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HUMAN CAPITAL, FINANCIAL DEEPENING AND INDUSTRIAL GROWTH IN SUB-SAHARAN AFRICA

[1]Adeyemi, P.A.[*] (Ph. D); [1]Oyesola T.A. (M.Sc.); [1]Ajayi M.O. (M.Sc.); [1]Akinbiola F.V. (Ph. D); [2]Ilori O.O. (Ph. D); [3]Oluyemi, B. (Ph. D); [4]Awe, F.D. (Ph. D)

[1] Department of Economics, Ekiti State University, Ado-Ekiti, Nigeria.

[2] Department of Accounting and Finance, Augustine University, Ilara-Epe, Lagos State, Nigeria.

[3] Department of Economics, Afe Babalola University, Ado-Ekiti.

[4] Department of Economics, Bamidele Olumilua University of Education, Science and Technology, Ikere-Ekiti.

***Corresponding author**: Adeyemi, P.A.; Email: paul.adeyemi@eksu.edu.ng

Abstract

This study examined the relationship between financial deepening, human capital and industrial outputs in sub-Saharan African countries. Specifically, the study investigated the effect of human capital and financial deepening on industrial output in sub-Saharan Africa. Data used covered 20 sub-Saharan African countries over the period from the year 1995 to 2025. The study employed Driscoll-Kraay estimation technique to capture the stated objective, with Panel Corrected Standard Errors (PCSEs) estimation for the robustness. The result reveals that human capital has significant negative effect on industrial output. The result also reveals that bank credit to private sector exerts positive but insignificant effect on industrial output. Additionally, the result for HK*BC, meaning that interaction between human capital and bank credit to private sector has significant negative effect on industrial output. This result therefore indicates that financial deepening measured as bank credit to private sector increases the negative effect of human capital on industrial output, thus confirming that financial deepening exhibit significant negative moderating effect on the relationship between human capital and industrial output across Sub-Saharan Africa". The study, therefore, concludes that negative interaction effect between human capital and financial deepening implies that greater financial deepening weakens the contribution of human capital to industrial output in Sub-Saharan Africa. In line with the finding of this study, it was recommended that government should ensure that financial sector reforms relating to deeper access to credit are implemented alongside strategies aimed at improving workforce productivity in order to address inadequacy in human capital so as to stimulate industrial output.

Keywords: Human Capital, Financial Deepening, Industrial Output and Driscoll-Kraay Estimation Technique.

1.0 INTRODUCTION

Financial deepening plays a central role in promoting economic growth by acting as a key transmission mechanism through which human capital development becomes industrial output. Consequently, it has

attracted substantial interest worldwide from economists and policymakers. Within the context of Sub-Saharan Africa (SSA), growing attention has been directed to the interaction among human capital, financial deepening, and industrial output, driven by the region's development challenges and opportunities. Human capital development refers to the "deliberate enhancement of the mental and intellectual capabilities of the human labor workforce, encompassing human-related characteristics such as skills, intelligence, experience, emotional capacity, knowledge, human relations, and management(Schultz, 1960; Adeyemi & Ogunsola, 2019). Financial deepening is also essential for strengthening a country's industrialization process (Ogundajo et.al,2024). However, the impact of financial development on economic outcomes may differ across countries depending on the quality of their human resources. In particular, countries with high-quality human capital stocks gain more from the financial sector because having abundant scientists, engineers, researchers, lawyers, managers, accountants, medical doctors, and financial analysts across diverse fields supports more effective and efficient decision-making among alternative financial options.

In the SSA framework, the measurement of human capital and financial deepening faces limitations because it often relies on narrow indicators. For example, primary school enrollment rates are used as measures of human capital, while the ratio of broad money to GDP is commonly used for financial deepening, yet these approaches fail to reflect the multidimensional nature of these constructs (Hanuskek and Woessmann, 2008). Moreover, the quality of education, health care services, access to well-developed formal financial services, stock market development, and the efficiency of financial intermediation are inadequately represented by traditional proxy variables, even though these factors are key determinants of industrial output. To address these gaps, this study will use broader indicators, including institutional quality, gross capital formation, and infrastructure.

The persistently high levels of youth unemployment in the region contribute to poverty and income inequality, which emphasizes the need for inclusive industrialization. In addition, the region shows meaningful differences in access to quality education, health care, and financial services, further obstructing the linkages among human capital, financial deepening, and industrial output. Limited access to credit facilities, the lack of infrastructural facilities, and inadequate financial institutions intensify the difficulties faced by industrial firms. Furthermore, the labor force's limited ability to adopt and implement modern industrial techniques constrains productivity growth and technological advancement. These challenges point to the need for a comprehensive analysis of how human capital and financial deepening interact to influence industrial output in Sub-Saharan Africa.

Despite the widely recognized importance of human capital and financial deepening for economic development, SSA countries continue to record relatively low levels of industrial output. The region's share of global manufacturing value added (MVA) remains stagnant at around 2% since 1990, and industrial productivity continues to lag far behind the global average (UNIDO, 2022, AFDB, 2022). This industrial stagnation coexists with persistently low investment in education and training, limited access to formal financial services, and insufficient development of capital markets..

In the literature, most studies treat human capital, finance, and industrial output in isolation rather than jointly over the time (1995-2025) horizon and the few studies that combine these three variables came up with mixed results as a result of context matters and measures used in their studies. The studies like (Popoola

et al., 2019, Olarenwaju *et al.,* 2021, Saka & Olanipekun, 2021, Ihensekhien & Sorweli, 2023 and Okeke & Elegbede (2024)) worked on the relationship between human capital and Industrial Output. Many studies such as (Ighoroje & Okoroyibo,2022, Suleiman et.al, 2024, Manasseh et.al, 2024 and Ogundajo et. al, 2024) were also carried out on the relationship between financial deepening and industrial growth) while the only few studies like (Alenoghena et. al., 2025) that combined three variables in single empirical study and the work did include some vital variables such as institutional quality, gross capital formation and infrastructure that can engender robust results". It is against this background that this study intends to fill these gaps. The rest of the paper is organised as follows: section two is on literature review. Section three presents the methodology, while section four discusses the results. Section five concludes and makes recommendations.

2.0 Empirical Literature

Popoola and colleagues (2018) investigated "human capital channels and productivity growth in Nigeria from 1980 to 2017 by using the Vector Error Correction model to assess both joint short- and long-run causality and the long-run behaviour of human capital channels on productivity. Their joint short- and long-run causality results show that there is no long-run causation. Adeyemi and Oladipo (2020) conduct a panel data analysis of the effects of human capital over 2000–2017. Using the Driscoll–Kraay robust standard errors estimator to control for cross-sectional dependence, they report that secondary school enrolment rates and health expenditure have positive and statistically significant effects on manufacturing productivity, whereas primary school enrolment rates are statistically insignificant. This outcome aligns with the theoretical claim that the skills needed to participate in modern manufacturing production are obtained mainly at the secondary and tertiary education levels. Olarewaju et al. (2021) assessed how human capital affects manufacturing value-added in Nigerian firms using Spearman correlation, finding that human capital significantly influences industrial output.

Nkoa (2018) examines the determinants of industrial performance in sub-Saharan Africa by analysing panel data for 48 countries over 1980–2015. He finds that financial development—proxied by private sector credit as a percentage of GDP—has a positive and statistically significant effect on manufacturing value-added, and that the magnitude of this effect grows with the quality of institutions and the extent of trade openness. This result supports the complementarity hypothesis: the growth gains from financial deepening for industrial output are greater in economies with stronger institutional arrangements that strengthen the rule of law, safeguard property rights, and ensure contract enforcement.

Using Nigeria as a case study, Ihensekhien and Soriweli (2023) investigate the relationship between human capital and industrial sector growth from 1986 to 2020. They apply an Autoregressive Distributed Lag approach and find that the government's recurrent education investment negatively and significantly affects industrial sector growth in the short run, but has a positive and statistically significant long-run effect. They also find that government health expenditure is positive and statistically significant in the short run, while in the long run it is negative and statistically insignificant. Saka and Olanipekun (2021) report that industrialisation positively affects economic growth in Nigeria over 1980–2016 using two-stage least squares. Olarewaju et al. (2021) further examine the impact of human capital on manufacturing value-added in Nigerian firms and, through Spearman correlation, show that formal training, high school education, and research significantly affect industrial production. Okeke and Elegbede (2024) use multiple linear

regressions to examine the effects of human capital development, employee coaching, and career support on organizational commitment among employees at Union Bank Plc Lagos, Nigeria. The study concludes that human capital development and employee coaching do not significantly affect organizational commitment, whereas career development has a significant effect on organizational commitment..

Adegbie et al. (2021) used an Autoregressive Distributed Lag model to show that financial deepening—driven by expanded credit to the private sector and the development of capital markets—significantly affected Nigeria's economic growth, especially in non-oil sectors such as agriculture and manufacturing. Igboroje and Okoroyibo (2022) likewise applied an Autoregressive Distributed Lag model to examine the link between financial deepening and economic development in Nigeria, using data from 1987 to 2018. Their results indicated that the ratio of money supply, the ratio of private sector credit to GDP, and the ratio of gross national saving to GDP all have a positive relationship with economic development in Nigeria. Elizabeth (2022) employed an Autoregressive Distributed Lag model and a Granger Causality test to assess the relationship between financial sector development and industrialization in Tanzania using annual data from 1990 to 2020. The Autoregressive Distributed Lag model results found a significant positive relationship between private sector credit and industrial value-added, while broad money had a significant negative effect. The Granger Causality test further showed bidirectional causality between domestic credit extended to the private sector and industrial value-added.

Ogundipe and Olayemi (2024) conducted an Ordinary Least Squares regression analysis to evaluate the performance of the banking sector in Nigeria during the COVID-19 pandemic. They concluded that the sector remained resilient despite the crisis, with digital banking and mobile financial services enabling essential continuity for businesses and individuals. The study also stressed that financial institutions need to address challenges related to credit risk management and capital adequacy in order to play a stronger role in Nigeria's post-pandemic recovery.

Suleiman et al. (2024) used a Vector Autoregression model to investigate the relationship between financial intermediation and economic development in Nigeria. The study relied on several indicators of financial intermediation, including bank assets to GDP, market capitalization to GDP, pension assets to GDP, and the real exchange rate, to evaluate their effects on human development outcomes. The findings showed that financial intermediation has a significant association with multiple dimensions of human development in Nigeria.

Manasseh et al. (2024) applied a Fully Modified Ordinary Least Squares approach and a dynamic Ordinary Least Squares framework to explore the nexus between financial deepening and economic growth in emerging African economies. The study reported bidirectional causality between domestic credit to the private sector, the money supply ratio, trade openness, and gross domestic product per capita, while indicating unidirectional causality running from capital formation to gross domestic product per capita. Ogundajo et al. (2024) employed multiple linear regression to assess how financial deepening and institutional factors affect industrial value-added in Sub-Saharan Africa. The study's results showed that both financial development and institutional quality positively influenced industrial value-added..

3.0 Methodology

3.1 Model Specification

This study relies on the Financial Intermediation Theory and Endogenous Growth Model. The theoretical relationship between financial development and output growth and by extension, industrial output has been extensively theorised, dating back to the classic works of Bagehot (1873) and Schumpeter (1911). Bagehot identified the role of the London financial markets in mobilising capital for the industrial investments that drove the British industrial revolution, while Schumpeter emphasised the role of bank credit in enabling entrepreneurs to redirect productive resources toward new technologies and business ventures, thereby driving innovation-led output growth. The theoretical model underlying the empirical specification draws on the financial intermediation theory and the endogenous growth framework of Lucas (1988), adapted for the industrial output context following the approach of Nkoa (2018) and Adeyemi and Oladipo (2020). The industrial production function takes the following general form:

IND = f(HK, FD, HK × FD, X)----------3.1

Where IND denotes industrial output (manufacturing value added as a percentage of GDP), HK denotes human capital development, FD denotes financial deepening measured in terms of bank credit to private sector (BC), HK × BC denotes the interaction term between human capital and financial deepening, and X denotes a vector of control variables including trade openness, infrastructure, institutional quality, foreign direct investment, and gross capital formation. Therefore, the modified model for this study is specified below:

$$IND = f(HK, BC, H * BC, TOP, INFRS, INQ, FDI, GCF) - - - - - - - - - - - - - 3.2$$

Explicitly, it can be restated as follows:

$$IND_{it} = \alpha_0 + \alpha_1 HK_{it} + \alpha_2 BC_{it} + \alpha_3 (HK * BC)_{it} + \alpha_4 TOP_{it} + \alpha_5 INFRS_{it} + \alpha_6 INQ_{it} + \alpha_7 FDI_{it} + \alpha_8 GCF_{it} + \varepsilon_{it} - 3.3$$

Where:

IND=Industrial output (in terms of manufacturing output as % of GDP)

HK=Human Capital (in terms of human capital index HCI+)

BC=Bank credit to private sector (a measure of financial deepening)

TOP=Trade openness

INFRS= Infrastructure (in terms of access to electricity)

FDI=Foreign direct investment

INQ=institutional quality (in terms of average index of the six governance indicators)

GCF=Gross capital formation

3.2 Estimation Techniques

The nature of the study requires that panel data regression analysis. The panel procedure starts from the panel unit root test, as all the variables must be tested for stationarity. The study employed Peseran's second generation panel unit root test and Westerlund (2007) cointegration analysis because of the presence of a cross-sectional dependence test. To address the presence of cross-sectional dependence, the study made use of Driscoll-Kraay estimation as the main estimation technique, followed by panel corrected standard error (PCSE) estimation technique as the robustness estimator to examine the interactive effect of human capital and financial deepening on industrial growth in Sub-Saharan Africa.

3.3 Sources of Data

The data for this study were secondary in nature and sourced from World Bank Development Indicator and IMF database

4.0 Results and Discussion

This section presents the cross-sectional dependence test, panel unit root test, cointegration analysis and Discroll-Kraay estimation technique.

4.1 Cross-sectional dependence test

Table 4.1: Cross-sectional Dependence Test Result

Variable	CD-test	P-value	Average joint T	Mean p	Mean abs(p)
IND	-2.9	0.004	31	-0.04	0.40
HK	7.804	0.000	31	0.10	0.56
BC	45.923	0.000	31	0.60	0.60
TOP	6.1	0.000	31	0.08	0.35
INFRS	68.373	0.000	31	0.89	0.89
INQ	52.759	0.000	31	0.69	0.69
FDI	6.213	0.000	31	0.08	0.21
GCF	8.954	0.000	31	0.11	0.30

Source: *Author's Computation (2026)*

Result of Cross-sectional dependence test in Table 4.1 reveals CD-test statistics and probability of -2.9 ($p < 0.05$) for IND, 7.804 ($p < 0.05$) for HK, 45.923 ($p < 0.05$) for BC, 6.1($p < 0.05$) for TOP, 68.373 ($p < 0.05$) INFR, 52.759 ($p < 0.05$) for INQ, 6.213 ($p < 0.05$) for FDI as well as 8.954 ($p< 0.05$) for GCF. The result reveals that industrial output, human capital, bank credit to the private sector, trade openness, infrastructure, institutional quality, foreign direct investment, and gross capital formation exhibit significant cross-sectional independence, indicating the presence of common shocks across panel units for all the variables employed in this study. Hence, the need to engage estimation results that account for cross-sectional dependence in the panels.

4.2 Panel Unit Root Test

Table 4.2: Pesaran's CADF Test Result

	Level			**First Difference**			I(d)
Variables	T-bar	Z[t-bar]	P-value	T-bar	Z[t-bar]	P-value	I(d)
IND	-2.251	-2.286	0.001	-	-	-	I(0)
HK	-1.314	-2.167	0.985	-2.467	-3.305	0.000	I(1)
BC	-2.223	-2.155	0.016	-	-	-	I(0)
TOP	-1.443	1.544	0.940	-4.355	-12.012	0.000	I(1)
INFRS	-1.973	-0.965	0.167	-4.969	-14.842	0.000	I(1)
INQ	-1.969	-0.945	0.172	-5.026	-15.104	0.000	I(1)
FDI	-2.495	-3.450	0.000				I(0)

GCF	-1.566	0.944	0.828	-4.489	-12.306	0.000	I(1)

Source: *Author's Computation (2026)*

Table 4.2 presents Pesaran's CADF test result for industrial output, bank credit to private sector, human capital, trade openness, infrastructure, institutional quality, foreign direct investment, and gross capital formation. The result shows that the Z(t-bar) statistics are statistically significant ($p < 0.05$) at level for industrial output, bank credit to the private sector and foreign direct investment, leading to the rejection of the null hypothesis of unit root. Hence, the result shows that industrial output, bank credit to the private sector and foreign direct investment, are stationary at level, that is integrated of order zero, I(0). The result also shows Z(t-bar) statistics are not statistically significant ($p > 0.05$) at level for human capital, trade openness, infrastructure, institutional quality and gross capital formation, but Z(t-bar) statistics of these variables are statistically significant at first difference. Therefore, the result demonstrates that human capital, trade openness, infrastructure, institutional quality and gross capital formation are not stationary at level, but at first difference and these variables are integrated of order one, I(1).

4.2 Panel Cointegration Test

Table 4.7: Westerlund Co-integration Test Result

	Statistics	**P-value**
Variance ratio	1.3007	0.0967

Source: *Author's Computation (2026)*

The result in Table 4.7 presents the Westerlund variance ratio test for panel cointegration, conducted to examine the existence of a long-run relationship among the variables in Model 1. The result shows a variance ratio statistic of 1.3007 with a probability value of 0.0967. Since the probability value is greater than 0.05, the null hypothesis of no cointegration is not rejected, indicating that cointegration does not exist among industrial output, bank credit o private sector, trade openness, infrastructure, institutional quality, foreign direct investment" and gross capital formation.

4.3 Main Estimation

Table 4.3: Driscroll-Kraay Estimation Result

Variables	**Coeff.**	**Std. Err**	**T-stat**	**Prob**
C	17.08434	1.591532	10.73	0.000
HK	**-.0365585**	**.0069821**	**-5.24**	**0.000**
BC	.0033114	.0090966	0.36	0.718
HK*BC	**-.0044739**	**.0003883**	**-11.52**	**0.000**
TOP	-.0115476	.0119838	-0.96	0.343
INFR	.0478959	.0044639	10.73	0.000
INQ	-.84918	.315467	-2.69	0.012
FDI	.1306022	.0636148	2.05	0.049
GCF	-.1574554	.0230113	-6.84	0.000
R-squared = 0.6218 F(8, 30) = 371.99 F-prob = 0.0000				

Source: *Author's Computation (2026)*

Table 4.3 shows the result of the Driscoll–Kraay estimator to determine the role of financial deepening (in terms of bank credit to private sector) on relationship between "human capital and industrial output in sub-Sahara Africa. Specifically, the result reveals coefficient and probability of -0.0365585 and 0.000 ($p < 0.05$) for HK, indicating that human capital has significant negative effect on industrial output. The result also reveals that bank credit to private sector exerts positive but insignificant effect on industrial output based on the coefficient and probability of 0.0033114 and 0.718 ($p > 0.05$) for BC. Additionally, the result shows coefficient and probability of -0.0044739 and 0.000 ($p < 0.05$) for HK*BC, meaning that interaction between human capital and bank credit to private sector has significant negative effect on industrial output. This result therefore indicates that financial deepening measured as bank credit to private sector increases the negative effect of human capital on industrial output, thus confirming that financial deepening exhibit significant negative moderating effect on the relationship between human capital and industrial output across Sub-Saharan Africa. Reported R-squared statistics of 0.6218 reflects that about 62.18% of the systematic variation in industrial output is explained by variation in human capital, bank credit to private sector, interaction of human capital and bank credit to private sector, and control variables (trade openness, infrastructure, institutional quality, foreign direct investment, and gross fixed capital formation).

4.4 Estimation Results

Table 4.4: Panel Corrected Standard Error (PCSE)

Variables	Coeff.	Std. Err	T-stat	Prob
C	17.08434	1.633794	10.46	0.000
HK	**-.0365585**	**.0077607**	**-4.71**	**0.000**
BC	.0033114	.0088265	0.38	0.708
HK*BC	**-.0044739**	**.004237**	**-10.56**	**0.000**
TOP	-.0115476	.0072715	-1.59	0.112
INFR	.0478959	.0051491	9.30	0.000
INQ	-.84918	.1876068	-4.53	0.000
FDI	.1306022	.0436542	2.99	0.003
GCF	-.1574554	.0223067	-7.06	0.000
Squared = 0.6418 Wald chi2(6) = 524.03 Prob > chi2 = 0.0000				

Source: *Author's Computation (2026)*

Table 4.4 depicts the result of the Panel Corrected Standard Error (PCSE) estimator to test robustness of Driscoll-Kraay estimation. Particularly, the result reveals coefficient and probability of -0.0365585 and 0.000 ($p < 0.05$) for HK, indicating that human capital has significant negative effect on industrial output. The result also reveals that bank credit to private sector exerts positive but insignificant effect on industrial output based on the coefficient and probability of 0.0033114 and 0.708 ($p > 0.05$) for BC. Additionally, the result shows coefficient and probability of -0.0044739 and 0.000 ($p < 0.05$) for HK*BC, meaning that interaction between human capital and bank credit to private sector has significant negative effect on

industrial output and hence, indicates that financial deepening measured as bank credit to private sector worsen the negative effect of human capital on industrial output. Reported R-squared statistics of 0.6418 reflects that about 64.18% of the systematic variation in industrial output is explained by variation in human capital, bank credit to private sector, interaction of human capital and bank credit o private sector, and control variables (trade openness, infrastructure, institutional quality, foreign direct investment, and gross fixed capital formation). Nevertheless, the Wald chi-square statistic of 524.03 ($p = 0.000 < 0.05$) indicates that the overall model is statistically significant. Importantly, the results in terms of coefficients are similar to those of the Driscoll-Kraay method establishing robustness in the result.

5.0 Conclusion and Recommendations

This study examined the relationship between financial deepening, human capital and industrial outputs in sub-Saharan African countries. The result reveals that human capital has significant negative effect on industrial output. The result also reveals that bank credit to private sector exerts positive but insignificant effect on industrial output. Additionally, the result for HK*BC, meaning that interaction between human capital and bank credit to private sector has significant negative effect on industrial output. This result therefore indicates that financial deepening measured as bank credit to private sector increases the negative effect of human capital on industrial output, thus confirming that financial deepening exhibit significant negative moderating effect on the relationship between human capital and industrial output across Sub-Saharan Africa". The study, therefore, concludes that negative interaction effect between human capital and financial deepening implies that greater financial deepening weakens the contribution of human capital to industrial output in Sub-Saharan Africa. In line with the finding of this study, it was recommended that government should ensure that financial sector reforms relating to deeper access to credit are implemented alongside strategies aimed at improving workforce productivity in order to address inadequacy in human capital and stimulates industrial output.

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