondents were prompted to indicate their level of agreement on whether their supply chain partners provide valuable market insights on emerging trends and customer feedback, thus leading to the development of innovative products. The outcomes revealed that a minor proportion of 1.9% (3) strongly disagreed, 7.1% (11) were in disagreement, 14.2% (22) took a neutral stance, whereas a further 31% (48) agreed, with the majority at 45.8% (71) strongly agreeing. The mean was computed at 4.12, with a Standard Deviation of 1.025. Lastly, they were asked to express their concurrence on whether the firm enhances the learning culture among supply chain partners for innovative purposes. A few participants at 1.3% (2) strongly disagreed, 6.5% (10) dissented; also, 13.5% (21) adopted a neutral position, and 38.1% (59) agreed, while the majority at 40.6% (63) strongly agreed. The mean recorded was 4.10, with a standard deviation of 0.955. These research findings align with those of Ominde *et al.* (2022).

Regarding company culture, participants were called upon to indicate their concurrence regarding the assertion that the firm allocates resources such as budget, time, and personnel to support innovation initiatives. The outcomes revealed that a small percentage of 2.6% () of the participants strongly disagreed, 6.5% (10) expressed disagreement, whereas 12.3% (19) remained neutral, and 37.4% (58) concurred, with the majority at 41.3% (64) strongly concurring. This was accompanied by a Mean of (M= 4.08 and a Standard deviation of 1.013). Subsequently, respondents were asked to indicate their level of agreement regarding whether their firm provides funds for research and development, innovation labs, and training programs to support innovative projects. A small percentage of 1.3% (2) strongly disagreed, followed by 7.1% (11) in disagreement, 13.5% (21) were neutral, while a majority of 54.2% (84) strongly agreed, and 23.9% (37) concurred, resulting in a mean of 3.92 and a standard deviation of 0.879. Similarly, respondents were tasked with revealing their stance on the declaration that the firm demonstrates a willingness to embrace new ideas and support employees' creativity, thus promoting an innovation culture. A significant majority of 40.6% (87) strongly agreed,

with 37.4% (58) in agreement, 12.9% (20) remained neutral, and 7.1% (11) in disagreement, while a small proportion of 1.9% (3) strongly disagreed. This was accompanied by a mean of 4.08 and a standard deviation of 0.997. Lastly, participants were instructed to express their agreement level concerning the statement that the firm encourages open communication to provide full support for adopting new technology if the benefits of such technology are well communicated. The majority, 55.5% (86) of the participants, agreed, followed by 23.3% (33) who strongly agreed, 12.9% (20) who were neutral, whereas 7.1% (11) disagreed, with a minority of 0.6% (1) strongly disagreed. This corresponded with a mean of 3.95 and a standard deviation of 0.844. These research findings are consistent with those of Munyi (2024).

Table 2: Descriptive Statistics on Innovation Strategies

Statement	1	2	3	4	5	Mean	Std. Dev.
Knowledge sharing							
The firm encourages a learning culture that encourages organizations to explore new ideas to support innovation.	1.3%	4.5%	12.3%	42.6%	39.4%	4.14	0.893
The firm encourages a collective knowledge repository that captures the expertise and insights of its staff.	1.3%	3.9%	14.2%	36.8%	43.9%	4.18	0.908
The firm encourages mentoring and coaching programs to share expertise to facilitate the development of skills and competencies.	1.9%	5.2%	12.3%	51.6%	29%	4.01	0.894
The firm has platforms with our supply chain partners to share knowledge and exchange ideas related to our product's supply chains.	1.9%	4.5%	11.6%	41.3%	40.6%	4.14	0.929
The firm motivates employees who bring creative ideas and knowledge to improve performance.	1.3%	4.5%	13.5%	42.6%	38.1%	4.12	0.897
Collaboration							
The firm has access to diverse expertise through collaborations, thus allowing for a comprehensive understanding of opportunities.	1.3%	5.8%	12.9%	38.1%	41.9%	4.14	0.940
The firm jointly solves its problems with supply chain partners through the exchange of ideas, and brainstorming leading to novel ideas.	1.3%	6.5%	14.2%	52.3%	25.8%	3.95	0.881
The firm supply chain partners provide valuable market insights on emerging trends and customer feedback, thus leading to developments of innovative products.	1.9%	7.1%	14.2%	31%	45.8%	4.12	1.025
The firm enhances the learning culture among supply chain partners for innovative purposes.	1.3%	6.5%	13.5%	38.1%	40.6%	4.10	0. 955
Company culture							
The firm allocates resources such as budget, time, and personnel to support innovation initiatives.	2.6%	6.5%	12.3%	37.4%	41.3%	4.08	1.013
The firm provides funds for research and development, innovation labs, and training programs to support innovative projects.	1.3%	7.1%	13.5%	54.2%	23.9%	3.92	0.879
The firm demonstrates a willingness to embrace new ideas and support employees' creativity, thus promoting an innovation culture.	1.9%	7.1%	12.9%	37.4%	40.6%	4.08	0.997
The firm encourage open communication to provides full support for adopting new technology if the benefits of such technology are well communicated.	0.6%	7.1%	12.9%	55.5%	23.9%	3.95	0.844
Aggregate mean						**4.07**	**0.927**

Strongly Disagree =1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree = 5

Hypotheses One

The first specific objective of the study was to ascertain the effect of measurement traceability on performance of food and beverage manufacturing firms in Tanzania. The associated null hypothesis was H_{01}: Measurement traceability has no significant influence on performance of food and beverage manufacturing firms in Tanzania. A univariate analysis was conducted in which performance of food and beverage manufacturing firms was regressed on measurement traceability. The associations' direction and strength were determined through path coefficients, and T statistics were used to evaluate the significance of these relationships. With an R square value of 0.552, approximately 55.2% of the variance in the dependent variable can be attributed to measurement traceability. This reveals that although measurement traceability is important, other factors affecting firm performance remain unaccounted for in this model. Therefore, the model indicates that measurement traceability is a key predictor of firm performance, covering a substantial portion of the variance.

The results from the variance analysis show that the F-statistic is 188.812, reflecting the ratio of variance explained by the model compared to the unexplained variance. A higher F-value indicates that the model effectively accounts for variability in the dependent variable. Additionally, the P-value of 0.000 signifies that the regression model is statistically significant, providing strong evidence to reject the null hypothesis. This suggests that measurement traceability significantly impacts the performance of food and beverage manufacturing firms. Accordingly, the ANOVA results confirm that measurement traceability is a crucial predictor of firm performance in the food and beverage manufacturing industry, supported by the notable F-value and the low p-value.

The standardized regression coefficient for measurement traceability is 0.367. This suggests that for every one-unit increase in measurement traceability, firm performance is expected to rise by 0.367 units, assuming all other factors remain constant. The t-statistic associated with the regression coefficient for measurement traceability at the 5% significance level is 13.741, indicating statistical significance. Both the constant and measurement traceability have a p-value of 0.000, suggesting that these coefficients are statistically significant. This provides strong evidence that measurement traceability positively impacts firm performance. The analysis of the coefficients confirms that measurement traceability is a significant predictor of performance in the food and beverage manufacturing sector, as indicated by both unstandardized and standardized coefficients. These findings support the hypothesis that enhancing measurement traceability contributes to improved firm performance. (Zhou et al., 2022) argued that effectively implemented traceability systems can mitigate food quality and safety risks, thereby reducing penalties for manufacturing firms. They also noted that regulatory support encourages food producers and suppliers to adopt quality and safety management practices in manufacturing. Furthermore, Zhou et al., (2022) identified that government disclosure of food safety information significantly influences the adoption of HACCP certification by meat producers in China. Hence, these findings are consistent with the results of this study.

Table 3: Regression Model Results on the Relationship between Measurement Traceability and Performance of Food and Beverage Manufacturing Firms

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.743[a]	.552	.549	.0056779

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.006	1	.006	188.812	0.000[b]
	Residual	.005	153	.000		
	Total	.011	154			

Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.061	.002		31.579	0.000
	Measurement traceability	.367	.027	.743	13.741	0.000

a. Dependent Variable: Performance of food and beverage manufacturing firms

$Y = 0.061 + 0.367\ x + error$

(X is measurement traceability)

Hypotheses Two

The study's second objective was to establish the moderating effect of innovation strategies on the relationship between measurement traceability and performance of food and beverage manufacturing firms in Tanzania. The R square for model one was recorded at 0.604, indicating that measurement traceability and innovation strategies account for 60.4% of the variation in the performance of food and beverage manufacturing firms in Tanzania. Further analysis revealed that the interaction between measurement traceability and innovation strategies leads to greater changes in firm performance, reflected in a new R square of 0.667. This suggests that model two explains approximately 66.7% of performance variance, marking an improvement over model one. The R square change of 0.063 and an F change of 28.579, with a significance level of 0.000, confirm that adding the interaction term enhances the model significantly. Consequently, these results indicate that both measurement traceability and innovation strategies play a crucial role in shaping the performance of food and beverage manufacturing firms, with innovation strategies moderating the relationship between measurement traceability and firm performance. This finding is consistent with the study's conclusions, underscoring the significance of integrating these components for improved supply chain performance.

Table 4: Model Summary of Moderated Measurement Traceability

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.777[a]	.604	.598	.0053607	.604	115.735	2	152	.000
2	.817[b]	.667	.660	.0049319	.063	28.579	1	151	.000

a. Predictors: (Constant), Innovation strategies, Measurement Traceability

b. Predictors: (Constant), Innovation strategies, Measurement Traceability, Measurement traceability X innovation strategies

A closer look at the ANOVA indicates that the regression model demonstrates a strong fit, supported by a notable F-statistic (F-value=115.735, P<0.05). After incorporating the interaction term, designated as model two, the model retains its significance (F-value=100.682, P<0.05). This suggests that innovation strategies have a considerable moderating effect on the relationship between measurement traceability and the performance of food and beverage manufacturing companies in Tanzania. The F-statistics for both models indicate that they effectively account for the variance in firm performance, with model one exhibiting a slightly higher F-value than model two. As such, both models demonstrate statistical significance, reinforcing the idea that measurement traceability and innovation strategies considerably influence firm performance. While the introduction of the interaction term in model two does not enhance the explained variance (sum of squares), it does result in a significant F-statistic, underscoring the importance of the relationship between measurement traceability and innovation strategies for a thorough understanding of firm performance.

Table 5: ANOVA of Moderated Measurement Traceability

ANOVA [a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.007	2	.003	115.735	.000[b]
	Residual	.004	152	.000		
	Total	.011	154			
2	Regression	.007	3	.002	100.682	.000[c]
	Residual	.004	151	.000		
	Total	.011	154			

a. Dependent Variable: Firm Performance

b. Predictors: (Constant), Innovation strategies, Measurement Traceability

c. Predictors: (Constant), Innovation strategies, Measurement Traceability, Measurement traceability X innovation strategies

Further analysis of the coefficients in model one reveals that adding the interactive term indicates measurement traceability is statistically significant (P=0.000, B=0.226), as are innovation strategies (P=0.000, B=0.199). In model two, measurement traceability presents a negative unstandardized coefficient of -0.209, implying that for every unit increase in measurement traceability, firm performance drops by 0.209 units when other variables are held constant. Meanwhile, the interaction between measurement traceability and innovation strategies shows a positive unstandardized coefficient of 0.063, suggesting that their interaction positively affects firm performance. Both innovation strategies and the interaction term are statistically significant, along with measurement traceability, highlighting their contributions to firm performance. Additionally, in model one, both measurement traceability and innovation strategies positively influence firm performance with significant statistical strength. However, in model two, while measurement traceability negatively impacts performance, its interaction with innovation strategies markedly improves performance. This suggests that innovation strategies can lessen the adverse effects of measurement traceability. The results indicate that measurement traceability alone may not yield positive results, but its effectiveness can be significantly improved when paired with innovation strategies. This underscores the need to assess both variables together to understand their synergistic impact on performance within the food and beverage manufacturing sector.

Table 6. Coefficients of Moderated Measurement Traceability

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.056	.002		24.921	.000
	Measurement Traceability	.226	.041	.456	5.536	.000
	Innovation strategies	.199	.045	.365	4.432	.000
2	(Constant)	.069	.003		21.064	.000
	Measurement Traceability	-.209	.090	-.424	-2.337	.021
	Innovation strategies	.204	.041	.375	4.941	.000
	Measurement traceability X innovation strategies	.063	.012	.908	5.346	.000

a. Dependent Variable: Firm Performance

The regression model obtained from the moderated effect of innovation strategies was

Performance= 0.069 + -0.209 measurement traceability + 0.204 innovation strategies + 0.063 measurement traceability x innovation strategies

Conclusion

The study advocates that enterprises should allocate resources toward high-calibre measurement instruments and calibration services. It is imperative to ensure that all measurement instruments exhibit precision and undergo routine calibration to attain accurate and dependable data. Consistent calibration not only preserves the integrity of the measurement devices but also guarantees that all measurements adhere to international standards. By implementing rigorous calibration schedules and utilising certified calibration services,

enterprises can ascertain that their measurement data remains accurate and traceable. Furthermore, manufacturing enterprises should develop a cohesive strategy incorporating measurement traceability within their innovation frameworks rather than viewing them as disparate entities. Firms can cultivate an environment where compliance and innovation coexist synergistically by harmonizing objectives across divisions such as quality assurance and research and development.

Similarly, promoting a culture that prioritizes adherence to measurement standards and inventive thinking is crucial for effectively reconciling these two dimensions. Training initiatives that emphasize problem-solving competencies alongside regulatory mandates can empower personnel to innovate within the confines of established protocols. Additionally, manufacturing firms should regularly evaluate resource allocation between measurement initiatives and innovation projects. By ensuring sufficient funding is directed towards both domains, organizations can uphold high-quality standards while simultaneously investing in prospective growth opportunities. Moreover, applying technology, including automation tools or data analytics platforms, can facilitate the simultaneous optimization of measurement processes and innovation endeavours. This enables firms to sustain elevated levels of accuracy while freeing resources for creative initiatives.

Recommendations

The study posits that organizations should prioritize integrating sophisticated technologies that augment traceability. Implementing technologies such as blockchain, the Internet of Things (IoT), and artificial intelligence (AI) can significantly enhance the precision and efficacy of traceability systems. Blockchain, for example, furnishes a transparent and immutable ledger for documenting transactions, ensuring that all data pertinent to the supply chain is accurate and resistant to tampering. IoT devices can provide real-time surveillance of goods throughout the supply chain, delivering essential data regarding the condition and positioning of products. AI can be employed to scrutinize extensive datasets, discern patterns, and anticipate potential disruptions, thereby facilitating proactive oversight of the supply chain.

Furthermore, manufacturing enterprises should establish digital platforms that promote supplier collaboration to enhance communication and information exchange across the supply chain. These platforms enable superior coordination, resulting in improved traceability. Additionally, manufacturing enterprises should foster a culture centred on innovation and continuous enhancement within the organizations, which will assist in sustaining efforts to improve traceability over time. Personnel should be empowered to propose improvements based on their practical experiences in the field.

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