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Original Article

Influence of Investment in Fourth Industrial Revolution (4IR) Technologies on Employment in Tanzania Manufacturing Sector

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ABSTRACT

The study assessed the influence of investment in 4IR technologies on employment in the manufacturing sector in Tanzania. Specifically, the study set out to establish the relationship and causality of investment in 4IR technologies on employment in the manufacturing sector. To achieve the research objectives, the study used a quantitative descriptive design to generate the required data. Moreover, the study used structured questionnaires for the cross-sectional survey, administered with 225 production managers of manufacturing industries in Tanzania. It used probability sampling in the form of cluster sampling. Additionally, the study used Pearson correlation and Ordinary Least Square methods to analyse the objectives of the study. This study has also revealed a strong positive correlation between investment in 4IR technologies and employment in the manufacturing sector. Further findings revealed a statistically significant causal effect between investment in 4IR technologies and manufacturing firms' employment, whereby, when manufacturing firms increase investment in 4IR technologies by 1 unit, the employment level increases by 3.13 units. These findings are supported by the two-way graph, which portrays growth in employment level in the Tanzanian manufacturing sector as investment in industry 4.0 technologies increases. This study recommends that the government of Tanzania prioritise and invest further in technologically supportive infrastructure and enhance technical education for skills matching to fully embrace and harness the benefits of the Fourth Industrial Revolution. It further recommends that the Tanzanian Government review and improve its Sustainable Industrial Development Policy of 2020 and the Integrated Industrial Development Strategy of 2025 to promote and support not only resource-based industries, but also technology-based industries, to speed up industrialisation and employment within the country. The government should also improve its investment policies by aligning them with technological changes brought by 4IR, to attract more foreign direct investments (FDIs) that accelerate importation, adoption and imitation of 4IR technologies from developed countries for furtherance of industrialisation within the country.

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INTRODUCTION

Sub-Saharan Africa is characterised by a youthful demographic with over 60% of its population under the age of 25. It faces unique challenges and opportunities brought by the emergence of the Fourth Industrial Revolution (4IR) (World Bank, 2024). The youth population in the region is projected to increase significantly. By 2030, the region is expected to host over a quarter of under 25 global youth population, most of them without a steady job and income (Mela Research, 2023).

The 4IR presented by advancements in automation and digital technologies, offers both opportunities and concerns for Sub-Saharan Africa. Despite the fact that technological advancements can lead to economic growth and innovation, there is fear of potential job displacements and widening inequalities if proactive policies are not designed and implemented (Fox and Signe, 2022). The existing challenges of the region, such as high unemployment rates and skill shortages, may be worsened by rapid technological changes. Measures to address challenges brought by the emergence of 4IR in Sub-Saharan Africa require targeted investments in technical education and skills development to align the workforce with emerging industry demands. Without such efforts, the benefits of the 4IR may be unevenly distributed and potentially deepen the existing socio-economic disparities (Fox and Signe, 2022).

The Tanzanian economy is characterised by poor infrastructure, a low level of digital literacy and technological backwardness, labour-intensive, a low level of technical education, as pointed out by Tanzania's industrial integrated development strategy of 2025. These characteristics will no longer attract FDIs because 4IR poses a challenge to the economic growth catch-up theory since it revises the rules of manufacturing (Lee et al., 2019). The emergence of fourth industrial revolution technologies forces a shift of manufacturing industries from poor countries like Tanzania to rich countries with cheap technology. With regards to prepositions given by Lee et al. (2019) and Schwab (2017), the Tanzania industrial integrated development strategy, which is based on low-cost labour, becomes irrelevant as innovation makes the cost of automation drop and smart productivity boost production. Thus, an outward shift of manufacturing industries to rich countries is expected because 4IR is expected to cause a massive decline in employment, revenue collection and economic growth (Nguvava, 2024).

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Most studies on the digital and technological revolution in Tanzania and outside Tanzania have given emphasis on how technological advancement has affected the performance of manufacturing industries and impaired the ability of governments to cope with the pace of technological transformation. For instance, the study by Ngepah et al. (2024) examined the performance of the manufacturing sector, with particular interest in identifying the emerging manufacturing sub-sectors, the drivers of their success, and challenges for sustained competitiveness in South Africa. A study by Kweka (2018) focused on manufacturing performance in Tanzania (challenges and prospects), given current technological developments. Another study by Salam et al. (2018) emphasised rapid technological change and industrial performance in developing countries. A study by Diyamett and Makundi (2012) focused on the Impact of ICTs Adoption and Application on Innovation in selected manufacturing firms in Tanzania. A study by Maskaeva et al. (2018) emphasised how technological advancements have impaired the ability of government revenue collecting authorities to collect tax revenue from digital businesses. This study focused on the emergence of 4IR technologies and their effect on employment in the manufacturing sector in Tanzania.

Other preceding scholars of 4IR subject like Lee et al. (2019) and Schwab (2017) focused on developed and advanced economies and how they will develop skill sets to match the requirements of the new technology and how they will accommodate structural adjustment challenges as workers lose their jobs and businesses no longer remain competitive but none of them paid any attention on possible effects of the 4IR to less developed economies like Tanzania, this study has bridged this gap. Some scholars like Ayentimi and Burgess (2019), Odenkule (2017) discussed the relevance of 4IR in Sub-Saharan Africa and Africa in general; none of them critically analysed the ultimate effects of 4IR on a country's employment level, specifically in the manufacturing sector, which has been covered in this study.

RESEARCH METHODOLOGY

Research Philosophy

This study adopted the ontology paradigm as a way of looking at the social reality as pointed out by Mertens (2010). Usually, a research approach is influenced by ontological and/or epistemological assumptions of the researcher. This study has embraced the positivism ideology. The philosophical stance adopted (positivism) aims to utilise hypotheses to test existing theories for generalisation purposes.

Research Design

This study used a quantitative descriptive design. Specifically, it employed quantitative and statistical aspects of data organisation, presentation and analysis through figures, numbers and tables. Deductive reasoning was used by this study, whereby the researcher collected data during the investigation of the problem and subjected the data from the investigation to analysis, thereafter drawing inferences and logical conclusions. A survey strategy was applied for the above design.

Area of Study

The study was carried out in Tanzania. A total of 61,110 manufacturing industries were involved. The number represents the sum of manufacturing industries in Tanzania by June 2020. A sample size was then drawn from the population, since it was unrealistic to reach every manufacturer within the country.

Data Collection Methods

Both primary and secondary data were collected in this study. Structured questionnaires for the survey were administered to production managers of manufacturing industries to collect primary data. The study also used secondary data to complement primary data. The main sources were documentary

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reviews of various official documents and reports (i.e., manufacturing industries' survey reports from the National Bureau of Statistics [NBS], the Tanzania Investment Reports from the Tanzania Investment Centre (TIC), relevant to the research problem.

Population and Sampling

The targeted population was all manufacturing industries in the country by June 2020. The targeted sampling unit was production managers of manufacturing industries. Since the study population was known with reliability and a sampling frame easily determinable, the study adopted a probabilistic sampling method. Specifically, the study used the cluster sampling technique. A sample of 225 manufacturing industries was used in this study to generate the required data. This study allowed the variability results of 5% (margin error), 90% confidence interval at all times, using the Cochran Formula for sample calculation, given by: $n = (Z^2*p*(1-p))/e^2$

Whereby;

n = sample size

Z = Z-score corresponding to the desired confidence level of 90%

P = estimated proportion of the population

e = acceptable margin of error

Pre-Testing of Questionnaire

Pre-testing was conducted in circumstances that were similar to the actual data collection and to the population members in the likeness of those sampled. Pre-testing of questionnaires used a total of 26 production managers of manufacturing industries, which was almost 12% of the total sample size, preceding the actual manufacturing industries survey. Sudman (1983) suggested the use of 20-50 cases during pre-tests as sufficient for discovering major errors in a questionnaire and ensuring data validity.

Data Analysis

Descriptive Statistics

Data was analysed quantitatively. Measures of central tendency, skewness and kurtosis of data covering the study period (2011 to 2020) were conducted using descriptive statistics.

Estimation Approach

The Ordinary Least Square method was used to operationalise the study objective. The model helped to estimate changes in the dependent variable (Employment Level) when an independent variable changed (Capital Investment in 4IR technologies). Regression analysis describes the relationship between variables by fitting a line to the data observed. Prior to regression analysis, stationarity of time series properties was tested using Augmented Dickey-Fuller (ADF), to understand the behaviour and patterns of the data.

To assess the influence of investment in 4IR technologies by Tanzania's manufacturing industries on employment levels, the following estimation model was used:

$$Y_t = \beta_o+\beta_1 X_t+ e_t \quad \text{..... 1}$$

Where;

Y_t Stands for the outcome variables (Employment level), and X_t stands for Capital Investment in 4IR technologies. β_0 is the constant term and β_1 is the coefficient relating the explanatory variable, and e_t stands for the error term.

Description of Variables

Dependent Variable

Employment Level

It has been measured as the actual annual number of people employed by the manufacturing sector in Tanzania during the period under review (2011-2020).

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Independent Variable

Investment in Modern Technology

This variable represents an investment made/spending by manufacturing firms in Tanzania for all the features of the 4th Industrial Revolution (artificial intelligence, nanotechnology, genetic engineering, bio-technology, 3-D printing, internet of things and cloud computing as a few examples), with regard to the modernisation of manufacturing techniques.

Reliability of Data

Cronbach's alpha was used to test the reliability coefficient, which calculates internal consistency by examining how each test item relates to each other and to the entire test., where "_ > .9 – Excellent, _ > .8 – Good, _ > .7 – Acceptable, _ > .6 – Questionable, _ > .5 – Poor, and < .5 – Unacceptable". Cronbach's alpha reliability coefficient, given as a value between 0 and 1, was employed in this study. The scale's items may be internally consistent when Cronbach's alpha is close to 1.0.

PRESENTATION OF FINDINGS AND DISCUSSION

Unit Root Test

Stationarity of time series data denotes that a variable's mean, variance, and autocorrelation remain constant across time. During this study, all variables were stationary at lag (0). Using the ADF test at this point, all the variables, P-values were less than 0.05, and the value for the ADF unit root test statistic was higher than the 5% critical value.

Table 1: Unit Root Test

Variable	P-Value	Remarks
Capital Invested in 4IR Technologies	0.0235	Lag (0)
Employment (number of employees)	0.0499	Lag (0)

Reliability Test

This study performed a reliability test on its variables. This test was conducted to ensure the internal consistency of the variables of the study. Cronbach's Alpha test was employed in this study. The test results portrayed a scale reliability coefficient greater than 0.65, which means the variables were consistent and reliable to be used for further statistical predictions.

Table 2: Cronbach's Alpha Test

Item	Value
Average interitem covariance	.0001877
Number of items in the scale	2
Scale reliability coefficient	0.7100

Descriptive Statistics

This study maximum and minimum values are very close to the mean of the sample; this is an indication that most observations of this study are not dispersed far from their mean. This finding has been complemented by the standard deviation approaching zero (very low dispersion). In the table below, the skewness of variables (capital invested in 4IR technologies and employment (number of people employed in manufacturing industries in Tanzania)) is portrayed by values approaching zero, indicating asymmetry distribution of named variables, that is, normal distribution of study data. To ensure reliability and consistency of data, all variable data were transformed to logarithms.

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Table 3: Descriptive Statistics

Variable	Observations	Mean	Std. Dev	Min	Max	Skewness	Kurtosis
Annual Capital Investment in 4IR Technology	10	26.953666	.0194808	26.92522	26.97458	0.3659	0.1403
Annual employment level in manufacturing Industries	10	9.892055	.0809948	9.745605	9.745605	0.1702	0.3387

Correlation Analysis of Investment in 4IR Technologies and Employment

Contrary to most literature on the effect of 4IR on employment in developed countries and some developing countries in Africa, in Tanzania's manufacturing sector, it has been witnessed a strong positive relationship of investment in 4IR technologies and employment. From Table 4 below, the Pearson correlation coefficient between the two variables is 0.7527, which means an injection of further investment in 4IR technologies by manufacturing firms in Tanzania leads to the creation of further employment opportunities rather than replacing human capital with technology. Tanzania as a country has an abundance of unexploited natural resources which provide assurance of unlimited opportunities for investment and therefore capital injection for acquisition of modern technology in the manufacturing sector accelerate further exploitation of natural resources, industrialization and job creation rather than replacing human capital with machines as it is the case in most developed countries.

Naude (2017) suggested that Africa is already home to a number of low-skilled jobs across industries, especially manufacturing and agriculture, as a result of low investment in education and training. Oketch (2014) further supported the argument and proposed that the skill shortage in key sectors across Sub-Saharan Africa worsens the inability of the region to fully participate in the 4IR. They suggested that widespread automation triggers mass unemployment, whereby 66% of all jobs, especially in the manufacturing sector, are threatened in Sub-Saharan Africa, but this may not be the case in Tanzania, as opposed to the current study correlation and regression results.

Table 4: Pearson Correlation

Variable Name	Capital Investment in 4IR	Employment Level
Capital Investment in 4IR	1.0000	
Employment Level	0.7527	1.0000

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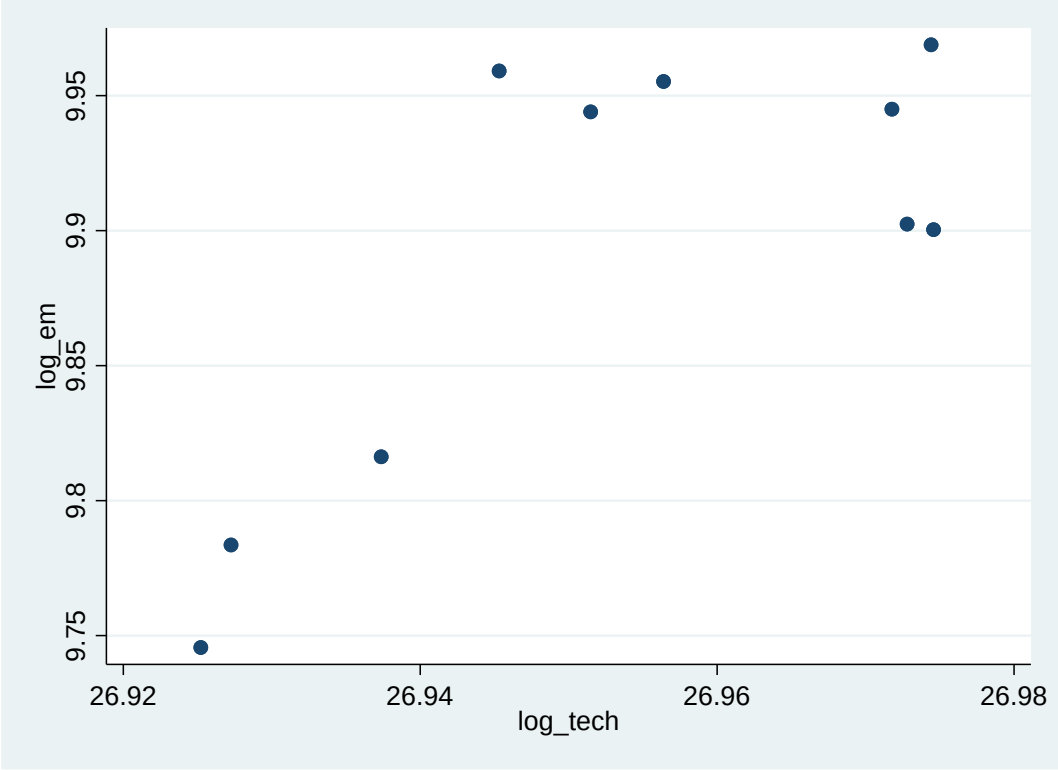
Two-way Graph on Investment in 4IR Technologies VS Manufacturing Sector Employment



Where;
Log_tech is an Annual Capital Investment in Modern Technologies
Log_em is an Annual Employment Level

The two-way graph displays the relationship between investment in modern technologies and employment in Tanzania's manufacturing sector, and further supports the correlation analysis results where investment in 4IR technologies strongly and positively influences the creation of further employment in the sector.

Regression Results

From the ANOVA table and regression summary, the probability (P) is 0.0120, which is less than 0.05, thus, these results are statistically significant and suitable for predictions. Generally, the dependent variable (employment) can be explained by an independent variable (Investment in 4IR technologies) by 56.66%, given the 95% confidence interval. From the regression summary table, the model regression coefficient is 3.129681, which means an increase in 1 unit of capital investment in 4IR technologies leads to a 3.13 increase in employment within the manufacturing sector in Tanzania.

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Table 5: Regression Summary Results

Source	SS	df	MS	Number of obs	=	10
				F(1, 8)	=	10.46
Model	.033454553	1	.033454553	Prob > F	=	0.0120
Residual	.025586897	8	.003198362	R-squared	=	0.5666
				Adj R-squared	=	0.5125
Total	.05904145	9	.006560161	Root MSE	=	.05655

log_em	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
log_tech	3.129681	.96769	3.23	0.012	.8981837	5.361178
_cons	-74.4643	26.08279	-2.85	0.021	-134.6113	-14.31727

Where log_tech is the Annual Capital investment in 4IR technologies
Log_em is the Annual Employment level

These findings are surprisingly contrary to the proposition made by Runde (2016) and Ayentimi (2019), that, fourth industrial revolution is expected to bring a number of adverse effects, especially to countries that are technologically backwards, like Tanzania. Such effects include, but are not limited to decline in investments, production and exports, skills mismatch, job dislocation and mass unemployment. This study's finding suggests injection of capital through imitation, adoption, and purchase of 4IR technologies leads to the growth of manufacturing investments and the creation of more employment opportunities in Tanzania. Developing countries like Tanzania are on the advantageous side as far as 4IR technology is concerned, the importation of such modern technology leads to further investments through exploitation of abundantly available resources and thus further employment. The Tanzanian government, under the Ministry of Education and Culture, is currently transforming its secondary school curricula to support technical education. It has set aside funds in the 2024/25 budget to train technical teachers and revive technical schools to ensure a pool of graduates with technical education, hence do away with the skills mismatch problem due to 4IR.

Gonese and Ngepah (2024) in their article titled “Fourth Industrial Revolution Technologies and their impact on Sectoral Employment in South Africa suggested that, emergence of 4IR has led to both positive and negative effects on employment. Their findings revealed a significant increase in both import and export of ICT as a result of 4IR technologies, which caused job displacement in South African industries due to a high level of automation. However, the study also highlights the positive influence of research and development, fixed broadband, internet usage and mobile phone adoption. They suggest, an increase in these indicators has the potential to generate employment opportunities in the malt-sectors. The current study focused on 4IR technologies adoption and their effect on employment in the manufacturing sector in Tanzania, and findings suggest adoption of 4IR technologies by the manufacturing sector positively influences employment. Tanzania is characterised by vast natural resources and fewer high-tech manufacturing firms thus, technological advancement creates a conducive environment for further local and foreign (FDI) investment and employment growth rather than unemployment.

CONCLUSION AND RECOMMENDATION

The objective of this study was to assess the influence of investment in 4IR technologies on employment in Tanzania's manufacturing industries for the period covering ten (10) years, 2011 – 2020. The study used primary annual data to estimate the

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relationship and degree of causality of investment in 4IR technology on the employment level of manufacturing firms. This study has found a strong and positive relationship between investment in technology and employment in Tanzania's manufacturing industry. This study has also revealed a statistically significant causal effect between investment in 4IR technology and manufacturing firms' employment, whereby, when manufacturing firms increase investment in 4IR technologies by 1 unit, the employment level increases by 3.13 units. These findings are supported by the two-way graph, which portrays growth in employment level in Tanzania's manufacturing industry as investment in industry 4.0 technologies increases. Therefore, the government of Tanzania should prioritise and invest further in technologically supportive infrastructure and enhance technical education for skills matching to fully embrace and harness the benefits of the Fourth Industrial Revolution. This study recommends that the Tanzanian Government review and improve its Sustainable Industrial Development Policy of 2020 and the Integrated Industrial Development Strategy of 2025 to promote and support not only resource-based industries, but also technology-based industries, to speed up industrialisation and employment within the country. The government should also improve its investment policies by aligning them with technological changes brought by 4IR, to attract more foreign direct investments (FDIs) that accelerate importation, adoption and imitation of 4IR technologies from developed countries for furtherance of industrialisation within the country.

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