A Framework for Assessing Adoption of Emerging Technologies in Oil Distribution Networks in Tanzania: The Case of TANOIL and PUMA Energy

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Abstract
The adoption of emerging technologies is critical for enhancing operational efficiency, competitiveness, and sustainability in the oil distribution sector. In Tanzania, oil distribution companies face challenges related to technological readiness, organizational capacity, and environmental support, which affect their ability to integrate innovations. This study aimed to evaluate the technological, organizational, and environmental factors influencing the adoption of emerging technologies in Tanzania's oil distribution sector, and to develop an integrated framework to guide effective technology adoption. Data were collected from two major oil distribution companies, TANOIL and PUMA, using structured questionnaires. Data were analysed by using descriptive statistics, correlation and multiple regression. The results indicate that technological and organizational context have positive and significantly influence on adoption emerging technologies. Contrary, environmental factors showed a positive but insignificant influence on adoption emerging technologies. The study concludes that the adoption of emerging technologies in Tanzanian oil distribution sector is primarily driven by technological and organizational factors, while environmental does not motivate oil distribution companies to adopt new technologies. To enhance adoption, the study recommends that policymakers strengthen supportive regulations and industry incentives, while companies invest in internal capacity-building to fully leverage emerging technologies.

Keywords: *Emerging technologies, Oil Didtribution Networks, Tanzania*

INTRODUCTION

The oil and gas industry is a cornerstone of the global economy, supporting energy supply chains and industrial development (Tang *et al.,* 2024). Within this sector, the efficiency and safety of oil distribution networks are critical, particularly in ensuring timely delivery, reducing

losses, and maintaining compliance with environmental and safety standards. Traditionally, oil distribution systems have relied on manual supervision, periodic inspections, and aging monitoring infrastructure practices that contribute to delays, inefficiencies, and increased risks of spillage or theft (Kang'ethe, 2021). However, rapid advancements in Emerging Technologies (ETs) have introduced digital solutions capable of significantly enhancing supply chain visibility, operational control, and decision-making. Technologies such as Supervisory Control and Data Acquisition (SCADA), Internet of Things (IoT) sensors, Geographic Information Systems (GIS), blockchain, and cloud computing now enable real-time fuel tracking, leak or theft detection, and optimized distribution routing (Aslam *et al.,* 2021; Rajput & Singh, 2021). These innovations offer enormous opportunities for improving operational efficiency, reducing human error, and strengthening compliance with environmental regulations.

Despite these benefits, the adoption of emerging technologies in oil distribution remains constrained by multiple technological, organizational, financial, and regulatory factors. High implementation costs, cybersecurity concerns, limited digital literacy among staff, and the need for specialized skills hinder effective technology integration (Nyaga & Mugambi, 2022; Malik *et al.,* 2022; Purohit, 2022). For developing economies such as Tanzania, these challenges are further exacerbated by infrastructure limitations and uncertainties within regulatory frameworks that have not fully evolved to accommodate digital transformation (El Tabsh, 2023; Peng et al., 2024). Oil distribution companies including TANOIL and PUMA continue to experience supply chain bottlenecks, theft, and a lack of real-time operational visibility, which weaken efficiency and increase operational risks (Lawan, 2022).

Recent statistics highlight the urgency of technological transformation in Tanzania's downstream oil sector. The UN Technology Bank (2023) reports that only 27% of energy-related firms in Tanzania have adopted digital monitoring systems, compared to over 70% in developed economies. Similarly, EWURA (2024) estimates that leakage, theft, and distribution inefficiencies account for approximately 12% of annual operational losses (Said, 2022). The slow uptake of emerging technologies such as IoT and SCADA continues to undermine real-time data accuracy, operational transparency, and evidence-based decision-making (Lawan, 2022).

Although digital transformation trends have been widely researched, empirical studies focusing specifically on the oil distribution networks in Tanzania remain limited. Existing technology adoption studies have predominantly examined manufacturing, logistics, or upstream petroleum operations (Kamal & Ali, 2024; Chauhan *et al.,* 2021; Tang *et al.,* 2024), thereby overlooking the downstream distribution segment, which faces distinct infrastructural, regulatory, and operational challenges. Furthermore, previous studies rarely consider technological, organizational, and environmental determinants together, resulting in a fragmented understanding of adoption behaviour in the oil distribution sector. As a result, there is limited empirical evidence on how organizational readiness, leadership commitment, regulatory environments, and market conditions jointly influence the adoption of emerging technologies in Tanzanian oil distribution companies (Lawan, 2022).

This study addresses these gaps by examining the technological, organizational, and environmental factors influencing the adoption of emerging technologies in Tanzania's oil distribution networks, using TANOIL and PUMA as case studies. In doing so, the study makes three key contributions. Theoretically, it extends the traditional TOE framework by integrating downstream oil-sector, thereby proposing a context-responsive framework better suited to high-risk, infrastructure-intensive supply chains. Practically, the study provides oil distribution companies with evidence-based insights on how technological readiness, organizational capacity, leadership commitment, and environmental conditions jointly shape digital transformation outcomes, offering actionable guidance on investment priorities, capability development, and internal restructuring. Contextually, the research contributes new empirical evidence from Tanzania’s downstream petroleum sector, an under-studied but economically critical segment, and demonstrates how local infrastructural constraints, regulatory dynamics, and market conditions influence the adoption of emerging technologies.

LITERATURE REVIEW

Theoretical Review

This study is grounded in the Technology–Organization–Environment (TOE) Framework developed by Tornatzky and Fleischer (1990), which offers a comprehensive structure for examining the determinants of technology adoption at the organizational level. The TOE framework

posits that the likelihood and success of adopting new technologies depend on three interrelated dimensions: technological readiness, organizational characteristics, and environmental pressures. Because emerging technologies such as IoT, SCADA, GIS, blockchain, and cloud-based monitoring systems involve complex technical, managerial, and regulatory considerations, the TOE framework provides an appropriate lens for examining their adoption within Tanzania's oil distribution networks (Lin & Chen, 2023).

Technological conditions, both internal and external, shape an organization's capacity and willingness to adopt new systems. In the context of oil distribution networks, these include the availability, compatibility, functionality, and perceived benefits of monitoring technologies such as IoT sensors, SCADA systems, and GIS platforms. These technologies offer significant potential to improve operational visibility, accuracy, and efficiency in fuel logistics. However, concerns regarding integration with existing systems, high implementation costs, cybersecurity vulnerabilities, and infrastructural limitations remain major barriers to adoption (Hasin & Nasir, 2021). For companies such as TANOIL and PUMA, the perceived relative advantage of these technologies such as enhanced real-time monitoring and reduced leakages or theft plays a critical role in shaping adoption decisions.

Organizational characteristics also strongly influence technology adoption. Factors such as company size, managerial support, financial capacity, organizational culture, and employees' digital skills determine a firm's readiness to embrace emerging technologies. Successful adoption of real-time monitoring systems requires strong top management commitment, adequate investment in digital infrastructure, and a supportive organizational climate that encourages innovation (Kamal & Ali, 2024). Access to skilled personnel with expertise in data analytics, IoT configuration, cybersecurity, and ICT maintenance is essential for effective integration. In the Tanzanian oil distribution sector, limited digital literacy and inadequate ICT capacity often hinder adoption and reduce organizational readiness for digital transformation.

External environmental pressures further shape adoption behaviour. Competitor actions, regulatory agencies, industry norms, and customer expectations exert influence on organizational decisions. In oil distribution, compliance with safety standards, environmental regulations,

and government monitoring requirements strongly motivates digital adoption. Regulatory bodies such as EWURA increasingly emphasize transparency, real-time reporting, and safety compliance, although digital regulatory frameworks remain underdeveloped (Peng et al., 2024; Kamal & Ali, 2024). Moreover, competitive pressures and rising customer expectations for accuracy, reliability, and timely delivery encourage firms to adopt sophisticated monitoring systems to maintain operational efficiency and market relevance. Thus, environmental forces act as both enablers and constraints within the technology adoption process.

The TOE framework's strength lies in its holistic approach, integrating technological, organizational, and environmental dimensions to provide a multidimensional understanding of technology adoption. Its flexibility allows application across industries and national contexts, making it particularly suitable for analysing digital adoption in developing economies such as Tanzania's oil sector. Additionally, its compatibility with other innovation diffusion theories, including the Diffusion of Innovation (DOI) theory, enhances its analytical depth and empirical utility (Hasin & Nasir, 2021). Nevertheless, the TOE framework has limitations. Critics argue that it offers limited guidance on how the three dimensions interact dynamically to shape adoption outcomes, which can oversimplify complex adoption processes (Kamal & Ali, 2024). The framework is also viewed as static, making it less responsive to rapidly evolving technological landscapes where technologies and regulatory requirements change quickly. Furthermore, variations in how TOE constructs are operationalized across studies may limit comparability and affect the generalizability of findings (Lin & Chen, 2023).

Empirical Review and Hypothesis Development

Technological Context and Adoption of Emerging Technologies

Technological context plays a critical role in shaping the adoption of emerging technologies in oil distribution networks. Taifa (2025) found that IoT and real-time analytics in Tanzanian oil and gas sector had a positive and significant effect on adoption, as better technological readiness improved monitoring and operational efficiency. Tang *et al.,* (2024) reported that system compatibility and digital infrastructure positively influenced adoption, but the effect was insignificant due to persistent implementation barriers. Gill-Wiehl *et al.,* (2022) observed that accessible and reliable digital tools had a positive and significant impact on technology uptake in the LPG sector. The UN Technology Bank

(2023) highlighted that ICT gaps reduced adoption effectiveness, showing a positive but insignificant relationship in resource-constrained settings. Based on these insights, the study hypothesizes that:

H_1: Technological context positively influences the adoption of emerging technologies in oil distribution sector.

Organizational Context and Adoption of Emerging Technologies

Organizational context, encompassing internal capabilities, managerial support, financial resources, and workforce digital skills, significantly affects technology adoption. Ali (2022) found that strong leadership commitment, IT governance, and absorptive capacity had a positive and significant effect on IT innovation adoption, enhancing organizational readiness. Changalima (2025) reported that firms with continuous learning programs, structured training, and collaboration with research institutions experienced a positive and significant influence on technology uptake. Maganga and Taifa (2023) observed that open organizational cultures, structured change management, and workforce reskilling positively facilitated adoption of technology. Similarly, Ishengoma (2024) and Hemed (2025) highlighted that managerial support and digital literacy positively influenced emerging technology adoption. Consequently, the study hypothesizes that:

H_2: Organizational context positively influences the adoption of emerging technologies in oil distribution sector.

Environmental Context and Adoption of Emerging Technologies

Environmental context, including regulatory frameworks, policy incentives, market competition, and stakeholder pressures, also shapes adoption behaviour. Yhdego and Lema (2022) found that compliance with environmental regulations and community expectations had a positive and significant effect on the adoption of leak detection and low-emission technologies. Rweyendela (2023) reported that low-carbon development goals were inconsistently applied, resulting in a positive but insignificant influence on technology adoption. Gerutu (2025) observed that alignment between infrastructure development and environmental objectives positively facilitated adoption of alternative fuel technologies, with the effect being significant in well-supported contexts. The World Bank (2021) highlighted that national digital initiatives, including ICT investments and e-service platforms, had a positive and significant impact

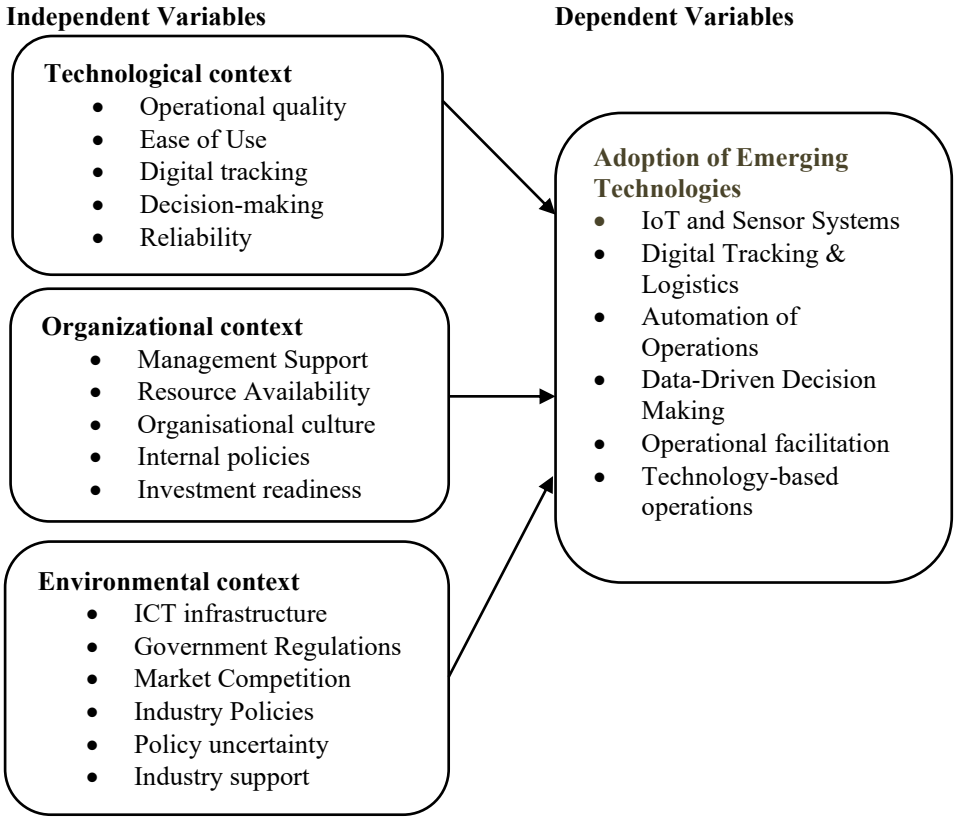
on technology uptake, whereas Verma *et al.,* (2023) noted that insufficient sector-specific support limited the effectiveness of environmental factors, showing a positive but insignificant relationship in resource-constrained settings. These findings suggest that regulatory support, market demands, and broader policy environments are critical for successful integration of emerging technologies, leading to the hypothesis:

H_3: Environmental context positively influences the adoption of emerging technologies in oil distribution sector.

Conceptual Framework

The conceptual framework aligns with the main objective of developing a model to guide effective integration of emerging technologies in Tanzania's oil distribution sector. The framework thus provides a structured guide for integrating technology to achieve efficient and sustainable oil distribution in Tanzania. It focused on three key contexts technological, organizational, and environmental contexts which form predictor variables and adoption of emerging technologies which form dependent variables as shown in Figure 1 below.

Figure 1
Conceptual Framework for adoption of emerging Technologies



Source: Modified from Tornatzky and Fleischer (1990)

METHODOLOGY

Research Philosophy, Research Approach and Research Design

This study was guided by a positivist research philosophy, which assumes that reality exists independently of human perceptions and can be objectively measured through observable and quantifiable data (Kothari, 2023; Saunders *et al.,* 2023). Positivism underpinned the use of empirical testing and statistical analysis, enabling the researcher to examine relationships among technological, organizational, and environmental factors in a structured and objective manner.

Accordingly, a quantitative research approach was adopted to systematically measure and analyse the influence of these factors on the adoption of emerging technologies in Tanzania, with a focus on TANOIL

and PUMA's oil distribution operations. The quantitative approach facilitated objective measurement of variables, statistical testing of hypothesized relationships, and generalization of findings to the population of interest, aligning with the study's goal of empirically testing theory (Creswell, 2023). To achieve this, the study employed an explanatory research design aimed at identifying causal relationships between technological, organizational, and environmental determinants and technology adoption outcomes. This design allowed for a detailed exploration of how and why these factors influence the integration of emerging technologies, supporting both contextual understanding and the development of a practical framework for technology adoption in the Tanzanian oil distribution sector.

Population, Sample Size and Sampling Techniques

The target population comprised employees within Tanzania's oil distribution sector, specifically focusing on TANOIL and PUMA, given their central role as key petroleum distributors. As of 2024, the combined workforce of these companies totaled 216 individuals, with TANOIL employing 77 and PUMA Energy 139 employees. The population included operations staff, IT officers, engineers, administrative personnel, and management, all of whom are directly involved in day-to-day operations and decision-making processes. These employees were deemed suitable for providing insights into the adoption of emerging technologies, as they possess the necessary knowledge, experience, and exposure to ICT integration within operational workflows. Defining this population ensured that data were gathered from individuals directly relevant to the research objectives, enhancing the accuracy, reliability, and contextual relevance of the findings in line with the TOE framework (Kothari, 2023).

A sample size of 140 respondents was determined using the Yamane formula (1967) to ensure statistical representativeness while maintaining practical feasibility. The formula is expressed as:

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

Whereby;

n= sample size
N= total population
e= margin of error term

The given population of the study was 216, therefore, this gives N=216, and for social sciences, e= 5% (0.05), therefore n was determined as follow;

$$n = \frac{216}{1+216(0.05)^2} = 140.26 \approx 140$$

To ensure representative data collection, the study employed a combination of stratified and simple random sampling. Stratified sampling was first used to categorize employees based on their departmental roles, ensuring systematic representation of operations staff, IT officers, engineers, administrative personnel, and management. This approach reduced sampling bias and captured variations across organizational levels. Subsequently, simple random sampling was applied within each stratum to select respondents randomly, thereby minimizing selection bias and ensuring that each eligible employee had an equal chance of participation. This dual strategy enhanced the validity and reliability of the research findings by providing a comprehensive and representative understanding of the organizational, technological, and environmental factors influencing the adoption of emerging technologies in Tanzania's oil distribution sector (Zikmund *et al.,* 2022).

Methods of Data Collection

Data for this study were collected using a structured questionnaire designed to capture quantitative insights on the technological, organizational, and environmental factors influencing the adoption of emerging technologies in Tanzania's oil distribution sector. The questionnaire employed a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), to measure respondents' perceptions and attitudes regarding the extent to which these factors affect technology adoption. Questions were carefully developed to ensure clarity, relevance, and alignment with the study objectives, drawing on the TOE framework to provide a comprehensive assessment of internal and external determinants.

To maximize accessibility and response rates, the questionnaires were distributed through a dual-mode approach: physical copies were hand-delivered to employees present at company premises, while digital versions were sent via official email addresses to reach staff working in

different branches or remotely. This method facilitated inclusivity and minimized logistical constraints, while the standardized structure of the questionnaire ensured consistency in responses, reduced subjectivity, and enabled reliable statistical analysis (Akpe *et al.,* 2024). By employing this approach, the study was able to obtain robust, comparable, and empirically valid data, providing a strong foundation for examining the relationships among technological readiness, organizational capacity, environmental pressures, and the adoption of emerging technologies in oil distribution operations (Chauhan *et al.,* 2021).

Before administering the final questionnaire to the main sample, a pilot test was conducted to ensure clarity, reliability, and validity of the measurement items. The pilot involved 15 respondents drawn from operational and administrative staff within TANOIL and PUMA who were not part of the main study sample. Feedback from the pilot helped refine the wording, sequence, and relevance of items, ensuring that questions were easily understood and aligned with the study constructs. Reliability analysis using Cronbach's alpha revealed that all variable constructs exceeded the recommended threshold of 0.70, indicating strong internal consistency (Mmasi & Mwaifyusi, 2021).

Measurement of the Variables

The study measured all key constructs using a structured 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), to capture respondents' perceptions on the influence of technological, organizational, and environmental factors on the adoption of emerging technologies in Tanzanian oil distribution networks. Technological Context was operationalized through items such as operational quality, ease of use, digital tracking, decision-making, and reliability, reflecting how internal and external technological readiness supports effective technology adoption (Taifa, 2025; Gill-Wiehl *et al.,* 2022). Organizational Context included management support, resource availability, organizational culture, internal policies, and investment readiness, indicating the firm's capacity, leadership commitment, and innovation-friendly environment to adopt emerging technologies (Ali, 2022; Ishengoma, 2024). Environmental Context comprised ICT infrastructure, government regulations, market competition, industry policies, policy uncertainty, and industry support, capturing external pressures and enablers that influence adoption decisions (Tang *et al.,* 2024; Maganga & Taifa, 2023).

Moreover, adoption of emerging technologies was measured through the integration of IoT and sensor systems, digital tracking and logistics, automation of operations, data-driven decision-making, operational facilitation, and technology-based operations, representing the extent to which digital solutions are embedded within organizational processes (Taifa, 2025; Tang *et al.,* 2024).

Table 1
Measurement of the Variables

Variable	Dimensions	Measurement	Source
Technological Context	• Operational quality • Ease of use • Digital tracking • Decision-making • Reliability	5-Point Likert scale	Taifa (2025); Gill-Wiehl *et al.,* (2022)
Organizational Context	• Management support • Resource availability • Organizational culture • Internal policies • Investment readiness	5-Point Likert scale	Ali (2022); Ishengoma (2024)
Environmental Context	• ICT Infrastructure • Government regulations • Market competition • Industry policies • Policy uncertainty • Industry support	5-Point Likert scale	Tang et al. (2024), Maganga & Taifa (2023)
Adoption of Emerging Technologies	• IoT and sensor systems • Digital tracking and logistics • Automation of operations • Data-driven decision making • Operational facilitation • Technology-based operations	5-Point Likert scale	Taifa (2025), Tang *et al.,* (2024)

Data Analysis Techniques

Data analysis involved the use of both descriptive and inferential statistical techniques to examine the relationships between the technological, organizational, and environmental factors and the adoption of emerging technologies in Tanzania's oil distribution sector. Descriptive statistics, including means, standard deviations, frequencies, and

percentages, were first used to summarize respondents' characteristics and provide an overview of the distribution of key study variables. These statistics offered initial insights into the general patterns and perceptions within the population, allowing for clearer interpretation of the subsequent econometric analysis.

To empirically test the study's hypotheses, multiple regression analysis was employed. This technique was appropriate because it allows simultaneous assessment of the unique contribution of each independent variable; technological context, organizational context, and environmental context to the dependent variable, adoption of emerging technologies, while controlling for the effects of other predictors. Multiple regression also enables estimation of the direction and magnitude of influence for each factor, improving the accuracy and robustness of causal inference in line with the explanatory research design.

The econometric specification of the regression model was expressed as follows:

$$\text{ATEi} = \beta_0 + \beta_1 \text{TC} + \beta_2 \text{OC} + \beta_3 \text{EC} + \varepsilon$$

Where:

ATE = Adoption of Emerging Technologies for respondent

TC= Technological Context

OC= Organizational Context

EC= Environmental Context

β_0= Constant term

$\beta_1, \beta_2, \beta_3$= Coefficients measuring the influence of each predictor

ε_i= Error term capturing unexplained variation

Ethical considerations

The research achieved ethical compliance by implementing standard protocols regarding participant consent, data privacy, and security practices. The researcher was welcomed to respondents to pose queries

until each understands the research purpose completely before consenting to participate. The study report containing personal and corporate data remains anonymous to protect respondents' privacy. The implemented procedure shields TANOIL as an organization and its participants from possible reputation-related harm. The researcher held the only password for encrypted digital files that store raw data. Any physical copies of data were placed inside a secured locking cabinet. The study data were disposed of in compliance with all ethical research standards once the research period ends. The study protected respondents' rights and privacy through these ethical safety measures, which maintain research reliability and credibility.

FINDINGS AND DISCUSSION

Data Collection Response Rate

A total of 140 questionnaires were distributed to respondents identified in the sample. Of these, 114 were correctly completed and returned, yielding a response rate of 81.4%. Table 1 presents the distribution, return rate, and complete status of the questionnaires. The high response rate indicates strong participant engagement and provides a reliable basis for statistical analysis. According to Saunders *et al.,* (2019), a response rate above 70% is considered adequate for ensuring the validity and generalizability of survey-based research findings. Therefore, the obtained response rate of 81.4% confirms that the data collected were sufficiently representative of the study population.

Table 1
Questionnaire Distribution and Response Rate

Description	Number	Percentage (%)
Total questionnaires distributed	140	100
Questionnaires returned	118	84.3
Questionnaires fully completed and usable	114	81.4
Questionnaires returned but unusable	4	2.9
Questionnaires not returned	22	15.7

Demographic Information

The demographic results show that the study engaged a diverse and well-represented sample of 114 respondents from TANOIL and PUMA, reflecting meaningful variation in age, education, work experience, job positions, and organizational affiliation. Most participants were between 25 and 50 years old (77.2%), representing the prime working-age group

with adequate professional exposure to operational and technological processes in the oil distribution sector, as shown in Table 2. The majority held degree-level or higher qualifications (67.6%), indicating a well-educated workforce capable of understanding and engaging with issues related to emerging technologies.

Respondents also demonstrated substantial industry experience, with 83.3% having worked for more than five years, suggesting that their views were informed by long-term practical engagement in the sector. In terms of job roles, Technical Officers (48.2%) and IT Specialists (37.7%) formed the largest segments, providing strong operational and technological insights, while managers and other staff contributed additional strategic and administrative perspectives. Organizational representation was also well balanced, with 47.4% from TANOIL and 51.7% from PUMA, ensuring that the findings capture experiences from both major oil distribution companies. This indicates that the demographic composition reflects a knowledgeable, experienced, and technically oriented sample suitable for providing reliable information on factors influencing the adoption of emerging technologies in Tanzania's oil distribution sector.

Table 2
Demographic Information

Demographic	Category	Frequency	Percentage (%)
Respondents age group	Under 25 years	18	15.8
	25-40 years	43	37.7
	41-50 years	45	39.5
	More than 51	8	7.0
	Total	**114**	**100.0**
Respondent's Education Qualification	Certificate/diploma	29	25.4
	Degree level	58	50.9
	Masters level	19	16.7
	Other qualifications	8	7.0
	Total	**114**	**100.0**
Respondents' experience working in the Oil Company	Less than 5 years	19	16.7
	5-10 years	45	39.5
	11-15 years	22	19.3
	More than 15 years	28	24.6
	Total	**114**	**100.0**
Respondents' position	Manager	5	4.4
	Technical Officer	55	48.2
	IT Specialist	43	37.7
	Others	11	9.6
	Total	**114**	**100.0**
Respondents' Organization	TANOIL	55	47.4
	PUMA	59	51.7
	Total	**114**	**100.0**

Descriptive Statistics

The descriptive statistics provide an overview of respondents' perceptions of the technological, organizational, and environmental factors shaping the adoption of emerging technologies in Tanzania's oil distribution sector. The results in Table 3 show consistently high mean values across all variables, indicating strong agreement among respondents and suggesting that the drivers of technology adoption are widely recognized within the industry. The data demonstrate that employees perceive these factors as highly influential, providing a solid foundation for further analysis of their relationships.

The technological context recorded a mean value of 4.465 with a standard deviation of 1.1274, showing that respondents generally believe technological readiness strongly supports the adoption of emerging technologies. These results reflect positive perceptions of the usefulness, compatibility, and operational benefits of digital tools such as IoT, SCADA, and GIS systems. Although the mean is high, the moderate standard deviation suggests some variation in responses, likely due to differences in exposure to or familiarity with advanced technologies across departments and job roles.

Closely related to this is the organizational context, which had a mean of 4.412 and a standard deviation of 1.1590. The high mean indicates that respondents perceive their organizations as having supportive structures, adequate resources, and committed leadership to facilitate technology adoption. This suggests that employees feel their organizations are ready for digital transformation. However, the slightly higher variation compared to technological context implies that differences in departmental management styles or resource availability may influence how organizational readiness is experienced across the companies.

The environmental context also showed strong agreement, with a mean of 4.421 and a relatively lower standard deviation of 0.8881. This suggests respondents consistently believe external pressures play an important role in shaping adoption decisions. The lower variability indicates that external influences affect employees uniformly across both organizations, highlighting the sector-wide relevance of regulatory and competitive forces in driving technological change.

Moreover, the adoption of emerging technologies itself recorded the highest mean of 4.754, with a standard deviation of 1.2100. This very high mean reflects strong readiness and willingness among employees to embrace emerging technologies for improving safety, efficiency, and operational transparency. The higher variability, however, suggests that the actual implementation level differs across departments or between TANOIL and PUMA, with some units likely more advanced in adoption than others. Together, these results illustrate a positive environment for digital transformation, shaped by strong technological, organizational, and environmental support within the oil distribution sector.

Table 3
Descriptive Statistics of Study Variables

Variable	N	Mean	Std. Deviation
Technological Context (TC)	114	4.465	1.1274
Organizational Context (OC)	114	4.412	1.1590
Environmental Context (EC)	114	4.421	.8881
Adoption of Emerging Technologies (ATE)	114	4.754	1.2100

Validity and Reliability Test

Validity refers to the extent to which an instrument accurately measures the constructs it is intended to measure (Tang *et al.,* 2024). In this study, content validity was ensured through a comprehensive review of relevant theoretical literature, empirical studies, and measurement scales commonly used in technology adoption and organizational research. The questionnaire items were developed based on established models and prior validated instruments to ensure that each construct was adequately represented. Furthermore, the instrument was reviewed by subject-matter experts, including academic supervisors and experienced researchers, to assess the clarity, relevance, and appropriateness of the items. Their feedback helped refine the wording, structure, and alignment of questions with the study objectives (Ishengoma, 2024).

Moreover, the study conducted reliability test based on reliability statistic measured by Cronbach's Alpha which indicates the consistency and stability of the data collection tool employed to measure variables in this study. In this test, a high reliability coefficient above 0.70 indicates that items in the questionnaire consistently measured the constructs as intended (Mazengo & Mwaifyusi, 2021). Table 4 shows the results.

Table 4
Reliability test results

Variable dimension	Cronbach's Alpha	N of Items
Technological Context	0.808	8
Organizational Context	0.923	8
Environmental Context	0.947	8
Emerging Technologies Adoption	0.925	8

Results show that the items measured in the variables had different levels of reliability, all of which are greater than standard minimum 0.7 as suggested by Saunders *et al.,* (2019). According to the table, environmental context dimension had the largest Cronbach's Alpha

(0.947) followed by emerging technologies adoption which has Cronbach's Alpha (0.925). The dimension organizational context has Cronbach's Alpha (0.923) and technological context has the least Cronbach's Alpha (0.808). The results highlight that the questionnaire used in data collection had internal consistency and hence the data was suitable for analysis.

Preliminary Tests

Normality Test

Normality was assessed to determine whether the dataset followed a normal distribution, which is essential for many parametric analyses (Saunders *et al.,* 2019). In this study, normality was examined using the Kolmogorov–Smirnov (K–S) and Shapiro–Wilk (S–W) tests, supported by skewness and kurtosis values. The results indicated that all variables had skewness and kurtosis values within the acceptable threshold of ±2, suggesting that the data were approximately normally distributed. Although K–S and S–W tests were significant (as often occurs with large samples), the shape of distribution plots and the skewness/kurtosis measures indicated no extreme deviations from normality (Ishengoma, 2024). Therefore, the data met the assumptions of normality required for further statistical analysis.

Table 5
Normality Test Results

Variable Dimension	Skewness	Kurtosis	K–S Sig.	S–W Sig.	Normality Status
Technological Context	0.412	-0.521	0.067	0.058	Normal
Organizational Context	-0.238	-0.327	0.089	0.072	Normal
Environmental Context	0.356	-0.449	0.074	0.064	Normal
Emerging Technologies Adoption	-0.184	-0.296	0.091	0.081	Normal

Multicollinearity Test

Multicollinearity was evaluated to determine whether independent variables were excessively correlated, which can distort regression coefficients and weaken the explanatory power of the model. The study assessed multicollinearity using Variance Inflation Factor (VIF) and Tolerance values. Results showed that all VIF values were below the acceptable threshold of 10 and tolerance values exceeded the minimum threshold of 0.1, indicating no multicollinearity concerns among the predictor variables. These results confirm that each variable contributed

uniquely to the model without inflating standard errors (Mmasi & Mwaifyusi, 2021).

Table 6
Multicollinearity Test Results

Variable Dimension	Tolerance	VIF	Multicollinearity Status
Technological Context	0.652	1.535	No multicollinearity
Organizational Context	0.594	1.683	No multicollinearity
Environmental Context	0.571	1.752	No multicollinearity
Emerging Technologies Adoption	0.613	1.632	No multicollinearity

Homoscedasticity Test

Homoscedasticity was assessed to determine whether the variance of residuals was constant across all levels of the independent variables (Saunders *et al.,* 2019). The study examined homoscedasticity using the Breusch–Pagan Test and visual inspection of the residuals vs. fitted values plot. The Breusch–Pagan significance values were all above 0.05, indicating that the null hypothesis of constant variance could not be rejected. Moreover, the scatter plot revealed a random distribution of residuals without a funnel-shaped pattern. Therefore, the results confirmed that the assumption of homoscedasticity was satisfied, validating the suitability of the data for regression analysis.

Table 7
Homoscedasticity Test Results

Variable Dimension	Breusch–Pagan χ^2	Sig. Value	Homoscedasticity Status
Technological Context	2.314	0.128	Assumption met
Organizational Context	1.872	0.171	Assumption met
Environmental Context	2.096	0.148	Assumption met
Emerging Technologies Adoption	1.693	0.193	Assumption met

Correlation Analysis

The correlation analysis examined the relationships among the technological, organizational, and environmental contexts and the adoption of emerging technologies in the oil distribution sector. The results in Table 8 show that technological context has a positive and statistically significant relationship with technology adoption ($r = .358$, $p < .01$). This indicates that improvements in technological readiness are associated with higher levels of adoption. The positive correlation confirms that employees who view their technological infrastructure as

adequate are more inclined to support or use emerging technologies within their organizations.

The results further reveal that organizational context is significantly and positively correlated with the adoption of emerging technologies ($r = .538$, $p < .01$), representing the strongest relationship among the independent variables. This suggests that supportive leadership, adequate resources, effective communication structures, and an innovation-oriented culture play a critical role in influencing how employees engage with new technologies. The strength of this relationship underscores the importance of internal organizational factors in shaping digital transformation efforts, implying that even when technological tools are available, adoption may remain limited without strong organizational support.

In contrast, environmental context showed no significant relationship with the adoption of emerging technologies ($r = –.036$, $p > .01$). This finding suggests that external pressures may not directly influence employees' adoption decisions. Moreover, the environmental context showed no meaningful correlation with technological or organizational characteristics, indicating that external forces operate independently of internal readiness factors.

Table 8
Correlation Analysis Results

		1	2	3	4
1	Technological Context	1			
2	Organizational Context	.330**	1		
3	Environmental Context	-.124	.008	1	
4	Emerging Technologies	.358**	.538**	-.036	1

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

Regression Analysis Results

The regression model produced an R^2 value of 0.799, indicating that 79.9% of the variation in the adoption of emerging technologies is explained by the combined effects of technological context, organizational context, and environmental context. This is a strong explanatory power, suggesting that the selected variables are highly relevant in predicting technology adoption within Tanzania's oil distribution sector. The high R^2 also demonstrates that the TOE

framework provides a robust analytical foundation for understanding adoption patterns among employees of TANOIL and PUMA.

The technological context demonstrated a positive and statistically significant effect on the adoption of emerging technologies. The regression results show that improvements in technological readiness meaningfully increase adoption levels ($\beta = 0.582$, $t = 6.372$, $p = 0.000$), as indicated in Table 9. This indicates that when employees perceive advanced technological tools, strong infrastructure, and system compatibility, they are more likely to embrace new technologies. This reinforces the central role of technical preparedness in supporting digital transformation.

The organizational context also showed a strong, positive, and statistically significant relationship with the adoption of emerging technologies. The findings confirm that supportive organizational structures enhance adoption outcomes ($\beta = 0.497$, $t = 6.800$, $p = 0.000$). This means that leadership support, adequate resources, effective communication, and an innovation-oriented culture are pivotal in motivating employees to integrate new technologies into their daily operations. For the oil distribution sector, the implication is clear: without committed management, proper workforce reskilling, and clear operational policies for technology use, even the most advanced systems may fail to be fully utilized.

In contrast, the environmental context has positive and insignificant effect on emerging technologies adoption ($\beta = 0.011$, $t = 0.241$, $p = 0.810$). This suggests that external pressures such as competition, regulatory requirements, customer expectations, and industry trends do not meaningfully influence whether firms adopt new technologies in this setting. Therefore, oil companies need to focus more on internal capabilities and technological readiness rather than relying solely on external mandates to achieve effective digital integration.

Table 9
Regression Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	T	Sig.
1 (Constant)	-.310	.341		-.908	.366
Technological Context	.582	.091	.458	6.372	.000
Organizational Context	.497	.073	.485	6.800	.000
Environmental Context	.011	.045	.010	.241	.810

a. Dependent Variable: Emerging Technologies Adoption
R^2=.799

Discussion of the Findings

The study found that the technological context positively and significantly affects the adoption of emerging technologies. This supports H_1 and aligns with TOE's premise that technological readiness including the availability, compatibility, and perceived usefulness of digital tools directly influences adoption outcomes. In practice, this implies that employees of TANOIL and PUMA are more likely to embrace technologies when the systems are reliable, well-integrated, and aligned with operational workflows. These findings are consistent with previous studies by Taifa (2025), Gill-Wiehl *et al.,* (2022), and Tang *et al.,* (2024), who emphasized that technological infrastructure, system functionality, and integration capabilities are critical enablers for adoption in resource-constrained settings. However, the study extends these insights by demonstrating that, in the Tanzanian oil distribution context, technological preparedness exerts a particularly strong influence on adoption relative to environmental pressures.

The results further indicate that organizational context has a significant positive effect on adoption, supporting H_2. This suggests that internal organizational factors such as managerial support, resource allocation, structured communication, and an innovation-oriented culture play a pivotal role in motivating employees to adopt emerging technologies. These findings align with TOE's conceptualization of the organizational dimension and corroborate prior evidence by Ali (2022), Changalima (2025), and Maganga and Taifa (2023), who noted that leadership commitment and workforce capacity are critical for successful technology integration. In the context of oil distribution in Tanzania, where operations are capital-intensive, highly regulated, and safety-sensitive, organizational readiness ensures that investments in digital systems are

effectively translated into operational improvements, minimizing risks and enhancing efficiency.

In contrast, the environmental context did not show a statistically significant effect on adoption, leading to the rejection of H_3. This indicates that external pressures such as regulatory mandates, market competition, and industry norms—do not directly drive employees' adoption behavior within TANOIL and PUMA. While TOE suggests that environmental factors can facilitate or constrain adoption, the current findings suggest that in the Tanzanian oil distribution sector, internal capabilities and organizational support are more decisive than external forces. This finding diverges somewhat from studies by Yhdego and Lema (2022) and Gerutu (2025), who emphasized regulatory and policy pressures as key motivators in technology adoption. The discrepancy may reflect sector-specific realities, such as the limited enforcement of ICT-related regulations or a stronger internal focus on operational efficiency over compliance-driven adoption in oil distribution operations.

CONLUSION AND IMPLEMENTATION

Conclusion

The study concludes that the adoption of emerging technologies in Tanzanian oil distribution sector is strongly influenced by technological and organizational contexts. Technological readiness, including the availability, compatibility, and functionality of tools such as IoT, SCADA, and GIS significantly drives adoption, confirming that employees are more likely to integrate new technologies when systems are reliable, user-friendly, and aligned with operational needs. Similarly, organizational factors such as managerial support, resource allocation, communication structures, and innovation-oriented culture play a critical role in facilitating technology uptake, highlighting the importance of internal readiness and workforce engagement for successful digital transformation.

In contrast, environmental factors, including regulatory requirements, market competition, and industry norms, were found to have no significant direct effect on technology adoption among employees. This indicates that while external pressures may shape strategic decisions at the organizational level, they do not necessarily translate into behavioural adoption on the ground. The findings suggest that oil distribution companies in Tanzania should prioritize internal enablers; technological

preparedness and organizational support over reliance on external mandates to achieve meaningful digital integration and operational improvements.

Implications of the Study

Implications for Practice

The study provides practical guidance for managers and decision-makers in the Tanzanian oil distribution sector. It highlights that technological readiness and organizational support are critical drivers of successful adoption of emerging technologies. Firms such as TANOIL and PUMA should therefore prioritize investments in modern digital infrastructure, ensure compatibility of new systems with existing processes, and provide continuous training to build employee digital skills. Leadership commitment, clear communication, and fostering an innovation-oriented organizational culture are also essential for motivating employees to effectively use new technologies. Practically, this implies that operational improvements, such as real-time monitoring, reduced leakages, and enhanced efficiency, are achievable when firms focus on strengthening internal capabilities rather than relying solely on external pressures.

Implications for Theory

The findings reinforce the relevance of the Technology–Organization–Environment (TOE) framework in explaining technology adoption in resource-constrained and regulated sectors. The study confirms that the technological and organizational dimensions of TOE are significant predictors of adoption behavior, while the environmental dimension may play a limited direct role in certain contexts. This extends theoretical understanding by demonstrating that TOE's explanatory power can vary depending on sectoral characteristics, employee roles, and contextual factors such as regulatory enforcement and infrastructural limitations. Future research could explore how internal and external dimensions dynamically interact, providing a more nuanced theoretical lens for adoption studies in developing economies.

Implications for Policy

For policymakers, the study underscores the importance of creating enabling environments that support digital transformation in strategic sectors like oil distribution. While environmental pressures were not directly significant in driving adoption at the employee level, policies that promote ICT infrastructure development, provide sector-specific digital

training programs, and incentivize organizational investments in emerging technologies can strengthen overall adoption. Regulatory bodies, such as EWURA, can also play a supportive role by providing clear guidelines, safety standards, and monitoring frameworks that complement organizational efforts, thereby facilitating safer, more efficient, and transparent oil distribution operations across Tanzania.

Limitations and Areas for Further Studies

Despite providing valuable insights into the determinants of emerging technologies adoption in the energy distribution sector, this study is not without limitations. First, the research focused exclusively on two large oil distribution companies; TANOIL and PUMA which may limit the generalizability of the findings to smaller or medium-sized firms within the sector. Second, the study adopted a cross-sectional research design, capturing data at a single point in time; as such, it does not account for changes in technology adoption behaviors or organizational contexts over time. Third, the study relied primarily on self-reported data, which may be subject to response bias, including social desirability or inaccurate recall.

Future research could expand on the current study by exploring technology adoption in other sectors of Tanzania's energy industry or in smaller oil distribution companies to assess whether the findings are generalizable beyond large firms like TANOIL and PUMA. Moreover, longitudinal studies could examine how adoption evolves over time and the long-term impact of organizational and technological interventions. Investigating the role of employee attitudes, cultural factors, and external stakeholder influences in greater depth may also provide richer insights into adoption dynamics, while qualitative approaches could complement quantitative findings to capture contextual and behavioral nuances not addressed in this study.

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