Threshold Effects between Longevity, Labour Productivity and Economic Growth in sub-Saharan Africa (SSA): a Non-dynamic Panel Data Analysis

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Abstract — **The theoretical demographic distribution stated that averagely the age group of the labour force is 15 to 64 years. Data showed that the highest longevity value of sub-Saharan Africans is approximately 54 years in the year 2010; 10 years less than the age of exit from the labour force, not to even compare with the developed countries. This study investigated the threshold effects in the relationship between longevity and labour productivity, and between longevity and economic growth in sub-Saharan Africa (SSA). Panel data spanning from 1990 to 2012 for 38 SSA countries were used and Hansen (1999) non-dynamic panel data test and estimation methods were adopted. The results revealed that, longevity was an increasing function of labour productivity and economic growth, with the significant threshold effects at ages 46.7 years on labour productivity and 67.5 years on economic growth. Among other things, food availability and capital accumulation were significantly required. Thus, policies that could accommodate people of age 67.5 years who are still fit to work, and provide entrepreneurial training and funds for the unemployed people in the ages 46 to 47 years are worthwhile in SSA countries. In addition, improvement in the provision of quality healthcare services at an affordable rate to the very poor sub-Sahara Africans is necessary to improve the quality of longevity in SSA.**

Keywords—longevity; threshold; panel; Hansen; labour; productivity; economic growth; SSA

1. INTRODUCTION

As most of the developed countries are concerned with aging population, the developing countries are battling with the challenge of short life span. Longevity, as an indicator of the extent of life span, is a variable of interest to economists in recent times. Longevity; an average number of years an individual is expected to live, given the prevailing and expected health condition over the life time, is an issue of concern, especially, in sub-Saharan Africa (SSA) countries.

Longevity in SSA region compares unfavourably low with most of other regions of the world. For instance, in East Asia and Pacific, longevity measured in years was 73 in 2004, and 74 in both 2008 and 2010, while in Europe and Central Asia, longevity was 74, 75 and 76 years in 2004, 2008 and 2010 respectively. Also, in Latin America and Caribbean, longevity in years was 73 in 2004, and 74 in 2008 and 2010, while in the Middle East and North Africa the longevity was 71 years in 2004 and 2008, and 73 years in 2010. All these are much higher than that of SSA region. A new child born in SSA countries in 2004 was expected to live for 52years, while those born in 2008 and 2010 were of 54 life-years [15]. Whereas, if the same child was born in any of the other regions cited, he/she would have an average of additional 20 years to live.

The theoretical demographic distribution stated that the age group of the labour force is 15 to 64 years. Reference [15] data showed that the highest longevity value of sub-Saharan Africans is approximately 54 years in the year 2010; 10 years less than the age of exit from the labour force, not to even compare with the developed countries. This means an absolute loss to productivity, if longevity is an increasing function of productivity.

Another look at this issue is to investigate if there exist threshold point estimates value of longevity in SSA countries for which productivity is optimized significantly. Considering the few available empirical work on threshold and effects, [13] studied Denmark and Italy annual data and found that health in the first 20 years of people had a significant and positive effect on labour productivity, while [4] concluded, after studying the OECD countries, that reduction in mortality below age 40 years generated productivity gains. Although, this imply the existence of a threshold effect in the relationship between longevity and productivity, these studies tend to be limited by proxies and methodology, thereby unable to obtain the precise most productive age values. Besides, none of the studies focused on SSA region.

Longevity, as human health variable, is a component of human capital. Thus, its influence on productivity of labour and productivity per capita (that is, economic growth), may be vital for policy and increase in the stock of knowledge. With the adaption of [11] threshold test using fixed-effect model and bootstrapping, this study determined the significant threshold point estimates of longevity in the longevity – labour productivity and longevity – economic growth planes,

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for which both labour productivity and economic growth were significantly optimized in SSA

2. MODEL SPECIFICATION

To obtain the threshold effects in the relationship between longevity (*LONG*) and labour productivity (*LPROD*), and between longevity (*LONG*) and economic growth (*EGROW*) for countries in SSA, nonlinear relationships are assumed between the two pairs of variables. Adapting from [11] similar to the adaption by [8], the models relating longevity and labour productivity, and longevity with economic growth after taking the natural logarithm of the variables are implicitly specified as follows;

$$\ln LPROD_{it} = \mu_i \beta_1 \ln(G_{it}) * I(LONG_{it} \leq \gamma_1) + \beta_2 \ln(G_{it}) * I(LONG_{it} > \gamma) + \epsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.1$$

Alternatively,

$$\ln LPROD_{it} = \begin{cases} \mu_i \beta_1 \ln(G_{it}) + \epsilon_{it} & LONG_{it} \leq \gamma_1 \\ \mu_i \beta_2 \ln(G_{it}) + \epsilon_{it} & LONG_{it} > \gamma_1 \end{cases} \ldots\ldots\ldots 2.2$$

Similarly,

$$\ln EGROW_{it} = \mu_i \varphi_1 \ln(X_{it}) * I(LONG_{it} \leq \gamma_2) + \varphi_2 \ln(X_{it}) * I(LONG_{it} > \gamma) + U_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.3$$

Alternatively,

$$\ln EGROW_{it} = \begin{cases} \mu_i \varphi_1 \ln(X_{it}) + U_{it} & LONG_{it} \leq \gamma_2 \\ \mu_i \varphi_2 \ln(X_{it}) + U_{it} & LONG_{it} > \gamma_2 \end{cases} \ldots\ldots\ldots 2.4$$

Where $\ln LPROD_{it}$ and $\ln EGROW_{it}$ are the dependent variables in equations 2.1 and 2.2, and 2.3 and 2.4 respectively. $LONG_{it}$ is the threshold variable for *i* individual country in time period *t*. G_{it} *and* X_{it} are vectors of other covariates, μ_i represents the level of country-*i*'s fixed-effect, u_t is the level of time-*t*'s fixed-effect.

According to [5], the traditional cross-sectional analyses usually focus on conditional convergence neglecting the nonlinear alternatives. However, if the aim of the model is not to study cross-country convergence but to determine whether or not nonlinearity exists between the two variables of interest, this can be done once the cross-country heterogeneity is taken care of.

Equations 2.2 and 2.4 indicate clearly that, the observations are divided into two regimes depending on whether the threshold variable ($LONG_{it}$) is smaller or larger than the threshold point (γ). The regimes or periods of longevity are distinguished by deferring regression slopes; β_1 *and* β_2 for labour productivity function and φ_1 *and* φ_2 for economic growth function. According to [11], for the identification of the parameters β_1 *and* β_2 and parameters φ_1 *and* φ_2, it is required that we assume the element of G_{it} *and* X_{it}, and the threshold variable are not time invariant and that ϵ_{it}*and* U_{it} are assumed to be independently and identically distributed (iid) with zero mean and finite variance σ^2. The iid assumption excluded the lagged dependent variables from G_{it} *and* X_{it}. By eliminating the individual effect μ_i through the removal of individual-specific means, the models 2.1 and 2.3 can be explicitly specified as follows;

$$\begin{aligned} lnLPROD = {} & C + \alpha_1 lnCAPITAPL_{it-1} + \alpha_2 lnCAPITAPL_{it-1}^{\ 2} \\ & + \alpha_3 lnCAPITAPL_{it-1}^{\ 3} \\ & + \alpha_4 [lnCAPITAPL_{it-1} * LONG_{it-1}] \\ & + \alpha_5 LONG_{it-1} + \alpha_6 LONG_{it-1}^{\ 2} \\ & + \alpha_7 LONG_{it-1}^{\ 3} + \varphi_1 lnFOOD_{it-1} \\ & * (LONG_{it-1} \leq \gamma) + \varphi_2 lnFOOD_{it-1} \\ & * (LONG_{it-1} > \gamma) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.5 \end{aligned}$$

$$\begin{aligned} lnEGROW = {} & C + \alpha_1 lnCAPITAPC_{it-1} + \alpha_2 lnCAPITAPC_{it-1}^{\ 2} \\ & + \alpha_3 lnCAPITAPC_{it-1}^{\ 3} \\ & + \alpha_4 [lnCAPITAPC_{it-1} * LONG_{it-1}] \\ & + \alpha_5 LONG_{it-1} + \alpha_6 LONG_{it-1}^{\ 2} \\ & + \alpha_7 LONG_{it-1}^{\ 3} + \beta_1 lnFOOD_{it-1} \\ & * (LONG_{it-1} \leq \gamma) + \beta_2 lnFOOD_{it-1} \\ & * (LONG_{it-1} > \gamma) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.6 \end{aligned}$$

The inclusion of the non-linear terms $LnCAPITAPL_{it-1}^2$, $LnCAPITAPL_{it-1}^3$, $(LnCAPITAPL_{it-1}) * (LONG_{i,t-1})$, $LONG^2{}_{i,t-1}$ and $LONG^3{}_{i,t-1}$, in the equation 2.5 and $LnCAPITAPC_{it-1}^2$, $LnCAPITAPC_{it-1}^3$, $(LnCAPITAPC_{it-1}) * (LONG_{i,t-1})$, $LONG^2{}_{i,t-1}$ and $LONG^3{}_{i,t-1}$, in equation 2.6 are to reduce the possibility of spurious correlations due to omitted variable bias.

Where G_{it}= Capital stock per labour (*lnCAPITAPL*) and food availability (*lnFOOD*) *and* X_{it} = Capital stock per capita (*lnCAPITAPC*) and food availability (*lnFOOD*). Studies have shown that food availability [3, 6 and 10] and capital [14] are some of the variables important in explaining the variation in labour productivity and growth of the economy [1].

3. METHOD OF ANALYSIS

The threshold effects of longevity on labour productivity and economic growth were obtained from the estimation of equations 2.5 and 2.6 respectively. These equations are non-dynamic fixed-effects panel-data model. They take-off with the assumption of absence of any unmeasured time invariant heterogeneity across countries [9], then, the bootstrap procedure proposed by [11] is applied to test for the existence of thresholds and obtain the threshold point estimates. Thereafter, the panel least squares estimation method is conducted as suggested by Hansen to determine the threshold effects (see [11]).

4. DATA MEASUREMENT AND SOURCES

For this study, panel data covering the periods 1990 to 2012 were used. Thirty-eight (38) of the forty-eight (48) SSA countries formed the sample[1]. The choice of this sample size

[1] The sampled countries included Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo Rep., Cote d'Ivoire, Equatorial Guinea, Ethiopia, Gabon, Gambia The, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Tanzania, Togo, Uganda, Zambia and Zimbabwe.

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was informed by the extent of data availability and the choice was carefully made to maximize the available observations.

Variable	Description	Measurement	Source(s) of Data
LONG	Longevity	This is life expectancy at birth which is the number of years a new born infant would live if prevailing patterns of mortality at the time of its birth are to stay the same throughout its life. It is an overall indicator of mortality and an important indicator of health status in a country (WDI, 2007)	World Development Indicators (WDI) online database published by World Bank Organization
LPROD	Labour productivity	This is real Gross Domestic Product (GDP) per worker. It is the purchasing power parity converted GDP chain per worker at 2005 constant prices in US dollars(WDI, 2007)	Penn World Table versions 7.1 and 8.0 [7] and [12]
EGROW	Economic growth	This is real Gross Domestic Product (GDP) per capita. It is the purchasing power parity converted GDP chain per capital at 2005 constant prices in US dollars(WDI, 2007)	WDI
FOOD	Food availability	This is food production index (2004 - 2006 = 100). Food production index covered food crops that are considered edible and that contained nutrients (WDI, 2007).	WDI
CAPITAPL	Capital stock per labour	This is the stock of capital at constant 2005 national prices (in million 2005 US $) taken as the ratio of employment(WDI, 2007)	Penn World Table version 8 [7].
CAPITAPC	Capital stock per capita	This is the stock of capital at constant 2005 national prices (in million 2005 US $) taken as the ratio of total population (WDI, 2007)	Penn World Table version 8 [7].

The data were sourced from World Development Indicators online database published by World Bank Organization and Penn World Table version 7.1 and 8.0 published by University of Pennsylvania. Few data were extrapolated. Table 4.1 presents information on the description, measurement and sources of data for the variables in this work.

Table 4.1: Sources of Data, Description and Measurement of Variables

5. EMPIRICAL RESULTS

5.1 Descriptive Summary of the Data

The summary of sample statistics of the series for the variables examined is presented in Table 5.1. All the variables except longevity are transformed into the logarithms of their levels. The longevity series is retained at levels as the threshold variable. The series in each variable are described using minimum, median and maximum. For longevity, the minimum value is as low as 26.8 years while the maximum value is 74.2 years.

Table 5.1: Sample Summary Statistics

Variables	Min.	25% quant	Median	75% quant	Max.
$lnEGROW$	4.717	5.758	6.224	6.816	9.609
$lnLPROD$	6.271	07.383	7.912	8.368	10.480
$lnCAPITAPC$	6.111	7.554	8.002	8.659	10.913
$lnCAPITAPL$	6.734	8.399	8.941	9.638	11.907
$lnFOOD$	3.078	4.264	4.562	4.709	5.150
$LONGEVITY$	26.76	47.743	52.726	57.487	74.207

5.2 Threshold Point Estimates between Longevity, Labour Productivity and Economic Growth in SSA

Adopting [11] threshold test in determining the threshold point estimates and estimating threshold effects in non-dynamic panels with individual specific fixed effects transformations, this study obtained six threshold values of longevity at which labour productivity is optimized and six threshold values of longevity at which economic growth is optimized. Table 5.2 presents the threshold point estimates results.

From table 5.2, six threshold point estimates are obtained and bootstrap[2] p-values of F-statistic tests are reported in parenthesis, while the corresponding asymptotic 95% confidence intervals are shown in the table. Out of the six threshold points estimated, only one threshold point ($\hat{\gamma}_2^r = 67.5\ years$) has statistically significant effect on economic growth at p=0.05. Therefore, 67.5 years is the threshold point of longevity for which the economic growth is significantly optimized. Also, the asymptotic confidence intervals for this threshold are very tight as shown in table 5.2. This is an indication of little uncertainty about the nature of this decision.

Also, for labour productivity, out of the six threshold points estimated, only one threshold value ($\hat{\gamma}_1^r = 46.7\ years$) had statistically significant effect on labour productivity at p<0.01. Thus, 46.7 years is the threshold point estimate of longevity for which labour productivity is optimized. The asymptotic confidence intervals for this threshold are very tight. This is indicating little uncertainty about this choice.

Table 5.2: Threshold Point Estimates between Longevity, Labour Productivity and Economic Growth

Threshold Variable: Longevity	Dependent Variables			
	Labour Productivity		Economic Growth	
	Estimates	95% Confidence Interval	Estimates	95% Confidence Interval
$\hat{\gamma}_1^r$	46.71*** (0.000)	[46.24, 47.13]	67.50** (0.053)	[67.50, 68.29]
$\hat{\gamma}_2^r$	56.14 (0.373)	[43.25, 56.84]	70.96 (0.813)	[46.28, 71.77
$\hat{\gamma}_3^r$	52.61 (0.637)	[40.49, 53.69]	52.08 (0.340)	[46.22, 55.30]
$\hat{\gamma}_4^r$	61.19 (0.717)	[35.79, 70.96]	47.76 (0.350)	[35.79, 56.76]
$\hat{\gamma}_5^r$	35.79	[35.79,	35.79	[35.79,

[2] Taking after the work of [11], 300 bootstrap replications were carried out in each of the bootstrap test.

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	(0.637)	70.51]	(0.847)	61.22]
$\hat{\gamma}_6^r$	50.89 (0.290)	[49.49, 51.02]	54.92 (0.247)	[46.35, 57.06]

*Note: ** and *** in the results indicate 5% and 1 % levels of significance and figures in the parenthesis, ( ), are Bootstrap P-values of F-statistic tests and [ ] are the confidence intervals*

The *Effective-Labour-Productivity-Age* of 46.7 years is simply a unique threshold point estimate among series of possible threshold point estimates in the longevity – labour productivity plane, for which labour productivity is significantly optimized. However, it should be noted that this does not suggest the age of exit from labour force or employment, but rather the age point in longevity function at which longevity is most impactful on productivity per unit of labour in SSA.

Similarly, the *Growth-Effective-Longevity-Age* of 67.5 years is the unique threshold point estimate, among series of possible thresholds, in the longevity – economic growth plane, for which economic growth is significantly optimized. This age does not suggest the only age impacting on economic growth, but rather the age point in longevity function at which longevity is significantly impactful on the growth of the economy in sub – Saharan Africa.

Furthermore, the locus of movement in the series of estimated threshold points in the longevity – labour productivity plane, is termed the *Longevity–Labour Productivity Threshold Path* (LPTP), while the locus of movement in the series of estimated threshold points in the longevity – economic growth plane is termed the *Longevity–Economic Growth Threshold Path* (LETP). The economic importance of LPTP and LETP is traceable to the fact that in analysing the working age distribution of population, LPTP and LETP show the various values of longevity that benefit the productivity per unit of labour and the growth of the economy respectively. LPTP signals to the employer of labour and the government in that, more productive efforts are extractible from longevity at these various threshold point estimates, while the most impactful ages of longevity in SSA are 46.7 and 67.5 years.

Based on the existence of a single significant threshold point estimate of longevity relative to labour productivity, and another single significant threshold point estimate relative to economic growth, thus, two longevity periods could be identified.

5.3 Threshold Effects between Longevity, Labour Productivity and Economic Growth in SSA

The regression slope estimates of the threshold point estimates are presented in tables 5.4 and 5.5. Yearly dummies are also included in all the models estimated in this section. From table 5.4, the approximate R^2 value of 0.98 suggests that, 98% of the variation in labour productivity is explained by the independent variables put together. The statistically significant F-statistic at P<0.01 imply that all the independent variables, put together, significantly explain the behaviour of labour productivity in SSA. It is, further, revealed that capital per unit of labour ($LnCAPITAPL_{it-1}$) is statistically significant in all the models estimated. The importance of capital per unit of labour for effective productivity of labour is also revealed. The inclusion of the non-linear terms $LnCAPITAPL_{it-1}^2$, $LnCAPITAPL_{it-1}^3$, $(LnCAPITAPL_{it-1}) * (LONG_{i,t-1})$, ${LONG^2}_{i,t-1}$ and ${LONG^3}_{i,t-1}$, in the regression was to reduce the possibility of spurious correlations due to omitted variable bias.

From column 1 of table 5.4, longevity has a positive and statistically significant effect on labour productivity at $p < 0.01$. When the average longevity of a country in SSA is at the threshold of 46.7 years, any health related improvement that raises longevity by 1 year will significantly increase labour productivity by 26.1%. The coefficient of the interactive effect between food availability and the point estimates of longevity revealed that food availability matter for longevity to have a significant positive effect on labour productivity.

From table 5.4 columns 2 and 3, both the longevity period before the threshold, and the period greater than or equal to the threshold point estimate, have positive and statistically significant effects on labour productivity. As expected, the coefficient of the point estimate before 46.7 years; $\beta_1 = 0.460$, (say, period 1) is less than the coefficient of the threshold point estimate and beyond; $\beta_2 = 1.692$ (say, period 2). On comparing the coefficients further, period 2's coefficient is almost 4 times the period 1($\beta_2 = 1.692/0.460\ \beta_1 = 3.6\ \beta_1$).

Table 5.4: Panel Least Square Estimates for Threshold Effect of Longevity on labour Productivity

Independent Variables	Dependent Variable: Labour Productivity		
	1	2	3
$LnCAPITAPL_{it-1}$	12.099*** (6.935)	14.910*** (8.092)	11.523*** (6.302)
$LnCAPITAPL_{it-1}^2$	-1.194*** (-6.196)	-1.542*** (-7.594)	-1.142*** (-5.654)
$LnCAPITAPL_{it-1}^3$	0.041*** (5.894)	0.054*** (7.391)	0.0395*** (5.379)
$(LnCAPITAPL_{it-1}) * (LONG_{i,t-1})$	-0.001 (-0.779)	0.0028* (1.873)	0.0005 (0.344)
$LONG_{i,t-1}$	0.261*** (5.392)	-----	------
${LONG^2}_{i,t-1}/10^3$	-4.944*** (-5.175)	0.0834 (0.392)	0.0425 (0.206)
${LONG^3}_{i,t-1}/10^6$	0.317*** (4.856)	-3.52** (-2.183)	-0.364 (-0.230)
$LONG_{i,t-1} < 46.7$	-----	0.460*** (2.797)	-----
$LONG_{i,t-1} \geq 46.7$	-----	-----	1.692*** (8.083)
$LnFOOD_{it-1} * (LONG_{it-1} < 46.7)$	0.348*** (9.956)	-----	0.3676*** (7.808)
$LnFOOD_{it-1} * (LONG_{it-1} \geq 46.7)$	0.369*** (10.43)	0.1196*** (3.212)	-----
C	-40.063*** (-7.653)	-42.483*** (-7.676)	-33.878*** (-6.233)
	Effects Specification		
Cross-section fixed (dummy variables)			
R-squared	0.9846	0.9825	0.9836

F-statistic	733.101	655.351	698.695
Prob(F-statistic)	0.0000	0.0000	0.0000

Note: **,**,*** in the results indicate 10%, 5% and 1% level of significance and figures in the parenthesis are t-statistic test. The F-statistic test reports the joint significance of the independent variables to the dependent variable. R^2 values give information the goodness-of-fit of the estimated model.*

Similarly, in the results of panel least square estimate for threshold effect of longevity on economic growth in table 5.5, for all the estimated models, the approximate R^2 value of 0.99 imply that 99% of variation in economic growth is explained by the exogenous variables put together. Also, the statistically significant F-statistic at P<0.01 means that all the exogenous variables, put together, significantly explained the behaviour of economic growth of SSA.

Table 5.5: Panel Least Square Estimate for Threshold Effect of Longevity on Economic Growth

Independent Variables	Dependent Variable: Economic Growth		
	1	2	3
$LnCAPITAPC_{it-1}$	4.334*** (2.829)	6.074*** (3.767)	5.763*** (3.731)
$LnCAPITAPC^2_{it-1}$	-0.453*** (-2.459)	-0.667*** (-3.440)	-0.651*** (-3.513)
$LnCAPITAPC^3_{it-1}$	0.0186*** (2.573)	0.0266*** (3.501)	0.027*** (3.683)
$(LnCAPITAPC_{it-1}) * (LONG_{i,t-1})$	-0.001839 (-1.307)	-2.50E-05 (-0.018)	0.0012 (0.919)
$LONG_{i,t-1}$	0.165*** (3.366)	-----	-----
$LONG^2{}_{i,t-1}/10^3$	-3.182*** (-3.245)	0.394** (1.990)	-0.0259 (-0.149)
$LONG^3{}_{i,t-1}/10^6$	22.4*** (3.258)	-3.73** (-2.324)	0.132 (0.095)
$LONG_{i,t-1} \leq 67.5$	-----	1.766** (2.364)	-----
$LONG_{i,t-1} > 67.5$	-----	-----	1.691*** (11.300)
$LnFOOD_{it-1} * (LONG_{it-1} \leq 46.7)$	-0.016*** (-4.234)	-----	----
$LnFOOD_{it-1} * (46.7 < LONG_{it-1} \leq 67.5)$	0.3303*** (10.519)	-----	----
$LnFOOD_{it-1} * (LONG_{i,t-1} > 67.5)$	0.082*** (5.870)	0.497*** (3.006)	----
$LnFOOD_{it-1} * (LONG_{it-1} \leq 67.5)$	-----	-----	0.274*** (8.865)
C	-12.718*** (-3.014)	-15.447*** (-3.452)	-13.525*** (-3.187)
	Effects Specification		
Cross-section fixed (dummy variables)			
R-squared	0.9829	0.9892	0.9901
F-statistic	658.018	1071.373	1168.197
Prob(F-statistic)	0.0000	0.0000	0.0000

Note: *** and *** in the results indicate 5% and 1% levels of significance and figures in the parenthesis are t-statistic test. The F-statistic test reports the joint significance of the independent variables to the dependent variable. R^2 values give information the goodness-of-fit of the estimated model.*

In addition, it is shown that capital per capita ($LnCAPITAPC_{it-1}$) and its powers are statistically significant in all the models estimated and reported in table 5.5. This is an indication of the existence of non-linear relationship between longevity ($LONG_{i,t-1}$) and economic growth (*lnEGROW*). These results also buttressed the importance of capital stock for the growth of the economies of the SSA countries. Furthermore, the inclusion of the non-linear terms $LnCAPITAPC^2_{it-1}$, $LnCAPITAPC^3_{it-1}$, $(LnCAPITAPC_{it-1}) * (LONG_{i,t-1})$, $LONG^2{}_{i,t-1}$ and $LONG^3{}_{i,t-1}$, in the regression was to reduce the possibility of obtaining spurious results due to omitted variable bias.

Considering the results in column 1 of table 5.5, longevity has a positive and statistically significant effect on economic growth at p < 0.01. When the average longevity of a country in SSA is at the threshold of 67.5 years, any health related improvement that raises longevity by 1 year will significantly raise economic growth by 16.5%. The coefficient of the interactive effect between food availability and the point estimate of longevity revealed that food availability matter for longevity to have a significant positive effect on economic growth.

It could be noted that at the longevity period of less than or equal to 46.7 years, the interactive effect between food availability and longevity is statistically significant but has negative effect. This may be an implication of unproductive longevity period among ages between 26.8 years (that is, the minimum longevity age in this study; see table 5.1) and the 46.7 years. Thus, unlike other periods shown in columns 1 to 3; food consumed at the period between ages 26.8 years and 46.7 years, may not be positively feeding back on economic growth. This could be an indication of high rate of youth unemployment in SSA countries.

The role of food availability and the accumulation of capital are very important for longevity to impact positively on both labour productivity and the growth of the economy. This results buttressed the findings of [2], and [3] that increase in food availability is vital for longevity. Even, the threshold point estimates of longevity made significant impact on labour productivity and economic growth, with the availability of substantial food production, and capital stock per labour and per capita. This implies that longevity may not be 'total' in itself.

6. CONCLUSION AND POLICY RECOMMENDATION

The focus of this study was to determine the threshold point estimates of longevity for which labour productivity and economic growth were significantly optimized. It was also to analyse the threshold effects of longevity on labour productivity and economic growth. Using panel data from 38 SSA countries and [11] threshold effects test for determining the threshold points and their effects, this study found that longevity was an increasing function of labour productivity and economic growth, with the significant positive threshold effects at ages 46.7 years on labour productivity and 67.5 years on economic growth, for which both were significantly

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optimized. Comparing the recent average longevity of 55 years of sub-Sahara Africans with the economic growth maximizing longevity of 67.5 years (longevity gap of 12.5 years) revealed that the economies of the SSA countries can grow through improved longevity. Among other things, food availability and capital accumulation were significantly capable to spur labour productivity and economic growth in the region.

Thus, this study recommended that the governments in SSA countries need to review the working age bracket and enact a planned policy that will accommodate people of age 67.5 years who are still fit to work. Also, they could provide entrepreneurial training and funds for the unemployed but physically fit people in the ages 46 to 47 years, to engage in productive activities. Besides, there is the need to improve on the provision of quality healthcare services at an affordable rate to the sub-Sahara Africans with a view to maintain and improve on the quality of longevity in SSA. This will lead to significant increase in labour productivity and economic growth. Also, policies that will promote food production and capital accumulation are vital to spur labour productivity and economic growth through longevity in SSA region.

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