Labour Productivity and Health Capital in Nigeria: The Empirical Evidence

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Abstract

This paper attempts to analyze the labour productivity effects of health capital in Nigeria. The GMM methodology was adopted in the estimation having tested for unit root and possible co-integration. We find that health capital investment is a significant determinant of labour productivity. Evident from the hypotheses the null hypothesis of an insignificant impact of health capital investment on labour productivity in Nigeria is vehemently invalidated on the basis of a significant Wald coefficient. The analysis indicates that health capital investment enhances productivity of the labour force. Given that Nigeria is a highly labour-intensive economy, importance must be accorded to having a healthier workforce in order to maximize productivity. Another essential finding in the study lies in the statistical significance of the education-labour and health capital-labour interaction terms. The Nigerian government has to build capacity through investment in education in order to enhance productivity of the labour force. This would protect the economy from further negative trends in productivity growth.

Key Words: Labour productivity, Labour-intensive, Health-labour force, Health capital, Nigeria

1. Introduction

A country's capability to improve its national output growth over time depends almost entirely on the size of its labour force. This in turn propels the country's productive capacity and hence raises productivity (Qaisar and Foreman-Peck, 2007). In Nigeria, labour productivity growth has been unsatisfactory. Indeed, there is a huge decline in GDP per worker over the years, this implies low GDP per person in the country. Nigeria's productivity growth dividend opportunity is very significant (OECD, 2008). However, the country has several challenges to realizing such a productivity dividend [Bloom and Humair (2010)]. According to the World Bank Report (2009), labour productivity in Nigeria is persistently low. Labour productivity recorded an average growth rate of 1.2 percent from 2000 to 2008. This average is below the rate of 1.9 percent recorded in the sub-Saharan African countries, 2 percent in low income countries as a whole, 1.7 percent in Ghana, and 2.2 percent in Cameroon [World Bank (2009)]. Table **1** below shows the regional analysis of labour productivity growth measured as growth in real GDP per worker.

Table 1: Percentage Share of Regions in Labour Productivity, World Profile (1987-2008)

Region(s)	Labour Productivity		Comparative Labour Productivity Level to US, PPP Adjusted
	1987-1995	**1995-2007**	**2008**
World	0.7	1.9	28
Western Europe	1.9	1.2	69
North America	1.3	2.1	98
Oceania	1.5	1.8	74
East Europe	-5.2	4.1	24
Asia	3.5	3.1	16
Latin America	0.3	0.6	28
Middle East	0.0	0.6	28
Africa	-1.1	1.3	6.0

Source: OECD (2008)

The regional analysis evidently shows differences in labour productivity growth across the regions of Western Europe, North America, Oceania, East Europe, Asia, Latin America, Middle East and Africa. Much significant disparity in the productivity of the labour force exists between the advanced and developing worlds. Interestingly, labour productivity decline is very high, even negative for Africa in some years. A detailed examination of the percentage shares reveals that the productivity of the labour force is higher in Western Europe than that of Latin America, Middle East and Africa. As it can be seen in Table 1, labour productivity growth in the former is almost twice higher than in the later. Prevalence of redundant labour, low income growth, lack of training, low level of technology, low level of capacity utilization, low investment expenditures, and poor performing infrastructure are critical factors, amongst others that are responsible for low productivity of the labour force in Africa (Mordi and Mmieh, 2008).

Nigeria has a population of 152.5 million, of which 33 percent constitute the labour force (Population Reference Bureau, 2009). The labour force is an asset in its capability to enhance productivity and growth (Nigeria Vision, 2020). Moreover, the health capital of an economy plays a critical role in a country's economic advancement. This is because it affects not only the well being of the citizenry, but also the level of productivity and hence growth. For example; due to longer life, healthy individuals may be inclined to accumulate savings than individuals in poor health. Higher savings as a proportion of national income increases investment prospects and may therefore lead to higher national output. In essence therefore, dramatic reduction in life expectancy affects the labour force and hence labour productivity in addition to the allied potential lasting adverse effects on growth particularly within the Nigerian economy. The justification for the role of health capital in the productivity of the labour force derives mainly from the convergence hypothesis [Chakraborty (2004)].

The convergence hypothesis states that an economy with a high rate of survival (measured by many years of life expectancy) will converge faster to steady-state growth paths. Health capital is a major source of wealth. This corroborates the saying that a healthier-nation is a wealthier-nation [Contoyannis and Forster (1999)]. By implication, ill-health has adverse effects on national savings (capital accumulation) and productivity of the labour force. Indeed, health improvements can influence the pace of income growth via their effects on labour market participation, workers' productivity, and increased savings [Bloom and Canning (2000), Bloom et al. (2001)]. In view of the foregoing, our task is to investigate empirically the labour productivity effects of health capital in Nigeria. By unraveling this task, the paper exhibits some policy significance. In the pursuit of the research objective, we tested the hypothesis that health capital investment does not stimulate labour productivity in Nigeria. The paper is organized into six sections. Section one is this introduction while section two reviews the country's profile of labour productivity, labour market and health capital. Section three is devoted to the empirical review of the link between health capital and labour productivity. In section four, the empirical model, methodology and data issues are discussed. The analysis of empirical results is taken up in section five. Section six concludes paper.

2. Nigeria's Profile of Labour Productivity and Health Outcomes

Nigerian Labour Market: Situation Analysis

Following the structural adjustment programmes, the Nigerian labour market underwent problems of unemployment, public sector down-sizing, low employment generation capacity, government contradictory discretionary policies and a sort of mismatch between labour demand and supply. The demand for labour is derived from production and distribution activities in the goods and services sectors. As a result, its size and shape are sensitive to what happens in the national economy [Bloom and Humair (2010)]. However, available data on the Nigerian labour market indicates that the demand for labour has been poor and volatile at best. As a result, majority of workers are engaged in the informal economy [Iwayemi and Jerome (1995)]. An analysis of the Nigerian labour force by sector shows that the service sector accounted for an estimated 24.4 percent of gross domestic product and employed 20 percent of labour in 2007. While industry accounted for 48.8 percent of gross domestic product and employed only 10 percent of the labour force, agriculture employed 70 percent of the labour force and contributed only 26.8 percent to GDP (Table **2)**. Recently, the Nigerian labour force is estimated to be 50.13million [CIA World Fact Book (2009)]. This seemingly qualifies it as the largest workforce in Africa. However, most of the Nigerian labour force is lost to brain drain as the country ranked 112 out of a total of 134 in the just concluded global brain drain analysis (Table **3)**.

Table 2: Percentage Distributions of the Nigerian Labour Force and GDP Composition by Sector, 2007

Sectors	Labour Force Composition by Sector (%)	GDP Composition by Sector (%)
Agriculture	70	26.8
Service	20	24.4
Industry	10	48.8

Source: CIA World Fact Book (2010)

Table 3: Global Competitiveness Index: Nigerian Labour Market Efficiency

Labour Market Efficiency	Score	Rank/134
Pay and Productivity	4.0	86
Brain Drain	2.5	112
Non-Wage Labour Costs (% Workers Salary)	9.0	28
Flexibility of Wage Determination	5.5	37
Co-operation in Labour-Employer Relations	4.5	67
Rigidity of Employment Index	7.0	8
Female-to-Male Participation Ratio in Labour Force	0.5	112

Source: EIU, CIA World Fact Book, UN, Transparency International (2010)

In a comparative analysis of the growth rates of the working-age and non-working-age population, UN World Population Prospects (2008) observed that the unemployment problem has escalated the age-dependency ratio to 2.6 percent dependants per worker higher than the world average of 1.1 percent for the period, 1970-2010. The UN projected a lower percentage of 0.7 percent that should be lower than the sub-Saharan average of 1.1 percent for the period, 2010-2050 (Table **4)**.

Table 4: Comparing Growth Rates of the Working-Age and Non-Working-Age Population (1970-2050)

Regions	Annual Average Growth Rate			
	1970-2010		2010-2050	
	Dependent Population (%)	Working-age Population (%)	Dependent Population (%)	Working-age Population (%)
Nigeria	2.6	2.7	0.7	2.0
Indonesia	0.9	2.3	0.8	0.4
Pakistan	2.5	3.0	1.0	2.3
Sub-Saharan Africa	2.6	2.8	1.1	2.3
World	1.1	1.9	0.8	0.7

Source: UN, World Population Prospects (2008)

To a large extent unutilized and under-utilized labour abounds in Nigeria. All these indicate that unemployment in the country has become tenacious. The severity of the unemployment problem in the Nigerian labour market varies across regions [USAID (2009)]. Soludo (2007) quoted 5.3 percent as the official Nigerian unemployment rate for 2006. Akinyosoye (2007) estimated that barely 25 percent of the working population considered wage-earners was employed in regular jobs whilst the remainder (75%) was self-employed. Recently, the World Bank reported the unemployment in Nigeria to be 40 million which in percentage is quoted to be 28.57 percent [World Bank (2009)]. According to Babalola (2007), the reality of world-wide mass-unemployment has already dawn upon Nigeria and is increasing year by year. In Norris's view, abundance has replaced scarcity in the classical labour supply-side equation [Norris (2008)]. Indeed, there is a mismatch between the supply of skilled labour and the absorptive capacity of the labour market in Nigeria. Such a mismatch has culminated into brain drain, increase in social vices and crimes (especially kidnapping), high dependency ratio, and decline in national output and/or fall in productivity especially when Okun's law is brought into focus such that a 1 percent fall in employment (increase in unemployment) implies 3 percent decline in output.

The unemployment problem in Nigeria is largely an outcome of the labour market mal-adjustment. For example, the country's labour force rose steadily from 32.2million in 1980 to 42.9 million in 1992, recording a growth rate of 33 percent. Thereafter, the labour force fell to 30.6 million in 1993 before recovering to 31.3 million in 2000 [Akinyosoye (2007)]. Although, friction and labour market mal-adjustments constitute the highly fluctuating trend in employment rates in Nigeria, Koshoni (1986) blamed the unemployment problem on bad economic planning which has adversely affected the construction of labour-intensive industries. This situation is now aggravated by the recent global economic downturn when far more than 80 percent of the country's total revenue witnessed a parallel shrink. An indication of the scale and complexity of the unemployment problem in Nigeria can be seen by reference to Table **5** which presents a snapshot of the projected Nigerian working age population, unemployment and volume of jobs needed if the economy is to break loose from her present predicament of declining productivity and slow growth trap. These statistics are illustrative in terms of providing a realistic guide as to the state of unemployment and job requirements in Nigeria between 2010 and 2030.

Table 5: Projected Nigerian Job Requirements, 2010-2030

Year	Working Age Population	Unemployment (%)	Jobs Needed	Between Years	Jobs to be Added
2010	85,525,401	20	52,358,719		
2015	97,731,223	15	63,570,579	2010-2015	11,211,860
2020	111,088,8501	10	76,509,768	2015-2020	12,939,189
2025	125,325,513	8	88,233,036	2020-2025	11,723,268
2030	140,036,212	7	99,661,452	2025-2030	11,428,415

Source: Bloom and Humair (2010)

Health Outcomes in Nigeria and the Burden of Diseases (BOD)

The goal of any national health system is to maximize national health capita status. In Nigeria however, diseases programmes such as HIV/AIDS, tuberculosis, malaria and others; such as reproductive health are often implemented within a weak health system with little impact on the average Nigerian. Disease burden explains a large percentage of avoidable mortality of the poor. In fact, the burden of diseases forms a basic health risk that is very much severe, confronting poor households [Fox et al. (2004)] in that, it cripples poor households' earning capacity as sick individuals do often lack the capability to contribute to productivity growth. In Nigeria, the poorer individuals through the primary health care utilize few resources while the rich can afford to consult private physicians. The routine immunization coverage rate in the country is totally inadequate while the referral system is either non-functional or ineffective [FMH (2005)]. As a consequence of mass allocation plan, the coverage of an expanded immunization programme dropped from 80 percent in 1992 to below 20 percent in 2001 [Akin et al. (1995)]. Indeed, the general health-care system in the country is in a face down condition. Maternal mortality rate of about one mother's death in every one-hundred deliveries is one of the highest in the world while less than five mortality rate together with adult mortality rate are higher than the average for sub-Saharan Africa. In a burden of disease study in Nigeria, Ogunseitan (2001) found that infections and childhood diseases account for the major disease burden in Nigeria during 1990-2000, HIV infection contributes to a substantial burden of disease.

If 10 percent case-conversion was assumed, HIV represents 22 percent of the total disease, while vector-borne diseases only accounts for 6 percent, environment-sensitive diseases like malaria and diarrhea are prevalent in the entire geographic area of the country except in the highland central plateau, 6 percent of the total burden is attributable to malaria in the local region compared to 9 percent for sub-Sahara Africa in 1990 global burden of disease study. As shown in Appendix X**,** the current burden of disease is dominated by malaria, yellow fever, tuberculosis and other environmental factors. These has showed up in high infant mortality rate per 1000 live births, neo-natal mortality, under five mortality rates in Nigeria (see Appendix XI).

According to Ogunseitan (2001), the epidemiology of disease in Nigeria is founded on widespread causes of child mortality including measles, tetanus, diphtheria, acute respiratory infection, diarrhea, malnutrition and tobacco related disease. Both chronic diseases such as malaria and acute seasonal epidemic of meningitis exert a big burden on the health of Nigerians. In Nigeria, malnutrition rates are very high with about 43 percent of children under-five being malnourished and about 27 percent being underweight. In particular, 17 percent of children are underweight [WHO (2003)]. Maternal mortality is the highest in Nigeria with about 1,100 mothers dying per 100,000 live births [FMH (2005)]. The economic consequences of a disease episode on an individual household can be very much magnified if the cost of dealing with the illness forces a household to spend so much of its productive resources on medical care to the point of depleting possessed assets while additionally incurring debts. Given that productivity growth effects cumulates over time, an economy with malaria ends up with a per capita income that is approximately half the per-capita income of the non-malarious economy control for other determinants of growth (Gallup and Sachs, 2000). A high disease burden creates a high turn-over of the labour force and lowers the extent of individual worker productivity. This has been the case in South Africa where firms have reportedly slashed back on investments for the reason that high prevalence of AIDS exacerbates expectations of very high worker turnover (Adeyi et al. 2006). This is in accord with the remark made in the CMH Report (2001) that a high incidence of disease among a firm's labour force engenders a high rate of turn-over and absenteeism. On average, firms must hire and train more than one laborer for each position to balance for the high turnover.

3. Empirical Review

Health capital is both a result and a determinant of labour and hence income level [Weil (2004)]. The mechanism is that richer nations have on average healthier workforce. The healthiness of the country's labour force determines importantly her level of productivity and hence economic growth. Labour productivity being the ratio of a volume measure of output to a volume measure of input, Pelkowski and Berger (2004), uses hours worked, labour force jobs and number of individuals' employment as measures of inputs. By intuition, labour productivity will vary as a function of the health capital of the economy amongst other factors of production and the efficiency with which these inputs are utilized. This provides the basis for diversity in labour productivity growth across regions, with production levels showing life-size split between advanced and developing countries. For example, GDP per capita grew fastest in East Europe, followed by Asia, then North America, and Western Europe but lowest in Latin America and Africa [Iverson (2006)].

An enormous body of empirical literature on the interactions between health and productivity of the labour force exist. These studies can be divided into those with a micro or individual orientation and those with a macro or national orientation. The key findings from the micro/individual level research are documented as follows: healthy workers are more productive; healthy workers and family members contribute to output by reducing absenteeism; ill health reduces hourly wages; lower expenditure on health care by households frees up resources for other productive activities like food and education and contributes to development; lower infant and child mortality in households lowers the family size and deepens investment on each child; ill-health generates poverty; income and education are key determinants of health [Gupta (2006)]. The micro links logically translate into macro links between health and productivity and growth. At the aggregate level, Bloom and Canning (2000) identify four pathways by which health can affect productivity namely; a healthy labour force may be more productive because workers have more physical and mental energy and are absent from work less often; individuals with a longer life expectancy may choose to invest more in education and receive greater returns form their investments; with longer life expectancy, individuals may be motivated to save more for retirement, resulting in a greater accumulation of physical capital; and improvement in the survival and health of young children may provide incentives for reduced fertility and may result in an increase in labour force participation which may, in turn, result in increased per capita income if these individuals are accommodated by the labour market.

Somewhat better-off was the case of Britain, only individuals in the bottom 3 percentile of consumption lacked enough energy for work, and those in the next 17 percentile had energy for about six hours of light work (1.09 hours of heavy work). Essentially, those in the bottom 20 percentile had such poor diets that they were excluded from the labour force. Barro and Sala-i-Martin (1995) documented that elasticity of productivity growth with respect to the log of life expectancy range between 0.046-0.082 for 134 countries. Using the log of GDP growth rate per capita as a productivity measure, Bhargava et al. (2001), studied the empirical link between labour productivity and health capital for 125 countries from pen World Tables and 107 countries from world Development Indicators (1965-90); and found that 1 percent change in adult survival rate is associated with a 0.05 percent increase in GDP growth rate. Measuring health capital by log of life expectancy, Bloom, Canning and Servilla (2001) observed that 0.04 each extra year of life expectancy leads to an increase of 4 percent in productivity growth. On their part, Knowles and Owen (1995) provide empirical evidence on the correlation between health capital (log of 80 years less life expectancy at birth) and labour productivity for 84 countries. According to these authors, elasticity of productivity growth with respect to log difference of GDP per working age person is respectively 0.381, 0.382, and 0.03. Bound (1991) uses labour force participation as a productivity measure and self-reported health status relative to those of same age with date of death as instrument for health limits. Bound's empirical evidence indicates that ill-health affects labour market participation of ill members and that of caring Household members. Chirikos and Nestel (1985) observed that average reduction in productivity due to shorter life expectancy represents a total loss of about 20 percent. Pelkowski and Berger (2004) use employment status and hours worked as productivity measure and self-reported health conditions a proxy for health capital. These authors found that ill health-conditions impact negatively on labour market-outcomes.

4. *Theory, Model, Methodology and Data*

Theoretical and Empirical Model

In the theory of human capital, the more educated and healthy are more productive. Thus, the productivity of the labour force is driven by her status of health capital and education [Kalemli-Ozcan et al. (2000)]. A healthy and educated work force is expected to contribute positively to the effectiveness and hence the productivity of a nation. In the main therefore, the production function can be explicitly expressed as:

$$GDP_t = K_t^{\varsigma} H_t^{\eta} E_t^{\lambda} L_t^{1-\varsigma-\eta-\lambda} A_{it}^{T} \tag{1}$$

Where Health (H) and education (E) are the two components of human capital and maintaining the assumption of constant returns to scale (*CRTS*), the augmented aggregate productivity function can be written as:

$$(GDPL) = \left(\frac{K_t}{L_t}\right)^{\frac{\varsigma}{1-\varsigma-\eta-\lambda}} \left(\frac{H_t}{L_t}\right)^{\frac{\eta}{1-\varsigma-\eta-\lambda}} \left(\frac{E_t}{L_t}\right)^{\frac{\lambda}{1-\varsigma-\eta-\lambda}} A_{it}^{T} \tag{2}$$

According to relation (4.2), labour productivity measured by output per worker $(GDPL)$ is derived as a function of physical, health and education capitals per unit of labour services i.e. $(K/L) = k^{\frac{\varsigma}{1-\varsigma-\eta-\lambda}}$, $(H/L) = h_t^{\frac{\eta}{1-\varsigma-\eta-\lambda}}$, and $(E/L) = e_t^{\frac{\lambda}{1-\varsigma-\eta-\lambda}}$ respectively. Total factor productivity is measured by the technological index of the country, A_{it}^{T}. Taking the log of (4.2) yields as follows:

$$Ln(GDPL) = \frac{\varsigma}{1-\varsigma-\eta-\lambda} Lnk + \frac{\eta}{1-\varsigma-\eta-\lambda} Lnh + \frac{\lambda}{1-\varsigma-\eta-\lambda} Lne + LnA_{it}^{T} \tag{3}$$

Following the technological diffusion process of Bloom, Canning and Sevilla (2002b) in modeling the country's aggregate productivity index $\left(A_{it}^{T}\right)$, we have that:

$$\Delta Ln\left(A_{it}^{T}\right) = \phi Ln\left(A_{it}^{*} - A_{it-1}^{T}\right) + \varepsilon_{5t} \tag{4}$$

Where ε_{5t} is a random shock; Nigeria has a ceiling level of *TFP* productivity given by A_{it}^{*}. The country's TFP adjusts toward this ceiling at the rate ϕ.

The ceiling specific level of productivity is also determined by a worldwide technological frontier (WWT), proxy by investment-GDP ratio and a set of country specific variables that affect productivity, (W_{it}^{T}) so that we specify as follows:

$$Ln\left(A_{it}^{*}\right)=\theta Ln\left(W_{it}^{T}\right)+Ln\left(WWT\right) \tag{5}$$

Given that technology gaps are not directly observed, we measure the lagged technology level directly by utilizing the fact that the lagged productivity level can be derived from (4.4) as:

$$Ln\left(A_{t-1}^{T}\right)=\omega Ln\left\{s(k)\right\}_{t-1}+\zeta Ln\left\{s(h)\right\}_{t-1}+\xi Ln\left\{s(e)\right\}_{t-1}-\gamma Ln\left[n+g+\delta\right]_{t-1}-Ln\left(GDPL\right)_{t-1} \tag{6}$$

Differencing (4.6) yields:

$$\Delta Ln\left(GDPL\right)=\omega\Delta Ln\left\{s(k)\right\}+\zeta\Delta Ln\left\{s(h)\right\}+\xi\Delta Ln\left\{s(e)\right\}-\gamma\Delta Ln\left[n+g+\delta\right]+\Delta LnA_{it}^{T} \tag{7}$$

Substituting for $\Delta Ln\left(A_{it}^{T}\right)$ using equations (4.4) and (4.5) yields the following labour productivity function.

$$\begin{aligned}\Delta Ln\left(GDPL\right)=&\ \omega\Delta Ln\left\{s(k)\right\}+\zeta\Delta Ln\left\{s(h)\right\}+\xi\Delta Ln\left\{s(e)\right\}-\gamma\Delta Ln\left[n+g+\delta\right]+\\&\phi\Big[Ln\left(WWT\right)+\theta Ln\left(W_{it}^{T}\right)+\omega Ln\omega Ln\left\{s(k)\right\}_{t-1}+\zeta Ln\left\{s(h)\right\}_{t-1}+\\&\Big[\xi Ln\left\{s(e)\right\}_{t-1}-\gamma Ln\left[n+g+\delta\right]_{t-1}-Ln\left(GDPL\right)_{t-1}\Big]+\varepsilon_{5}\end{aligned} \tag{8}$$

Unlike Lucas (1988) and Romer (1990), we envisage in this study that healthy-labour force$(HCTLAB)$, educated-labour force$(EDULAB)$, government's investment in health(HPU) and in education, (GIN_{t}^{E}) influence labour productivity. Thus, our labour function becomes:

$$\begin{aligned}\Delta Ln\left(GDPL\right)=&\ \omega\Delta Ln\left\{s(k)\right\}+\zeta\Delta Ln\left\{HPU\right\}+\xi\Delta Ln\left\{GIN_{t}^{E}\right\}-\gamma\Delta Ln\left[n+g+\delta\right]+\\&\lambda Ln\left[HCTLAB\right]+\varpi Ln\left[EDULAB\right]+\\&\phi\Big[Ln\left(WWT\right)+\theta Ln\left(W_{it}^{T}\right)+\omega Ln\omega Ln\left\{s(k)\right\}_{t-1}+\zeta Ln\left\{s(h)\right\}_{t-1}+\\&\Big[\xi Ln\left\{s(e)\right\}_{t-1}-\gamma Ln\left[n+g+\delta\right]_{t-1}-Ln\left(GDPL\right)_{t-1}\Big]+\varepsilon_{5}\end{aligned} \tag{9}$$

However, this modeling approach encompasses the estimation of the labour productivity function in first differences as advocated by Lee, (1982), Qaisar and Foreman-Peck (2007). Examining the correlation matrix amongst the variables, Table 6 shows a clear case of perfect multicollinearity between most of the regressors and their corresponding lagged values and this informed the need to drop all offending variables. Therefore, we include a vector of other relevant variables i.e. $V_{J,it}=\left\{INGDR,(W/P),PNSTR\right\}$ that could determine labour productivity of the labour force in the Nigerian context.

$$\begin{aligned}\Delta Ln\left(GDPL\right)=&\ \omega\Delta Ln\left\{s(k)\right\}+\zeta\Delta Ln\left\{HPU\right\}+\xi\Delta Ln\left\{GIN_{t}^{E}\right\}-\gamma\Delta Ln\left[n+g+\delta\right]+\\&\sum\nolimits_{J}\Im_{J}^{V}Ln\left\{V_{J,it}\right\}+\lambda Ln\left[HCTLAB\right]+\varpi Ln\left[EDULAB\right]+\\&\phi\Big[Ln\left(WWT\right)+\theta Ln\left(W_{it}^{T}\right)+\omega Ln\omega Ln\left\{s(k)\right\}_{t-1}+\zeta Ln\left\{s(h)\right\}_{t-1}+\\&\Big[\xi Ln\left\{s(e)\right\}_{t-1}-\gamma Ln\left[n+g+\delta\right]_{t-1}-Ln\left(GDPL\right)_{t-1}\Big]+\varepsilon_{5}\end{aligned} \tag{10}$$

Given the fact that the order of integration of each variable is taken into consideration in formulating the error correction models, the static regression equation for labour productivity became as re-specified.

$$Ln\left(GDPL\right)=\omega Ln\left\{s\left(k\right)\right\}+\zeta Ln\left\{HPU\right\}+\xi Ln\left\{GIN_t^E\right\}-\gamma Ln\left[n+g+\delta\right]+ \sum_J \Im_J^V Ln\left\{V_{J,it}\right\}+\lambda Ln\left[HCTLAB\right]+\varpi Ln\left[EDULAB\right]+ \phi\left[Ln\left(WWT\right)+\theta Ln\left(W_{it}^T\right)-Ln\left(GDPL\right)_{t-1}\right]+\varepsilon_{5t} \quad (11)$$

Where,

$$\omega=\frac{\varsigma}{1-\varsigma-\eta-\lambda};\zeta=\frac{\eta}{1-\varsigma-\eta-\lambda};\xi=\frac{\lambda}{1-\varsigma-\eta-\lambda};\gamma=\frac{\varsigma+\eta+\lambda}{1-\varsigma-\eta-\lambda}$$

This is a model of conditional convergence in labour productivity. The speed of convergence (ϕ) is the rate at which productivity gaps are converging. In the special case where $(\phi=0)$, there will be no technological diffusion. The variables HCTLAB and EDULAB are interacted, thus we include health capital-labour interaction and education-labour interaction. Health capital-labour interaction measure healthy labour in Nigeria, education-labour interaction measure the educated labour force and health education-labour interaction is a measure of the healthy educated labour force in Nigeria. The justification for the interaction is to evaluate the magnitude of the effects of health capital and education in productivity of the Nigerian labour force. We expect a positive impact of the healthy labour force on productivity. This is premised on the ground that with growth in labour supply, productivity is enhanced and hence a spillover effect on the growth of national output. The education variable is expected to contribute positively and significantly to labour productivity. Elsewhere, it has been empirically evaluated that education constitutes an essential determinant of productivity and growth by reducing structural unemployment (Beauchemin 2001; Blankenau and Simpson 2004).

Methodology of the Study

We tested for unit root and stationarity of the series using the Phillips-Perron (PP); Kwiatkowski, Phillips, Schmidt and Shin (KPSS) and Augmented Dickey Fuller (ADF) tests using the following relevant test equation for the Dickey Fuller (DF) test [Dickey and Fuller (1979), (1981), Dickey *et al.,* (1986), (2006)]:

$$Z_t=\gamma Z_{t-1}+U_t,U_t \sim IID\left(0,\sigma^2\right),\left[-1\leq\gamma\leq 1\right] \quad (12)$$

Where Z is the variable tested for stationarity, U is the stochastic error term which should satisfy the zero mean and unit variance conditions. Thus, the test equations are estimated by the Ordinary Least Squares (OLS) technique under the null and alternative hypotheses:

$$H_0:\gamma=1,H_1:\gamma\neq 1$$

However, if U violates the aforementioned assumptions, then equation (11) is augmented with p-lagged values in the endogenous variable as an augmented Dickey Fuller equation given by,

$$\Delta Z_t=\theta_1+\theta_2 t+\delta Z_{t-1}+\sum_{i=1}^{P}\lambda_i\Delta Z_{t-1}+\in_t,\in_t \sim IID\left(0,\sigma^2\right) \quad (13)$$

Where Δ is the difference operator, t is the time trend, $\in$ is the white noise error term which is independently and identically distributed with zero mean and constant variance. Having ascertained stationarity of the series, we tested for co-integration of the variables in the study using the Johansen and Juselius's approach on estimation of the following relation;

$$\Delta Z_t=\psi_0+\pi Z_{t-p}+\sum_{i=1}^{P-1}\psi_i Z_{t-1}+\in_t,\in_t \sim IID\left(0,\sigma^2\right) \quad (14)$$

Where the vectors ΔZ_t and ΔZ_{t-1} are I(1) variables. Thus, the long-run equilibrium relationship amongst the variables is determined by the rank of π , often denoted by r, under the null hypothesis that there are at most r co-integrating vectors against the alternative that the number of vectors is less than or equal to r where r is 0, 1, 2,…, n. The test of the null hypothesis of co-integrating vector was conducted on the basis of the trace and maximum eigen value statistics given respectively by;

$$\lambda_{trace} = -\left(\frac{T}{2}\right)\sum_{i=r+1}^{n} Log\left(1-\hat{\lambda}_i\right)$$

$$\lambda_{\max eigv} = -TLog\left(1-\hat{\lambda}_{r+1}\right) \quad (15)$$

In view of the fact that co-integration tests are sensitive to choice of lag length in the Johansen procedure, a test for the optimal lag lengths of the related Vector Auto-Regression (VAR) was conducted. This was found unavoidable because the JML co-integration test is preceded by an estimation of a VAR model which for the sake of empirical consistency should acquire the appropriate lag length. In what follows therefore, the Akaike Information Criterion (AIC), Final Prediction Error (FPE), Likelihood Ratio (LR), Schwartz Information Criterion (SIC) and Hannan Quin (HQ) criteria were utilized in selecting the appropriate lag order required for the co-integration test. On the validity of moment restriction, two tests (Newey-West and Sargan tests) were employed in this study for testing the validity of over-identifying restrictions and instruments under the null.

H_0 : Moment conditions are satisfied (valid) vs. H_1 : Invalid moment conditions

Failure to reject the validity of the restrictions under the null renders support to our model. The moment restrictions which were defined by the set of orthogonality conditions, $E\left\{g_T\left(Z_T^{'}e\right)\right\}=0$ may be sufficient to exactly identify (if $L=K$) or over-identify ($L>K$) the parameters of the model. Thus, if $L>K$, β_{GMM} is over identified that is, the number of moment restrictions L is greater than the number of parameters estimated K. Thus,

$$Identification\begin{cases} L=K \\ L>K \end{cases} \quad (16)$$

In the exactly identified case, the criterion for the GMM estimation is exactly zero because there are equal numbers of moment restrictions as there are parameters to estimate. In essence, there are zero degrees of over-identification such that the weighting matrix V is irrelevant to the solution. The Breusch-Godfrey LM test statistic was employed as an asymptotic test for autocorrelation. It is specifically developed for testing the following hypothesis of a general autoregressive or moving average disturbance processes.

$$H_0:\rho=0 \ ; H_1:\rho\neq 0\left\{\varepsilon_t = AR\left(J\right) or \varepsilon_t = MA\left(J\right)\right\}$$

White test was also utilized in this study as a general asymptotic test for heteroskedatsicity under the null; $\sigma_i^2=\sigma^2\forall i\left(Homoskedasticity\right);\sigma_i^2\neq\sigma^2\forall i\left(Heteroskedastciciy\right)$. We further employ the Wald test criterion for testing coefficient restrictions. The Wald test exhibits a quadratic form which involves the use of the estimated information matrix and the linear restrictions under the hypothesis with a set of J linear restrictions of the following form;

$$H_0: R\beta = q$$
$$H_1: R\beta \neq q$$

Where R denotes $\left(J\times K\right)$ matrix of full rank of known constants, and q is a known J-dimensional vector of constants. The Wald statistic is given by,

$$W^1 = \frac{\left(R\beta-q\right)^{'}\left[R\left(X^{'}X\right)^{-1}R\right]^{-1}\left(R\beta-q\right)}{e^{'}e/\left(n-k\right)} \sim \chi_J^2 \text{ under } H_0 \quad (17)$$

Data

Data inconsistency has proved remarkably evident in low-income countries including Nigeria especially when the same series are sought from different sources. This has been attributed to many gaps in coverage, reflecting underlying weaknesses in national data tracking systems [Goldsbrough, Adovor and Elberger (2007)]. With this caveat in mind, the main sources of data include the World Development Indicators (2008), African Development Indicators (2009), UNDP Human Development Index, World Bank's Socio-Economic Time-Series Access and Retrieval System (STARS), Penn-World Tables [Version 6.0], International Monetary Fund (IMF) and Central bank of Nigeria's Statistical Bulletin.

The empirical evidence in this research uses secondary school-enrollment rates as a proxy for education, investment-GDP ratio as a proxy variable for worldwide technological transfer, health capital is proxy by life expectancy and labour is proxy by the Nigerian labour force. The wage rate is proxy by average real wage in the production sector. Labour input is proxy by the Nigerian labour force. Labour productivity is measured as output per unit of labour service defined as output-labour ratio.

4. Empirical Results

Stationarity and Co-integration Tests Results

Appendix III illustrates the visual plots of all the series in the study over the period, 1975 to 2010. The graphical display shows that none of our series was stationary at level as they all drift far apart from equilibrium in the short-run. Intuitively, the graphical plot provides evidence in favor of a time variant mean suggesting non-stationary processes in the levels of all the variables. Indeed, none of the series exhibits a definite trend but rather revealing high level of fluctuations over time. In effect, it shows that there is no propensity for the variables to move together towards equilibrium.

[1]See Appendix XII for a formal derivation of the Wald test statistic

We further employ the formal tests which include the ADF, PP and KPSS tests. Appendices II and III shows the stationarity and unit root test results with the test equation including drift on one hand drift and trend on the other. The results of the tests show that none of the variables is stationary at level justifying the results of the graphical test and hence a proof of confirmatory data analysis [Brooks (2002)]. However, on application of the tests to the first differences of the series, they all became stationary imply that all the variables in the study are integrated of order one, I(1). Having established the order of integration of the series, we employed both the Engle-Granger and Johansen's and Juselius' Maximum Likelihood (LM) co-integrating techniques under the trace and maximum eigen value test statistics to explore the possibility of long-run equilibrium between the variables under study. The test results are as presented in Appendices IV and V**.** The results show evidence of long-run equilibrium relationship amongst the variables under the present study. In particular, the trace test validates the null hypothesis of at most **3** co-integrating relations and maximum eigen statistics validates the null of at most **2** co-integrating vectors.

Analysis of Regression Estimates

The results for the labour productivity function are presented in Table **7.** The regression estimates shows some robust significance of health, education and labour interactive terms. Thus, the labour productivity effect of healthy-labour and educated labour is highly remarkable. The empirical evidence therefore strongly indicates that an educated, healthy-labour force is among the key determinants of labour productivity in Nigeria. Accordingly, the results indicate that healthy-labour force is one factor that determines productivity. The significant effect is in line with the empirical results obtained by Beauxhemin (2001) and Blankenau and Simpson (2004). Specifically, the analysis indicates that a ten percentage point increase in the size of the healthy-labour force is associated with 0.6 percent rise in the productivity of labour for a given disequilibrium in the aggregate production function (see Table 7). This indeed confirms the theoretical fact underlying the Solow's production function that the productivity and hence output of an economy grows in response to larger size of the labour input. Thus, in a developing country like Nigeria where natural resources depend on the productive capacity of individuals, resources will tend to be highly utilized. These put together will predictably promote productivity growth in the long-run. The statistical significance is an indication that healthy and educated labour force is a powerful instrument for increasing productivity in Nigeria.

The estimated coefficient for government investment in education is estimated with a negative and insignificant value even at the 10 percent level. According to this result, a ten-percentage point increase in government expenditure in education will diminish the productivity of the Nigerian labour force by 3 percent. One would expect that investment in education would enhance human capacity and other social services and consequently productivity. The reverse seems to be the case. The insignificance and hence unexpected sign of the variable could be explained by the fact that successive Nigerian governments have undermined the need to invest substantially in the educational sector.

The results show a positive impact of real wages on productivity. This indeed conforms to expectations. The result suggests that with 1 percent increase in real wage rate, labour productivity will rise up to the tune of 0.03 percent. The significance of the wage rate effect in this study further approximate those of a perfectly competitive labour market in most developing economies where the wage rate is a reflection of the marginal productivity of the labour force. The wage rate effect suggests that with higher wages, the workforce would rather prefer to be more productive. Put differently, with higher wages individuals would prefer work to leisure. The empirical plausibility lies in the fact that better health influences the decision to supply labour via its impact on wages. Thus, if wages are linked to productivity in this regard, and healthier workers are more productive, health improvements are therefore expected to increase wages and hence the incentives to increase labour supply. Estimated with a positive sign, foreign direct investment inflows which serve as conduit for worldwide technological transmissions, accounts for a significant effect on the productivity of the Nigerian labour force. This in quintessence is a measure of the substitution-effect. By intuition, given the slow pace of technological advancement in the country, use is made of the current level of worldwide technology. The estimated effect of public health investment on labour productivity is positive and significant at the 5 percent level. According to this result, a one-percentage point increase in government investment expenditure in health will boost productivity of the Nigerian labour force up to the tune of 0.2 percent (see Table 6). The error correction term (*ecm*) indicates that almost fifty percent (47%) of the disequilibrium between the short-run and long-run output per worker is adjusted within one year.

Table 6: Parsimonious Regression Estimates of Labour Productivity Function

Explanatory Variables	**Methodology: System Generalized Method of Moments**	
	Coefficient (t-values)	**p-values(s)**
Constant	-0.138(-5.485)	(3.0485)
$\Delta Ln(HPU)$	0.026**(3.972)	(0.0002)
$\Delta Ln(INGDR)$	0.077*(4.263)	(0.0000)
$\Delta Ln(W/P)$	0.026*(2.999)	(0.0112)
$\Delta Ln(GIN^E)$	-0.030(-1.107)	(0.0330)
$\Delta Ln(PNSTR)$	0.128*(3.698)	(0.0000)
$\Delta Ln[EDULAB]$	0.135*(3.446)	(0.0000)
$\Delta Ln[HCTLAB]$	0.068*(6.555)	(0.0000)
Error Correction Term		
$ecm_{(t-1)}$	-0.469*(-3.175)	(0.0001)
Diagnostic Test Statistic(s)		
R^2 (Adjusted R^2)	57.9% (52%)	
F-Statistic	12.9	
Newey-West ξ Statistic	1.050(0.222)	Valid Moment Conditions
SarganTest Statistic	1.333(0.992)	Valid Instruments
White Test Statistic	1.126(0.2060)	Homoskedastic Residuals
ARCH Test Statistic	0.133(0.013)	Homoskedastic Residuals
Jarque-Bera Statistic	0.781(0.236)	Gaussian Distribution
Durbin-h Statistic	1.53	Non-autocorrelated Residuals
Breusch-Godfrey LM Statistic	1.065(0.009)	Non-autocorrelated Residuals
*(**) indicates variable significance at 1%(5%) levels respectively; t-ratios are reported in parantheses		

Stability and Residual Diagnostic Tests Results

The CUSUM and CUSUMSQ reveals satisfactory plot of the recursive residuals at the 95 percent significance level. Remarkably, cumulative sum of square residuals reveals that none of the parameters falls outside the critically dotted lines. This empirically dismisses any trace of inconsistent parameter estimates. The results of the CUSUM tests are provided in Appendix VI**.** Evidently, stability hypothesis is validated for the period under analysis. The validity of stability of the regression relationships over time further enhances the standard significance of the conventional test statistic(s) without trace of nuisance parameters obtained in the study. Model stability is further established in this study given the empirical evidence that the recursive residuals in the regressions persistently drift within the error bounds [-2 and +2]. This facilitated the adaptive configuration of the cusum test parameters thereby correcting any trace of endogeneity and/or simultaneity bias and serial correlation.

Thus, the t^{th} recursive residuals are the *expost* prediction error for all regressands in the study. This is because estimation utilized only the first t-1 observations. Given that the recursive estimation is computed for subsequent observations beyond the sample period, it therefore portrays the one-step prediction error graphically depicted as one-step probability recursive residuals [Appendix VII]. The kernel density plot shows evidence of Gaussian normality of the distribution of residuals. Further, a plot of the sample autocorrelation function (AC) against different lags yielded the correlogram of the regression residuals. The correlogram portrays an explicit representation of stationary residuals adjudged on the ground that the autocorrelations at various lags drift around zero that is, the zero axis as indicated by the solid vertical line. The Box-Pierce's (Q) statistic also shows that the residuals are white noise. The adequacy of the specification was therefore established on the basis of the satisfactorily robust test statistic(s) obtained from the diagnostic tests conducted on the regression residuals. The empirical distribution test for model residuals also provides evidence of normality with a Jarque-Bera test statistic of 0.77 [Appendix VIII].

5. Conclusion and Recommendations

In this paper, an attempt has been made to analyze the labour productivity effects of health capital in Nigeria. Utilized in the paper is the methodology of Generalized Method of Moments (GMM). From the estimation exercise, it was empirically ascertained that health capital investment is a significant determinant of labour productivity in the Nigerian economy. As evident from the results, the null hypothesis of an insignificant impact of health capital investment on labour productivity in Nigeria is vehemently invalidated on the basis of a significant Wald coefficient. The analysis indicates that health capital investment enhances productivity of the labour force. This indeed, further substantiates and enhances the positive significant coefficient of the healthy-labour force variable. From policy perspectives therefore, since Nigeria is highly labour-intensive, a higher value must be accorded to having a healthier workforce in order to maximize productivity. Therefore, the Nigerian government needs to invest significantly on health capital. Also, the study essentially finds significant impact of the education-labour and health capital-labour interaction terms. This in essence signifies that the functioning of the labour force has a close link with education. This is because the supply of labour (demand for labour) to a large extent depends on the qualification acquired through education as well as healthiness, thus justifying increased budgetary allocations to health and education. This is because even when there is an increase in the productivity growth in response to the size of the labour force, it takes the educated and healthy, the (competent) to bring out the resourceful use of such labour services for greater productivity. The Nigerian government has to build capacity through investment in health and education in order to enhance productivity of the labour force. This could protect the economy from further negative trends in productivity growth. The analysis indicates that health capital investment enhances productivity of the labour force.

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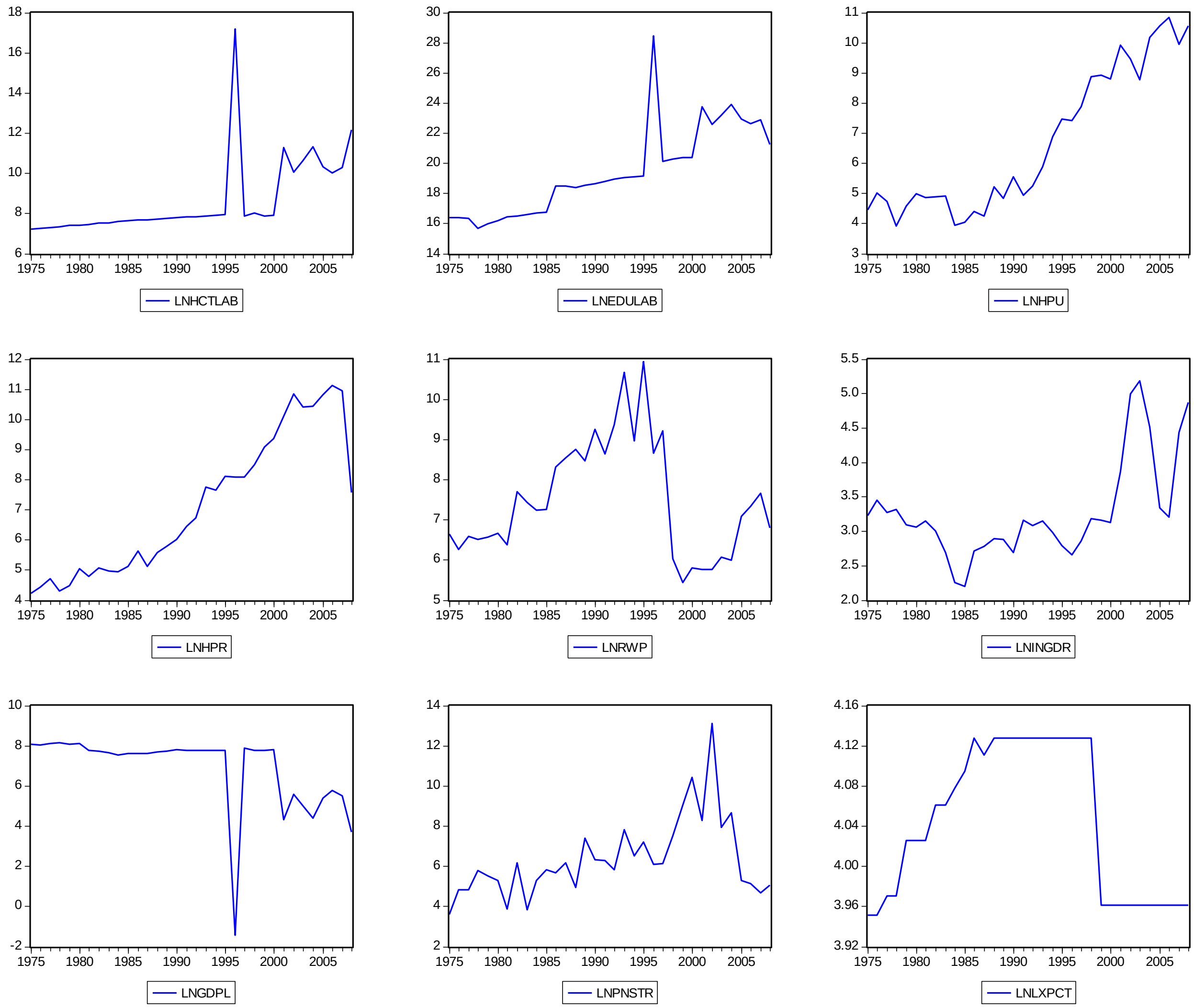
Appendix I: Graphical Results of Stationarity Test



Appendix II: Unit Root Tests Results Based on DF and ADF Tests Procedures

Variables	DF (ADF) Test Statistic	95% Critical Value	Remark
$\Delta Ln\left(GIN^{E}\right)$	-5.3825(-5.999)	-2.9850(-3.5229)	1(1)
$\Delta Ln\left(PNSTR\right)$	-9.9989(-10.443	-2.9850(-3.5229)	1(1)
$\Delta Ln\left(HPU\right)$	-3.3456(-5.8899)	-2.9850(-3.5229)	1(1)
$\Delta Ln\left(INGDR\right)$	-10.4699(-15.6125)	-2.9850(-3.5229)	1(1)
$\Delta Ln\left(W/P\right)$	-4.3883(-6.8222)	-2.9850(-3.5229)	1(1)
$\Delta Ln\left[EDULAB\right]$	-3.9666(-6.9662)	-2.9850(-3.5229)	1(1)
$\Delta Ln\left[HCTLAB\right]$	-5.4692(-18.2699)	-2.9850(-3.5229)	1(1)
[1]unit root tests include intercept and Trend. Lag order for each variable was determined by Schwarz Information Criterion			

Appendix III: Stationarity Tests Results Based on PP and KPSS Tests Techniques

Variables	**Phillips-Perron (PP) and Kwiatkowski et al (KPSS) Test Technique**						**Conclusion**
	Phillips-Peron (PP) Test Statistics			**Kwiatkowski (KPSS) Test Statistics**			
	Constant & Trend	**Critical Value**	**Remark**	**Constant & Trend**	**Critical Value**	**Remark**	
$\Delta Ln\left(GIN^{E}\right)$	-10.99	-3.489	I(1)	0.099	0.739	I(1)	Stationary
$\Delta Ln\left(PNSTR\right)$	-10.35	-3.489	I(1)	0.455	0.739	I(1)	Stationary
$\Delta Ln\left(HPU\right)$	-9.88	-3.489	I(1)	0.299	0.739	I(1)	Stationary
$\Delta Ln\left(INGDR\right)$	-6.55	-3.489	I(1)	0.088	0.739	I(1)	Stationary
$\Delta Ln\left(W/P\right)$	-18.26	-3.489	I(1)	0.185	0.739	I(1)	Stationary
$\Delta Ln\left[EDULAB\right]$	-10.33	-3.489	I(1)	0.222	0.739	I(1)	Stationary
$\Delta Ln\left[HCTLAB\right]$	-12.56	-3.489	I(1)	0.555	0.739	I(1)	Stationary
Notes: The Spectral Estimation Method is Bartlett Kernel for the PP and KPSS tests. Mackinnon Critical Value and the KPSS Critical Values are at the 1% level of significance.							

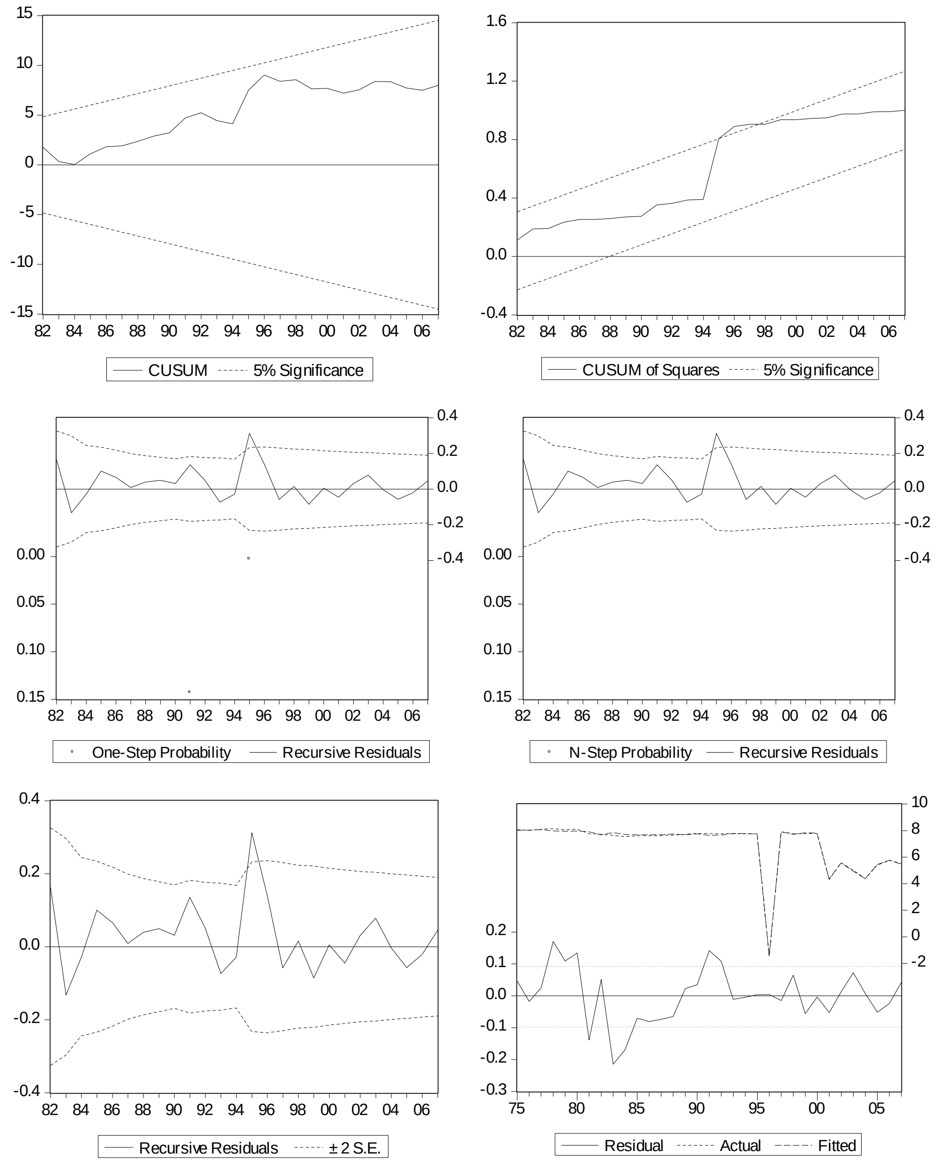
Appendix IV: Co-integration Test Results Based on Engle-Granger Two-Step Approach

Variables	DF (ADF) Test Statistic	95% Critical Value	Statistical Inference
Residual Vector	-4.3338(-6.2329)	-2.9850(-3.5229)	1(0), Co integrated

Appendix V: Co-integration Test Results Based on Johansen's Maximum Likelihood

Null Hypothesis	**Trace Statistic**	**5% Critical Value**	**Maxeigenvalue**	**5% Critical Value**
$H_0 : r = 0$	43	20.9	32.8	23.45
$H_0 : r \leq 1$	66	19.5	26.8	20.6
$H_0 : r \leq 2$	38	32.6	23.6	22.7
$H_0 : r \leq 3$	21.5	18.3	10.3	19.2
Notes: r denotes the number of co-integrating vectors; Akaike Information Criterion (AIC) and Schwartz Bayesian Criterion (SBC) produced the same highest lag order required in the co-integration test				

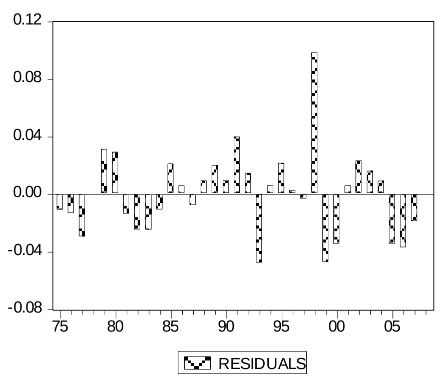
Appendix VI: CUSUM and CUSUMSQ Tests of Model Stability

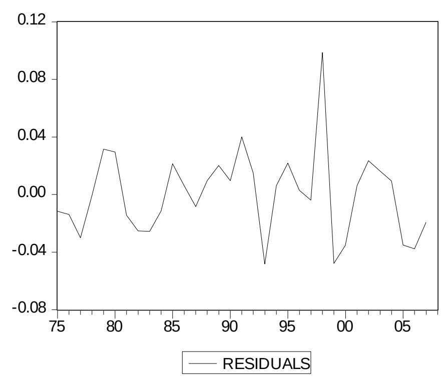


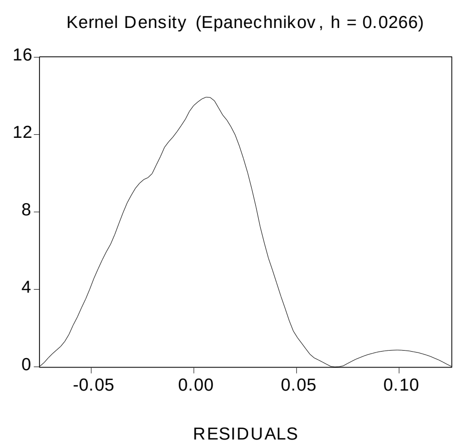
Appendix VII: Diagnostic Tests on Residuals of Labour Productivity Equation Correlogram of Residuals

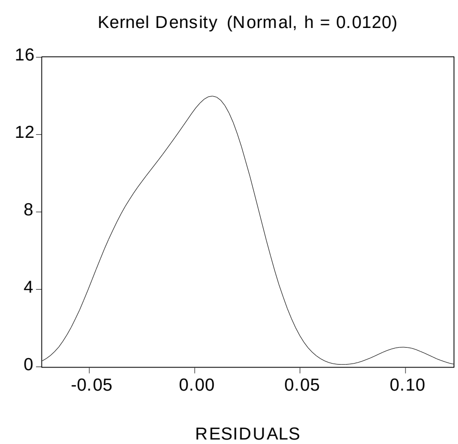
Sample: 1975 2011
Included observations: 35

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>. | . |</td><td>. | . |</td><td>1</td><td>0.052</td><td>0.052</td><td>0.0979</td><td>0.754</td></tr>
<tr><td>.**| . |</td><td>.**| . |</td><td>2</td><td>-0.289</td><td>-0.292</td><td>3.2062</td><td>0.201</td></tr>
<tr><td>. *| . |</td><td>. *| . |</td><td>3</td><td>-0.105</td><td>-0.078</td><td>3.6335</td><td>0.304</td></tr>
<tr><td>. *| . |</td><td>. *| . |</td><td>4</td><td>-0.076</td><td>-0.166</td><td>3.8628</td><td>0.425</td></tr>
<tr><td>. *| . |</td><td>. *| . |</td><td>5</td><td>-0.121</td><td>-0.188</td><td>4.4704</td><td>0.484</td></tr>
<tr><td>. |*** |</td><td>. |*** |</td><td>6</td><td>0.383</td><td>0.360</td><td>10.741</td><td>0.097</td></tr>
<tr><td>. |* . |</td><td>. | . |</td><td>7</td><td>0.155</td><td>0.014</td><td>11.808</td><td>0.107</td></tr>
<tr><td>.**| . |</td><td>. *| . |</td><td>8</td><td>-0.253</td><td>-0.111</td><td>14.769</td><td>0.064</td></tr>
<tr><td>. *| . |</td><td>. | . |</td><td>9</td><td>-0.097</td><td>0.034</td><td>15.224</td><td>0.085</td></tr>
<tr><td>. | . |</td><td>. *| . |</td><td>10</td><td>0.010</td><td>-0.064</td><td>15.229</td><td>0.124</td></tr>
<tr><td>. | . |</td><td>. |* . |</td><td>11</td><td>-0.016</td><td>0.072</td><td>15.242</td><td>0.172</td></tr>
<tr><td>. |* . |</td><td>. | . |</td><td>12</td><td>0.136</td><td>0.009</td><td>16.256</td><td>0.180</td></tr>
<tr><td>. |* . |</td><td>. *| . |</td><td>13</td><td>0.073</td><td>-0.081</td><td>16.561</td><td>0.220</td></tr>
<tr><td>.**| . |</td><td>. *| . |</td><td>14</td><td>-0.216</td><td>-0.091</td><td>19.405</td><td>0.150</td></tr>
<tr><td>. *| . |</td><td>. *| . |</td><td>15</td><td>-0.175</td><td>-0.140</td><td>21.371</td><td>0.125</td></tr>
<tr><td>. | . |</td><td>. *| . |</td><td>16</td><td>-0.031</td><td>-0.134</td><td>21.436</td><td>0.162</td></tr>
</table>









Appendix VIII: Empirical Distribution Test for Model Residuals

Hypothesis: Normal

Sample: 1975 2011, Included Observations: 35

Method	Value	Adj. Value	Probability
Lilliefors (D)	0.103840	NA	> 0.1
Cramer-von Mises (W2)	0.037246	0.037794	0.7224
Watson (U2)	0.037182	0.037728	0.6724
Anderson-Darling (A2)	0.221090	0.226398	0.8175

Method: Maximum Likelihood - d.f. corrected (Exact Solution)

Parameter	Value	Std. Error	z-Statistic	Prob.
MU	1.40E-15	0.017008	8.22E-14	1.0000
SIGMA	0.099172	0.012207	8.124038	0.0000
Log likelihood	30.82658	Mean dependent var.		1.40E-15
No. of Coefficients	2	S.D. dependent var.		0.099172

Appendix IX: Results of Wald Hypothesis Testing with Linear Restrictions in Coefficient(s)

Null ($H_0^{(1)}$): Health capital investment does not stimulate labour productivity in Nigeria			
Test Statistic	Value	Probability	Remark
Chi-square	35.512	0.000	Invalidated
Null Hypotheses Summary: Normalized Restriction [=0]			

Appendix X: Death Cases and Fatality Ratios of Notifiable Diseases, Nigeria, 2000- 2009

Disease	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Cholera											
Deaths	61	7869	663	266	471	140	4546	851	277	2085	17229
Cases	4101	62418	8687	4160	3173	3364	59136	13411	9254	26358	194062
CFR[2]	15	126	76	64	148	42	77	63	30	79	89
CSM[3]											
Deaths	784	695	563	472	437	1388	11231	965	797	165	17497
Cases	7804	6992	6418	4209	6119	7376	108546	39973	10793	1946	200176
CFR	100	99	88	112	71	188	103	24	74	85	87
Diphtheria											
Deaths	2	64	3	0	0	5	55	166	3	15	313
Cases	1768	2849	2351	2042	1363	1556	2768	3285	6071	3769	27822
CFR	1	22	1	0	0	3	20	51	0	4	11
G Worm[4]											
Deaths	7	23	0	0	0	0	0	0	1	38	69
Cases	9050	5479	6749	5356	3388	1848	14388	10426	13419	9603	112398
CFR	1	7	0	0	0	0	0	0	0	4	1
Hepatitis											
Deaths	69	60	48	53	33	54	38	39	42	20	456
Cases	5495	8897	8291	6312	4283	3599	5436	2664	8158	3264	56399
CFR	13	7	6	8	8	15	7	15	5	6	8
Leprosy											
Deaths	7	17	35	0	0	1	0	0	0	0	60
Cases	20557	13641	14875	14706	10422	8105	7687	8524	10177	3704	112398
CFR	0	1	2	0	0	0	0	0	0	0	1
Malaria											
Deaths	2284	1947	1068	719	1686	3268	4773	4603	6197	1891	28436
Cases	1116992	909656	1219348	981943	1175004	1133926	1149435	1148542	2122663	732170	11689679
CFR	2	2	1	1	1	3	4	4	3	3	2
Measles											
Deaths	1399	388	1032	373	696	671	2031	1147	1804	2751	12292
Cases	115682	44026	85965	54734	108372	49880	102166	73735	164069	132856	931485
CFR	12	9	12	7	6	13	20	16	11	21	13
Pertussis											
Deaths	184	66	1	61	65	51	186	222	216	121	1173
Cases	42929	18685	22147	23800	34792	13639	26745	33729	49550	22162	288178
CFR	4	4	0	3	2	4	7	7	4	5	4
Tuberculosis											
Deaths	213	487	230	192	379	407	380	331	454	152	3225
Cases	20122	19626	14802	11601	15202	10040	121025	11388	19368	9329	252503
CFR	11	25	16	17	25	41	3	29	23	16	13

Source: Ogunseitan (2001).

Appendix XI: Basic Health Indicators across Regions and Locations in Nigeria

Indicators	North-East	North-West	North-Central	South-East	South-West	South-South	National	Rural	Urban
Health Access (%)	48.4	55.3	61.1	37.1	73.1	45.9	55.1	47.8	70.9
Infant Mortality Rate (Per 1,000 Live Births)	125.0	114.0	103.0	66.0	69.0	120.0	100.0	121.0	81.0
Under 5 Mortality Rate (Per 1,000 Live Births)	260.0	269.0	165.0	103.0	114.0	176.0	201.0	243.0	153.0
Neo-natal Mortality Rate (%)	53.0	61.0	55.0	34.0	53.0	39.0	48.0	60.0	37.0
Received 2+Tetanus Toxid Doses (%)	46.0	31.0	21.0	78.0	62.0	74.0	41.0	32.0	61.0
Received Vitamin A	19.0	12.0	7.0	52.0	34.0	48.0	20.0	14.0	33.0
Acute Respiratory	50.0	20.0	33.0	37.0	25.0	53.0	31.0	28.0	40.0
Measles Immunization (%)	53.6	56.8	76.6	84.2	86.4	73.0	68.6	80.5	63.5
Population (%)	13.6	25.6	14.5	11.7	19.7	15.0	100.0	65.0	35.0
Male Headed Household (%)	95.6	97.5	88.3	76.2	80.0	76.6	85.7	83.0	87.1
Female Headed Household (%)	4.4	2.5	11.7	23.8	20.0	23.4	14.3	17.0	12.7
Safe water Source (%)	30.7	50.6	48.9	40.8	73.5	45.9	51.4	40.0	73.4
Safe Sanitation (%)	45.4	61.6	46.6	69.5	62.1	55.0	57.6	47.6	77.0
Waste Disposal Improvement (%)	6.2	10.7	8.8	9.0	36.0	13.2	16.1	4.8	37.9
Diarrhea Incidence (%)	5.5	4.8	5.5	5.7	4.1	4.1	4.9	5.1	4.3
Anti-malaria Measures (%)	80.5	81.7	72.2	71.9	87.4	69.8	78.3	85.1	74.9
Consultations with Traditional Healers	10.3	10.5	7.1	4.7	5.5	9.3	7.5	4.6	9.1

Quintiles	1	2	3	4	5
Infant Mortality Rate	133	140	110	87	52
Under 5 Mortality Rates	257	293	215	179	79

Source: National Bureau of Statistics (NBS) (2007)

Appendix XII: Formal Derivation of Wald Coefficient Restriction Test Statistic

The Wald test exhibit a quadratic form which involves the use of the estimated information matrix and the linear restrictions. The Wald statistic is computed by using the sum of squared residuals from regression with and without the restrictions imposed. The relevant hypothesis underlying the Wald test statistic with a set of J linear restrictions is stated as of the form below;

$$H_0 : R\beta = q$$
$$H_1 : R\beta \neq q$$

Where R denotes $(J \times K)$ matrix of full rank of known constants, and q is a known J -dimensional vector of constants. Empirical implementation of the Wald statistic proceeds as follows;

$$R\beta - q = \{0\} = R\left[\beta + \left(X^{'}X\right)^{-1} X^{'}\varepsilon\right] - q = R\left(X^{'}X\right)^{-1} X^{'}\varepsilon \text{ that is;}$$

$$R\beta - q = 0 \tag{A1}$$
$$= R\left[\beta + \left(X^{'}X\right)^{-1} X^{'}\varepsilon\right] - q \tag{A2}$$

Then, $$R\beta - q = R\left(X^{'}X\right)^{-1} X^{'}\varepsilon \tag{A3}$$

Given that the matrix of the quadratic form is idempotent, it econometrically indicates an idempotent quadratic form in a normally distributed random vector whose rank is determined on estimation of the *trace statistic* as below;

$$tr\left\{X\left(X^{'}X\right)^{-1} R^{'}\left[R\left(X^{'}X\right)^{-1} R^{'}\right]^{-1} R\left(X^{'}X\right)^{-1} X\right\} \tag{A4}$$
$$= tr\left\{\left(X^{'}X\right)^{-1} R^{'}\left[R\left(X^{'}X\right)^{-1} R^{'}\right]^{-1} R\left(X^{'}X\right)^{-1} X^{'}X\right\} \tag{A5}$$
$$= tr\left\{\left(X^{'}X\right)^{-1} R^{'}\left[R\left(X^{'}X\right)^{-1} R^{'}\right]^{-1} R\right\} \tag{A6}$$
$$= tr\left\{\left[R\left(X^{'}X\right)^{-1} R^{'}\right]\left[R\left(X^{'}X\right)^{-1} R^{'}\right]^{-1}\right\} \tag{A7}$$
$$= tr\{I_J\} \tag{A8}$$
$$= J \tag{A9}$$

This indicates that in consideration of the linear restrictions $R\beta = q$ under the null hypothesis, the Wald test statistic has a limiting chi-squared distribution with $[J]$ degrees of freedom. By intuition, its distribution is that of σ^2, the scale factor given by an estimate of the residual variance in the *OLS* fitted $\left\{\sigma^2 \square\ s^2 = \left(e^{'}e/n-k\right)\right\}$ so that the Wald statistic is obtained as a ratio of the covariance matrix to the estimate of σ^2.

Recall, $$R\beta - q = R\left(X^{'}X\right)^{-1} X^{'}\varepsilon, \varepsilon \square\ N\left(0, \sigma^2 I\right) \tag{A10}$$

Thus, $$E(Rb) = R\beta \tag{A11}$$
$$Var(Rb) = E\left[R(b-\beta)(b-\beta)^{'} R^{'}\right] \tag{A12}$$
$$= R\,\text{var}(b)R^{'} \tag{A13}$$
$$= \sigma^2 R\left(X^{'}X\right)^{-1} R^{'} \tag{A14}$$

$$Rb \sim N\left[R\beta, \sigma^2 R\left(X^{'}X\right)^{-1} R^{'}\right] \quad \text{(A15)}$$

$$R\left(b-\beta\right) \sim N\left[0, \sigma^2 R\left(X^{'}X\right)^{-1} R^{'}\right] \quad \text{(A16)}$$

$$R\left(b-q\right) \sim N\left[0, \sigma^2 R\left(X^{'}X\right)^{-1} R^{'}\right] \quad \text{(A17)}$$

$$R\left(b-q\right)^{'}\left[\sigma^2 R\left(X^{'}X\right)^{-1} R^{'}\right]^{-1} R\left(b-q\right) \sim \chi^2\left(J\right) \quad \text{(A18)}$$

$$W = \frac{\left(R\beta-q\right)^{'}\left[R\left(X^{'}X\right)^{-1} R\right]^{-1}\left(R\beta-q\right)}{e^{'}e/\left(n-k\right)} \sim \chi_J^2 \text{ under } H_0 \quad \text{(A19)}$$

Where W is the computed Wald statistic, χ_J^2 denotes a chi-squared distribution with J degrees of freedom. Equivalently, J is the number of restrictions imposed on the parameter vector β.

Equations (A13), (A14), (A16) and (A18) immediately follow from $E\left(b\right)=\beta$, $Var\left(b\right)=E\left[\left(b-\beta\right)\left(b-\beta\right)^{'}\right]=\sigma^2\left(X^{'}X\right)^{-1}$, $E\left(b-\beta\right)=0$, $1/\sigma^2\left(X^{'}AX\right) \sim \chi_{(J)}^2$