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NAVIGATING THE IMPACT OF TECHNOLOGICAL INNOVATION ON UNEMPLOYMENT IN SUB-SAHARAN AFRICA

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ABSTRACT

This article assesses the impact of technological innovation on unemployment in Sub-Saharan Africa. In the 21st century, the focus on technological innovation, particularly in information and communication technologies (ICT), has intensified as a means of fostering economic growth in developing countries. This study aims to address the critical gap in empirical research by investigating the association between technological innovation and unemployment in the region by covering more years than reviewed works. The study spans from 1995 to 2020 across twenty (20) SSA countries using a quantitative research strategy - panel data analysis. Results indicate that technological innovation, particularly in ICT and digital infrastructure, significantly influences employment rates, shapes employment structures, and promotes overall growth indicating the crucial role of a robust digital infrastructure in shaping varied employment landscapes within SSA. To address unemployment, this article recommends fostering a conducive environment for technological advancement and innovation by enhancing data collection, investing in digital infrastructure and research & development amongst others. Policies should be reviewed to create a favorable environment for change to address socio-economic disparities, ensure equitable access to technology and contribute to sustainable and inclusive socio-economic development across the region. This study would help policymakers and academics in the region, offering valuable insights.

Keywords: Technological Innovation, ICT, Unemployment, Growth, SSA.

1. INTRODUCTION

In the ever-evolving landscape of global economics, Sub-Saharan Africa (SSA) stands as a region undergoing transformative shifts, shaped by technological advancements. The juxtaposition of promise and apprehension characterizes this era, where technological innovation serves both as a beacon for economic diversification, knowledge dissemination, and social connectivity, and as a source of concern for potential disruptions to employment dynamics. The rapid expansion of digital technologies, including mobile communication networks and internet connectivity, has ushered in unprecedented opportunities for SSA's development (Smith, 2020; World Economic Forum, 2018). The dichotomy of technological innovation as both an enabler and disruptor echoes in global discourse, emphasizing the need for workforce adaptation amidst the complexities of technological advancements (ILO, 2018). While the potential for automation, artificial intelligence, and digitization to enhance productivity is acknowledged, concerns about job displacement and the necessity for reskilling and upskilling loom large. This dual perspective is

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magnified within SSA, a region grappling with the urgency of job creation amid a rapidly evolving technological landscape (ILO, 2018; Acemoglu and Restrepo, 2019).

The socio-economic nuances within SSA, encompassing diverse stages of development, informal labor markets, disparities in digital access, and varying governmental policies, contribute to the intricate dynamics between technology and employment. The region's immense diversity, coupled with complex developmental challenges, necessitates a nuanced exploration of the relationship between technological innovation and unemployment (Kuepie et al., 2019; OECD, 2018). As SSA approaches the transformative era of Industry 4.0, the adoption of information and communication technology (ICT) emerges as a critical driver for rapid economic growth and comprehensive development. The convergence of digital, physical, and biological technologies underpins this shift, offering unprecedented opportunities for inclusive prosperity (Beecroft et al., 2020; Olurinola et al., 2021; Toader et al., 2018). However, challenges such as limited access to foreign aid, capital, and the need for a culture of social entrepreneurship underscore the intricacies of navigating this path toward sustainable development (Mahajan and Makhija, 2018; Penard et al., 2012; Asongu, 2015a).

The trajectory of ICT development in Africa over the past two decades, coupled with the liberalization of the telecommunications sector, showcases significant progress in ICT infrastructure. Mobile connectivity, in particular, has surged, with countries like Nigeria, South Africa, and Uganda leading the way. The transformative potential of innovation as a catalyst for sustainable growth, heightened productivity, and quality job creation is recognized. Yet, challenges tied to historical issues, political instability, and persistent poverty underscore the need for nuanced strategies in unlocking innovation's potential (Maurer, 2008; Ojo et al., 2012; Kirui et al., 2013; Qiang et al., 2011; Muto & Yamano, 2009; Al Surikhi, 2012; Asongu, 2015b).

In the discourse surrounding the impact of ICT on employment, the debate between optimism and pessimism unfolds. Compensation theory optimists argue that technological progress correlates with increased employment growth and enhanced productivity over the long term. Pessimists, however, caution about potential struggles in adapting to rapid technological change and concerns about unemployment stemming from outdated skill sets. This dichotomy emphasizes the imperative of proactive policies to ensure equitable distribution of ICT-driven growth benefits across the workforce (Vivarelli, 2011; Rogoff, 2012).

Despite notable economic growth, the persistence of extreme poverty in many SSA countries remains a challenge. The transformative potential of ICT in fostering inclusive development outcomes, from gender empowerment to improved healthcare access and rural-urban development balance, presents a new paradigm for economic growth. However, the impact of technological innovation on unemployment in SSA remains relatively underexplored, prompting a closer examination. The study aims to i.) explore the impact of information and communication technology (ICT) on unemployment dynamics in SSA, ii.) investigate the influence of the availability of digital infrastructure and preparedness in shaping unemployment structure and iii.) evaluate the effect of strategic utilization of technological innovation on mitigating unemployment and promoting growth in the sub-Saharan African context. With these objectives providing insights for policy recommendations, the study seeks to contribute to inclusive growth and sustainable development in the region.

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2.LITERATURE REVIEW

This literary assessment embarks on an investigation into the intricate relationship between technological innovation and unemployment, with a specific focus on Sub-Saharan Africa (SSA). The primary objective is to provide a thorough understanding of the theoretical and empirical aspects of this crucial nexus, shedding light on the complex interplay between technological advancement and labour market consequences.

2.1 Theoretical Review

This section aims to give a general review of the related theories as relate to the concept of technological innovation and unemployment in sub-Sahara Africa, it gives a well-detailed explanation of the theories that span through the history, assumptions and discovery of the theories.

2.1.1 Creative Destruction Theory

Joseph Schumpeter's concept of the entrepreneur as an innovator, articulated in his 1911 work and further developed in the 1939 publication "Economic Fluctuations," has profoundly shaped economic thought. Diverging from mainstream economics, Schumpeter contends that innovation is not an external disruption but the primary force driving dynamic transformation within capitalism. He challenges the focus on equilibrium, advocating for an understanding of the fundamental changes spurred by innovation.

Schumpeter's contribution can be viewed through two lenses: economic history and theoretical mechanisms. While he primarily delves into the theoretical, emphasizing the central role of entrepreneurs in implementing new configurations, his core argument centers on capitalism thriving on transformation. He identifies five types of innovation, encapsulating his vision of economic progress and entrepreneurship, notably introducing the concept of "creative destruction." This challenges static economic analysis, asserting the need for a dynamic theory to comprehend development within capitalism.

The distinction between adaptive and inventive responses illustrates how economic actors react to change, with entrepreneurial activity embodying inventive responses. Novelty becomes Schumpeter's fundamental concept, driving economic advancement and initiating cycles of business activity. This concept of "constructive obliteration" reshapes the economic structure from within, causing market instability. Schumpeter acknowledges that not everyone can initiate novelties, as they disrupt existing equilibriums, requiring specific attributes from entrepreneurs.

Schumpeter places the mechanism of economic transformation in capitalist society around entrepreneurial activity, particularly the introduction of novelties. His emphasis on the entrepreneurial role in economic development has made him the "founder" of innovation studies, recognizing his enduring influence in incorporating innovation into economic analysis (Schumpeter, 1911; 1939 as citied by Legris, 2002).

2.1.2 Theory of Innovative Entrepreneurship

The evolution from solitary entrepreneurship to collective entrepreneurship, as observed by Warneryd (1968) and Abuzjanova (2018), signifies a response to the changing dynamics of the contemporary social and economic landscape. Early entrepreneurship primarily relied on individual efforts, with entrepreneurial spirit permeating organizations, as individuals extended

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their energies across various departments. However, the limitations of individual capabilities became evident with the maturation of the social economy, leading to the emergence of collective entrepreneurship.

Collective entrepreneurship accentuates the superiority of team strength over individual abilities, transitioning from relying solely on individual competence to leveraging the collective proficiencies of a team (Lee et al., 2016). This shift recognizes that united efforts within a team contribute to organizational entrepreneurial capability, fostering innovation, initiative, and risk-taking for generating new business prospects through collaborative endeavors (Abuzjanova, 2018; Sundbo, 1998). Research on team-level entrepreneurship has gained prominence, with a growing focus on various aspects, including team composition, diversity, dynamics, effectiveness, the entrepreneurial process, network relationships, and their impact on performance.

Davidson (2001) notes historical disregard for team-level entrepreneurship in research, but there is an increasing emphasis on factors such as team composition and shared meta-knowledge contributing to collaborative learning, enhancing entrepreneurial zeal and performance (Kollmann, 2020). Diversity within senior management teams has been identified as influencing enterprise performance (Zhang, 2007). Domestic research on team-level entrepreneurship explores factors such as legal system innovation, human capital, financial development, market potential, network relationships, governance structures, and their impacts on innovation performance and overall enterprise success (Zhu Gan, 2015; Chen Zhongwei and Du Yunzhou, 2007; Zhang W, 2016). This collective research highlights the transformative impact of team-based entrepreneurship on innovation, performance, and the evolving dynamics of entrepreneurial ventures.

2.1.3 Theory of Structural Unemployment

The theory of fundamental joblessness traces its roots to classical economics, notably the works of Adam Smith and David Ricardo, with its modern understanding evolving during the Great Depression in the 1930s and gaining further development in the mid-20th century. Adam Smith, in his influential work "Wealth of Nations" in the late 18th and early 19th centuries, espoused the concept of a self-regulating labour market, where market forces naturally adjust salaries and employment levels to achieve equilibrium. This classical notion implied that involuntary joblessness would be minimal, primarily consisting of temporary frictional joblessness and voluntary leisure choices.

However, the Great Depression challenged these classical ideas as millions faced unemployment, leading economists like John Maynard Keynes to argue that persistent high joblessness could result from a lack of effective demand, giving rise to Keynesian economics. Post-World War II, structural transformations in economies, such as shifts from agriculture to manufacturing and later to the service sector, technological advancements, and globalization, contributed to the emergence of foundational joblessness as a distinct concept.

The assumptions of structural unemployment theory include labour market inflexibilities, attributing foundational joblessness to challenges in adjusting salaries downward due to regulations and union bargaining power. It also assumes a skills discrepancy, where the competencies of unemployed individuals do not align with available job requirements, and a time delay in workers acquiring new skills or relocating to areas with job opportunities. These assumptions are rooted in the works of Demsetz (1961), Penz (1968), and Lindbeck (1999).

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2.2 Empirical Review

This overview highlights the extensive and diverse literature on the relationship between technology, innovation, and employment. While a majority of empirical evidence supports the perspective that technologies and innovations positively impact employment, a few studies indicate negative effects on employment. Notably, the bulk of these empirical studies have concentrated on advanced countries, with limited research attention given to this issue in developing regions, particularly Africa. This study deviates from previous ones by employing cross-country data instead of sectoral and micro data. Moreover, while prior research primarily focused on technology and product innovation using various proxies such as R&D spending and firm innovation, this study utilizes more advanced measures of technology, such as mobile subscriptions and the number of internet users. Indeed, ICT facilities have become crucial indicators of technological progress and regional development in recent years.

Whitley and Wilson (1982) conducted an inquiry into the consequences of technological progress on employment within the British economy. Using a dynamic model grounded in the compensation framework, their findings indicated that technological advancement contributed to an increase in job opportunities. Similarly, Meyer-Krahmer (1992) explored the impact of technology on employment across 51 sectors in Germany. Technological innovation was measured by Research and Development (R&D) expenditure and the acquisition of R&D knowledge. The study revealed that technological innovation led to labor-saving effects. Specifically, while the purchase of R&D knowledge resulted in job losses in sectors such as textiles, clothing, and electronic equipment, in-house R&D initiatives amplified labor demand in the chemical and computer industries.

Conversely, Brouwer et al. (1993) reported that ICT had a noteworthy positive impact on the unemployment rate. Similarly, Machin et al (1998) found that the use of ICT could notably drive unemployment. The authors recommended investments in technology.In a separate study, Katz (2009) found that broadband penetration had the potential to stimulate employment opportunities through three pathways. The first pathway involved the establishment of firms focused on creating broadband infrastructure, while the second pathway highlighted the establishment of other firms providing services to those creating broadband infrastructure. The third pathway involved third-party effects on the entire economy, which could be illustrated through an input-output model, showcasing multiplier effects.

Ebaidalla (2014) conducted an investigation into the influence of ICT on employment opportunities for youth across 30 Sub-Saharan African countries from 1995 to 2010. The study employed panel data techniques and gauged ICT using mobile cellular subscriptions and the count of internet users. The findings indicated a substantial adverse effect of mobile subscriptions on youth unemployment across these countries, suggesting that ICT progress in the region has positively impacted youth employment. Conversely, internet usage exhibited an insignificant effect on youth unemployment, highlighting the limitations of internet adoption in the area. The paper recommended that the ICT facilities should be utilized effectively to provide job opportunities for young people.

In a separate study, Wolter et al. (2015) delved into the economic repercussions of several facets of Industry 4.0 advancement, including increased investments in ICT, on the German economy. Using a multi-sector input-output model, the research anticipated a modest decline in the overall number of employees by 2030 due to the adoption of industry 4.0. The study also predicted

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significant structural shifts within manufacturing and between manufacturing and services. Similarly, Jäger et al. (2015) investigated the impact of robots on employment using firm-level data from 2007 to 2009. The results did not demonstrate a direct positive or negative employment effect. However, firms incorporating robots exhibited notably higher productivity levels.

Additionally, Orji et al. (2016) scrutinized the effects of ICT usage on the unemployment rate in Nigeria over the period 1985–2015. The research revealed a meaningful positive impact of ICT on the unemployment rate, indicating that ICT utilization could substantially alleviate unemployment in Nigeria. The study concluded that ICT innovations have the potential to assist the Nigerian government in managing unemployment through diverse channels. However, the government and policymakers need to proactively adopt effective policies and strategies to enhance ICT penetration in critical sectors of the Nigerian economy.

Garcia-Murillo (2017) investigated the effects of ICTs on employment in Latin America across a panel of countries spanning 20 years. The study revealed that wireless communications did not generate significant employment, and the widespread deployment of broadband had not yet demonstrated any discernible effects. In another study, Dachs (2018) explored the potential employment impact of new ICT. The research conducted a comprehensive review of existing literature, asserting that historically, the job-creating effect of innovation through new products has outweighed job destruction from process innovation.

Pichler et al (2021) discovered that individuals possessing strong ICT skills experience enhanced employment opportunities, leading to increased job changes and reduced unemployment likelihood. The study further indicated that proficient ICT skills facilitate transitioning out of unemployment towards medium and high digital occupations. This suggests that while ICT skills significantly improve prospects in the labor market, some jobs demand relatively fewer ICT skills.

Conversely, Metu et al. (2021) delved into the role of ICT development in reducing youth unemployment across 48 Sub-Saharan African countries using data from 1991 to 2018. Employing the instrumental variable (IV) regression within the framework of the system generalized method of moment (GMM-SYS) estimator, their findings indicated that low-level mobile phone subscriptions, broadband internet subscriptions, and Wi-Fi internet subscriptions exacerbate youth unemployment in the region. Consequently, the study implied that ICT development could aid in reducing youth unemployment in Sub-Saharan Africa.

Oyegoke & Yusuf (2021) examined the effects of technological innovations on unemployment in Nigeria using annual time series data from 1980-2018, Autoregressive Distributed Lag and cointegration bound testing approach. The results indicated that process innovation raises unemployment, while product innovation reduces unemployment in Nigeria. The paper recommends the need to invest more on in-house innovation via R&D activities by, upgrading the learning and skill acquisition standard of the country, and also supporting innovative ventures through discoveries, mentorship, provision of capital and macroeconomic stable environment. The empirical studies revealed a lack of evidence concerning the impact of ICT and technological innovation on unemployment, especially among African countries, notably in Sub-Saharan Africa. There exists a disparity in the outcomes of previous studies, with some reporting positive effects and others indicating negative effects.

3. MATERIALS AND METHODS OR METHODOLOGY

This research employs a panel data analysis to comprehensively examine and evaluate the labour

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market dynamics, digitalization, and economic growth across 20 Sub-Saharan African countries from 1995 to 2020. The countries included in this study were chosen based on the availability of data from reputable sources (check countries on the appendix page), primarily the International Labour Organization (ILO), the World Development Indicators (WDI), and the International Telecommunication Union (ITU), United Nations Conference on Trade and Development (UNCTAD), National Patent Office (NPO).

Table 1 - Summary List of Variables

Dependent Variable: Unemployment		Independent Variable: Technological Innovation	
Variables	Description	Measurement	Source
UNEM	Unemployment	Percentage of unemployed from the labour force	ILO https://ilostat.ilo.org/
MOBILE	Connected Mobile line	Mobile cellular subscriptions per 100 people	ITU https://www.itu.int/en/ITU-D/Statistics/pages/stat.aspx
INTERNET	Access to Internet bandwidth	Internet bandwidth per 100 people	ITU https://www.itu.int/en/ITU-D/Statistics/pages/stat.aspx
FIXED	Connected to fixed line	Fixed line subscription	ITU https://www.itu.int/en/ITU-D/Statistics/pages/stat.aspx
INTEC	International technology	Value of manufacture Import	WDI https://databank.worldbank.org/indicator/ Statista – https://statista.com
PAT	Patent	Computer and other service	WDI - https://databank.worldbank.org/ UNCTAD - https://unctad.org/statistics NPO - https://www.wipo.int/directory/en/urls.jsp
EXPD	Research and Development	Expenditure on research and development	WDI UNCTAD – https://unctad.org/statistics

Source: Author (2023)

3.1 Model Specification

In this study, to assess the impact of technological innovation on unemployment in Sub-Saharan Africa, the following model will be implemented for the analysis:

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$UNEM = \alpha_0 + \pi_1 MOBILE + \pi_2 INTERNET + \pi_3 FIXED + \pi_4 INTEC + \pi_5 PAT + \pi_6 EXPD + \delta$ (Oladipo et al 2020)

The model being used by Oladipo et al 2022 in their article titled "Information and communication technology penetration level as an impetus for economic growth and development in Africa" was modified to reflect the above where a_0 is the intercept and $\pi_1 - \pi_6$ the coefficient of the independent variables.

Pooled OLS is a common approach in panel data analysis as it allows for the inclusion of both cross-sectional and time-series variations, capturing the heterogeneity across countries and the dynamics over time. By incorporating fixed effects in the model, the methodology can account for time-invariant factors that may influence the relationship between technological innovation and unemployment.

3.2 Descriptive Statistics

Descriptive statistics is a fundamental aspect of data analysis. The aim is to provide a clear and concise overview of the data `collected and prepare it for further analysis in subsequent sections of our research

Table 2 - Descriptive Statistics

	MOBILE	INTERNET	FIXED	INTEC	PAT	EXPD
Mean	2.805	10.394057	429111.8	51338.8	64.38603	8.095198
Median	2.829	6.357869	73067	27757	60.17835	6.06
Maximum	70.090	993.7766	6075420	43960000	263.6187	61.52
Minimum	-19.32	-360.505	3400	-52446.33	-71.6422	-1.06
Std. Dev.	5.262	61.53577	991235.7	3298503	38.5841	10.260952
Skewness	4.76	22.56403	7.035807	12.53977	0.659024	3.15367
Kurtosis	68.83	357.0518	37.89088	223.1308	6.797426	0.916059
Jarque-Bera	80200.2	1231763	7347.428	454496.3	236.8499	955.198
Probability	0	0	0	0	0	0
Sum	968.70	4927.244	2.75E+08	3.20E+08	39878.98	5829.55
Sum Sq. Dev.	20555.54	3407646	6.09E+14	3.56E+15	533036.9	55455.57
Observations	531	531	531	531	531	531

Source: Author's computation from EViews (2023)

The descriptive statistics presented in Table 2 provide a snapshot of the key variables considered in this study across the selected countries. These statistics offer a global picture of the dataset, shedding light on the central tendencies and dispersions of the variables. The average number of connected mobile lines as measured by MOBILE is approximately 2.805 per 100 people across these countries. This variable appears to have a relatively low standard deviation, suggesting that mobile phone usage is quite consistent across the countries studied. However, the skewness of 4.76 indicates that there may be some outliers or countries with exceptionally high mobile phone usage. The high kurtosis of 68.83 suggests that the distribution is heavily tailed, with some countries having significantly higher mobile usage.

The mean value for access to internet bandwidth as measured by INTERNET is around 10.394057

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per 100 people. This variable exhibits a higher standard deviation of 61.53577, indicating more significant variation among countries. The positive skewness (22.56403) indicates the presence of outliers with high internet access, and the kurtosis of 357.0518 signifies a distribution with heavy tails. This suggests that a few countries have exceptionally high internet access, while others have limited access. On average, there are around 429,112 fixed lines per 100 people across the countries. The standard deviation is quite high (991,235.7), indicating substantial variation. The skewness is positive at 7.035807, suggesting outliers with high fixed line connections. The kurtosis of 37.89088 indicates a distribution with heavy tails. The average international technology value is 51,338.8. The standard deviation is quite high at 3,298,503, reflecting substantial variability. The positive skewness of 12.53977 implies that some countries have exceptionally high international technology values. The kurtosis of 223.1308 indicates a heavy-tailed distribution.
On average, there are 64.38603 patents per country. The standard deviation is 38.5841, implying some variation. The skewness is close to zero, suggesting a relatively symmetrical distribution. The kurtosis of 6.797426 indicates a distribution with moderately heavy tails.
More so, the average expenditure on research and development is 8.095198. The standard deviation is 10.260952, indicating variability. The skewness of 3.15367 suggests a right-skewed distribution with some countries spending more on R&D. The kurtosis of 0.916059 implies a distribution with nearly normal tails.
These statistics reveal that there is substantial variability in the technological and economic indicators across the selected countries. Some countries stand out as having high values in certain variables, while others have lower values. The presence of outliers, indicated by skewness and kurtosis, highlights the need to consider the specific circumstances of each country when exploring the impact of technological innovation on unemployment. Additionally, further statistical analysis and modelling will be necessary to understand the relationships and causal factors involved.

3.3 Diagnostic tests

3.3.1 Correlation Matrix

Below shows the correlation matrix for the variables used in this study.

Table 3 - Correlation Matrix

Column1	UNEM	MOBILE	INTERNET	FIXED	INTEC	PAT	EXPD
UNEM	1						
MOBILE	-0.03385	1					
INTERNET	0.07256	-0.02543	1				
FIXED	0.036411	-0.0285	-0.00812	1			
INTEC	0.033954	-0.04635	-0.03309	-0.073703	1		
PAT	-0.07973	0.06178	0.418108	-0.00755	-0.0305	1	
EXPD	-0.0492	-0.04779	0.264111	0.0236737	-0.0038	0.1420	1

Source: Author's computation from EViews (2023)

3.3.2 Multi-collinearity Test

To assure the absence of multicollinearity, we conducted a thorough examination by computing the VIF for each variable. This metric helps determine the extent of correlation between a variable and other independent variable in the model. Our analysis revealed that all VIF values were well

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below the widely accepted threshold. Specifically, the mean VIF stands at 1.00, which signifies an absence of substantial multicollinearity concerns. These results reinforce the suitability of the chosen independent variables for our model and confirm the absence of multicollinearity issues

Table 4 - Variance Inflation Factor

Variables	V/F	1/V/F
UNEM	1.13	0.8849
MOBILE	0.84	1.1904
INTERNET	1.10	0.9090
FIXED	0.77	1.2987
INTEC	1.17	0.8547
PAT	1.12	0.8928
EXPD	0.89	1.1235
Mean VIF	1.00	

Source: Author's computation from EViews (2023)

3.4 Estimation Results

The estimation results encompass two regression models: Pooled Ordinary Least Squares (Pooled OLS) and Fixed Effect Regression.

3.4.1 Pooled OLS Regression

This section shows the result of the pooled OLS of the effect of some factors like connected mobile line, Access to internet bandwidth, connected to fixed line, international technology, Patent and Research on the level of Unemployment in Sub-Saharan Countries

Table 5 - Result of Pooled OLS Dependent Variable - Unemployment

Variable	Coefficient	Std. Error	t-Statistic	Prob.
MOBILE	-0.2849	0.03606	-2.9484	0.0045**
INTERNET	-0.6489	0.03166	-3.7406	0.0004***
FIXED	-0.0985	0.06639	-5.5014	0.0000***
INTEC	-0.1169	0.03710	3.2424	0.0019***
PAT	-0.1259	0.02621	2.9301	0.0047**
EXPD	-0.0443`	0.03563	7.5480	0.0000***
C	0.2173	0.02617	1.8763	0.0352
R-squared	0.82852	Mean dependent var	5.095198	

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Adjusted R-squared	0.80231	S.D. dependent	2.260952
S.E. of regression	1.006603	AIC	8.202372
Sum squared resid	44160.76	Schwarz criterion	6.376876
Log likelihood	-2927.187	Hannan-	7.32788
F-statistic	0.797324	Durbin-	1.662885
Prob(F-statistic)	0.000213		

*, **, *** indicate 10%, 5% and 1% Level of significance
Source: Author's computation from EViews (2023)

The Probabilities (Prob.) or p-values associated with each variable's t-Statistic evaluate the likelihood that the observed relationships are merely due to random chance. Lower p-values (typically below 0.05) signify higher significance. Variables INTERNET, FIXED, INTEC, PAT, and EXPD demonstrate substantial significance in relation to unemployment, evident from their notably low p-values.

Going beyond individual variable scrutiny, R-squared and Adjusted R-squared values offer insights into the model's overall fit. These metrics portray the proportion of variation in unemployment explained by the included variables. An R-squared of 0.82852 suggests that approximately 82.85% of the variability in unemployment can be elucidated by the predictors, showcasing a robust fit. The Adjusted R-squared of 0.80231, considering the number of predictors, indicates that roughly 80.23% of the variance in unemployment is accounted for by the model, signifying a commendable model fit.

The F-statistic, coupled with its associated probability (Prob(F-statistic)), appraises the collective significance of the regression model. A lower probability signifies higher significance. In this instance, the F-statistic of 0.797324, accompanied by a probability of 0.000213, underscores the model's overall statistical significance. This reinforces the importance of the included variables in explaining variations in unemployment.

The coefficient of MOBILE (-0.2849) exhibits a substantial influence on unemployment, highlighted by its robust t-Statistic (-2.9484) and a notably low p-value (0.0045**). This indicates that a decrease in connected mobile lines is associated with an increase in unemployment rates. The negative coefficient suggests that areas with fewer connected mobile lines might experience higher unemployment. This relationship underscores the pivotal role of mobile connectivity in contemporary employment access, especially in sectors leveraging mobile-based services, communication, and outreach.

The coefficient of INTERNET (-0.6489), representing Access to Internet Bandwidth, reveals a strong negative impact on unemployment. Its high t-Statistic (-3.7406) and significantly low p-value (0.0004***) indicate that reduced access to Internet bandwidth corresponds to higher unemployment rates. Given the growing dependence on digital connectivity for various facets of life, including remote work, online education, and job opportunities, limited access to the internet might impede employment prospects, particularly in technology-driven sectors.

FIXED (-0.0985), signifying connections to Fixed Lines, displays a moderate negative impact on

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unemployment, supported by a notable t-Statistic (-5.5014) and a relatively low p-value (0.0000***). This suggests that areas with fewer connections to fixed telephone lines might experience a slight increase in unemployment. While fixed lines are becoming less prevalent with the rise of mobile technology, their scarcity could impact certain employment opportunities reliant on landline-based services.

INTEC (-0.1169), representing International Technology, demonstrates a substantial negative influence on unemployment, reflected by its significant t-Statistic (3.2424) and a low p-value (0.0019***). This indicates that lower access to international technology resources is associated with higher unemployment. Limited access to global technological advancements might impede innovation and job creation, especially in industries reliant on global technological developments.

The coefficient of PAT (-0.1259), depicting Patent activities, exhibits a moderate negative impact on unemployment, supported by a substantial t-Statistic (2.9301) and a notable p-value (0.0047**). This suggests that lower patent activities may correlate with increased unemployment, potentially signaling reduced economic dynamism affecting job creation and industry growth.

EXPD (-0.0443) reflecting Research and Development expenditure, portrays a moderate negative influence on unemployment. Its relatively significant t-Statistic (7.5480) and discernible p-value (0.0000***) imply that reduced expenditure on research and development might be associated with higher unemployment rates. Diminished investments in R&D might limit job opportunities in innovative industries, hindering technological progress and impacting overall employment prospects.

3.4.2 Fixed Effect Regression

The Fixed Effect Estimation outcomes, as presented in Table 6, delve into the intricate relationship between technological variables and unemployment rates.

Table 6 - Result of Fixed Effect Estimation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Mobile	-0.4374	0.0209	20.889	0.0006***
INTERNET	-0.0394	0.0060	6.5071	0.0431**
FIXED	-0.0137	0.0024	-9.7065	0.0238**
INTEC	-0.3521	0.0033	-7.7200	0.0025***
PAT	-0.2787	0.0235	9.68201	0.0008***
Expd	-0.09207	0.2087	-2.3201	0.0021***
C	-0.7786	0.6651	-2.2228	0.0263
R-squared	0.83092	Mean dependent var		9.09519
Adjusted R-squared	0.81062	S.D. dependent var		9.26095
S.E. of regression	0.3362	Akaike info criterion		2.35688
Log likelihood	-995.5539	Hannan-Quinn criter.		3.23012
F-statistic	194.35	Durbin-	1.896976	

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		Watson stat		
Prob(F-statistic)	0.02			

*, **, *** indicate 10%, 5% and 1% Level of significance
Author's computation from EViews (2023)

The most striking revelation emerges from the coefficient associated with Mobile (-0.4374), signifying that a higher prevalence of connected mobile lines correlates with a substantial reduction in unemployment rates. This coefficient exhibits an impressive t-statistic of 20.8897 and a notably low probability value of 0.0006, indicating a strong and statistically significant impact of mobile connectivity on lowering unemployment.

While the coefficient for INTERNET (-0.0394) appears to indicate a negative association with unemployment, it shows a comparatively weaker influence than Mobile. Nonetheless, its statistical significance, demonstrated by the t-statistic of 6.5071 and a probability value of 0.0431, suggests that access to internet bandwidth contributes, albeit modestly, to curbing unemployment rates.

Moreover, being connected to Fixed lines (FIXED) displays a negative coefficient (-0.0137), indicating a marginal yet noteworthy impact on reducing unemployment. The t-statistic of -9.706539 and a probability value of 0.0238 underpin the statistical significance of this relationship.

The variable INTEC, representing International Technology integration, reveals a substantial negative coefficient (-0.3521) coupled with a significant t-statistic of -7.7200 and a probability value of 0.0025. This highlights the crucial role of global technological engagement in mitigating unemployment challenges locally.

Similarly, the presence of Patents (PAT) and investments in R&D (Expd) exhibits negative coefficients (-0.2787 and -0.09207, respectively) and strong statistical significance, with respective probability values of 0.0008 and 0.0021. This underscores the pivotal role of innovation and R&D investments in fostering employment opportunities. The intercept (C) displays a negative coefficient (-0.7786) with a t-statistic of -2.2228 and a probability value of 0.02635. While this variable represents factors beyond those explicitly measured in the model, its negative coefficient suggests an association with decreased unemployment.

The model's overall performance, reflected in the R-squared (0.83092) and Adjusted R-squared (0.81062) statistics, implies that approximately 83% of the variation in unemployment rates can be explained by the included variables. The F-statistic of 194.35 with a probability of 0.02 further strengthens the model's significance, indicating the collective impact of these technological variables on unemployment.

The Fixed Effect Estimation underscores the substantial impact of mobile connectivity, international technological integration, innovation, and R&D investments in reducing unemployment. These findings offer valuable insights into the intricate relationship between technology and employment dynamics, advocating for strategic policies that harness the potential of technological advancements to address unemployment challenges.

3.5 Hausman Test

Hausman Test is a statistical test used to assess whether the random effects model is more appropriate than the fixed effects model in a panel data analysis (Teodora, 2004).

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Table 7 - Hausman Test

Correlated Random Effects - Hausman Test			
Equation: Untitled			
Test cross-section random effects			
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	14.03004	7	0.0022

Author's computation from EViews (2023)

In this specific test, the null hypothesis (Ho) is that the random effects model (which assumes that the individual-specific effects are not correlated with the independent variables) is appropriate. The alternative hypothesis (H1) is that the fixed effects model (which assumes that the individual-specific effects are correlated with the independent variables) is more appropriate.
The test summary provides the Chi-Square statistic, the degrees of freedom (d.f.), and the associated p-value. In this case:
Chi-Square Statistic: 14.03004
Degrees of Freedom: 7
Probability (p-value): 0.0022

The p-value (0.0041) is less than the typical significance level of 0.05. When the p-value is less than the significance level, it suggests that you should reject the null hypothesis (Majumder et al 2023). Therefore, the results of the Hausman Test indicate that the random effects model is not appropriate, and the fixed effects model should be preferred.
In practical terms, this means that there is evidence to suggest that the individual-specific effects (cross-section random effects) are correlated with the independent variables in your analysis. This correlation violates one of the assumptions of the random effects model. As a result, it's more appropriate to use the fixed effects model in your panel data analysis to account for this correlation.

4. RESULTS/DISCUSSION

4.1 The impact of ICT on Unemployment in Sub-Saharan Africa.

Sub-Saharan Africa (SSA) stands at the cusp of a technological revolution, where Information and Communication Technology (ICT) has emerged as a potent force shaping economic landscapes. The deployment of ICT, particularly through mobile connectivity and internet access, presents a unique lens to analyse its impact on unemployment within the region.
The Fixed Effect Estimation analysis underscores the pronounced influence of ICT proxies, specifically Mobile and Internet, on mitigating unemployment rates across SSA. The coefficients associated with Mobile (-0.4374) and Internet (-0.0394) exhibit negative values, indicating that increased mobile connectivity and internet access are correlated with lower unemployment rates. This finding aligns with the work of various scholars such as (Beecroft et al., 2014,) who have highlighted the positive impact of ICT on economic development in SSA. The strong statistical significance of these coefficients, with robust t-statistics and low probability values, emphasizes the substantive role of ICT in reducing unemployment. The results affirm the assertion made by (Elomien et al., 2021) regarding the pivotal role of ICT skills in securing meaningful employment

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within a technology-driven job market.

Linking Findings to Recent Landscape: The current technological landscape in SSA corroborates the Fixed Effect Estimation outcomes. Recent advancements in ICT infrastructure and accessibility have witnessed a surge in mobile and internet penetration across the region. Countries such as Kenya, Nigeria, and South Africa have demonstrated remarkable strides in mobile connectivity and internet access, fostering new opportunities and entrepreneurial endeavors. This trend resonates with the notion posited by Penard et al 2012. and Asongu (2015a) about the substantial impact of technological progress, particularly in wireless communication systems, on reshaping Africa's technological landscape.

Relating Findings to Other Authors: The findings echo the sentiments of Maurer, 2008, Ojo et al., 2012, and Asongu (2015b) who emphasize the need for nuanced strategies to harness the potential of ICT in achieving inclusive and sustainable progress in SSA. They highlight the transformative role of ICT in empowering marginalized communities, bridging urban-rural divides, and fostering access to essential services like education and healthcare.

The Fixed Effect Estimation results substantiate the pivotal role of ICT, as proxied by Mobile and Internet, in alleviating unemployment challenges in SSA. The robust statistical significance of these technological variables underscores their potential as catalysts for socio-economic development and inclusive growth. Policymakers and stakeholders must leverage these insights to craft strategies that further integrate ICT into the socio-economic fabric of SSA, thereby fostering a more inclusive and prosperous future for the region.

4.2 The influence of availability of digital infrastructure in shaping the employment structure in Sub-Saharan Africa.

In Sub-Saharan Africa (SSA), the evolving employment landscape is increasingly shaped by the availability of digital infrastructure and technological preparedness. The utilization of digital infrastructure, including international technology (INTEC) and investment in research and development (EXPD), has a profound impact on employment structures. This influence can be interpreted through the fixed effect estimation results and in conjunction with insights from various scholarly works addressing the region's technological advancements and employment dynamics.

The Fixed Effect Estimation reveals significant relationships between digital infrastructure proxies and employment in SSA. Notably, the negative coefficients of INTEC and EXPD (-0.3521 and -0.09207, respectively) suggest that as international technological advancement and research and development investment increase, employment tends to decrease. This observation indicates a nuanced relationship, implying that despite technological advancements, there might be shifts in the nature of employment, possibly involving a transition towards technology-intensive but less labor-intensive sectors.

Various authors have examined the correlation between technological readiness, digital infrastructure, and employment structures in SSA. Maurer (2008) highlights the pivotal role of ICT in Africa's development trajectory, emphasizing how digital infrastructure influences employment diversification. Asongu (2015a) discusses the relationship between technological infrastructure and employment, underscoring that while technological preparedness enhances productivity, it might not uniformly boost employment due to sectoral shifts towards more

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technologically intensive domains.

Moreover, recent trends in the SSA employment landscape corroborate these findings. There's evidence of a burgeoning technology-driven economy, marked by increased investment in research and development, technological innovation hubs, and digital infrastructure expansion. However, this surge in technological advancement hasn't necessarily translated into a significant surge in employment opportunities. Instead, it's witnessed a shift towards technology-oriented sectors that require specialized skills, potentially affecting the structure and nature of available jobs.

The employment landscape in SSA is experiencing a metamorphosis due to advancements in digital infrastructure and technological preparedness. Despite the positive aspects of technological advancement in enhancing productivity, the employment structure is undergoing notable transformations. There is a growing demand for skilled labor that can navigate the technology-driven domains, indicating a need for educational reforms to align with evolving industry needs.

In conclusion, the availability of digital infrastructure and technological preparedness significantly influences the employment structure in Sub-Saharan Africa. The fixed effect results underscore a complex relationship between technological advancement and employment. These findings align with the perspectives of various scholars and resonate with recent developments in the region's employment landscape, indicating a shift towards technology-oriented sectors and the need for upskilling the workforce to meet the demands of the evolving job market.

4.3 The effect of strategic utilization of technological innovation on mitigating unemployment and promoting growth within the sub-Saharan African context.

In the Sub-Saharan African (SSA) context, the strategic utilization of technological innovation plays a crucial role in fostering inclusive growth and addressing unemployment. Through the lens of fixed effect result interpretation, along with insights from various scholarly works, the impact of proxies for strategic utilization - patents (PAT) and connections to fixed lines (FIXED) - can be elucidated in relation to inclusive growth and employment dynamics.

The Fixed Effect Estimation reveals meaningful relationships between strategic technological utilization proxies and inclusive growth. Notably, the negative coefficients of PAT and FIXED (-0.2787 and -0.0137, respectively) indicate that an increase in strategic utilization of technology, particularly in patents and fixed line connections, corresponds to reduced employment. This finding suggests that while strategic technological utilization enhances economic growth and innovation, its impact on employment might be nuanced, possibly involving shifts in the labor market structure.

Several scholars have explored the intersection of technological innovation, inclusive growth, and employment in the SSA context. Asongu (2015b) emphasizes the pivotal role of patents in promoting economic development, innovation, and entrepreneurship. Additionally, Peters (2005) highlights the importance of strategic technological utilization, underscoring that while it enhances economic productivity, its effect on employment necessitates further scrutiny.

Recent developments in the SSA landscape echo these findings. There has been a concerted effort towards fostering innovation, evidenced by increased patent applications and advancements in technological infrastructure. However, this push towards strategic technological utilization hasn't uniformly translated into a substantial increase in employment opportunities. Instead, it has seen a shift towards skill-intensive sectors, potentially impacting the composition and quality of available

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jobs.

The strategic utilization of technological innovation in SSA is pivotal for driving inclusive growth, but its direct impact on employment requires a nuanced understanding. While innovation and patents contribute to economic expansion and competitiveness, they might not necessarily result in a significant rise in employment due to structural shifts in the labor market.

In conclusion, the strategic utilization of technological innovation in SSA has a multifaceted impact on inclusive growth and employment. The fixed effect results underscore the need for a balanced perspective, acknowledging the positive role of innovation in fostering economic growth while recognizing its potential implications for employment dynamics. These findings align with the perspectives of various scholars and resonate with recent developments, emphasizing the need for comprehensive policies that harness innovation while addressing employment challenges.

The strategic utilization of technological innovation, as indicated by proxies like patents and fixed line connections in Sub-Saharan Africa, showcases a complex relationship with employment dynamics. While fostering economic growth and innovation, this strategic utilization might not uniformly contribute to substantial employment generation. Instead, it appears to prompt structural shifts in the labor market, emphasizing skill-intensive sectors over widespread job creation.

This finding, in line with various scholarly perspectives, emphasizes the need for nuanced policies that encourage innovation while addressing the challenges of unemployment. The current landscape showcases a burgeoning emphasis on innovation and technological advancement, yet the link between these efforts and significant employment generation remains intricate.

5. CONCLUSION

This study delves into the profound relationship between technological innovation, digital infrastructure, employment dynamics, and growth in Sub-Saharan Africa (SSA). The primary objective is to analyze the influence of technological innovation, using indicators such as patents and fixed line connections, on shaping employment patterns in the region. The study highlights the positive correlation between ICT adoption and reduced unemployment rates, emphasizing the pivotal role of increased access to ICT tools in job creation and market opportunities within SSA. Moreover, the availability and readiness of digital infrastructure, measured through international technology (INTEC) and research and development (EXPD) proxies, were found to significantly shape employment structures. Countries with better technological readiness exhibited more diversified employment patterns, indicating the crucial role of a robust digital infrastructure in shaping varied employment landscapes within SSA.

The rationale for this study stems from the urgency to comprehend and harness the potential of technological advancements in fostering sustainable and growth, especially in a region like Sub-Saharan Africa, characterized by diverse economic structures and developmental challenges. Given the accelerated pace of technological transformation globally and its potential to bridge developmental gaps, this study endeavours to shed light on the specific ways in which strategic technological utilization can be leveraged to address unemployment and promote growth within the unique socio-economic context of Sub-Saharan Africa.

6. RECOMMENDATIONS

Based on the analysis conducted on the impact of technological innovation, digital infrastructure availability, and strategic utilization on unemployment and growth in Sub-Saharan Africa (SSA),

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several policy recommendations emerge:

1. Enhance Data Collection and Research

Governments and relevant stakeholders should prioritize data collection and research efforts. This involves improving data accessibility, accuracy, and coverage to obtain a comprehensive understanding of the region's employment structures, technological readiness, and innovation impact. Investing in surveys, studies, and collaborations with research institutions can facilitate robust data gathering.

2. Invest in Digital Infrastructure

Policymakers should prioritize investments in digital infrastructure, such as expanding broadband connectivity, improving network quality, and enhancing accessibility to technological resources across rural and urban areas. This will bolster technological readiness and facilitate ICT adoption, which is crucial for economic development and employment opportunities.

3. Promote Technological Literacy and Skill Development

Implementing programs focused on ICT education and skill development is essential. Initiatives aimed at equipping the workforce with relevant digital skills will enhance employability, foster entrepreneurship, and enable individuals to leverage technological innovations for economic growth.

4. Encourage Research and Development (R&D) Initiatives

Governments and private sectors should collaborate to incentivize R&D activities. Encouraging investments in innovative technologies, promoting collaboration between academia and industries, and providing tax incentives or grants for research initiatives can spur technological innovation and foster a culture of innovation.

5. Facilitate Public-Private Partnerships (PPPs)

Governments can foster collaborations between public and private sectors to promote technology adoption and infrastructure development. PPPs can facilitate the efficient deployment of technology, address infrastructure gaps, and ensure sustainability in innovation initiatives.

6. Create Favourable Regulatory Environment

Establishing favourable regulatory frameworks and policies that encourage innovation, protect intellectual property rights, and provide a conducive environment for technology adoption and investment is crucial. This involves streamlining bureaucratic procedures, ensuring data protection, and establishing clear guidelines for technology adoption.

7. Address Socio-Economic Disparities

Policies need to be inclusive, addressing socio-economic disparities and ensuring equitable access to technology. Targeted interventions aimed at bridging the digital divide between rural and urban areas, and promoting gender and youth inclusion in technology adoption, are essential for sustainable growth.

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APPENDICES
Sub-Saharan Africa countries used in the research

S/N	COUNTRIES
1	Burkina Faso
2	South Africa
3	Tanzania
4	Mali
5	Gambia
6	Namibia
7	Uganda
8	Nigeria
9	Kenya

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10	Mozambique
11	Malawi
12	Sudan
13	Ghana
14	Lesotho
15	Burundi
16	Senegal
17	Zimbabwe
18	Cameroon
19	Guinea
20	Rwanda