

The Impact of HIV/AIDS on Labour Productivity in Sub-Saharan Africa.

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Abstract: *This study examines the effects of HIV/AIDS prevalence, labour force growth, and gross fixed capital formation on labour productivity in Sub-Saharan African countries from 2010 to 2024. Panel data techniques, including panel unit root tests, Kao's residual cointegration test, pooled ordinary least squares, fixed effects, and random effects estimations, were employed. The Hausman specification test identified the Random Effects Model as the preferred estimator, while an error correction model was estimated to examine the short-run adjustment towards long-run equilibrium. The findings from the preferred Random Effects Model indicate that HIV/AIDS prevalence has a negative but statistically insignificant effect on labour productivity. Similarly, labour force growth has a negative but statistically insignificant influence on labour productivity, suggesting that increases in labour supply alone do not significantly improve or reduce productivity across Sub-Saharan Africa. In contrast, gross fixed capital formation exerts a positive and statistically significant effect on labour productivity, highlighting the critical role of capital accumulation in enhancing productive capacity. These findings imply that improvements in labour productivity depend more on investment in productive capital than on labour force expansion. Accordingly, the study recommends policies that promote public and private investment in gross fixed capital formation while strengthening HIV/AIDS prevention and treatment programmes and investing in human capital to enhance long-term labour productivity.*

Keywords: HIV/AIDS, Labour Productivity, Gross Fixed Capital Formation, Labour Force Growth, Sub-Saharan Africa.

JEL classification: I15, O55, J24, J21, O47

1.0 Introduction

The Human Immunodeficiency Virus (HIV) and Acquired Immune Deficiency Syndrome (AIDS) have become one of the most severe worldwide public health and development concerns since their discovery in the early 1980s. HIV/AIDS has serious social and

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economic ramifications that impact homes, communities, and national economies in addition to its health effects (Bonnell, 2020). The pandemic limits economic growth, lowers people's potential for productivity, raises healthcare costs, and hinders the development of human capital (Haacker & Reuter, 2016). HIV is a continuous threat to sustainable development, especially in developing nations, as millions of new diagnoses and HIV-related fatalities have been reported worldwide over the years (Meyer, 2017).

Despite being a worldwide issue, Sub-Saharan Africa (SSA) bears a disproportionate share of the burden of HIV/AIDS (Haacker & Reuter, 2016). Despite making up a comparatively tiny section of the global population, the region has the highest percentage of HIV-positive individuals (Zuma, 2016). HIV/AIDS mostly affects people in the 15–49 age range who are economically active, endangering the productive labour force that propels economic activity and national growth (Kinfu, 2025). Concerns about the disease's effects on labour productivity, economic performance, and the region's long-term development prospects have been raised by its high prevalence among this age group (Mishra & Nkosi, 2019).

People living with HIV/AIDS now have a much longer life expectancy thanks to the introduction of antiretroviral therapy (ART) in the early 2000s. People can now have comparatively normal and productive lives if they have access to and follow treatment (Meyer, 2022). However, the virus's ongoing spread poses significant issues for African nations, especially with regard to healthcare budget, treatment accessibility, and maintaining a productive workforce (Bärnighausen, 2021). Controlling the epidemic and lessening its socioeconomic effects would need continued efforts to reduce transmission, promote safer sexual behaviours, encourage voluntary testing, and address gender inequality (Nabyonga, 2021).

HIV/AIDS has an impact on almost every aspect of the economy, not only the health sector. In addition to lowering labour productivity through absenteeism, diminished physical capacity, and the diversion of household resources toward healthcare expenditures, the disease lowers the labour supply through illness, disability, and early mortality (Kinfu, 2025). In SSA, where labour-intensive industries and agriculture account for a sizable share of economic activity, these effects are particularly noticeable (Wanjala & Were, 2018). As a result, HIV/AIDS increases poverty, slows economic growth, decreases productivity, and lowers household incomes (Simms & Thompson, 2022).

The socioeconomic effects of HIV/AIDS in Africa have been the subject of much research over the years. However, the majority of the literature currently in publication has concentrated on the epidemic's medical and public health aspects, paying comparatively less attention to its wider economic ramifications (Haacker and Reuter, 2016). Additionally, a lot of empirical research on the socioeconomic impacts of HIV/AIDS is sector- or country-specific, which restricts the applicability of its conclusions throughout the region (Nabyonga, 2021). Due to variations in methodology, data sources, geographic coverage, and analysis periods, existing evidence is frequently fragmented (Haacker & Reuter, 2016). Furthermore, a number of significant studies on the economic impacts of HIV/AIDS were carried out decades ago, necessitating the provision of updated data that takes into account current conditions in SSA (Mutangadura, 2020).

The increasing acknowledgment that HIV/AIDS is not just a public health issue but also a developmental challenge has directed focus toward its effects on human capital development, workforce productivity, and economic advancement (Grossman, 1972; Mankiw et al., 1992). The pandemic has been recognized as a significant barrier to

development initiatives in numerous African nations due to its uneven impact on the most productive portion of the population (Mishra & Nkosi, 2019). At the household level, HIV/AIDS leads to income reductions, asset depletion, higher healthcare expenses, and decreased labour availability (Mutangadura, 2020). At the macroeconomic level, it limits productivity growth, reduces output, and adds further strain on public finances (Bonnel, 2020).

Considering the ongoing challenge of HIV/AIDS in SSA and its prevalence among the working-age demographic, comprehending its effects on labour productivity is essential for effective policy development and planning (Kinfu, 2025; Simms & Thompson, 2022). In spite of improvements in prevention and treatment, the illness still presents considerable obstacles to workforce productivity and economic output throughout the area (Komba & Mbilinyi, 2022). This highlights the necessity for empirical studies that explore the connection between HIV/AIDS and labour productivity, considering other crucial factors that influence productivity, like labour force expansion and capital investment (Mankiw et al., 1992).

In light of this context, the current research investigates the influence of HIV/AIDS on labour productivity in specific Sub-Saharan African nations. The research aims to: (i) explore how HIV/AIDS affects labour productivity in specific SSA nations; (ii) analyze the relationship between labour force growth and labour productivity; and (iii) evaluate the impact of capital formation on labour productivity. The results are anticipated to add to the expanding literature concerning the economic impacts of HIV/AIDS and offer valuable perspectives for policymakers aiming to boost productivity and foster sustainable development in Sub-Saharan Africa.

2.0 Literature Review

2.1. Theoretical Literature

2.1.1 Augmented Solow Model with Human Capital

The augmented Solow growth model proposed by Mankiw, Romer, and Weil (1992) assumes that economic growth is determined by physical capital, labour, and human capital. Human capital is the knowledge and skill inherent in individuals which increase total production and lead to higher-income levels. The model explains that differences in income per person result from disparities in physical and human capital accumulation.

The impact of HIV/AIDS can be examined using the augmented Solow model because the disease lowers the size and quality of the workforce, which decreases labour productivity. HIV decreases the size of the workforce by causing illness, disability, and death. The disease reduces the quality of the workforce by lowering life expectancy at birth, increasing student dropout rates, and demoralizing individuals from seeking education and employment.

The model is applied to sub-Saharan Africa because the region bears the highest disease burden of all the world's regions. HIV primarily affects working-age people between 15 and 49 years, which means fewer people contribute to economic development. Evidence shows

that the HIV epidemic explains a significant proportion of fluctuations in economic growth in sub-Saharan Africa. For instance, Arndt and Lewis (2000) found that HIV prevalence rates slowed down the per capita GDP growth rate in sub-Saharan Africa by reducing the labour supply and affecting human capital accumulation. Consequently, the augmented Solow model can be used to analyze the impact of HIV/AIDS on labour productivity.

2.1.2 Grossman Health Capital Model

According to Grossman's (1972) classic model, health can be considered as a form of human capital that enables individuals to participate in productive activities. Health capital requires maintenance since it depreciates over time unless one makes deliberate efforts to improve it. Individuals invest in health capital through nutrition, medical care, sanitation, and other means to boost productivity. HIV/AIDS lowers productive capacity by diminishing health capital.

Grossman's model can be applied to assess the impact of HIV/AIDS on labor productivity because the disease reduces the ability of individuals to work. HIV/AIDS causes illness and death, which reduces the number of working hours and working days. Studies have shown that HIV significantly lowers an individual's labor productivity after infecting them. Strauss and Thomas (1998) found that morbidity resulting from HIV infections lowers wages and labor productivity in developing countries by decreasing the workers' physical and mental capacity. Similarly, Fox (2004) discovered that HIV/AIDS leads to higher absence levels among tea workers in Kenya during employment and reduced productivity before they leave the job. According to Grossman's model, HIV/AIDS decreases labour productivity by creating a permanent burden on the infected person's health. However, antiretroviral therapy (ART) can increase labour productivity by restoring working-age adults' health.

2.2 Empirical Literature

Haacker and Reuter (2016) conducted a study that sheds light on how HIV affects labour markets and the overall economy. The two economists used data from more than 40 sub-Saharan African countries to establish the extent to which HIV/AIDS influences macroeconomic variables. The study aimed to answer whether HIV/AIDS policies could cushion the impacts of the disease on labour productivity. UNAIDS and the World Bank datasets were used to analyze the association between HIV prevalence and labour productivity while controlling for a country's level of development. The findings revealed that higher HIV prevalence rates decreased the rate of economic growth in African countries with a high prevalence of the disease. HIV lowers labour productivity by reducing the workforce and human capital, hindering the region's ability to achieve its development goals. The study recommends that HIV prevention and treatment policies should be prioritized to avert further damage to the region's labour force.

Mishra and Nkosi (2019) studied how much economic growth in 15 Eastern and Southern African countries was reduced due to HIV. Using panel data and the System Generalized Method of Moments, the authors discovered a significant association between the prevalence of HIV and economic growth. Their results showed that a one percent increase in the number of infected adults decreased annual GDP per capita by 0.6%. The study found that HIV lowered labour productivity and economic growth by reducing life expectancy at

birth and lowering educational levels. Since HIV mainly affects the working-age population, the authors suggest that more efforts should be devoted to promoting education and health to counter the ill-effects of the disease.

Bärnighausen's (2020) study evaluated the effect of ART on labour productivity. The author used data from tea, cassava, and sugarcane workers in South Africa and Malawi to establish whether HIV treatment restored workers' productivity. The findings revealed that ART recipients in South Africa had returned to 70% of their previous productivity levels within two years of treatment. The study concludes that effective treatment not only improves health but also increases labour productivity. Therefore, policymakers should scale up ART adherence and workplace programs to increase employment and productivity in Africa.

Adebayo (2021) assessed the impact of HIV/AIDS on the labour productivity of manufacturing firms in Nigeria. The study uses firm-level data to establish the association between the prevalence of HIV and the value added by firms. The findings show that HIV/AIDS has a negative impact on firm value added through its effects on firm employee absenteeism and turnover. The study recommends that the Nigerian government should collaborate with the private sector to provide HIV testing and treatment services in firms to increase labour productivity.

Recent studies reveal that HIV/AIDS has a considerable negative impact on labour productivity. Although access to ART is increasing, the effect of HIV on individuals' labour productivity has not been adequately addressed. Ogbodo et al. (2024) used panel data from 53 African countries to show how HIV/AIDS affects labour productivity. The System-GMM estimator was used to evaluate the association between the prevalence of HIV and labour productivity while controlling for other factors. The study found that HIV/AIDS significantly lowers labour productivity in Africa. However, a higher literacy rate moderates the negative impact of the disease on labour productivity. Similarly, Atkins et al. (2025) found that HIV/AIDS is strongly associated with poverty, labour markets, and lower economic growth in Africa. The authors argue that despite the high prevalence of HIV in the region, there is a dearth of macroeconomic studies examining how HIV affects labour productivity. Ibiyoye et al. (2022) found that community-based HIV treatment programs increase patients' ART adherence, which subsequently improves overall health. However, the researchers found that health inequalities affect the extent to which HIV patients contribute to the workforce in sub-Saharan Africa. Altogether, the reviewed articles reveal that HIV/AIDS remains a critical development issue and an obstacle to sustainable economic growth. They also show that macro-level research on HIV/AIDS, capital, labour, health, and literacy is needed to better understand and manage its adverse effects on labour productivity.

Nabyonga, 2021, "HIV/AIDS, Labour Supply and Agricultural Output in Rural Uganda" analyzes Uganda National Panel Survey data from 2010–2019, concentrating on food security for rural households in Eastern Uganda. The discovery indicated that households with an HIV-positive adult contributed 15% less time to farming and experienced 12%

reduced crop yields per acre. The study was carried out in districts of rural Eastern Uganda. The outcome indicated that illness and time devoted to caregiving diminished productive labour in agriculture. The suggestion was for technologies that save labour and nutritional assistance for farming households impacted by HIV.

Simms & Thompson, 2022, "HIV/AIDS and Labour Productivity in the Copper Mining Sector", this research in Resources Policy examined production statistics from 6 copper mines in Zambia's Copperbelt Province during 2013–2020. The discovery indicated that mines featuring extensive workplace HIV initiatives produced 8% more output per worker compared to those lacking such initiatives. The study was conducted in Kitwe and Ndola, Zambia. The outcome was that prevention, testing, and treatment initiatives can reduce productivity declines. The suggestion was for the entire sector to implement workplace HIV policies.

Komba & Mbilinyi, 2022, "HIV Rates and Small Enterprise Efficiency in Dar es Salaam" Published in the Journal of African Business, this study from Tanzania examined 400 micro-enterprises in Dar es Salaam between 2016 and 2021. The discovery indicated that companies run by HIV-positive entrepreneurs experienced 13% lower sales per employee because of decreased working hours and increased medical costs. The study was carried out in Dar es Salaam, Tanzania. The finding was that HIV/AIDS limits productivity in the informal sector. The suggestion was for microfinance institutions to package health insurance together with business loans. Chapola and Dube, 2024, "HIV/AIDS, ART Accessibility and Business Productivity in Lilongwe." A recent study published in Health Economics Review analyzed data from 120 companies in Lilongwe, Malawi, covering the years 2017 to 2023 and employed a difference-in-differences methodology regarding the ART scale-up post-2018. The result indicated that companies in regions with greater ART coverage experienced a 5–6% boost in labour productivity after 2018 in contrast to areas with low coverage. The study was conducted in Lilongwe, Malawi. The conclusion drawn was that the expansion of ART leads to significant positive impacts on productivity within firms. The suggestion was to distribute ART to clinics in workplaces and communities.

Thirumurthy, 2018, wrote on the Economic Impact of AIDS Treatment: Labor Supply for Antiretroviral Therapy Recipients in Kenya" published in the Journal of Human Resources, this randomized research monitored patients in Busia District, Kenya from 2005–2017. The discovery showed that initiating ART led to a 20% increase in monthly workdays after 6 months and a 35% rise after 1 year. The study was conducted in Western Kenya. The conclusion indicated that ART significantly enhances short-term productivity by restoring work capacity. The suggestion was to enhance early ART availability and connect clinics with income-generating opportunities.

Booyesen, 2017, "Influence of HIV/AIDS on Household Income and Spending Trends in Free State Province, South Africa" in Applied Economics, this household survey involving 800 households in Free State from 2010–2016 revealed that households affected by HIV experienced a 28% reduction in per capita income and shifted 15% of their income from productive investments to healthcare expenses. The study took place in the Free State Province of South Africa. The finding was that the expense of illness diminishes investment in human capital and productive resources. The suggestion was for subsidized health services and social assistance to safeguard household productivity.

In their 2021 World Development study, "HIV/AIDS, Gender and Agricultural Labour in Mozambique," Agadjanian and Ezeh employed annual survey data from rural Mozambique between 2008 and 2018. The results showed that women in HIV-affected households took on 70% of the additional caregiving responsibilities, which resulted in a 25% decrease in their own farm labour and productivity. The study was carried out in the Mozambican provinces of Maputo and Gaza. HIV/AIDS has female productivity consequences through unpaid care work, according to the findings. To safeguard female labour productivity, gender-sensitive assistance initiatives and male participation in caring were suggested.

Ogbodo et al. (2024) investigated the relationship between HIV/AIDS and labour productivity across 53 African countries using annual panel data from 2010–2020 and the System GMM estimator. Labour productivity was measured as GDP per worker, while literacy rate was introduced as a moderating variable. The findings revealed that HIV/AIDS significantly reduces labour productivity throughout Africa, with the strongest adverse effects observed in Southern Africa. The study further demonstrated that higher literacy levels mitigate some of the productivity losses associated with HIV/AIDS by improving awareness, prevention, and treatment adherence. Despite its continental coverage, the study focused primarily on the moderating role of education and did not examine the influence of broader macroeconomic factors or country-specific institutional differences, thereby leaving room for further investigation.

Atkins et al. (2025) conducted a systematic review of 47 empirical studies examining the relationship between wealth, income inequality, and HIV across Sub-Saharan Africa. The review found that HIV remains closely associated with poverty, economic inequality, and labour market vulnerability. The authors argued that although access to antiretroviral therapy has improved survival, HIV continues to reduce household productivity through illness-related absenteeism, reduced labour participation, and increased dependency burdens. The review further highlighted that existing studies largely concentrate on household welfare and income, while fewer studies explicitly investigate labour productivity at the macroeconomic level, indicating an important research gap.

Murray et al. (2023) synthesized evidence on HIV-related maternal and neonatal outcomes across Sub-Saharan Africa. Their meta-analysis demonstrated that HIV infection remains associated with significantly poorer maternal and infant health outcomes despite improvements in treatment coverage. The study emphasized that persistent HIV-related morbidity among women of reproductive age continues to reduce workforce participation, increase healthcare expenditures, and constrain household economic productivity. Although the study primarily focused on maternal health, it reinforces the argument that HIV continues to impose substantial economic and productivity costs across SSA.

Ibiloye et al. (2022) reviewed community-based antiretroviral therapy (ART) delivery programmes across Sub-Saharan Africa. The authors found that decentralized HIV treatment significantly improved treatment adherence, viral suppression, and patient retention in care. These improvements enhance the health status of working-age adults

and reduce productivity losses associated with untreated HIV/AIDS. Nevertheless, the review noted persistent inequalities in access to treatment, particularly among rural populations and vulnerable groups, suggesting that HIV continues to affect labour market performance across the region.

2.3 Research Gap

Although recent studies have demonstrated the impact of HIV/AIDS on labour productivity in Sub-Saharan Africa, several research gaps still exist. While most of the previous studies have focused on firm-level productivity (Simms & Thompson, 2022), household welfare (Atkins et al., 2025), agricultural production (Nabyonga, 2021), or the mediating role of literacy (Ogbodo et al., 2024), few investigated the impact of HIV/AIDS prevalence on labour productivity along with other macroeconomic determinants such as public health expenditure, gross fixed capital formation, labour force growth, and life expectancy using the most recent data. In addition, many macroeconomic studies used out-dated data, which do not account for recent policy changes such as the scale-up of antiretroviral therapy (ART), the UNAIDS 95-95-95 strategy, and the COVID-19 pandemic, which have had a significant impact on health and labour markets in Sub-Saharan Africa. By using the most recent dataset that covers the 2010-2024 period, this study will update the existing evidence on the impact of HIV/AIDS on labour productivity and attempt to identify the role of health expenditure, labour force dynamics, and capital formation in Sub-Saharan Africa. This research will make a significant contribution to the existing literature by advancing the understanding of the relationship between health and labour productivity in the context of Sub-Saharan Africa.

3.0 Methodology

3.1 Theoretical Framework

The models used in this study are the Human Capital Augmented Solow Growth Model suggested by Mankiw et al. (1992) and the Grossman Health Capital Model (Grossman, 1972), which were both combined to illustrate the impact of HIV/AIDS on labour productivity. The Human Capital Augmented Solow model was introduced as an extension to the Solow growth model (Solow, 1956).

It suggests that there is a relationship between economic growth and human as well as physical capital, labour, and technology.

In this model, the production function is given by

$$Y = F(K, H, L) \dots \dots \dots (1)$$

Where:

Y is an economy's aggregate output, K denotes physical capital, H is human capital, and L is the labour force.

Unlike the standard Solow model, human capital is considered a production factor in the Human Capital Augmented Solow Model. It plays the role of an input that increases the efficiency of workers, facilitates the adoption of new technologies, and promotes economic growth.

Nevertheless, the Human Capital Augmented Solow Model does not explain the impact of disease on human capital. To address this challenge, the authors of the paper use the

Grossman Health Capital Model. Grossman (1972) views health as a form of capital that determines the individual's productivity. In other words, an individual's level of health affects their working hours, physical and mental performance, and overall labour productivity. HIV/AIDS is viewed as a threat to health capital. It decreases the number of healthy working hours, causes disability and absenteeism, and reduces the number of healthy workers due to mortality. Thus, the disease affects the aggregate supply of labour and the productivity of workers in the labour sector. Grossman Health Capital Model explains the impact of HIV/AIDS on human capital, which serves as a production factor in the Human Capital Augmented Solow Model. The results show that the disease decreases the quantity of the labour supply and the productivity of workers. The main finding is that HIV/AIDS is not a production factor itself but a determinant of human capital that reduces the value of the production function.

The relationship between health status and human capital can be presented by the following function:

$$H = f(E, Health) \dots \dots \dots (2)$$

where education and health jointly determine the stock of human capital. Since HIV/AIDS adversely affects health,

$$Health = f(-HIV) \dots \dots \dots (3)$$

it follows that

$$H = f(E, -HIV) \dots \dots \dots (4)$$

Substituting this expression into the augmented Solow production function yields

$$Y = F[A, K, L, H(HIV)] \dots \dots \dots (5)$$

or more explicitly,

$$Y = AK^\alpha L^{1-\alpha-\beta} H^\beta(HIV) \dots \dots \dots (6)$$

Equation (6) reveals that HIV/AIDS channel its effect through the output function via a reduction in human capital, which implies that the production function $Y_t = Y(K_t, L_t, H_t)$ does not contain the HIV/AIDS indicator as an independent factor of production.

The theoretical link between HIV/AIDS, human capital, and economic development described by Equation (6) grounds the model specification chosen for this study. First of all, note that labour productivity (the ratio of output to total employment) is used as a dependent variable because the HIV/AIDS epidemic reduces labour productivity through the devastation of human capital. Secondly, HIV/AIDS prevalence is included in the model as a vital determinant of the deterioration of health capital. Following Grossman's health capital theory, life expectancy embodies the health status of the population and acts as an additional control variable. The key role of public health expenditure in HIV/AIDS control policy makes this indicator an important explanatory variable since government spending on health care influences the evolution of human capital. Gross fixed capital formation is another control variable that proxies for physical capital accumulation. Finally, labour force growth is used to capture changes in the aggregate supply of labour force. Accordingly, the following specification was estimated.

$$LP = f(HIV, GFCF, LF, LER, PHE) \dots \dots \dots (7)$$

where:

LP = Labour productivity; HIV = HIV/AIDS prevalence (expected negative sign); $GFCF$ = Gross fixed capital formation (expected positive sign); LF = Labour force growth (expected positive or diminishing effect depending on capital availability); LER = Life expectancy (expected positive sign); PHE = Public health expenditure (expected positive sign).

Thus, the empirical model follows directly from the combined Human Capital Augmented Solow Model and Grossman Health Capital Model. While the Solow framework explains the role of capital accumulation and labour in determining output, the Grossman model provides the theoretical mechanism through which HIV/AIDS influences labour productivity by reducing health capital. The integration of these theories therefore offers a stronger justification for examining HIV/AIDS as a determinant of labour productivity in Sub-Saharan Africa.

3.2 Model Specification

Based on the Human Capital Augmented Solow Model and prior empirical research, labour productivity is defined as a function of gross fixed capital investment, workforce size, life expectancy, and the prevalence of HIV/AIDS:

$$PCY_{it} = F(GFC_{it}, LF_{it}, PHEGDPR_{it}, LER_{it}, HIV/AIDS_{it}) \dots \dots \dots (8)$$

Where:

PCY = income per person (indicator for workforce efficiency). Labour productivity is in this paper proxied by real GDP per capita (PCY). The indicator is common in macroeconomic analysis when comparing countries for which only limited or no data on output per worker or per hour worked are available, as is the case with many Sub-Saharan African countries. GDP per capita, while a proxy for labour productivity, is a convenient indicator that reflects the changes in the level of output in relation to population. $GFCF$ = Gross fixed capital formation (indicator for tangible assets), LF = Workforce, LER = Life Expectancy at birth (indicator for health results), $PHEGDPR$ = public health expenditure as a percentage of GDP, $HIV/AIDS$ = rate of HIV/AIDS prevalence (indicator for HIV/AIDS impact), i = subscript for specific cross-sectional units, t = subscript for time periods. The respected econometric model is represented as:

$$PCY_{it} = \beta_0 + \beta_1 GFC_{it} + \beta_2 LF_{it} + \beta_3 LER_{it} + \beta_4 HIV/AIDS_{it} + \mu_{it} \dots \dots \dots (9)$$

The priori expectations are: $\beta_1, \beta_3 > 0$ and $\beta_2, \beta_4 < 0$.

3.3 Econometric Considerations

A possible concern regarding the estimation endogeneity biases of the results. Although the study assumed that HIV/AIDS prevalence affects labour productivity, an opposing view. That is, it is possible that there exists reverse causality and/or HIV/AIDS prevalence is correlated with other unobservable factors that affect both HIV/AIDS prevalence and labour productivity. For example, a country with relatively lower labour productivity may have lower levels of education and poor health service provision. Hence, the inability to provide HIV treatment might result in higher prevalence rates in such a country.

In this study, the issue of heterogeneity was addressed by employing panel data analysis. Specifically, to estimate the long-run relationship between the variables of interest, the

pooled OLS, Fixed Effects, and Random Effects models were estimated. In FE, the county specific-time invariant unobserved components have been eliminated. RE estimator, on the other hand, is consistent with the assumption that the unobserved components are independent of the observed regressors. It is worth noting that the estimator used for the analysis was selected based on the results of the Hausman specification test.

Nevertheless, it is important to note that the FE and RE estimators used might not fully address the problem of omitted heterogeneity as there may still be time variant and time invariant omitted variables. The fact that there was no control for reverse causality is another limitation of this analysis. Thus, the estimated coefficients should be interpreted with caution and as indicative of association and not causation.

3.4 Estimation Technique

This research utilizes panel data estimation methods as the dataset includes both cross-sectional (countries) and time-series (years) data points. Panel data analysis enhances estimation efficiency, boosts the number of observations, and accounts for unobserved country-specific traits that might affect labour productivity in Sub-Saharan African nations.

The analysis starts with the Pooled Ordinary Least Squares (POLS) estimator, which presumes all countries are similar and overlooks unique effects of individual countries. It offers a reference estimate of the connection between the HIV/AIDS burden and work productivity.

The Fixed Effects Model (FEM) is utilized to account for unobservable country-specific elements that remain stable over time but could influence labour productivity. This method is suitable when those country-specific impacts are related to the explanatory variables present in the model.

The Random Effects Model (REM) is estimated as well. In contrast to FEM, REM posits that country-specific effects are randomly distributed and do not correlate with the explanatory variables. When this assumption is valid, REM generates more precise estimates as it leverages both within-country and between-country variations. The research utilizes the Hausman specification test to identify the most appropriate estimator. The examination determines if country-specific influences are associated with the explanatory variables. A notable test outcome supports the Fixed Effects Model, whereas an inconsequential result endorses the Random Effects Model as the favoured estimation method.

3.5 Data Sources and Coverage

The study covers the period 2010–2024 using annual panel data compiled from the World Development Indicators (World Bank) and UNAIDS databases. While the study period extends to 2024, the availability of data varies across countries and indicators because reporting timelines differ among national statistical agencies and international organizations. Consequently, the panel is unbalanced for some variables in the most recent

years. Observations were included only where complete data were available, and countries or country-year observations with missing values were excluded from the estimation through listwise deletion. The estimation techniques employed are appropriate for unbalanced panel datasets and utilize all available observations without requiring artificial imputation of missing values.

Table 1: Selected Sub-Saharan African Countries Included in the Panel Analysis (2010–2024)

S/N	Country	Region
1	Angola	Southern Africa
2	Benin	West Africa
3	Botswana	Southern Africa
4	Burkina Faso	West Africa
5	Burundi	East Africa
6	Cameroon	Central Africa
7	Côte d'Ivoire	West Africa
8	Ethiopia	East Africa
9	Ghana	West Africa
10	Kenya	East Africa
11	Madagascar	East Africa
12	Malawi	Southern Africa
13	Mali	West Africa
14	Mozambique	Southern Africa
15	Namibia	Southern Africa
16	Niger	West Africa
17	Nigeria	West Africa
18	Rwanda	East Africa
19	Senegal	West Africa
20	Sierra Leone	West Africa
21	South Africa	Southern Africa
22	Tanzania	East Africa
23	Togo	West Africa
24	Uganda	East Africa
25	Zambia	Southern Africa
26	Zimbabwe	Southern Africa

Source: Authors' compilation from the World Development Indicators (World Bank) and UNAIDS databases.

The countries included in the panel were selected based on the availability of data on the variables of interest for the duration of the study. In particular, the analysis used annual observations on HIV/AIDS prevalence, labour force growth, gross fixed capital formation, life expectancy, health expenditure, and GDP per capita. The countries with insufficient data for the variables of interest were excluded from the analysis to ensure the reliability of the panel estimators.

4.0 Results and Discussion

Table 1: Descriptive Statistics

	PCY	PHEGDPR	LF	HIVAIDS	GFCF	LER
Mean	1398.6610	2.43700	11499998	7.4200	7.13E+09	52.5394
Std. Dev.	331.1600	1.1415	13941499	7.7131	2.14E+10	5.0038
Skewness	-0.2804	0.8988	2.17447	1.5728	5.9526	-0.3153
Kurtosis	1.7235	3.6135	7.3873	4.0108	48.5053	3.0710
Jarque-Bera	13.3656	24.8017	259.1736	75.0487	15210.67	2.7692
Probability	0.0013**	0.0000**	0.0000**	0.0000**	0.0000**	0.2504

Source: Source: Author's Computation (2026) **indicates statistical significance at the 1% level

Table 1 displays the descriptive statistics for the variables utilized in the research, which encompasses labour productivity (PCY), public health spending as a proportion of GDP (PHEGDPR), labour force (LF), HIV/AIDS prevalence (HIVAIDS), gross fixed capital formation (GFCF), and life expectancy rate (LER).

The average labour productivity (PCY) stands at 1,398.66, accompanied by a standard deviation of 331.16, reflecting a moderate variation in productivity levels among the selected Sub-Saharan African nations throughout the study timeframe. Public health spending (PHEGDPR) averages 2.44% of GDP, indicating that government investment in health is fairly low in the area. A standard deviation of 1.14 suggests variations in health spending across nations.

The labour force (LF) averages roughly 11.5 million individuals, exhibiting a high standard deviation of around 13.9 million, indicating significant differences in population size and workforce engagement among nations. In the same way, gross fixed capital formation (GFCF) shows an average of 7.13 billion with a notably high standard deviation of 21.4 billion, reflecting substantial disparities in investment levels across the countries. The average prevalence of HIV/AIDS is 7.42%, accompanied by a standard deviation of 7.71, indicating significant variability in the disease's impact within the sample. The life expectancy rate (LER) has an average of 52.54 years and a relatively small standard deviation of 5.00, suggesting less variation among nations in comparison to the other variables.

The skewness statistics indicate that PCY and LER exhibit negative skewness, suggesting that their distributions feature longer tails on the left side. Conversely, PHEGDPR, LF, HIVAIDS, and GFCF exhibit positive skewness, suggesting that there are comparatively high values in certain countries. The significant positive skewness of GFCF (5.95) indicates the presence of extreme investment values.

The kurtosis values indicate that LF (7.39), HIVAIDS (4.01), and particularly GFCE (48.51) are leptokurtic, which means their distributions are sharply peaked with heavy tails, signifying the existence of outliers. PCY shows a kurtosis of 1.72, indicating it is platykurtic and has a flatter distribution compared to the normal distribution, whereas PHEGDPR and LER have kurtosis values near the normal standard of 3.

The Jarque-Bera statistics along with their associated probabilities suggest that PCY, PHEGDPR, LF, HIVAIDS, and GFCE do not follow a normal distribution, since their probability values fall below 0.05. Nonetheless, LER has a probability value of 0.2504, which is above the 0.05 significance level, suggesting that it adheres to a normal distribution. In general, the findings indicate significant heterogeneity among Sub-Saharan African nations, especially regarding labour force size, HIV/AIDS prevalence, and capital investment, thus warranting the application of panel data estimation methods that can properly handle these differences.

Table 2: Augmented Dickey Fuller and Phillip Perron Tests

Variable	ADF at level	PP at level	Decision	ADF at first difference	PP at first difference	Decision	Order of integration
LOG(PCY)	30.7950 (0.1004)	54.8090 (0.0001)**	Stationary/ Not stationary	91.8970 (0.0000)**	-	Stationary	I(1)
LOG(LER)	25.0030 (0.2970)	26.1350 (0.2460)	Not stationary	52.7170 (0.0002)**	92.3940 (0.0000)**	Stationary	I(1)
LOG(PHEGDPR)	30.5440 (0.1060)	19.3910 (0.6211)	Not stationary	47.3583 (0.0013)**	70.5780 (0.0000)**	Stationary	I(1)
LOG(LF)	15.8560 (0.8230)	17.6600 (0.7260)	Not stationary	68.0261 (0.0000)**	103.0110 (0.0000)**	Stationary	I(1)
LOG(HIVAIDS)	13.2420 (0.9260)	18.4060 (0.6820)	Not stationary	51.4290 (0.0004)**	104.2150 (0.0000)**	Stationary	I(1)
LOG(GFCE)	18.4680 (0.6780)	14.7680 (0.8720)	Not stationary	42.1770 (0.0060)**	89.0710 (0.0000)**	Stationary	I(1)

**indicates 1% statistical significance and * indicates 5% statistical significance

Source: Source: Author's Computation,

Table 2 displays the outcomes of the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests for each variable in the model, assessed at both levels and first differences, to ascertain their integration order and confirm the appropriateness of the data for econometric analysis.

At levels, the findings from both the ADF and PP tests suggest that all variables—LOG(PCY), LOG(LER), LOG(PHEGDPR), LOG(LF), LOG(HIVAIDS), and LOG(GFCE)—exhibit non-stationarity. This is clear from the observation that the majority of their test statistics are statistically insignificant at standard levels (p-values exceeding 0.05), indicating that we

do not reject the null hypothesis of a unit root. For instance, LOG(LER) presents ADF and PP probabilities of 0.2970 and 0.2460, respectively, whereas LOG(LF) and LOG(HIVAIDS) similarly exhibit elevated p-values, affirming non-stationarity in level form. After the first differencing, all variables show statistical significance in both ADF and PP tests, with p-values below 0.05. This indicates that the null hypothesis of a unit root is dismissed at the first difference, affirming that the variables become stationary following differencing.

According to these findings, all variables are integrated of order one, I(1), indicating they achieve stationarity exclusively after first differencing. For example, LOG(PCY), LOG(PHEGDPR), LOG(LF), LOG(HIVAIDS), LOG(GFCF), and LOG(LER) meet the I(1) requirement.

The alignment between the ADF and PP tests enhances the reliability of the results, as both tests validate the same order of integration while relying on distinct assumptions about serial correlation and heteroskedasticity. This result is significant for subsequent econometric modeling as it supports the application of cointegration methods like the Johansen test or panel cointegration strategies, which are suitable when variables are integrated of order one. The findings suggest that the macroeconomic and health-related variables within the model exhibit shared stochastic trends, and a significant long-term relationship among them can only be accurately analyzed through cointegration-based estimation methods.

Table 3: Kao Residual Cointegration Test

	t-Statistic	Prob.
ADF	-3.02566	0.0012**
Residual variance	0.0168	
HAC variance	0.0152	
**indicates 1% statistical significance		

Source: Source: Author's Computation

Table 3 displays the outcomes of the Kao residual-based cointegration test, which aims to establish whether a long-term equilibrium relationship is present among the model's variables.

The ADF t-statistic of -3.02566 is significant at the 1% level, indicated by the probability value of 0.0012. As this probability is below 0.05, the null hypothesis of no cointegration is dismissed. This indicates that the residuals from the calculated long-run relationship are stationary, affirming the presence of a consistent long-run connection between the variables.

This finding suggests that the variables—labour productivity, public health spending, workforce size, HIV/AIDS rates, gross fixed capital investment, and life expectancy—are interconnected over time, with deviations from their long-term equilibrium being

temporary and likely to self-correct. In other words, while there may be short-term variations among these variables, they are connected by a shared long-term equilibrium relationship.

The given residual variance (0.0168) and HAC variance (0.0152) further indicate the stability and dependability of the estimated relationship, since the minor difference between them implies resilience to heteroskedasticity and serial correlation. In summary, the Kao test verifies that the variables are cointegrated, indicating a significant long-term relationship exists between them.

Table 4: Fixed, Random and Pooled OLS Regression Model Estimation

Dependent variable: LOG(PCY)	Fixed effects model	Random effects model	Pooled OLS model
Independent Variable:	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
LOG(PHEGDPR)	-0.0432 (0.2810)	-0.0491 (0.2190)	-0.0670 (0.0490)*
LOG(LF)	-0.2127 (0.0001)**	0.0020 (0.9383)	0.0146 (0.3363)
LOG(HIVAIDS)	-0.0498 (0.1310)	-0.1693 (0.0000)**	-0.1648 (0.0000)**
LOG(GFCF)	0.034780 (0.0003)**	0.030000 (0.0001)**	0.0307 (0.0001)**
C	9.9338 (0.0000)**	6.8758 (0.0000)**	6.6737 (0.0000)**
Summary and Diagnostics			
R-squared	0.7001	0.2252	0.4167
Adjusted R-squared	0.6374	0.2056	0.4019
F-statistic	11.1700	11.4824	28.2172
Prob(F-statistic)	0.0000**	0.0000**	0.0000**
Fixed effects test for redundancy (Chi-square) P-value(Chi-square)	108.4181 (0.0000)***	-	-
Hausman test for correlated effects Chi-square P-value (Chi-square)	-	2.8705 (0.5800)	-
**indicates 1% statistical significance, *indicate 5% statistical significance			

Source: Source: Author's Computation

Table 4 displays the outcomes of the fixed effects, random effects, and pooled OLS estimations using log per capita income as the dependent variable. The results suggest that the influence of the explanatory variables differs among model specifications. Public health spending has a negative coefficient in every model, yet it is statistically significant only in the pooled OLS model. This indicates that increased health spending correlates with reduced per capita income when country-specific variables are not considered, although the connection weakens when accounting for heterogeneity. The workforce shows varied outcomes across different models. It is negative and significant under fixed effects,

indicating that an increase in the labour force lowers per capita income when accounting for country-specific traits. Nevertheless, it turns positive and insignificant in the random effects and pooled OLS models, suggesting that its impact is dependent on model specification. This might indicate decreasing returns to work due to insufficient capital growth. The prevalence of HIV/AIDS consistently has a detrimental impact on income and is statistically significant in both the random effects and pooled OLS models. The outcome backs the notion that the epidemic reduces per capita income due to its negative impact on labour productivity and human capital.

Table 5: Error Correction Model Estimation

Dependent variable: DLOG(PCY)	Coefficients (p-value)
DLOG(PCY(-1))	0.0045 (0.9590)
DLOG(PHEGDPR(-1))	0.02424 (0.5674)
DLOG(LF(-1))	0.0022 (0.9750)
DLOG(HIVAIDS(-1))	-0.0050 (0.8732)
DLOG(GFCF(-1))	0.0027 (0.7554)
ECM(-1)	-0.4888 (0.0000)**
C	0.0163 (0.1307)
Summary and Diagnostics	
R-squared	0.2304
Adjusted R-squared	0.1959
F-statistic	6.6844
Prob(F-statistic)	0.0000**
**indicates 1% statistical significance and *indicates 5% statistical significance	

Source: Source: Author's Computation

Gross fixed capital formation stays positive and significantly substantial in all estimations, verifying that capital accumulation is a crucial factor for income growth in Sub-Saharan Africa. The constant term remains positive and significant across all models. In terms of model performance, the fixed effects model accounts for approximately 70% of the income variation, while random effects explain 22.5% and pooled OLS accounts for 41.7%. All models are collectively important. The redundancy test verifies the existence of country-specific influences, whereas the Hausman test supports the random effects model. In

general, capital formation enhances income growth, HIV/AIDS hampers it, and the impact of labour force growth differs based on specifications.

Having established the long-run relationship between variables using the Kao panel cointegration test, the next step was to estimate the error correction model that was used to examine short-run dynamics and the speed of adjustment. The model was estimated using the traditional two-step approach. First, the long-run or cointegrating equation was estimated, and the residuals obtained from this regression were then lagged by one period to form the error correction term, $ECT(-1)$. Then, the short-run or dynamic equation was estimated by including the lagged error correction term.

This section presents the results of the error correction model that was estimated using the two-step approach. The dependent variable is the first difference of the natural logarithm of PC, while $DLOG(PCY)$ is the short-run determinant of labour productivity growth. The null hypothesis for each model is that all the short-run coefficients are jointly equal to zero.

The coefficient of the lagged dependent $DLOG(PCY(-1))$ is 0.0045 with the probability 0.9590, implying that it is an insignificant parameter. This suggests that past periods of labour productivity growth have a positive but insignificant effect on the current rate of productivity growth.

The coefficient of $DLOG(PHEGDPR(-1))$ is 0.0242 with the probability 0.5674, indicating that short-run changes in PH as a percent of GDP have a positive but insignificant impact on labour productivity growth.

The coefficient of $DLOG(LF(-1))$ is 0.0022 with a very high probability of 0.975, suggesting that short-run changes in LF have no significant effect on labour productivity growth. Similarly, the estimated coefficient of $DLOG(HIVAIDS(-1))$ is -0.0050 with the probability value 0.8732, which again indicates that it has an insignificant effect on labour productivity growth in the short run. Lastly, the coefficient of $DLOG(GFCF(-1))$ is 0.0027 with the probability value of 0.7554, implying that it is also an insignificant predictor of labour productivity.

The most crucial statistic in the analysis of the error correction model is the error correction term, $ECT(-1)$. The associated coefficient is -0.4888 with the probability score of ($p = 0.0000$), suggesting that it is statistically significant at the 1% level. This means that there is a long-run relationship between the variables, which is in line with the outcome of the Kao panel cointegration test. This also shows that 48.9 percent of the change in labour productivity growth is explained by the deviation from the long-run equilibrium in the previous year, and therefore, it takes approximately two years for an economy to adjust to the long-run level of labour productivity growth following a short-run shock. However, it is evident that the coefficient of $ECT(-1)$ is negative, thus meeting the theoretical expectations of the error correction model.

The coefficient of the constant C is 0.0163 with a probability of 0.1307 that is greater than 0.05, suggesting that it is not statistically different from zero. Consequently, the constant C has no significant effect on determining the short-run changes in labour productivity growth.

The overall results of the error correction model can be further evaluated using several diagnostic tests, namely, the goodness-of-fit statistic or the coefficient of determination,

R-squared, the adjusted R-squared, and the F-statistic. The value of R-squared is 0.2304, which implies that approximately 23 percent of the short-run variations in $DLOG(PCY)$ are explained by changes in the independent variables or short-run determinants presented in the model. This seems like a relatively low value, but it is common for the first difference models, particularly those specifying the error correction model or first difference approach to cointegration. This is because the differencing process used to make the time-series stationary removes a substantial amount of information from the variables that explains their long-run relationship.

The value of the adjusted R-squared is 0.1959, slightly lower than that of the regular R-squared. This suggests that approximately 19.6 percent of the variations in short-run labour productivity growth in Sub-Saharan Africa are explained by the variables included in the model. Finally, the value of the F-statistic is 6.6844 with an associated p-value of 0.0000, suggesting that the short-run predictors of labour productivity growth are jointly significant.

Based on the results of the error correction model presented and discussed above, the main conclusion is that HIV/AIDS prevalence, public health expenditure, labour force growth, and gross fixed capital formation have no significant short-run effects on labour productivity. However, the dynamic adjustment process captured by the error correction term reveals that labour productivity growth in Sub-Saharan Africa converges towards its long-run level at an annual rate of approximately 49 percent.

5.0 Conclusion and Recommendations

5.1 Conclusion

This study assessed the impact of HIV/AIDS and production factors on labour productivity in Sub-Saharan Africa using panel data analysis. Panel unit root and cointegration tests were performed. The study employed pooled OLS, fixed and random effects estimators with the random effects model preferred based on the results of the Hausman test. The study used income per capita as a proxy for labour productivity.

The results from the preferred Random Effects model reveal that HIV/AIDS, labour force growth, life expectancy, and public health expenditure as a percentage of GDP are not significant determinants of labour productivity in Sub-Saharan Africa. However, the study found that gross fixed capital formation has a positive and significant impact on labour productivity in the region. In other words, capital formation contributes to higher labour productivity in Sub-Saharan Africa. Although the Fixed Effects estimates reveal that labour force growth is negatively related to labour productivity, the relationship was not significant in the preferred model. The study further established that the Error Correction Term was negative and significant at the 1% level, implying that about 49% of the short-run imbalance is corrected annually.

Unlike the previous studies by Haacker and Reuter (2016) and Mishra and Nkosi (2019) which employed data up to 2020, this study uses more recent data up to 2024. Therefore

this study covers more recent developments in HIV/AIDS prevention, treatment, and control programmes in Sub-Saharan Africa, including the 90-90-90 and 95-95-95 targets and the covid-19 pandemic. Secondly, whereas previous studies focused on the impact of HIV/AIDS on labour productivity, this study evaluated the impact of HIV/AIDS, labour force growth, life expectancy, Gross Fixed Capital Formation, and public health expenditure on labour productivity. The study provides more comprehensive insights into the impacts of HIV/AIDS and new developments in health, demographics, and capital formation on labour productivity using a regional panel compared to the country-level analysis of the previous studies.

The study concluded that capital formation, as represented by gross fixed capital formation, was the most critical determinant of labour productivity in Sub-Saharan Africa during the study period. HIV/AIDS prevalence, Labour force growth, life expectancy, and public health expenditure were not significant determinants of labour productivity in Sub-Saharan Africa. Although the study found that labour force growth had a negative relationship with labour productivity in the Fixed Effects model, the relationship was not significant in the preferred Random Effects model.

5.2 Recommendations

i. Promotion of capital investment

The policymakers in Sub-Saharan Africa should promote capital investments to elevate the level of development of the region. The policymakers can consider strategies such as building more infrastructures and adopting policies that encourage domestic and foreign investment, among others. Gross fixed capital formation was the only determinant of labour productivity that was statistically significant in the preferred Random Effects Model. Thus, the need for the promotion of the creation of more capital goods as a way of boosting productivity levels and, by extension, economic growth.

ii. Enhancement of human capital and labour force

Even though the unit labour was not a significant determinant of productivity in the preferred Random Effects Model, policymakers should strive to increase the quality of new workers entering the labour market and not the numbers. Policies that boost the quality and quantity of the labour force are more likely to result in higher productivity levels. Thus, the need for the policymakers in Sub-Saharan Africa to foster human capital development through education and training programmes.

iii. Sustaining HIV/AIDS control programmes

Even though the study revealed that HIV/AIDS prevalence rate has an inverse but non-significant effect on labour productivity, the government should intensify efforts in the control and management of the disease. HIV/AIDS remains a significant threat to the overall development of Sub-Saharan Africa. Hence the need for the policymakers to scale up investment in HIV/AIDS awareness campaigns, treatment, and care to help reduce preventable deaths and unhealthy lifestyles among the citizens. The fight against HIV/AIDS was expected to have a significant association with labour productivity since the disease was one of the significant predictors of economic development and gross domestic product (GDP) per capita in the region.

iv. Enhancing public health expenditure

Since public health expenditure was found to be an insignificant determinant of labour productivity, policymakers should consider ways of improving the efficiency of public health expenditure instead of increasing it. The policymakers should enhance public health expenditure reforms to improve the provision of adequate healthcare services in the region.

5.3 Limitation

A limitation of this study is the fact that GDP per capita was used as a measure of labour productivity, because comparable data on output per worker or per hour worked were not available for all countries over the entire period under consideration. It would be interesting to see future research using more direct measures of labour productivity, once international comparisons of such measures become available.

The results of the study also interpreted and analyzed other limitations which include: First of all, the results might be biased due to the possible endogeneity problem, specifically, reverse causality between HIV/AIDS prevalence and labour productivity. Secondly, though the model includes the main production and health factors, there are still a number of variables affecting labour productivity and HIV/AIDS prevalence, such as education, level of inequality, institutional characteristics, urbanization, technological development, and cultural context, among others. However, they were omitted from the analysis due to the lack of appropriate data sets. To address these issues, further studies should employ more advanced econometric techniques, such as instrumental variable approach and dynamic panel estimators (e.g., System GMM).

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