Innovations

The Role of Digital Technology on Labor productivity of Sub-Saharan Africa: Evidence panel data analysis

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Abstract
This study examines the role of digital technology on labor productivity. The required data for this study was obtained from 33 Sub –Saharan African countries from 2010 to 2020 and employed a one-step systems Generalized Method of Moments of estimation. The findings indicate that digital technology has a significant positive effect on labor productivity in the short run. Besides, the result also reveals that the lag of labor productivity has a significant positive effect on labor productivity in the short run. Unlike other; foreign direct investments, the level of inflation and general government final consumption expenditure has a significant negative effect on economic growth. The finding from the long-run model analysis shows that digital technology has a significant positive influence on labor productivity in the long run. The result also depicts that foreign direct investment, inflation, and general government final consumption expenditure have a long-run negative effect on labor productivity. From a policy point of view, the overall result shows a need for investment in digital technology development and a well-defined guiding principle to manage general government final consumption expenditure, inflation, and foreign direct investment.

Keywords: 1.*Digital Technology; 2.Labor productivity; 3.One-step system Generalized Method of Moments; 4.Principal component analysis*

1. Introduction

Digital technology refers to the use of advanced information and communication technology to collect, store, analyze and share physical information and market information in each link of the product value chain, providing important technical support for innovation in various fields and considered the main productive resource that determines the growth of overall social welfare(Obukhova et al. 2020). It can alsobe defined as digitalization is the use of digital technologies and digitized data, impacts how work gets done, and transforms how customers and companies engage and interact(Schelenz and Schopp 2018)

Digitalization transforms our everyday life, our way of communication and information, as well as our relationship with other people. It is affecting all aspects of human life and economies are changing as a result of this technology. It can also be viewed as a tool to provide competitiveness of the state and high standards of living. It alters how businesses develop, create goods and services, and engage with other businesses, employees, customers, and governments and has a significant potential to raise factor productivity(Metlyakhin et al. 2020).

Labor productivity which is an increase in the amount of output produced by workers per a given unit is the basis for improving the welfare of all citizens and economic growth as a whole. It is one of the fundamental factors influencing the economy in most developing countries and the variation in productivity rates in certain or all economic sectors affects economic development(Rodrigo Garcia Motta, Angélica Link, Viviane Aparecida Bussolaro et al. 2021).

Labor productivity can beinfluenced by many factors. The main determinants of Labor productivity growth are scientific and technical progress in general, as well as the use of digital technologies and computerization of labor in particular. Digital technology has opened up several important opportunities to improve labor productivity in Sub-Saharan Africa(Atkinson and McKay, n.d.). Digitalization in terms of higher internet penetration increases labor productivity, particularly in the sectors of utilities, trade, and transportation, and boosts the share of services (as a percent of total value added)(Simione and Li 2021). It increases labor productivity by reducing the cost of production and as the economy becomes more digital impact of technological progress on labor productivity increases(Banga and Velde 2018).

Sub-Saharan Africa is characterized by a lowlevel of labor productivity and a high unemployment rate. This low Labor productivity in the area relies on the traditional sector and labor productivity growth is only 0.6 percent in2018 in the region(Employment and Outlook 2019).The region shows sluggish growth in labor productivity which is a key driver of growth and development and left the region lagging behind many developing countries(Abdurohman. A. H. 2016). Adapting and using digital technology can improve the production process and labor productivity((Bahrini and Qaffas 2019) and (States, Africa, and Report 2018)recommendedharnessing digitalization as one of the solutions for low labor productivity.Enhancing labor productivity in Sub-Saharan Africa requires digital technology development because itincreasingly covers various spheres of economic activities and creates new opportunities for socio-economic development. The formation of effective digital technology will open significant opportunities for the creation and development of business, it will help to increase investment flows, accumulation of human and financial resources, and increase labor productivity in the region (Bayuo 2017)

The recent empirical studies on the relationship between digital technology and laborproductivity revealed that an improvement in digital technology increases labor productivity in the region(Danquah and Owusu 2021) and (Ballestar et al. 2021). However, (Metlyakhin et al. 2020) found that access to digital technology in terms of the internet for pc and otherincrease unproductive use of working hours and hurtsthe level of labor productivity.

There is an extensive literature in advanced countries on the effect of digital technology on labor productivity. By contrast, in developing countries like Sub- Saharan African countries, very few studies have focused on these issues. This study had set a goal to contribute to the literature and to fill this gap by examining the role of digital technology on Labor productivity in Sub –Saharan Africa by employing one step system GMM.

2. Literature Review and Conceptual Framework

There is adebate on the relationship between labor productivity, and digital technology. Scholars are divided into techno-optimist and techno-pessimists and fight over whether or not digital technology benefits or harm labor productivity (Diermeier and Goecke 2017). According to techno-optimists digital technology has a positive impact on labor productivity. For instance, (Borowiecki et al. 2021) investigate the impact of

digitalization on labor productivity by employing panel data analysis and found that, digital technology has a positive impact on firms' labor productivity.(Xiong and Chen 2022)also researched digital Transformation and Enterprise total factor productivity by using the method of machine learning and concluded that digital technology improves factor productivity. As pointed out by (Arsić 2020)Digitalization has always fueled economic growth, improved standards of living, and opened up avenues to new and better kinds of work. It changing the world of work and reshaping labor markets. There are many opportunities for digital jobs and the wider use of digital tools governments, businesses, and individuals can benefit today from new digital jobs and the use of digital tools. Digital technologies provide the advantage of catching up in diversification, productivity, and complexity, and leapfrogging into advanced technologies and industries for developing countries. Technologies are present for improving access to labor markets and ensuring decent work. (Schulte and Howard 2019)also said, technological change creates abundant opportunities for workers and boosts economies. As technology advanced the way work is done and the number of jobs created has outstripped the number of jobs eliminated.

(No et al. 2019)tried to explain the impact of technology on productivity and employment by using two effects that are, displacement effect and reinstatement effect. To him,technology enables capital to replace labor and reduce labor demand and share of labor in value-added which called as displacement effect. The effect of technology is counterbalanced by the creation of new tasks in which labor has a comparative advantage. The introduction of new tasks changes the content of production in favor of labor because of the reinstatement effect and always raises the labor share and labor demand. Here reduced labor by displacement effect offset by reinstatement effect means digital technology has a positive effect on employment and labor productivity growth.

Empirical studies by (Fagerberg 1995),(Harcourt 1962), and (Abramovitz 1986) have suggested that there is a close correlation between technological advancement and productivity growth. Accordingly country with high innovation activity has high productivity. (Mačiulytė-Šniukienė and Gaile-Sarkane 2014), has also highlighted the importance of digital technology, as it has a broader impact on economic growth through enhancing productivity. As found by(Borowiecki et al. 2021)digitalization positively influences labor productivity, even though its effect slows emerging due to time lag. Pessimists'views techno-pessimists) on the effect of digital technology on labor productivity quarreled that, technology is not without challenges and also it brings risks. According to(States, Africa, and Report 2018), increasing in use of digital technology in the form of AI and automation may reduce the relative cost of production in emerging economies, decreasing the comparative advantage of low-cost labor in those countries and causing unemployment. Even though digital technology brings economic growth, prosperity, and welfare, it can create technological unemployment and job polarization erosion of employment,(Zee 2016) and (Carlaw and Lipsey 2003). Studies by (BBVA 2015); and (WTO 2017)also reveal that digital technology causing mass unemployment, due to machines replacing human labor. Throughout history, technological change has often been a source of anxiety for many workers. In England between 1811 and 1816, a group of workers who called themselves "Luddites" destroyed machinery which they believed was threatening their jobs, especially in cotton and woolen mills. The idea of "technological unemployment" as a new disease was already highlighted by prominent economists like John M. Keynes (in the 1930s) and Wassily Leontief (in the 1950s). Nineteenth-century economists like Karl Marx and David Ricardo also predicted that the mechanization of the economy would worsen conditions for workers, ultimately condemning them to live on a subsistence wage. (Hernandez et al. 2016)have also claimed that such disruptive technologies reduce the demand for labor and put workers at a permanent disadvantage. According to (Nguimkeu and Okou 2021),digitalization has fueled worries about the loss of jobs for less-trained employees in several wealthy nations. Hence, this study aims to examine the role of digital technology on labor productivity of Sub-Saharan Africa by using dynamic panel GMM as it indicated in Fig.1 (conceptual framework).

3. Research Methodology

To analyze therole of digital technology on labor productivity in Sub-Sahara African countries, the study employed a quantitative research approach through the help of the one-step system GMM method of data analysis for the time of 2010- 2020 based on data availability and model suitability.

3.1. Data sources and description

Standardized secondary data on required components were taken from reputable data sources, such as the World development indicators, the World Economic Forum, the African Development Bank, the International Telecommunication Union, The world labor organization,and national reports of countries on the issues and other related sources.

3.1.1 Computing digital technology Index

Digital technology which isan interest explanatory variable has no established aggregate indicator that can be used as its measure As indicated by(Schelenz and Schopp 2018) mostofthe studies either use proxies or compute the digital index. Digital technology indices were computed by using the principal component analysis (PCA) method. The justification for the PCA is that there are many indicators of digital technology which often leads to not knowing which of these indicators best captures digitalization or which is most appropriate for empirical analysis, coupled with the fact that there often exists a high correlation among them. Here digital technology index was constructed from different technological indicators and categorized as, the overall digital index, the digital infrastructure index, the digital usage index, and the digital empowerment index. This Study split digital technology into three pillars such as the Digital Infrastructure Index, the digital usage index, and the digital empowerment index. In addition to the three sub-indices, the overall digital technology index was also constructed from all digital technology indicators by using principal component analysis. To check the validity of the principal component analysis, the Kaiser-Meyer-Olkin (KMO) index was employed. The Kaiser-Meyer-Olkin (KMO) index which is the measure of sampling adequacy test was used to test the validity of the principal component analysis. According to (Ul Hadia, Abdullah, and Sentosa 2016)a value above 0.50 justifies the use of PCA, and the number of components considered in the calculation of the digital index is determined by the Eigenvalue rule

Table 1: The Kaiser-Meyer (KMO) index and Eigenvectors for digital indices

Variables	value			
	Digital Technology index	Digital infrastructure index	Digital usage index	Digital empowerment index
PCA eigenvectors (highest)	3.94	2.285	2.653	1.35
Proportion explained	0.737	0.57	0.53	0.45
Kaiser-Meyer-Olkin	0.6358	0.5913	0.7348	0.5520

Source: own computation, 2022

As shown in Table 1 above all indices have Kaiser-Meyer-Olkin valuesgreater than 0.5 and therefore it is justifiable to employ principal component analysis (PCA) to construct a digital technology index.

3.2. Econometric model specification

The data collected from different reputable sources were analyzed by using an econometric model that is Dynamic panel GMM through employing the Stata version14.2. Among the Dynamic panel GMM model, the one-step system GMM model was used based on its suitability to achieve the required objective. To find a proxy variable for digital technology principal component analysis was employed to calculate the digital technology index. Regarding data presentation different figures, tables, graphs, and others were used.

According to (Gbedjemaiho 2020)and (Roodman 2009),dynamic system GMM is increasingly popular in a situation with small T(time) and large N(individuals).Meaning a few periods and many individuals with independent variables that are not strictly exogenous, indicate that they are correlated with past and possibly current realizations of the error, fixed effects, heteroskedasticity, and autocorrelation within individuals.
In line with the above model justification, dynamic panel GMM is a suitable model to address the required objective of the study. Dynamic panel GMM equation that adopted from(Gbedjemaiho 2020) and (Roodman 2009)is written as follows:

$$lprod_{it=\beta_0} + \beta_1 lprod_{it-1} + \beta_2 Hc_{it} + \beta_3 Inv_{it} + \beta_4 \text{Gdppec}_{it} + \beta_5 Inf_{it} + \beta_6 Fdi_{it} + \beta_6 ggcfx_{it} + \beta_7 INFI_{it} + \beta_8 USAI_{it} + \beta_9 Empi_{it} + \varepsilon_{it} 1$$

Where:

$lprod$= is a dependent variable that is a rate of growth of labor productivity (measured as the ratio of GDP at constant prices to the number of employees).

Hc= Changes in human capital (measured by: the change in the percentage of the
Population ageds 25 to 64 have completed at least upper secondary education).

Inv_{it}=is the share of gross fixed capital formation on GDP

Gdppec_{it}= GDP per capita growth

$ggcfx_{it}$=General government final consumption expenditure, percentage of GDP

Inf_{it}=inflation rate, expressed as the annual average change

Fdi_{it}=foreign direct investment, as net inflows, percentage of GDP

$INFI_{it}$=Digital technology infrastructure index

$USAI_{it}$=Digital technology usage index

$Empi_{it}$=Digital technology empowerment index

4. Findings and discussion

4.1. Descriptive Statistics

In this part of the paper, descriptive statistical tools such as mean, standard deviation, and minimum and maximum values were used to analyze the quantitative data obtained from secondary data sources. As shown in Table 2, the Log of labor productivity has a mean value of 9.257 with a standard deviation of 0.968 and its lag has a mean value of 9.256 and a 0.973 standard deviation. The second explanatory variable that is foreign

direct investment has a mean of 3.657 and a standard deviation of 4.93.The mean and standard deviation of the number of labor's logarithmic distribution are 15.229 and 1.499, respectively.The log of Trade openness has a mean of 20.99 and a standard deviation of 2.103.Another important explanatory variable is the general government's final consumption expenditure which has a mean and standard deviation of 84.243and 15.011 respectively.7.235 mean and 34.355 standard deviations characterize inflation. The GDP per capita is represented in the model by a mean and standard deviation of 8.174 and .872, respectively, whereas the mean and standard deviation for investment are 24.058 and 8.409, respectively. Regarding descriptive statistics results for interest variables which are the overall digital technology index and its three sub-indices; the digital usage index has a mean of -0.4972with 1.158standard deviations. The digital empowerment index exists in the model with 1.030and0.556 mean and standard deviation respectively. The mean and standard deviation of the digital infrastructure index is .004527 and 0.779, respectively. Finally, the model includes the over-digital technology index with a 0.473 mean and 0.617 standard deviations.

Table 2: Descriptive Statistic

Variable	Mean	SD	Min	Max
Labor productivity *	9.257	0.968	7.640	11.658
Lag of Labor productivity *	9.256	0.973	7.479	11.658
Foreign direct investment	3.657	4.93	-11.198	39.456
Number of labor*	15.229	1.499	12.076	17.946
General government finalconsum.exp.	84.243	15.011	31.717	134.55
Trade openness*	20.990	2.103	17.112	37.634
GDP per capita *	8.174	.872	6.496	10.533
Digital infrastructure index*	.004527	.77940	-2.999	2.4030
Digital usage index*	-.4972	1.158	-6.234	2.464
Digital empowerment index*	1.030	.556	-2.83065	-2.830
Overall digital technology index*	.473	.617	-1.139-	2.445
Inflation rate	7.235	34.355	78.562	557.201
Investment	24.058	8.409	5.400	60.807

Source: Prepared by the authors, 2022

(*) refers variable is in natural logarithm

4.2. Empirical Findings and Discussion

The major problem in a panel data specification is the existence of country-specific unobserved heterogeneity. The one-step system GMM estimator is used to control the problem where the lagged values of the dependent and pre-determined variables are included as instruments. However, the instruments' validities are tested using Hansen's statistics test and the second-order autocorrelation test of the disturbance terms. The test results included in table 3 confirm the validity of the instruments used.

Table 3: Empirical results of one-step System GMM on effects of digital technology on labor productivity

Dependent variable: Labor productivity *		
Variables	Coefficient	Std. Err
Lag labor productivity *	0.955***	0.012
Digital technology index	0.021**	0.008
Digital infrastructure index	0.017***	0.005
Digital usage index	0.005**	0.002
Digital empowerment index	-0.004	0.003
Gross fixed capital formation(Inv)	0.001	0.001
General government consumption expenditure	-0.001*	0.001
Trade openness*	-0.002	0.001
Inflation rate	-0.000*	0.000
Foreign direct investment	-0.001**	0.000
Constant	0.568***	0.510
Year dummies		yes
Observations		198
Number of groups		29
AR(1)		0.011
AR(2)		0.637
Hansen		0.280
Number of instruments		28

Source: computed by the authors, 2022

*** p<0.01, ** p<0.05, * p<0.1

As reflected in table 3, the effects of the lag of labor productivity on current labor productivity (0.9547) indicate that a percentage change in a lag of labor productivity is associated witha0.9547% increase in its current year in the short run at 1% significance level on average ceteris paribus in Sub-Saharan African

countries. The result demonstrates also that, when other variables in the study area are held constant, an increase in the digital technology index is related to a 2.08 percent increase in labor productivity in the short run at a 1% significance level in the short run.To see the contribution of digital technology to labor productivity in terms of its pillar,the digital infrastructural index positively predicts labor productivity(0.0170) and shows that change in the infrastructural index leads to a 1.7 percent increase in Sub-Sahara Africa's labor productivity at 1% level of significance in the short run. Similarly,the digital technology usage index has also a positive role in labor productivity (.00459)revealing that an increase in the digital usage index coupled with a 0.459 percent increase in labor productivity at a 5% level of significance in the short run. The conclusion is that, in the short run, digital technology has a favorable impact on Sub-Saharan Africa's labor productivity.

Among controlled explanatory variables general government final consumption expenditure hurts labor productivity (.-.00103) meaning a unit increase in general government final consumption expenditure is associated with 0.103 decreases in labor productivity at a 10% significance level in the short run. This unwanted result of general government expenditure is justified differently by different scholars. For instance (Iwegbunam 2017) found that excessive public capital expenditure might bring the unwanted outcome of government general consumption expenditure.(T. T. Chu, Hölscher, and McCarthy 2020) pointed out that general government expenditure harmsthe economy dueto allocating government spending in favor of non-productive expenditure. Similarly(K. Chu 1995) concludes that undesirable result of government spending is due to Unproductive expenditures that arise because of uncertainties, the lack of a well-trained civil service, inadequate checks and balances in the political and budgetary process, and corruption. From this one can conclude that to have positive effect of general government final consumption expenditure on labor productivity, government spending and allocation should favor towards productive expenditure.

The effect of inflation on Sub-Saharan Africa'slabor productivity was also investigated. As depicted in table 3, a unit rises in inflation level coupled with a 0.027 percentage change in labor productivity in the short run at a 10% level when other things are constant in the region. The finding of this paper is supported by (Akinlo 2005) who found that level of inflation has negatively influenced labor productivity. (Behera 2014)also found that though moderate inflation is good, higher inflation can hurt the economy.
Foreign direct investment has a negative effect (-0.00098) which meansone unit increase in FDI leads to a 0.098 percent decrease in labor productivity at a 5% significance level when other things are constant in the short run in the study area.Even though foreign direct investment (FDI) is becoming increasingly important for the whole economy in terms of investment, employment, and foreign exchange theoretically, the result of this study shows the undesired results.Many studies give justification for this negative influence of FDIon labor productivity in the region. For instance (Kamara 2013)said that problems in human capital and infrastructure development lead to a negative effect of FDI in Sub-Saharan Africa's economy.Similarly (Edrees 2015)also conclude that though FDI is expected to have positive spill-over effects on the economy theoretically, due to poor human capital and infrastructure in the area, FDI hurtsthe development of the region.From the result of this study and other empirical justifications, it is possible to conclude that, the effect of FDI on the economy in general and labor productivity, in particular, depends on the level of human capital and infrastructural development in the region.

As shown in Table 4below, except for inflation all significant explanatory variables in the short run have alsoa significant long-run effect on labor productivity in Sub-Saharan Africa.

Table 4: Long-run coefficient for the significant explanatory variables

Labor productivity *	Coef.	Std. Err.	z	P>|z|
Digital infrastructure index (_nl_1)	0.3648	.085	4.26	0.000
Digital infrastructure index (_nl_1)	0.3765	.0735	5.12	0.000
Digital usage index(_nl_1)	0.1014	.0402	2.52	0.041
Foreign direct investment(_nl_1)	-0.0217	.0106	-2.04	0.041
General government expenditure(_n1_1)	-0.0229	.0088	-2.58	0.010

Source: own computation, 2022

From the long-run estimation result, a unit increase in the digital technology index leads to a 36.48 percent change in labor productivity in Sub-Saharan Africa at a 1% significance level in long run. The result also revealed that a one-unit increase in the digital infrastructure index is associated with a 37.65 percent change in labor productivity of the region at a 1% level of significance in the long run. From the result in table 4 one can see that, an increase in digital index coupled with a 10.14 percent increase in labor productivity of the study area at 5%. Hence this implies that digital technology has both short-run and long-run effects on the labor productivity of Sub-Saharan Africa and the long-run effects are greater than short-run effects as indicated in short-run and long-run coefficients.

In contrast to others, a unit change in foreign direct investment resultedina 2.17 percent reduction in labor productivity in sub-Saharan Africa at a 5% significance level in the long run.When we compare the short-run and long-run effects of foreign direct investment on labor productivity, foreign direct investment has a more long-run effect on labor productivity (-2.17%) than the short-run (-0.098%) in the region.

General government final consumption expenditure hurts the labor productivity of the region in the long run. Here a unit increase in general government expenditure is associated with a 2.29% reduction in labor productivity of the area in the long run. This variable has more long-run (-2.29) than short-run (-.0.103) effects on labor productivity in the region.

5. Conclusion

The findings have a wide range of policy implications. First, the study finds that both in the long run and the short run, digital technology positively predicts labor productivity in Sub-Saharan Africa. In general, the labor productivity of the region is positively affected by digital technology, digital technology infrastructure, and digital usage indices. Hence, there have to be investments in the region's digital technology development to increase its contribution to labor productivity.

Second, the finding showed that general government final consumption expenditure had a considerable adverse effect on the labor productivity of the region and has policy implications that policymakers should play role in improving the productivity of public expenditure and reduce unproductive expenditures that arise because of uncertainties, the lack of a well-trained civil service, inadequate checks and balances in the political and budgetary process, and corruption. From this one can conclude that to the positive effect of general government spending on labor productivity, the allocation should favorproductive expenditure.

Third, the Inflation level has also hurt the labor productivity of the region and has policy implications that call for policy attention regarding inflation in the region.

Finally, the finding shows that foreign direct investment harms the labor productivity of the region due to poor human capital and infrastructural development. This has an important implication for policymakers

that, investment in human capital and infrastructural development can change the effects of foreign direct investment on the labor productivity of the area.

Abbreviations

AR(1) First -order autocorrelation test

AR(2) Second-order autocorrelation test

FDI foreign direct investment

GDP Gross domestic product

GMM Generalized Method of Moments

KMO.The Kaiser-Meyer-Olkin

PCA Principal Component analysis

SSA Sub- Saharan Africa

WTO World Trade Organization

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