The Dynamics of Financial Development, Globalization, Economic Growth and Life Expectancy in Sub-Saharan Africa

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Abstract: The importance of life expectancy is recognized in the development economics literature because of its increasing effects on labor productivity and economic growth in in long-run. However, no published study to date empirically examines the nonlinear relationships between globalization, financial development, economic growth and life expectancy in Sub-Saharan African (SSA) countries. Therefore, our study intends to fill this gap by using non-parametric cointegration test and multivariate Granger causality test towards a non-linear empirical understanding of the factors affecting the life expectancy. We consider the case of 16 Sub-Saharan African economies using annual data over the period 1970-2012. The empirical analysis indicates that financial development, globalization and economic growth appear to have a positive impact upon life expectancy in Sub-Saharan African economies, except for Gabon and Togo. Our empirical findings may provide insightful policy implications towards improving population health conditions which are vital for promoting the productivity of labour force and long-run economic growth in Sub-Saharan African countries. In light of these policy implications, governments should incorporate globalization, financial development and economic growth as key economic instruments in formulating sustainable developmental policy to promote life expectancy for the people in Sub-Saharan African countries.

***Keywords*:** Financial development; Life expectancy; Sub-Saharan Africa; Nonlinear causality

***JEL Classifications*:** F6; O16

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1. Introduction

For traditional welfare economists, the role of income growth is of special interest as it is the key to the satisfaction of individuals (Deaton 2008). Subsequently, DiTella *et al.* (2010) in their study observed that income growth provides only a temporary boost to life satisfaction. For instance, Veenhoven (1991) reported that additional gains in income level no longer matter for individuals' happiness, indicating that more income improves happiness only until basic needs are met, and beyond that point, income enables people to be hunger free and help their children become disease free. As a result, much of the improvement in peoples' happiness came from the reduction of child and infant mortality; millions of children were decimated out of abject poverty and the lack of instituted basic improvements in sanitation and public health (Ebenstein *et al.* 2015). In a sharp contrast, Easterlin (1974, 1995) noted that population happiness is not associated with increasing per capita income. It is further argued that there exists no long-run relationship between a nation's income and its average level of life satisfaction (Helliwell 2003; Blanchflower and Oswald 2004). Instead, improvement in population satisfaction depends on family circumstances (e.g., employment and marital status) and health (Easterlin 2003). In addition, Kahneman *et al.* (2006) argued that the fundamental determinants of life satisfaction neutralize the effects of income level. Subsequently, Kahneman and Deaton (2010) indicated that high income only improves evaluation of life but not emotional well-being. Similarly, Sen (1987) signaled the role of basic institutionally provided daily life capabilities as opposed to high income or luxuries that eventually enable people to lead a good life.[1] According to UNDP's Human Development Report (1990), the leading instruments for human development are life expectancy, adult literacy and decent living. Among all instruments of human development, life expectancy is a vital source of human well-being in the society (Deaton 2008).[2] In the early work of Sen (1984), it has been argued that a better provision of social services including clean drinking water, health care, sanitation and elementary education leads to human development, thereby improving healthy life expectancy at birth. Consequently, it can be inferred that capability development is the key to healthy life expectancy.

Yet, it does not necessarily lead to the possession of income and wealth at the disposal of individuals in societies. Given the importance of both the capability approach and the disposable income level, still it is disappointing that developing countries present poor life expectancy in light of the rapid globalization of the 21st century. Hence, there is a need to go beyond the concept of "welfare economics" in making better assessment of life expectancy, especially in the case of developing countries.

However, understanding the determinants of life expectancy at birth has become a very important issue for developing countries on several grounds. Life expectancy assumes a vital role not only in case of human health but also under the context of national development. For instance, better life expectancy at birth is the most important indicator of human health, enabling individuals to remain as productive as possible, thereby adding to economic growth. In addition, the size of health care industries at both micro and macro levels for developing countries tends to grow based on the demand for better life expectancy. A plethora of empirical studies investigate the impact of economic, social and environmental factors on life expectancy, in Sub-Saharan African countries in particular and developing countries in general. By inspecting this line of research, it is essential to define the effects of economic growth (income level), globalization, and financial development as key possible determinants of life expectancy observed in the field of development economics literature. Therefore, it is important to understand theoretically and empirically the economic importance of each factor in the dynamics of life expectancy in developing countries.

Globalization is widely understood when economies are closely integrated, sharing their social norms and political platforms (Dreher 2006). Dreher (2006) also argued that globalization helps open economies to grow and prosper, indicating that it may be beneficial for economic growth and development of a nation. In this line, Sirgy *et al.* (2004) explore the impact of globalization on life expectancy in developing countries, as those nations suffer more particularly vis-à-vis health outcomes. Though few studies explore the effect of globalization on human health

(Sirgy *et al.* 2004; Tsai, 2007; Owen and Wu 2007; Bussmann 2009), it is evident by the majority of them that there exist various channels by which globalization may affect life expectancy (Lichtenberg 2005; Stark 2004; Bergh and Nilsson 2010). The first channel is the *income effect* whereby globalization raises the purchasing power of the population via an international skilled-labor migration pattern. The increasing income of people may be invested in disease free food and safety measures, health care and assessing vaccinations that in turn positively affects human health. In contrast, globalization can impact public health adversely in case individuals spend their income on health-deteriorating consumption namely resort to military (fast) food, with severe harmful effect on health. The second channel called the *education effect*, demonstrates that globalization may improve health via increasing literacy. This happens because people working abroad get better education and eventually become cautious enough to take care of their health efficiently (Strak 2004). The third channel entails the *technology effect,* which infers that globalization inherits the use of technology with positive effects on health. It implies that countries accessing medical technologies and new health caring drugs improve life expectancy significantly (Lichtenberg 2005). As Papageorgiou *et al.* (2007) argued, affordable technology diffusion via medical experts is beneficial for contributing towards better life expectancy mainly in the case of large technology importing countries. In this vein, Deaton (2004) suggested that closer integration amongst economies enhances advanced health-related knowledge for all of them. The final channel described as the *intake effect,* poses that globalization has led to changes in lifestyle whereby people turn out to be addicted to Western diet styles with high fat and sugar contents, thus severe health consequences for the population (Medez and Popkin 2004).

More recently, Claessens and Feijen (2006) demonstrated that financial development may affect life expectancy via various patterns. Firstly, through the *income effect* channel they show that financial development gears industrialization and economic output. The growth of industrialization and economic activities generates employment opportunities and increases the income of households. An increasing income not only helps the population to save money but also

enables them to spend money for better food, nutritional intakes, housing, health care treatment, better living, working conditions, thereby enhancing life expectancy overall. Secondly, *the education effect* reveals that as accessing financial resources could significantly help people spend money for better education, it thereby increases skill employment opportunities. With better income and educational awareness, people become health conscious, which in turn may eventually increase their life expectancy. Thirdly, the *gender equality effect* provides proof that financial development empowers women in self-generating income activities. Self-employed empowered women take better care of their children and invest more money on health. Evidently, the access to financial services by women indirectly improves family health and life expectancy. Finally, financial development improves life expectancy via the *infrastructure effect,* which shows that it gears economic output with the help of both public and private investments in building health care infrastructure, such as hospitals and clinics with availability of life-saving drugs. Nonetheless, financial development could influence life expectancy negatively particularly when low-income or underprivileged households need high-valued mortgage assets as collaterals for accessing the required financial capital from banking institutions. This may be further argued by the fact that households are forced to sell their existing assets to make repayments of principal amounts and interest rates. The practice of selling their existing wealth decreases their income level and reduces proper investment on health, thereby adversely affecting life expectancy.

The literature in the field of development economics has recognized the importance of life expectancy as it not only increases the productivity of labor force but also adds higher economic growth in long run. Despite that significance of life expectancy on the productive health of people and long-run economic development, numerous existing works on life expectancy have studied the macroeconomic health effects of globalization, financial development and economic growth on life expectancy within country specific or panel framework (Alam *et al.* 2016, 2016b; Bergh and Nilsson 2010; Sirgy *et al.* 2004). To the best of our knowledge, no published study has empirically examined the causal relationships between globalization, financial development,

economic growth and life expectancy in Sub-Saharan African countries. Therefore, our study is motivated to fill this gap in contributing to the existing literature, by investigating the non-linear cointegration and non-parametric causal effects of globalization, financial development and economic growth on life expectancy in 16 Sub-Saharan African countries. Moreover, our study contributes to the existing literature by four ways: (i), firstly, we conduct a nonlinear, non-parametric analysis of the interplay between financial development, globalization, economic growth and life expectancy for 16 Sub-Saharan African economies.(ii), secondly, we employ the non-parametric unit root testing by Bierens (1997a) to confirm whether non-stationarity is present or not in our investigated variables;(iii) thirdly, as a follow-up step we utilize the nonparametric cointegration test of Bierens (1997b) to establish any inherent nonlinearities incorporated in the long-run relationship between our variables. Wang-Phillips (2009) structural nonparametric cointegrating regression modeling is also employed to examine the long-run relationship between life expectancy and its determinants. (iv) Finally, the multivariate nonparametric Granger causality test by Diks-Wolski (2016) is applied towards examining non-parametric causal relationships between the series. The non-linear methods used in this study are superior than the traditional linear cointegration and causal techniques because it will capture the non-linear pattern of the time series data. As a result, it enables us to capture the true impact of the macroeconomic factors on life expectancy in Sub-Saharan economies. Interestingly, as opposed to the rest of the literature, our empirical results indicate that all variables are nonlinearly cointegrated. Furthermore, financial development, globalization and economic growth present a positive impact upon life expectancy. Hence, financial development is of paramount importance in improving life expectancy in the investigated economies, except perhaps for Gabon and Togo. In general, globalization adds to life expectancy and economic growth also improves it. The Granger causality analysis performed shows that a feedback effect exists between financial development and life expectancy in all countries with the exceptions of Burundi, Gabon, Nigeria and Togo. Unidirectional causality is observed from financial development to life expectancy in Burundi and

Nigeria, hitherto life expectancy Granger causes financial development in Gabon and Togo. Globalization and life expectancy presented a bi-directional relationship for all sampled countries. In addition, a feedback spillover mechanism was observed between economic growth and life expectancy with the exceptions of Cameroon, Gambia, Sierra Leone and South Africa. Unidirectional causality is detected from economic growth to life expectancy in Cameroon and Sierra Leone and life expectancy Granger caused economic growth in case of South Africa. These findings provide insightful policy implications towards improving health outcomes via financial development, economic growth and globalization. Subsequently, all the above determinants can be of crucial economic importance regarding the improvement of life expectancy.

This paper is structured as follows: Section 2 reviews the literature. Section 3 describes our data and presents the implemented methodologies. Section 4 outlines the empirical results and their economic inference. Finally, Section 5 concludes and provides policy implications.

2. Literature review

Since the pioneering contribution of Auster *et al.* (1969), there has been much empirical discussion about the determining factors that affect life expectancy in developing countries, namely by Grossman (1972), Rodgers (1979), Anand and Ravallion (1993), Jagger and Robine (2011), and Wilkinson (1992) among others. The factors influencing life expectancy include income, education, income inequality and unemployment. However, their impact on life expectancy is controversial across studies and many times the findings are inconclusive. To be the best of our knowledge, no published work has investigated the empirical linkages between life expectancy, globalization, financial development and economic growth under a time series-modeling framework. We have divided the relevant literature into three categories exploring i.e., financial development-life expectancy linkage, globalization-life expectancy nexus as well as life expectancy versus economic growth.

2.1. Financial development-Life expectancy linkage

The pioneering work of Claessens and Feijen (2006) suggested various channels effects (e.g., income, gender, education and infrastructure effects) through which financial development may influence life expectancy. According to the income effect channel, increased financial development implies the development in the banking and stock market activities. For instance, the growing banking sector not only enables access the financial institutions for the bank credit and enables industry and government sectors to investment in the growth of industrialization and employment opportunities. The rising employment opportunities will result in increased income of the people. The increased income level not only helps people to support their consumption and saving activities but also allow them to afford the better food, cloth, housing, health care treatment, and make investment in conducive working and living conditions that significantly improve life expectancy. The education effect is considered as a second channel which indicates that the people with access to financial services will help them to investment on education. The increased investment on education increases human capital that helps people to be part of better employment opportunities. As a result, the better employment opportunities not only increase the income of the people but also improves the living conditions of people with better access to food, cloth and housing. The better living conditions improve health and life expectancy of the people. The gender effect is the third channel which shows that the financial development helps women to be empowered in income generating activity and family decision making than a man. For instance, women with access to financial services from the financial institutions will enjoy the benefit of human capital through investment in education. The increased human capital allows skilled women to get job and at the same time helps married women to investment money on medical treatment of their children and spend money in enhancing family welfare than a man does. Hence access to financial services by women will indirectly improve the health condition and life expectancy. Infrastructure effect is the final channel through which financial development improves life expectancy. For instance, greater financial development increases economic growth

and thereby it enables both public and private sectors to increase investment in the creation of health care infrastructure, e.g. clinics and hospitals which may produce better health care outcomes. This could be one of the reasons for the promotion of better life expectancy. In contrast, financial development has adverse effect on life expectancy of the people. For instance, a poor household requires high mortgage asset to access the bank credit from the financial institutions. In such circumstance, a poor household will sell all productive assets in order to get the credit from the banking sector and eventually it will decrease the income. The decreased income will adversely affect the living and health conditions. The poor health outcomes result in low life expectancy. Moreover, financial development may cause a financial crisis that slowdowns long-lasting economic growth when the financial services are mismanaged by the financial institutions or the user of financial services (Kindleberger 1978). The financial crisis during 2008-2009 is another example where both government and households have experienced low spending on health care, insurance and infrastructure which also negatively affects the health system of a country.

Motivated by the theoretical mechanism presented in the study of Claessens and Feijen (2006) on financial development and its linkage with life expectancy, Alam *et al.* (2016a) indicated the positive and significant impact of financial development upon life expectancy in India. This implies that financial development is beneficial for promoting life expectancy in India. Their findings did not only add to the relevant stream of the literature but also offered important fiscal guidelines and best practices for policy makers and government to consider the development of the financial sector as an economic tool towards improving the physical health of people.[3]

Moreover, Outreville (1999) found a positive impact of human capital on financial development in case of 57 developing countries. In contrast, Hakeem and Oluitan (2012) found that financial development Granger causes human capital. Nik *et al.* (2013) found a negative and significant impact of financial development on human capital. They rationalized this result arguing that it is due to the lack of effective financial resources' allocation by the banking system.

Akhmat *et al.* (2014) found that financial development and human development have long-run relationship and financial development promotes human capital in South Asian Association for Regional Cooperation (SAARC). Moreover, Sehrawat and Giri (2014) found that financial development Granger causes human development, indicating that the former contributes to the development of human capital, hence increases life expectancy in India. Hatemi-J and Shamsuddin (2016) showed that human development causes financial development, while this does not apply reversely for Bangladesh. Similarly, Sehrawat and Giri (2017) found evidence of positive impact of financial development upon human capital, thereby indicating that financial development could act as an important driver for economic growth of human capital also resulting significant improvement of life expectancy in 10 major Asian countries.

2.2. Globalization - Life expectancy nexus

It is evident that globalization integrates less globalized economies with high globalized economies in terms of exporting and importing goods and services. Besides inflows of remittances and technology help developing countries to increase their economic activities and reduce poverty. But a plethora of theoretical literature also established the link between globalization (e.g., trade openness and foreign direct investment) and health through various channels (Borensztein et al. 1998; Yanikkaya 2003). The income effect is the first channel, indicating that the countries with passing globalization enjoys the significant benefit of higher economic growth. The increased economic growth will increase the income of the people through creating employment opportunities. The rising income enables people to afford better food, nutrition, cloth and housing. It also helps people to invest money on quality healthcare treatment that not only improves working conditions and health outcomes but also promotes life expectancy. The education effect is the second channel, indicating that globalization helps people to migrate to rest of the countries and eventually remittances inflows enable to investment on human capital. The people with better human capital not only gets higher salary from the job market but also promote

their life expectancy through improving health outcomes. The technology transfer effect is the third channel, indicating that globalization is the driver of technology diffusion from advanced countries to developing economies (Xu and Wang 2000; Ciruelos and Wang 2005). The reason is that most of the research and development (R&D) is made on better health-driven technology (Papageorgiou et al. 2007). They argue that the integrated countries with access to better technology for sanitation and medical treatment will help them to improve the health conditions of the people. While many channels indicate the positive effect of globalization on health, others also believe the adverse effect of globalization on life expectancy. Kawachi and Wamala (2006) argued that globalization is not beneficial for life expectancy as countries with greater integration may hamper the health of their people by inviting infectious diseases such as HIV and H5N1 from the rest of the countries. Subsequently, Owen and Wu (2007) also argue that globalization increases the inflows of foreign investors to developing countries which has adverse effect on the health of natural environment and life expectancy of the people. For instance, the foreign investors from developed countries come to developing countries not only because of profit opportunities but also due to the lack of stringent environmental regulations. As a result, foreign investors deteriorate the health of natural environment by creating the negative externality to nature in terms of massive pollution. Such a pollution haven also damages the health of the people residing in the area where the industry is located. Eventually, the people suffer from massive pollution and their life expectancy got adversely affected due to bad health conditions.

Sirgy *et al.* (2004) argued that the impact of globalization on life expectancy is controversial, namely both positive and negative effects were observed vis-à-vis life expectancy. Proponents of globalization report that it is one of the most significant drivers for the improvement of life quality (e.g., Zoellick 2001; Thorbecke and Eigen-Zuchhi 2002). Pro-globalists recognize trade and economic openness as fertile opportunities to increase productivity and wages, hence improving quality of life especially for low-skilled workers. On the contrary, opponents of globalization notice a negative impact on job market of low-skilled workers (e.g. Strange 1996),

mainly in the manufacturing sector. The argument of hyper-globalists concerning job losses has been nullified by Krugman (1996) who argued that the declining jobs growth of the manufacturing industry is not caused by globalization, but mainly by technological changes impacting economies. Moreover, hyper-globalists consider that government fiscal policies have become powerless towards improving quality of life. Illustrating the gloomy picture of interconnected economies, while linking the ambiguous relationship between globalization and health, globalists in general argue that it has become a great threat to "open world" in 21st century. Influenced by the double-bladed human consequences of globalization reported first by Sirgy *et al.* (2004), few studies took over empirical efforts in examining the relationship between globalization and life expectancy.

Wei and Wu (2002) being one of the seminal studies on this topic, documented the positive effects of trade openness on life expectancy[4]. In a similar vein, Levin and Rothman (2006) reported that increased trade openness reduces infant mortality and malnutrition. Furthermore, Owen and Wu (2007) found that increased trade openness reduces infant mortality and adds to life expectancy, albeit mainly in developing countries. The effect of trade openness in improving population health is beneficial for developing countries especially regarding lower income individuals, whilst it diminishes for higher income levels. The increased trade openness is not significantly associated with the reduction of infant mortality or the improvement of life expectancy in richer countries. This implies that increased trade openness is beneficial for poor countries. Their findings also demonstrate the establishing positive correlation between economic openness and physical health, which is due to knowledge spillovers and policy environment.[5] Bussmann (2009) failed to support their theoretical premise that trade has a significant and positive impact on women's health care for a sample of 134 countries.[6] Ovaska and Takashima (2006) reported the vital role of economic freedom in improving life expectancy, yet only for large-sized economies. In accordance with the findings of Ovaska and Takashima (2006) and

Pritchett and Summers (1996) theorized that open economies present greater possibility of improving life expectancy than highly restricted economies.

Using a comprehensive measure of globalization i.e., including economic, political and social globalization as developed by Dreher (2006), Tsai (2007) indicated that the positive effect of political globalization on human development index (life expectancy, adult literacy and GDP per capita) is evident, while both economic and social globalization is unable to exercise significant impact upon the quality of life. They also showed that globalization improves human welfare in highly industrialized countries and hampers it in case of developing countries. Papageorgiou *et al.* (2007) revealed that importing medical technology is the key to improving life expectancy in the case of 67 countries.

Next, Bergh and Nilsson (2010) noted the insignificant effects of political and social globalization on life expectancy for 92 countries. Following Owen and Wu (2007), Stevens *et al.* (2013) found the positive effect of increased trade openness on human health and welfare was pronounced in lower income countries compared to the developed ones. Additionally, they showed the presence of non-linear relationships between income and health, indicating that the effect of increased trade openness on health outcomes decreases as income increases and declines for higher income levels, i.e. an inverted-U shaped link was revealed between trade openness and life expectancy. They detected that increased trade openness is positively associated with income level and health outcomes at a decreasing rate up to a threshold point whereby the impact on health is significantly lower over and beyond the threshold. They further argued that knowledge spillover is one of the transmission mechanisms in developing countries leading to the improvement of living and health conditions. For example, as international trade strengthens the global diffusion of telemedicine and medical tourism, it benefits developing countries improve life expectancy. Lastly, they report the harmful impact of increased trade openness on life expectancy in developed countries due to long-working hours, unfolded mental pressure and sleep

deprivation combined with consumption addition to widely processed food available in supermarkets.

In a more recent study, Bezuneh and Yiheyis (2014) illustrated that trade liberalization bears a negative effect on food availability, which in turn shows hampering effects on public health for 37 developing countries. Herzer (2017) observed the positive impacts of trade openness upon health measured by means of life expectancy in USA. Lin *et al.* (2015) indicated that trade openness is not beneficial towards reducing infant mortality for least 48 developing countries. They further argued that higher trade is an increasing factor of child mortality via pollution of the environment. In contrast, Alam *et al.* (2016b) concluded that trade openness and FDI both increase life expectancy in the long-run, and cause life expectancy in the short-run for Pakistan. In a similar vein, Nagel *et al.* (2015) reported non-linear co-movement between FDI and population health in the presence of per capita income in case of 179 countries, further indicating that FDI positively improves population health at lower income and deteriorates it for higher income levels. Furthermore, Herzer (2017) reported positive and long-run effects of trade openness on population health as measured by life expectancy and infant mortality for a sample of 74 countries. However, the strength of this relationship appeared to vary across countries. Their results further reveal the beneficial effects of trade openness on population health in countries with lower development and less market regulations. This implies that trade openness and foreign direct investment promote life expectancy in Pakistan by increasing population health condition.

2.3. Economic growth versus Life expectancy

Deaton (2008) in a theoretical work argued that without health, people cannot become beneficial to society. So, without income, health alone does little enabling the population to lead a good life. In such a light, it may be further argued that economic growth is important for better life expectancy of the people living in the society and better life expectancy is also essential for long-run economic growth. For instance, increased economic growth of an economy may allow the

government to stimulate higher investment on employment opportunities, human capital generation, promoting financial development, creating women's empowerment, reducing income inequality, enhancing health infrastructure and importing better technology for hospitals. If the working conditions and health outcomes of the people are improved with mitigating above factors, then it may have a chance of promoting better life expectancy of the people living in the society. Better life expectancy, on the other hand, is vital for achieving long-run economic growth. For instance, the people with good health and better life expectancy will increase their productivity which is responsible for higher economic growth in the long-run. However, there is an on-going debate in the existing literature upon the impact of life expectancy (i.e. health) on economic growth (i.e. wealth) or vice versa vis-à-vis the effect of economic growth on life expectancy. Though a substantial body of empirical studies has examined the relation between life expectancy and economic growth (e.g., Acemoglu and Johnson 2007; Lorentzen *et al.* 2008), the overall findings remain inconclusive and mixed. However, the overall outcome of the relevant stream of literature implies that there may be an inverted U-shaped relationship between life expectancy and economic growth. This implies that increasing life expectancy may be good for the growth of a nation up to a threshold point, whereby thereafter growth becomes controversial and sometimes detrimental (Kelley and Schmidt 1995, 2005).

Acemoglu and Johnson (2007) using a sample of 47 rich, middle-income and poor countries find a negative but statistically insignificant impact of life expectancy on economic growth. Instead, Zhang and Zhang (2005), Bloom *et al.* (2010), Turan (2009) and Aghion *et al.* (2010) report a significantly positive effect of life expectancy vis-á-vis economic growth. Van Kippersluis *et al.* (2009) concluded that there is no evidence of income-related health inequality in most European countries namely it is not higher among younger than older generations. Swift (2011) found the significant and increasing spillovers of life expectancy emerge upon economic growth for 13 OECD countries. Hansen and Lønstrup (2015), using a world panel of 119 countries over the period 1940-1980, demonstrates that the U-shaped relationship between life expectancy

and economic growth might be a realistic attribute. This is among the first studies presenting mixed results at a global level. Similarly, Jaunky (2013) confirms the existence of a U-shaped relationship between – what they define – as life expectancy at birth (health) and economic growth (wealth) for a sample of 107 countries. Kunze (2014) in his work, while theoretically, insists that life expectancy deteriorates economic growth, at the same time empirically reveals a pattern of non-linear relationship. Mahyar (2016) found that life expectancy is positively and significantly associated with economic growth in Iran. Interestingly, Ebenstein *et al.* (2015) in their study found that rapid economic development is beneficial for Chinese growth in life expectancy at a regional and macro level. Recently, Hansen and Lønstrup (2015) reported the negative and significant interrelationship between life expectancy and economic growth for 35 countries. Alam *et al.* (2016a) found the positive and significant effect of economic growth on life expectancy which indicates that economic growth promotes life expectancy in India.

Against this literature (see Table A1 of the Appendix), which renders inconclusive and controversial results across countries investigating the determinants of life expectancy using time series or panel approaches. To our knowledge, no published study has yet examined the impacts of globalization, financial development and economic growth upon life expectancy in case of 16 Sub-Saharan African countries within a time series modelling framework. Under this novel context, our study is motivated to expand the existing literature by investigating the factors and the effects of globalization, financial development and economic growth on life expectancy for the proposed dataset 1970-2012 utilizing up-to-date nonlinear and nonparametric econometric methodologies beyond the well-established linear benchmark techniques. The findings bearing policy implications are also discussed in the concluding section.

3. Data and Methodology

This study employs nonlinear and nonparametric econometric methods to analyze the nexus between financial development, globalization, economic growth and life expectancy using data

from 1970 to 2012[7] for the case of Sub-Saharan African countries.[8] As commonly used in the existing literature (Levin 2005; Shahbaz *et al.* 2017) domestic credit to the private sector in real US$ is used as a proxy for financial development (denoted as F_t).[9] We use data on domestic credit to private sector (as % of GDP) and real GDP, obtained from the World Bank (2016) World Development Indicators (WDI). We calculate domestic credit to private sector in real US$ (base year = 2010). Interestingly though, unlike previous studies, we use a newer more improved index of globalization (indicated by the symbol G_t) i.e., the KOF index of overall globalization developed by Dreher (2006). The overall globalization index is a weight age average of economic globalization (36%), social globalization (38%) and political globalization (26%) simultaneously, and is considered to be far more informative than other measurements such as trade openness, imports or exports as a share of GDP.[10] Next, the real GDP per capita (in constant 2010 US$) is taken as a surrogate for economic growth (denoted as Y_t) from World Development Indicators (World Bank, 2016). Ultimately, life expectancy data (symbolized by E_t), obtained from World Development Indicators (2016), incorporates "*the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life*". All four variables are transformed into natural logarithms,[11] as it is conventionally performed in the existing literature according to Gries *et al.* (2009). The model in its estimable form is given as follows:

$$\ln LE_t = \beta_0 + \beta_1 \ln FD_t + \beta_2 \ln GL_t + \beta_3 \ln Y_t + \varepsilon_t \qquad (1)$$

Table 1 provides the descriptive summary statistics of $\ln \mathrm{FD}_t$, $\ln GL_t$, $\ln Y_t$, and $\ln \mathrm{LE}_t$ for the 16 Sub-Saharan African countries. It is obvious that the variables revolve around their mean while their standard deviations are relatively low. In particular, the standard deviation of $\ln F_t$ is

the only one substantially larger than other. Interestingly, some of the investigated variables suffer from non-normality.

TABLE-1: Descriptive Statistics

Country	Variable	Mean	Median	Max.	Min.	Std. dev.	J.B.	Prob.
Burundi	$lnFD_t$	3.1604	3.3754	3.7882	2.0162	0.4905	4.4233	0.1095
	$lnGL_t$	3.0392	2.9715	3.4767	2.7073	0.2342	3.5057	0.1733
	lnY_t	5.5491	5.5719	5.7837	5.3234	0.1587	4.2721	0.1181
	$lnLE_t$	3.8947	3.8842	4.0216	3.7792	0.0658	1.2989	0.5223
Cameroon	$lnFD_t$	5.1378	4.9109	6.1236	4.1999	0.6045	4.0628	0.1312
	$lnGL_t$	3.4988	3.4369	3.7844	3.1928	0.1855	3.3757	0.1849
	lnY_t	7.0371	7.0320	7.4224	6.7373	0.1754	1.3384	0.5121
	$lnLE_t$	3.9456	3.9572	3.9998	3.8303	0.0419	13.5590*	0.0011
Cote d'Ivoire	$lnFD_t$	5.9324	6.0768	6.8553	5.0199	0.6122	4.6129**	0.0996
	$lnGL_t$	3.6589	3.5866	3.9229	3.4061	0.1643	4.6312**	0.0987
	lnY_t	7.3458	7.2617	7.7820	7.0516	0.2168	3.9973	0.1355
	$lnLE_t$	3.8978	3.9032	3.9687	3.7783	0.0503	1.7200	0.4232
Ethiopia	$lnFD_t$	3.4534	3.4534	4.0858	2.3906	0.4657	1.7577	0.4153
	$lnGL_t$	3.3697	3.3696	3.6517	3.1287	0.1998	3.4262	0.1803
	lnY_t	5.4061	5.3381	5.9718	5.0984	0.2163	8.4586*	0.0146
	$lnLE_t$	3.9306	3.9133	4.1399	3.7767	0.1133	2.1922	0.3342
Gabon	$lnFD_t$	7.2584	7.1573	8.1068	6.6187	0.4342	2.6010	0.2724
	$lnGL_t$	3.7549	3.7448	3.9366	3.5430	0.1009	0.8672	0.6482
	lnY_t	9.2909	9.2928	9.8778	8.8803	0.1810	9.6706*	0.0079
	$lnLE_t$	4.0521	4.0854	4.1476	3.8428	0.0824	10.4520*	0.0054
Gambia (The)	$lnFD_t$	4.1043	4.1310	4.9399	2.9534	0.5452	2.0095	0.3661
	$lnGL_t$	3.7140	3.6202	3.9860	3.5554	0.1629	6.1398*	0.0464
	lnY_t	6.2477	6.2523	6.3325	6.0729	0.059	12.0680*	0.0024
	$lnLE_t$	3.9275	3.9603	4.0906	3.6342	0.1302	4.1125	0.1279
Ghana	$lnFD_t$	4.1195	4.0008	5.5038	2.3813	0.8540	2.1016	0.3497
	$lnGL_t$	3.6669	3.5715	3.9949	3.2303	0.2152	1.3448	0.5105
	lnY_t	6.8700	6.8497	7.3588	6.5533	0.1824	2.8215	0.2440
	$lnLE_t$	4.0149	4.0422	4.1105	3.8986	0.0629	2.9998	0.2232
Kenya	$lnFD_t$	5.2240	5.2220	5.7471	4.5095	0.2403	1.7135	0.4246
	$lnGL_t$	3.5699	3.5647	3.8560	3.2258	0.2202	4.9947**	0.0823
	lnY_t	6.7628	6.7574	6.9500	6.3987	0.0895	65.3481	0.0000
	$lnLE_t$	4.0215	4.0277	4.0989	3.9276	0.0541	3.4403	0.1790
Madagascar	$lnFD_t$	4.1749	4.2759	4.8272	3.4145	0.4211	3.9472	0.1390
	$lnGL_t$	3.2194	3.1320	3.7421	2.8413	0.3080	4.1384	0.1263
	lnY_t	6.2032	6.1208	6.6264	5.9273	0.1990	5.0978**	0.0782
	$lnLE_t$	3.9769	3.9435	4.1627	3.8018	0.1114	3.5396	0.1704
Mauritius	$lnFD_t$	7.5203	7.5917	9.0315	6.2326	0.9057	2.9367	0.2303
	$lnGL_t$	3.8699	3.7944	4.2213	3.6012	0.1944	3.9386	0.1396
	lnY_t	8.3592	8.3818	9.0238	7.7421	0.4156	2.8271	0.2433
	$lnLE_t$	4.2478	4.2508	4.3022	4.1722	0.0342	1.8658	0.3934
Nigeria	$lnFD_t$	5.2606	5.2366	6.7410	4.3735	0.4970	8.5720*	0.0138
	$lnGL_t$	3.7170	3.7331	4.0190	3.3264	0.1999	2.2292	0.3281
	lnY_t	7.3789	7.3714	7.7829	7.0450	0.2217	3.7563	0.1529

	$lnLE_t$	3.8359	3.8330	3.9533	3.7180	0.0548	0.1123	0.9454
Rwanda	$lnFD_t$	3.2968	3.2360	4.4621	1.8655	0.6044	0.4072	0.8158
	$lnGL_t$	3.0691	2.9455	3.7769	2.6631	0.3446	4.8726**	0.0875
	lnY_t	5.9315	5.9248	6.4266	5.3104	0.2055	2.9768	0.2257
	$lnLE_t$	3.8170	3.8381	4.1399	3.2988	0.2164	5.5517**	0.0623
Senegal	$lnFD_t$	5.3439	5.4094	5.8324	4.7829	0.3082	2.6163	0.2703
	$lnGL_t$	3.7037	3.6831	3.9890	3.3340	0.1832	1.2747	0.5287
	lnY_t	6.8117	6.8099	6.9249	6.6758	0.0684	2.0057	0.3668
	$lnLE_t$	3.9850	4.0484	4.1793	3.6692	0.1412	5.3597**	0.0686
Sierra Leone	$lnFD_t$	2.9531	3.0736	3.7350	1.5981	0.5908	2.9591	0.2277
	$lnGL_t$	3.3150	3.2182	3.8231	3.0737	0.1957	9.2392*	0.0099
	lnY_t	6.0976	6.1238	6.3088	5.7206	0.1706	3.8283	0.1475
	$lnLE_t$	3.6854	3.6781	3.9070	3.5441	0.0935	4.3849	0.1116
South Africa	$lnFD_t$	8.7099	8.6366	9.3770	8.2613	0.3570	4.0030	0.1351
	$lnGL_t$	3.8317	3.6707	4.1738	3.5976	0.2340	6.3336*	0.0421
	lnY_t	8.7862	8.7776	8.9311	8.6719	0.0729	2.1366	0.3436
	$lnLE_t$	4.0381	4.0271	4.1324	3.9427	0.0623	3.3633	0.1861
Togo	$lnFD_t$	4.6808	4.7304	5.2385	4.1025	0.2966	1.4151	0.4928
	$lnGL_t$	3.6193	3.6173	3.9015	3.3073	0.1672	1.0709	0.5854
	lnY_t	6.2922	6.2992	6.5270	6.0150	0.1041	0.0032	0.9984
	$lnLE_t$	3.9793	3.9920	4.0699	3.8402	0.0545	6.7943*	0.0335

Notes: Max. = Maximum; Min. = Minimum; Std. Dev. = Standard Deviation; J.B. = Jarque-Berra normality test; and Prob. = Probability. * Reject H_0: Normality if Prob.<0.0500. ** Reject H_0: Normality if Prob.<0.1000.

Further, model (1) is tested for functional form (linearity) using the Hsiao *et al.* (2007) test. As can be seen from Table 2, the test statistic rejects the null hypothesis of a linear function for all of the 16 Sub-Saharan African economies. As such, there is statistical evidence that model (1) is not linear in parameters for all the sample economies in this study. The nonlinearity of the effect of financial development (and perhaps the other regressors) on life expectancy can be intuitively justified as the four channels–through which the former affects the latter–can have varying impacts. In particular, there is a diminishing marginal rate of return to financial development (Outreville 2013); a small improvement in financial development has a larger effect on life expectancy in lower and lower middle income countries that it has on upper middle and high income countries (Claessens and Feijen 2006). In addition, the economic growth, spurred by financial development, may not be equitable and rising inequality may lead to stagnant and/or lower life expectancy (Cervellati and Sunde 2005). As such, the income effect of financial development on life expectancy may be a double-edged sword and the relationship is likely to be

a nonlinear one (Stevens et al. 2013). The education and gender equality effects will also exhibit diminishing marginal returns, as improvements in education and gender equality greatly affects household nutrition and health at lower level of income. The infrastructure effect of financial development on life expectancy is expected to have a level effect; with improvements in healthcare finance and healthcare infrastructure after the economy and the financial sector reaches a critical mass. Accordingly, the effect of financial development on life expectancy appears to be multifaceted, as the different channels of the former affects the latter in differing magnitudes and levels (Claessens and Feijen 2006). Thus, these two indicators, along with the other model variables, are expected to have a nonlinear relationship, especially in developing and emerging economies.

Subsequently, only nonparametric econometric testing methods could provide unbiased, efficient and consistent estimates from our data and model, as opposed to common linear alternatives. To avoid further complicating the analysis due to nonlinearity and to allow for a smooth comparison of the empirical results, we opt for the sole employment of nonparametric methods, which allow the data to determine inherently their functional forms without imposed restrictions. In this way, the nonparametric methods could detect and capture both linear and nonlinear features in the datasets.

TABLE-2: Linearity Test

Country	Test statistic ($\hat{J}_n$)	Simulated *p*-value	Linear function?
Burundi	3.4795*	0.0000	No
Cameroon	3.4667*	0.0000	No
Cote d'Ivoire	2.9820*	0.0025	No
Ethiopia	3.0779*	0.0000	No
Gabon	4.5837*	0.0000	No
Gambia (The)	2.0945*	0.0025	No
Ghana	3.0733*	0.0000	No
Kenya	3.1201*	0.0000	No
Madagascar	1.6035*	0.0025	No
Mauritius	2.1536*	0.0025	No
Nigeria	3.1207*	0.0000	No
Rwanda	1.2490**	0.0677	No

Senegal	4.7164*	0.0000	No
Sierra Leone	2.3830*	0.0000	No
South Africa	2.8495*	0.0025	No
Togo	4.3648*	0.0000	No

Notes: H_0: Linear functional form. *p*-values simulated by 399 replications. * If *p*-value < 0.0500, reject H_0 at 5% level. ** If *p*-value < 0.1000, reject H_0 at 10% level.

3.1. Bierens (1997a) nonparametric unit root test

We investigate the order of integration for financial development ($\ln F_t$), globalization ($\ln G_t$), economic growth ($\ln Y_t$) and life expectancy ($\ln E_t$) via the use of the nonparametric unit root test developed by Bierens (1997a). Under this approach, the null hypothesis entails a unit root with a drift while the alternative comprises a nonlinear trend stationarity process. Conventional parametric unit root tests such as the Augmented Dickey-Fuller test may suffer from incorrect non-rejection of nonstationarity for a variable series due to the presence of nonlinearities. This may lead to the parametric unit root tests suffering from type II error. Unlike parametric approaches, Bierens (1997a) testis able to account for the presence of such nonlinearities while examining the variables for stationarity[12]. For a variable z_t estimating the following auxiliary function is required to perform the Bierens (1997a) test for unit root:

$$z_t - z_{t-1} = a \cdot z_{t-1} + b_1 \cdot (z_{t-1} - z_{t-2}) + \ldots + b_p \cdot \left(z_{t-p} - z_{t-p-1}\right) + b_{p+1} + b_{p+2} \cdot P_{t,1} + \ldots + b_{p+m+1} \cdot P_{t,m} + u_t \quad (2)$$

where, if $t = p + 2, \ldots, n$, u_t is the white noise term, and t the standardized time, the trended Chebishev time polynomials can be denoted as $P_{t,k}$'s. The variable z_t is a unit root with a drift process under the null:

$$a = b_{p+2} = \ldots b_{p+m+1} = 0 \quad (3)$$

Under the alternative, z_t is a nonlinear trend stationary process for which $a < 0$. In this study we employ the test statistic ($\hat{A}_m$) designated by the formula: $n(a-1)$.

3.2. Bierens (1997b) nonparametric cointegration test

The nonparametric Bierens (1997b) cointegration test is able to test for nonlinear cointegration unlike the benchmark parametric ones of Johansen and ARDL bound tests. The latter suffer from false rejections of the true null hypothesis, i.e., from type I error due to presence of nonlinearities in the model[13]. The Bierens (1997b) test employs the computation of two random matrices A_m and B_m whereby it applies that the natural number $m \geq q$. According to Bierens (1997b), these two matrices represent the sums of the outer products of the weighted means of z_t and $z_t - z_{t-1}$. The generalized eigenvalues of a pair of the matrices $A_m$and $B_m + c\left[\frac{{A_m}^{-1}}{n^2}\right]$, where c is a positive constant with a default value of 1, are extracted. The power of the test can be enhanced by lowering the value of c, but this has the unintended effect of introducing size distortions. The number of cointegrating vectors is detected using the generalized eigenvectors of the matrices A_m and $\left[A_m + c\left[\frac{A^{-1}{}_m}{n^2}\right]\right]^{-1}$. The test statistic following Bierens (1997b) is denoted by λ_{min}. The null hypothesis can be simply outlined as $r = 0$ against the alternative of $r \geq 1$.

3.3. Wang-Phillips (2009) structural nonparametric cointegrating regression

Wang and Phillips (2009) introduce a structural nonparametric cointegrating regression process of the following nonlinear form:

$$y_t = f(x_t) + u_t, \qquad (t = 1, 2, \ldots, n) \qquad (4)$$

where u_t is a zero mean stationary equilibrium error, x_t is a jointly dependent non-stationary regressor, and f is an unknown function to be estimated via the observed data $\{y_t, x_t\}_{t=1}^{n}$. The standard kernel smoothing of $f(x)$ in model (4) is:

$$\hat{f}(x) = \frac{\sum_{t=1}^{n} y_t K_h(x_t - x)}{\sum_{t=1}^{n} K_h(x_t - x)} \tag{5}$$

with $K_h(s) = (\frac{1}{h})K(\frac{s}{h})$, and $K(x)$ representing a nonnegative real function with bandwidth parameter $h \equiv h_n \to 0$ as $n \to \infty$. Similar to the standard linear cointegrating regression model, the regressor and the dependent variable can be jointly dependent and contemporaneously correlated. According to Wang and Phillips (2009), joint dependence is known to bring about major complications under a nonparametric framework. This includes identification bias in standard kernel estimates and frequently "ill-posed inverse problems". However, Wang and Phillips (2009) argue that the asymptotic limit theory for the self-normalized estimate is identical to that of the stationary case (without endogeneity)[14]. As such, the Wang-Phillips (2009) testing procedure is impervious to biases and inconsistencies arising from endogeneity of the integrated or near-integrated regressors within the structural nonparametric regression. This approach is capable of detecting nonlinearity as well as linearity in the structural cointegrating regression.

3.4. Diks-Wolski (2016) multivariate nonparametric Granger causality

Diks and Wolski (2016) (hereafter referred to DW) extended the nonparametric Granger causality testing of Hiemstra and Jones (1994) under a multivariate framework, the simplest being the bivariate case described in Diks and Panchenko (2006). Assume $\{X_t\}$ and $\{Y_t\}$ as lagged vectors of time series i.e.,$X_t^{l_X} = X_{t-l_X+1} \dots X_t$and $Y_t^{l_Y} = Y_{t-l_Y+1} \dots Y_t$. The lag lengths are finite equal to l_X and l_Y respectively and, as such, the test for conditional independence can be specified as:

$$Y_{t+1}|\left(X_t^{l_X}, Y_t^{l_Y}\right) \sim Y_{t+1}|Y_t^{l_Y} \tag{6}$$

Under a bivariate setting[15], when $Z_t = Y_t + 1$,$W_t = (X_t^{l_X}, Y_t^{l_Y}, Z_t)$ is an $(l_X + l_Y + 1)$-dimensional vector with an invariant distribution. The null hypothesis which can be defined by the ratios of the joint distributions, implies that the conditional distribution of Z given $(X, Y) = (x, y)$ is the same as that of Z given $Y = y$ only. This allows formulating the joint probability distribution $f_{X,Y,Z}(x, y, z)$, for lag lengths (l_X, l_Y) equal to 1:

$$H_0: \frac{f_{X,Y,Z}(x,y,z)}{f_{X,Y}(x,y)} = \frac{f_{Y,Z}(y,z)}{f_Y(y)} \tag{7}$$

Similarly, the null hypothesis can be redefined as:

$$H_0: \frac{f_{X,Y,Z}(x,y,z)}{f_Y(y)} - \frac{f_{X,Y}(x,y)}{f_Y(y)} \cdot \frac{f_{Y,Z}(y,z)}{f_Y(y)} = 0 \tag{8}$$

It is worthwhile noting that equation (8) is similar to $f_{X,Y,Z}(x, y|z) = f_{X,Y}(x|y) = f_{Z,Y}(z, y|z)$. For each fixed value of *y*,X and $Z$are specified conditionally independent on $Y = y$. Diks and Wolski (2016) show that for any weight function $g(X, Y, Z)$,

$$E\left(\left[\frac{f_{X,Y,Z}(x,y,z)}{f_Y(y)} - \frac{f_{X,Y}(x,y)}{f_Y(y)} \cdot \frac{f_{Y,Z}(y,z)}{f_Y(y)}\right] g(X,Y,Z)\right) = 0 \tag{9}$$

The test statistic thus is specified as:

$$T_n(\epsilon_n) = \frac{n-1}{n(n-2)} \times \sum_{i=1}^{n} \left(\hat{f}_{X,Y,Z}(X_i, Y_i, Z_i)\hat{f}_Y(Y) - \hat{f}_{X,Y}(X_i, Y_i)\hat{f}_{Y,Z}(Y_i, Z_i)\right) \tag{10}$$

where ϵ_n is the bandwidth, dependent on the sample size n. The multivariate DW approach, tests the direction of Granger causality between Y_t and X_t while conditioning on an additional variable $\{Q_t\}$[16]. Consequently, equation (6) is transformed into the following:

$$Y_{t+1} \left| \left(X_t^{l_X}, Y_t^{l_Y}, Q_t^{l_Q} \right) \sim Y_{t+1} \right| \left(Y_t^{l_Y}, Q_t^{l_Q} \right) \tag{11}$$

Increasing the dimensions of the test (i.e. from 2 to 3 variables) however, substantially increases the bias of the estimator, violating the consistency of the test statistic in equation (10). Such estimation bias can be decreased by "*sharpening*" the data. As Diks and Wolski (2016) explain the Data Sharpening (DS) process is a way of "perturbing" the original dataset by applying a data-driven map $\psi_p(\cdot)$, obtained based on DS bandwidth ε_{DS} using a nonparametric kernel-based estimator of the local derivative (gradient) of the density function. The sharpened test statistic, $T_n^S(\varepsilon)$, plugs the sharpened density estimators into the test statistic (10) in order to arrive at the following set-up:

$$T_n^S(\varepsilon) = \frac{n-1}{n(n-2)} \times \sum_i \left(\hat{f}_{X,Y,Z}^S(X_i, Y_i, Z_i) \hat{f}_Y^S(Y_i) - \hat{f}_{X,Y}^S(X_i, Y_i) \hat{f}_{Y,Z}^S(Y_i, Z_i) \right) \tag{12}$$

The DW procedure for testing Granger non-causality compared to the bivariate Diks-Panchenko (2006) approach is unbiased, consistent and efficient in terms of direction of causality especially under a multivariate framework. The test statistic has to be estimated using an appropriate optimal bandwidth based on the sample size. Diks and Panchenko (2006) noted that a reasonable bandwidth choice for empirical applications usually lays within the bounds [0.5, 1.5].

4. Empirical results

Table 3 presents the nonparametric Bierens (1997a) unit root test results[17] for $\ln F_t$, $\ln G_t$, $\ln Y_t$, and $\ln E_t$. The test statistic rejects the null of stationarity for all variables in log-levels and for all investigated economies, whilst they appear stationary in first differences i.e., I(1). Next, we employ the nonparametric tests for cointegration and causality between life expectancy and its determinants.

TABLE-3: Unit Root Analysis

Country	Variable	Levels		First differences	
		Test statistic ($\widehat{A}_m$)	*p*-value	Test statistic ($\widehat{A}_m$)	*p*-value
Burundi	$lnFD_t$	-18.1802	0.1900	-59.2573*	0.0300
	$lnGL_t$	-5.4290	0.7500	-297.6126*	0.0000
	lnY_t	-6.8152	0.8350	-40.7564*	0.0000
	$lnLE_t$	-29.7914	0.3800	-107.5677*	0.0100
Cameroon	$lnFD_t$	-19.1403	0.3000	-23.6134*	0.0200
	$lnGL_t$	-14.9650	0.3100	-180.5185*	0.0000
	lnY_t	-11.8453	0.4700	-26.3430*	0.0200
	$lnLE_t$	-9.1796	0.5000	-35.6068*	0.0000
Cote d'Ivoire	$lnFD_t$	-0.3568	0.9700	-29.0735*	0.0000
	$lnGL_t$	-5.2292	0.8600	-34.6704*	0.0100
	lnY_t	-10.5890	0.5000	-32.5006*	0.0467
	$lnLE_t$	-15.8851	0.3700	-19.3003*	0.0100
Ethiopia	$lnFD_t$	-9.2712	0.5200	-23.4808*	0.0200
	$lnGL_t$	-17.8737	0.1400	-62.4813*	0.0100
	lnY_t	-0.2614	0.9700	-28.3389*	0.0000
	$lnLE_t$	-5.6348	0.4600	-26.3742*	0.0160
Gabon	$lnFD_t$	-19.8213	0.1500	-45.6355*	0.0100
	$lnGL_t$	-15.2540	0.1700	-58.1008*	0.0000
	lnY_t	-12.4158	0.5400	-36.3674*	0.0250
	$lnLE_t$	-6.8033	0.5500	-208.2392*	0.0200
Gambia (The)	$lnFD_t$	-3.6272	0.9100	-48.0279*	0.0100
	$lnGL_t$	-5.3698	0.7100	-80.1337*	0.0180
	lnY_t	-15.1348	0.2900	-54.2695*	0.0000
	$lnLE_t$	-3.5273	0.2100	-114.5194*	0.0100
Ghana	$lnFD_t$	-8.5976	0.6800	-55.9120*	0.0000
	$lnGL_t$	-6.3270	0.8700	-47.3641*	0.0000
	lnY_t	-1.6739	0.9500	-52.7139*	0.0200
	$lnLE_t$	-3.7559	0.7200	-191.3543*	0.0200
Kenya	$lnFD_t$	-37.6589	0.1100	-59.5988*	0.0000
	$lnGL_t$	-13.1724	0.3700	-41.6042*	0.0000
	lnY_t	-14.2987	0.3400	-26.2905*	0.0300
	$lnLE_t$	-32.4224	0.1400	-1480.7023*	0.0000

Madagascar	$lnFD_t$	-9.2259	0.5500	-52.6700*	0.0000
	$lnGL_t$	-7.2726	0.5600	-53.6127*	0.0000
	lnY_t	-5.5993	0.6900	-270.1609*	0.0100
	$lnLE_t$	-6.9530	0.4600	-190.1981*	0.0000
Mauritius	$lnFD_t$	-10.8663	0.4700	-40.0796*	0.0200
	$lnGL_t$	-5.6662	0.7500	-44.6907*	0.0100
	lnY_t	-8.4686	0.6700	-1481.4580*	0.0000
	$lnLE_t$	-14.4392	0.3000	-22.6510*	0.0300
Nigeria	$lnFD_t$	-8.1001	0.6800	-43.9126*	0.0133
	$lnGL_t$	-11.0430	0.4000	-30.7470*	0.0300
	lnY_t	1.9578	1.0000	-52.9955*	0.0000
	$lnLE_t$	-11.5171	0.5100	-65.9805*	0.0300
Rwanda	$lnFD_t$	-10.6592	0.8900	-68.5086*	0.0200
	$lnGL_t$	-1.4833	0.9600	-84.6396*	0.0200
	lnY_t	-16.7313	0.2900	-114.2604*	0.0000
	$lnLE_t$	0.6703	0.9400	-108.7834*	0.0000
Senegal	$lnFD_t$	-25.3920	0.1600	-35.1077*	0.0300
	$lnGL_t$	-10.6469	0.4400	-62.3981*	0.0000
	lnY_t	-4.9905	0.8900	-106.4523*	0.0100
	$lnLE_t$	-17.6034	0.2600	-243.7189*	0.0000
Sierra Leone	$lnFD_t$	-3.3620	0.8700	-49.5726*	0.0200
	$lnGL_t$	-4.6098	0.8300	-1149.1315*	0.0000
	lnY_t	-3.6097	0.8900	-43.8224*	0.0200
	$lnLE_t$	3.4699	0.9600	-47.4764*	0.0300
South Africa	$lnFD_t$	-11.0785	0.4200	-48.6374*	0.0000
	$lnGL_t$	-6.7790	0.7200	-25.9454*	0.0400
	lnY_t	-1.3513	0.9200	-36.6260*	0.0300
	$lnLE_t$	-4.4894	0.5400	-247.6287*	0.0200
Togo	$lnFD_t$	-7.8012	0.6300	-44.8646*	0.0000
	$lnGL_t$	-16.6662	0.2900	-31.3376*	0.0100
	lnY_t	-15.1175	0.3500	-40.9707*	0.0150
	$lnLE_t$	-14.5338	0.5500	-142.1079*	0.0100

Note: In estimating the test statistic, the optimal value of p is chosen by the Schwarz (1978) Bayesian Criterion (SBC). p-values are simulated for relevant sample size using 100 replications.H_0: Series is non-stationary with a drift. H_1: Series is a nonlinear trend stationary process. *Reject H_0 if the p-value is< 0.0500.

The detected integration of the variables leads to the application of Bierens (1997b) test to examine the long-run relationships reported in Table 4. The null hypothesis of no cointegration (i.e., r=0) is rejected at 5% level of significance for all 16 Sub-Saharan economies. The null of one cointegrating vector (r=1) is not rejected in the case of Ghana and Nigeria. In Burundi, Cameroon, Cote d'Ivoire, Ethiopia, Gabon, Madagascar, Rwanda, Sierra Leone, South Africa and Togo, the null of one vector is rejected while the null of two (r=2) is not. Further, the case of r=2

is rejected in favor of the alternative of three vectors (r=3) only for Gambia (The), Kenya, Mauritius and Senegal. Therefore, one cointegrating equation will be utilized for Nigeria and Ghana, two vectors are applied for Burundi, Cameroon, Cote d'Ivoire, Ethiopia, Gabon, Madagascar, Rwanda, Sierra Leone, South Africa and Togo, and lastly three cointegrating vectors describe better the series of Gambia, Kenya, Mauritius and Senegal. As at least one cointegrating vector is found, we can conclude that there is a nonlinear long-run equilibrium[18] between 1970 and 2012 in the model for all 16 cases. This finding is in conformant with our hypothesis and is in line with similar studies including Alam *et al.* (2016a,b) and Sehrawat and Giri (2014, 2017). In addition, the presence of nonlinear cointegration indicates that the relationship financial development, globalization, economic growth and life expectancy may be developing over time.

TABLE-4: Cointegration Testing

Country	H_0 vs. H_1	m	Test statistic	Critical value (5%)	Critical value (10%)	r
Burundi	r=0 vs. r=1	5	0.00002*	0.005	0.011	
	r=1 vs. r=2	4	0.00035*	0.008	0.017	
	r=2 vs. r=3	4	0.23825	0.046	0.076	2
Cameroon	r=0 vs. r=1	5	0.00019*	0.005	0.011	
	r=1 vs. r=2	4	0.00309*	0.008	0.017	
	r=2 vs. r=3	4	0.11524	0.046	0.076	2
Cote d'Ivoire	r=0 vs. r=1	5	0.00025*	0.005	0.011	
	r=1 vs. r=2	4	0.00056*	0.008	0.017	
	r=2 vs. r=3	4	0.09597	0.046	0.076	2
Ethiopia	r=0 vs. r=1	5	0.00000*	0.005	0.011	
	r=1 vs. r=2	4	0.00065*	0.008	0.017	
	r=2 vs. r=3	4	0.33928	0.046	0.076	2
Gabon	r=0 vs. r=1	5	0.00000*	0.005	0.011	
	r=1 vs. r=2	4	0.00243*	0.008	0.017	
	r=2 vs. r=3	4	0.18371	0.046	0.076	2
Gambia (The)	r=0 vs. r=1	5	0.00033*	0.005	0.011	
	r=1 vs. r=2	4	0.00132*	0.008	0.017	
	r=2 vs. r=3	4	0.02268*	0.046	0.076	
	r=3 vs. r=4	4	0.98671	0.158	0.244	3
Ghana	r=0 vs. r=1	5	0.00009*	0.005	0.011	
	r=1 vs. r=2	4	0.02892	0.008	0.017	1
Kenya	r=0 vs. r=1	5	0.00000*	0.005	0.011	
	r=1 vs. r=2	4	0.00250*	0.008	0.017	
	r=2 vs. r=3	4	0.02193*	0.046	0.076	

	r=3 vs. r=4	4	0.25772	0.158	0.244	3
Madagascar	r=0 vs. r=1	5	0.00004*	0.005	0.011	
	r=1 vs. r=2	4	0.00119*	0.008	0.017	
	r=2 vs. r=3	4	0.17469	0.046	0.076	2
Mauritius	r=0 vs. r=1	5	0.00000*	0.005	0.011	
	r=1 vs. r=2	4	0.00255*	0.008	0.017	
	r=2 vs. r=3	4	0.01167*	0.046	0.076	
	r=3 vs. r=4	4	1.27846	0.158	0.244	3
Nigeria	r=0 vs. r=1	5	0.00000	0.005	0.011	
	r=1 vs. r=2	4	0.03191	0.008	0.017	1
Rwanda	r=0 vs. r=1	5	0.00174*	0.005	0.011	
	r=1 vs. r=2	4	0.00213*	0.008	0.017	
	r=2 vs. r=3	4	0.32875	0.046	0.076	2
Senegal	r=0 vs. r=1	5	0.00006*	0.005	0.011	
	r=1 vs. r=2	4	0.00459*	0.008	0.017	
	r=2 vs. r=3	4	0.02194*	0.046	0.076	
	r=3 vs. r=4	4	0.45639	0.158	0.244	3
Sierra Leone	r=0 vs. r=1	5	0.00012*	0.005	0.011	
	r=1 vs. r=2	4	0.00611*	0.008	0.017	
	r=2 vs. r=3	4	0.08915	0.046	0.076	2
South Africa	r=0 vs. r=1	5	0.00230*	0.005	0.011	
	r=1 vs. r=2	4	0.00584*	0.008	0.017	
	r=2 vs. r=3	4	0.08725	0.046	0.076	2
Togo	r=0 vs. r=1	5	0.00008*	0.005	0.011	
	r=1 vs. r=2	4	0.00101*	0.008	0.017	
	r=2 vs. r=3	4	0.13953	0.046	0.076	2

Note: r is the number of cointegrating vectors. * Reject H_0 at the 5% level of significance if test statistic < 5% critical value.

Then, a long-run equation is estimated for the 16 countries. The estimates of the Wang-Phillips (2009) nonparametric structural cointegrating equation procedure namely the coefficient and associated p-values, are shown in Table 5. The empirical evidence shows that financial development is positively and significantly linked with life expectancy in case of Burundi, Cameroon, Cote d'Ivoire, Ethiopia, Gambia, Ghana, Kenya, Madagascar, Mauritius, Nigeria, Rwanda, Senegal and South Africa, at 1% level of significance. This demonstrates the crucial role of financial development in increasing life expectancy. However, the positive effect of financial development on life expectancy is also nonlinear, meaning the impact has likely improved over time. This is in line with the rapid improvement in financial development in Sub-Saharan Africa

between mid-1990s to 2010s (International Monetary Fund 2016). It also likely that financial development improved life expectancy in these economies through the income, gender equality, education and technology effects. The positive and significant relationship shown for these Sub-Saharan African countries is similar to the ones reported by Alam *et al.* (2016a, b) and Sehrawat and Giri (2014, 2017) for the Indian economy.

In case of Gabon and Togo, financial development affects life expectancy insignificantly. Undoubtedly, Gabon is a Central African country and rich in natural resources. Yet it ranks poorly in relation to quality of life. Particularly, the poor performance of the human development index may indicate the ineffectiveness of income, education and technology effects that is impeding financial development towards life expectancy improvement. Also, for Togo, despite the fact that financial development positively influences life expectancy, it proves to be non-effective. This appears interesting as Xu (2000) finds Togo to be one of the few countries where financial development has a long-term negative influence on economic growth and investment between 1960 and 1993. Thus, the income, education and technology effects may have largely been ineffective. These observations should be a matter of further investigation and concern for policy makers as the government has not utilized up to the present day, financial development to promote life expectancy.

Next, the link between globalization and life expectancy is found to be positive and statistically significant for all sampled countries in our study. It is well-established that globalization increases life expectancy via *income, education, technology* and *intake effects*. For example, this finding is clearly documented in the studies of Tsai (2007), Owen and Wu (2007), Bergh and Nilsson (2010) and Herzer (2017). Sundaram *et al.* (2011) observe that, for sub-Saharan Africa to catch up to the rest of the world, the region has to mobilize resources for growth and development. Globalization–by way of injecting foreign funds–holds the key to this goal. The region has undertaken drastic reforms aimed at improving openness in the past three decades and it is no surprise that globalization is found to improve life expectancy; as well as quality of life

(Sundaram *et al.* 2011). In contrast, Bezuneh and Yihey (2014) for 37 developing countries and Lin *et al.* (2015) for 48 developing countries, found that globalization is not beneficial for individual health as it hampers life expectancy. Nevertheless, the results of our work are in accordance with the above stream of literature.

Economic growth affects life expectancy significantly for all economies except Gambia (The), whereby an insignificant linkage is detected. Even though Gambia is the smallest country in the African mainland, it faces development challenges as documented under the Millennium Development Goals (MDGs) report. It is a critical subject matter whether life expectancy may be improved by economic growth indirectly via enhancing human development; and perhaps gender equality. In general, the empirical evidence we provide shows that economic growth increases life expectancy, whereas opponents of this assumption e.g. Hansen and Lønstrup (2015) advocate in favor of an inverse relationship at least in case of 35 countries they explored. Regardless, economic growth and life expectancy have improved significantly (in tandem) in sub-Saharan Africa in recent decades (Sundaram *et al.* 2011). Our causality results are a testament to the positive effect of economic growth on life expectancy in the region.

Technically speaking, the rightmost column of Table 5 indicates the bandwidth used inside the kernel density smoothing function used for each country. The bandwidths are reasonably low (between 0.167 and 0.333) and do not require "over-smoothing". The impact of financial development, globalization and economic growth appear to be more than unit-elastic. This is expected as small increments in financial development could potentially promote significantly health generic financing including providing loans, health insurance, clinical care and establishing connections to public and private health providers in order to facilitate access to health care (Leatherman and Dunford 2010). It is a fact that a plethora of microfinance institutions from developing countries has expanded their services and their accompanying financial products beyond basic health services, such as health education and health insurance (Pronyk *et al.* 2006). In turn, this could have a synergistic effect upon health (life expectancy). There are several other

indirect mechanisms, which show how financial development improves health, via the augmentation of the disposable income, or the advancement of education and gender equality.

TABLE-5: Structural Cointegrating Long-Run Analysis

Regressand	**Regressors**						**Bandwidth**
ln LE$_t$	***lnFD$_t$***		***lnGL$_t$***		***lnY$_t$***		
Country	**Coeff.**	***p*-value**	**Coeff.**	***p*-value**	**Coeff.**	***p*-value**	
Burundi	3.9497*	0.0000	4.0009*	0.0000	3.8722*	0.0000	0.250
Cameroon	3.9565*	0.0000	3.9456*	0.0000	3.9712*	0.0000	0.250
Cote d'Ivoire	3.9111*	0.0000	3.8959*	0.0000	3.8907*	0.0151	0.250
Ethiopia	4.0564*	0.0000	4.0478*	0.0000	4.1393*	0.0000	0.250
Gabon	4.1039	0.9270	4.1027*	0.0000	3.8595*	0.0000	0.250
Gambia (The)	3.8848*	0.0000	4.0712*	0.0000	3.9468	0.5906	0.333
Ghana	4.1082*	0.0000	4.0866*	0.0000	4.0655*	0.0148	0.167
Kenya	4.0911*	0.0000	4.0327*	0.0000	4.0695*	0.0000	0.250
Madagascar	3.8164*	0.0000	4.1358*	0.0000	3.8215*	0.0000	0.250
Mauritius	4.3018*	0.0000	4.2871*	0.0000	4.2977*	0.0000	0.200
Nigeria	3.9292*	0.0000	3.8359*	0.0000	3.9513*	0.0000	0.250
Rwanda	4.1394*	0.0000	3.8170*	0.0000	4.1399*	0.0000	0.250
Senegal	3.9117*	0.0000	4.1574*	0.0000	3.9678*	0.0000	0.250
Sierra Leone	3.7059*	0.0000	3.9032*	0.0000	3.6855*	0.0000	0.250
South Africa	3.9518*	0.0000	4.0381*	0.0000	4.0028*	0.0000	0.250
Togo	3.9898	0.1104	4.0189**	0.0733	4.0012*	0.0992	0.250

Note: Coeff. refers to coefficients.H_0: Coefficient estimate = 0. * Reject H_0 if the *p*-value is< 0.0500.

Tables 6 to 8 provide the direction of causality between financial development, globalization, economic growth and life expectancy.[19] Table 6 indicates a strong feedback effect emerging between financial development and life expectancy in all countries except Burundi, Gabon, Nigeria and Togo. In view of these findings, it is interesting to note that the causal bidirectional impact of financial development and life expectancy is not uniform across all countries. A rational explanation could be that countries like Burundi and Nigeria are able to expand financial institutions in order to increase saving capacity for the underprivileged population and, consequently, people with access to nearby financial institutions might be reducing current expenditure being able to increase their savings capacity. Eventually, saving could enable them to spend more money in well-being, thereby achieving a longer life expectancy.

According to the recent report of the African Economic Outlook (2016), low and medium level of human development index is the basis for the existence of unidirectional causality runs from financial development to life expectancy in case of Burundi and Nigeria. Mlachila (2016) further noted a reason that low level of human development index for Burundi may be due to the nature of non-intensive resources and heavy dependence on agriculture sector. They further argued that the medium level of human development for Nigeria could be due to the advantage of being an oil exporting country. Gabon and Togo are both exceptional countries of the Sub-Saharan African region where life expectancy Granger causes financial development. This may be due to the support of a healthy life that increases productivity of households and thereby encourages demand for savings especially in case of financial institutions. In case of Sierra Leone, no causal linkage is observed in either direction, i.e. a neutral effect is detected. While this is not a common trait in Sub-Saharan region, countries like Sierra Leone might be prototypical in what is called neutrality of financial development impact on population life expectancy.

Nevertheless, the ubiquitous causation from financial development to life expectancy is in accordance with the positive correlations found between the two in Table 5. Generally, this causal link is the result of the drastic improvement of the financial sector in Sub-Saharan Africa since the mid-1990s (International Monetary Fund 2016). Globalization and life expectancy presented a bi-directional relationship for all sampled countries. Also, a feedback spillover mechanism is observed between economic growth and life expectancy with the exceptions of Cameroon, Gambia, Sierra Leone and South Africa.

The causality results between globalization and life expectancy are reported in Table 7. Interestingly, nonlinear Granger causality analysis shows that globalization and life expectancy are bi-directionally interlinked for all 16 Sub-Saharan African countries. This further implies that those countries are not only benefitted from growing globalization, but from improved life expectancy as well. Specifically, with the advent of globalization individuals acquire higher income hence can access qualified doctors and hospitalization within the boundaries of their

country and not necessarily only abroad. This in turn, leads to higher life expectancy by improving their living conditions. On the other hand, the population is benefited from life expectancy as it can also cause globalization per se. For instance, people with better health present higher productivity, thereby they might become able to attract foreign investments into their countries to get maximization of individual or corporate profits. The causation from globalization to life expectancy also conforms to the results in Table 5 and provides further proof of improvements in globalization increasing life expectancy in sub-Saharan Africa in last few decades (Sundaram *et al.* 2011). These findings are also in conformity with that of the existing literature.

Lastly, causal relationships between economic growth and life expectancy are reported in Table 8. A bidirectional dependence is shown in case of Burundi, Cote d'Ivoire, Ethiopia, Gabon, Ghana, Kenya, Madagascar, Mauritius, Nigeria, Rwanda, Senegal and Togo. Unidirectional causal links are observed from economic growth to life expectancy only for Cameroon and Sierra Leone, which subsequently implies that economic growth is the key to the improvement of physical health. Mlachila (2016) in their recent study also argued that the unidirectional causality running from economic growth to life expectancy Cameroon is possible which may be due to productive intervention of expansionary fiscal policy and stabilizing and lowering inflation role of monetary policy. As a result, poor people benefit from productive job creative intervention of the fiscal government and are able to increase their savings due to increasing purchasing power, which is facilitated by the monetary policy via lowering price level in the commodity market. This in turn helps poor people to invest their more saved money on health and education, and thereby it causes better life expectancy. Only for Gambia, no dynamic causal interrelationship is found between economic growth and life expectancy in any explored direction.

In light of these findings, it is inferred that any macroeconomic policy designed to directly or indirectly "undermine" the growing capacity of a nation, will also inflict upon life expectancy. In case of South Africa, life expectancy is the primary driver of economic growth, namely healthy life expectancy adds to economic growth via the increase of productivity. Additionally, a neutral

effect also exists as noted in case of Gambia. Any governmental policy targeting growth increase will not have any effect whatsoever upon life expectancy, and vice-versa. Again, the observed causation from economic growth to life expectancy is in line with the regression findings in Table 5 and appear to be in line with intuition and empirical evidence. Sub-Saharan Africa has seen remarkable economic growth in the recent decades and the causal linkage between the two (including from life expectancy to economic growth) is a testament to the indispensable role economic growth plays in improving life expectancy and vice-versa (Sundaram *et al.* 2011).

TABLE-6: Causality Analysis: Financial Development vis-à-vis Life Expectancy

Country	$lnFD_t \Rightarrow lnLE_t$		$lnLE_t \Rightarrow lnFD_t$		Condition	Bandwidth
	Test stat. $(T_n^s(\varepsilon))$	*p*-value	Test stat. $(T_n^s(\varepsilon))$	*p*-value		
Burundi	1.8976*	0.0289	1.1572	0.1236	lnG_t, lnY_t	1.3456
Cameroon	1.5075**	0.0658	1.5551**	0.0600	lnG_t, lnY_t	1.3456
Cote d'Ivoire	2.1944*	0.0141	1.6469*	0.0498	lnG_t, lnY_t	1.3456
Ethiopia	3.9937*	0.0000	3.2273*	0.0006	lnG_t, lnY_t	1.4082
Gabon	0.3432	0.3657	1.8274*	0.0338	lnG_t, lnY_t	1.3456
Gambia (The)	2.4931*	0.0063	1.9538*	0.0254	lnG_t, lnY_t	1.3456
Ghana	2.0792*	0.0188	1.6851*	0.0460	lnG_t, lnY_t	1.3456
Kenya	1.7351*	0.0414	2.2698*	0.0116	lnG_t, lnY_t	1.3456
Madagascar	3.2879*	0.0005	4.0222*	0.0000	lnG_t, lnY_t	1.3456
Mauritius	6.9124*	0.0000	5.9493*	0.0000	lnG_t, lnY_t	1.3771
Nigeria	1.9426*	0.0260	1.1169	0.1320	lnG_t, lnY_t	1.3456
Rwanda	1.7481*	0.0402	1.8385*	0.0330	lnG_t, lnY_t	1.3456
Senegal	1.9538*	0.0254	1.3709**	0.0852	lnG_t, lnY_t	1.3456
Sierra Leone	0.9162	0.1798	0.7754	0.2191	lnG_t, lnY_t	1.3456
South Africa	2.2316*	0.0128	3.0205*	0.0013	lnG_t, lnY_t	1.3456
Togo	1.0606	0.1444	1.4215**	0.0776	lnG_t, lnY_t	1.3456

Note: Tests are performed on standardized data transformed to uniform marginals. Lag selection, $l_X=l_Y=l_Q=1$, is made by minimizing SBC. H_0: No Causality. * Reject H_0 if *p*-value < 0.0500. ** Reject H_0 if *p*-value < 0.1000

TABLE-7: Causality Analysis: Globalization vis-à-vis Life Expectancy

Country	$lnGL_t \Rightarrow lnLE_t$		$lnLE_t \Rightarrow lnGL_t$		Condition	Bandwidth
	Test stat. $(T_n^s(\varepsilon))$	*p*-value	Test stat. $(T_n^s(\varepsilon))$	*p*-value		
Burundi	3.6913*	0.0001	3.7974*	0.0001	lnF_t, lnY_t	1.3456
Cameroon	1.8484*	0.0323	2.0694*	0.0193	lnF_t, lnY_t	1.3456
Cote d'Ivoire	1.4047**	0.0801	3.0415*	0.0012	lnF_t, lnY_t	1.3456
Ethiopia	3.1299*	0.0009	3.2651*	0.0005	lnF_t, lnY_t	1.4082
Gabon	1.7877*	0.0369	1.8033*	0.0357	lnF_t, lnY_t	1.3456
Gambia (The)	2.6007*	0.0047	2.9372*	0.0017	lnF_t, lnY_t	1.3456
Ghana	2.3000*	0.0107	2.9405*	0.0016	lnF_t, lnY_t	1.3456
Kenya	1.4438**	0.0744	1.9159*	0.0277	lnF_t, lnY_t	1.3456
Madagascar	3.6127*	0.0002	4.0149*	0.0000	lnF_t, lnY_t	1.3456
Mauritius	5.2608*	0.0000	6.0616*	0.0000	lnF_t, lnY_t	1.3771
Nigeria	3.4348*	0.0003	2.5850*	0.0049	lnF_t, lnY_t	1.3456
Rwanda	2.2588*	0.0119	1.7596*	0.0392	lnF_t, lnY_t	1.3456
Senegal	2.6319*	0.0042	2.6613*	0.0039	lnF_t, lnY_t	1.3456
Sierra Leone	2.2492*	0.0122	1.9832*	0.0237	lnF_t, lnY_t	1.3456
South Africa	2.8110*	0.0025	1.8400*	0.0329	lnF_t, lnY_t	1.3456
Togo	1.7025*	0.0443	1.6202*	0.0526	lnF_t, lnY_t	1.3456

Note: Tests are performed on standardized data transformed to uniform marginals. Lag selection, $l_X=l_Y=l_Q=1$, is made by minimizing SBC. H_0: No Causality. * Reject H_0 if *p*-value < 0.0500. ** Reject H_0 if *p*-value < 0.1000.

TABLE-8: Causality Analysis: Economic Growth vis-à-vis Life Expectancy

Country	$lnY_t \Rightarrow lnLE_t$		$lnLE_t \Rightarrow lnY_t$		Condition	Bandwidth
	Test stat. $(T_n^s(\varepsilon))$	*p*-value	Test stat. $(T_n^s(\varepsilon))$	*p*-value		
Burundi	2.7716*	0.0028	4.8436*	0.0000	lnF_t, lnG_t	1.3456
Cameroon	1.3511**	0.0883	1.0789	0.1403	lnF_t, lnG_t	1.3456
Cote d'Ivoire	2.0082*	0.0223	1.4910**	0.0676	lnF_t, lnG_t	1.3456
Ethiopia	1.4273**	0.0767	2.3089*	0.0105	lnF_t, lnG_t	1.4082
Gabon	1.3875**	0.0826	1.8951*	0.0290	lnF_t, lnG_t	1.3456
Gambia (The)	1.2635	0.1032	1.2268	0.1100	lnF_t, lnG_t	1.3456
Ghana	1.3364**	0.0907	2.8878*	0.0019	lnF_t, lnG_t	1.3456
Kenya	2.2801*	0.0113	1.6154**	0.0531	lnF_t, lnG_t	1.3456
Madagascar	3.7778*	0.0001	3.9169*	0.0000	lnF_t, lnG_t	1.3456
Mauritius	7.3182*	0.0000	7.0764*	0.0000	lnF_t, lnG_t	1.3771
Nigeria	2.3999*	0.0082	2.7157*	0.0033	lnF_t, lnG_t	1.3456
Rwanda	1.8773*	0.0302	2.4580*	0.0070	lnF_t, lnG_t	1.3456
Senegal	3.0396*	0.0012	3.0000*	0.0014	lnF_t, lnG_t	1.3456
Sierra Leone	1.3599**	0.0869	1.1340	0.1284	lnF_t, lnG_t	1.3456
South Africa	0.6347	0.2628	2.2204*	0.0132	lnF_t, lnG_t	1.3456
Togo	2.0662*	0.0194	1.4083**	0.0795	lnF_t, lnG_t	1.3456

Note: Tests are performed on standardized data transformed to uniform marginals. Lag selection, $l_X=l_Y=l_Q=1$, is made by minimizing SBC. H_0: No Causality. * Reject H_0 if *p*-value < 0.0500. ** Reject H_0 if *p*-value < 0.1000.

The overall empirical evidence shows that our causality analysis provides practically identical results to those of Wang and Phillips (2009) regarding long-run interdependencies among the investigated measures, except perhaps only for South Africa. Thereby, this might be perceived as a robustness indication of our empirical results. However, beyond Wang and Phillips (2009), we also report the nonlinearity dynamic causal interrelationships between financial development, globalization and life expectancy for a different dataset of the Sub-Saharan economics. Further robustness of the Diks and Wolski (2016) causality analysis (Tables 6 to 8) is established by performing the Hiemstra and Jones (1994) nonparametric causality test.[20]

5. Conclusions and Policy Implications

This novel study attempts a significant contribution to the existing literature, by investigating the dynamic relationship between financial development, globalization, economic growth and life expectancy in case of 16 Sub-Saharan African countries. This is the gap found in the existing literature and has substantial policy implications on improving public health. Altogether, they have motivated us to carry out an empirical exercise on the effects of financial development, globalization and economic growth on life expectancy for 16 Sub-Saharan African countries within a time series framework. Methodologically, we employed non-parametric unit root and cointegration testing methods introduced by Bierens (1997a, b) and Wang and Phillips (2009) to establish non-stationarity and nonparametric structural cointegration namely a long-run interdependence between the examined variables. Lastly, multivariate nonlinear causality tests by Diks and Wolski (2016) are employed to investigate the dynamics of the inherent underlying relationships.

Our findings indicate that all variables are nonlinearly cointegrated, a result never reached by other studies before treating the system of explored variables as linear, both in terms of co-movements and detected inter linkages. Interestingly, nonlinear regressions show that financial development improves life expectancy for almost all cases. Hence, financial development may be

effective in improving survivability of poor people in most of the Sub-Saharan African region. Similarly, economic growth is found to be positively linked with life expectancy, which highlights the crucial role of economic growth in life expectancy. This implies that an increased economic growth is not only beneficial for the creation of employment opportunities and but also helps people to invest money on the protection of their better health.

The nonlinear causality analysis revealed a feedback effect between financial development and life expectancy only except in the cases of Burundi, Gabon, Nigeria and Togo. In particular, financial development causes life expectancy in Burundi and Nigeria, whilst a unidirectional causality is found running from life expectancy to financial development for Gabon and Togo. Globalization also adds to life expectancy. Globalization and life expectancy present a bi-directional relationship for all sampled countries. Also, a feedback spillover mechanism is observed between economic growth and life expectancy with the exceptions of Cameroon, Gambia, Sierra Leone and South Africa.

Our findings have interesting policy implications for Sub-Saharan African countries. In terms of empirical evidence, it was found that financial development and globalization positively influence life expectancy, indicating that they are both effective measures towards improving the physical health of people. This result is consistent with the findings by Alam *et al.* (2016a,b), Sehrawat and Giri (2014, 2017) for India and Akhmat *et al.* (2014) for SAARC countries. In addition, it appears to be in accordance with the outcome of Tsai (2007) in his cross-sectional analysis, of Owen and Wu (2007) for a very large set of countries except Africa, of Bergh and Nilsson (2010) for 92 countries and of Herzer (2017) for 74 countries, which all reported globalization to be the key to life expectancy improvement. Furthermore, our results conform to the observed improvements in financial development, economic growth, globalization and life expectancy in sub-Saharan Africa since the past few decades (International Monetary Fund 2016).

Overall, on the policy side we argue that governments and policy makers in Sub-Saharan African countries should not underestimate the role of financial development, economic growth

and globalization play upon life expectancy. Especially, governments of the Sub-Saharan African countries should encompass best practices for physical health improvement of their population depending on those results, as these variables are extremely beneficial in improving life expectancy. As such, improvement of the financial sector should be viewed as a key to improving health, quality of life, productivity, and, eventually, the economic growth of developing economies in sub-Saharan Africa. Policymakers should embrace financial development as a policy tool in economic development as well as an improvement of quality of life in developing economies, especially in sub-Saharan Africa. Finally, economic growth is the driver of life expectancy which bears some policy implications for Sub-Saharan Africa region. Since people benefit from increased economic growth in terms of promoting their better working conditions and productive health, both the government should create more income-generating growth in long-run for Sub-Saharan Africa region. Policymakers should also add economic growth as better health promoting economic instrument in life expectancy function of Sub-Saharan Africa region.

The documented feedback effect, in this study, between financial development – as well as globalization and growth – and life expectancy in the majority of the Sub-Saharan African economies, further illustrates that life expectancy is caused fundamentally by globalization and financial development. It is also critical for increasing Sub-Saharan Africa's ability to promote greater degree of globalization and expansion of Pan-African banks for inclusive and sustainable financial development. This will further require sub-Saharan African countries to increase economic integration and deepen their financial depth, access and efficiency of both the financial institutions and markets (World Economic Forum 2016[21]; and Mlachila *et al.* 2016). Consequently, the imperative is now for policy-makers, businesses and governments to work mutually to enhance globalization and strengthen financial system development that can eradicate ''poverty multiplier'' and eventually improve ''healthy and long-life'' of the underprivileged people in case of Sub-Saharan African countries. Without this, it becomes hard for Sub-Saharan African region to achieve salutary economic growth along with inclusive financial inclusion and

productivity-driven life expectancy in the long-run. Hence, it is a timing opportunity for policymakers and governments should incorporate both globalization and financial development as primary economic instruments in their fiscal and monetary policy design to promote life expectancy perspectives for these underprivileged Sub-Saharan countries.

This line of research may be extended by observing the time-varying relationship between financial development, economic growth, globalization and life expectancy. In addition, it may also be useful to observe how volatilities in the financial sector may affect health, quality of life as well as economic growth of a developing economy in Sub-Saharan Africa and elsewhere. However, the theoretical literature argues that it becomes difficult to understand life expectancy for Sub-Saharan African countries only by controlling financial development, economic globalization and economic growth. This implies that better life expectancy may be at risk if the health conditions of the people are adversely affected by environmental degradation. Therefore, it is important to study the effects of financial development or financial instability, and economic growth on energy demand or environmental quality in case of Sub-Saharan Africa as it has been found in the recent studies of Mahalik et al. (2017), Danish and Wang (2018), Danish and Baloch (2018), Danish et al., (2018a), Danish et al. (2018c), Danish et al. (2019b), Baloch et al. (2018), Baloch et al. (2019a), and Baloch et al. (2019b). Moreover, few studies also highlighted the role of imported technology, pattern of renewable and non-renewable on environmental quality for Pakistan, China and BRICS countries (Danish et al., 2017; 2018b; 2019b).[22] Motivated by these studies, we identify an additional gap for future research while examining the impact of environmental degradation on life expectancy for Sub-Saharan African countries within both the frameworks of time series and panel analysis. In doing this, it would largely inform government and educate policymakers about the possible impact of environmental degradation shock on life expectancy in Sub-Saharan African countries. The similar research gap may be extended to other high, middle and low income countries.

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Appendix

Table-A1: Existing studies on the effects of financial development, globalization and economic growth on life expectancy.

Study	Country/Region (Data)	Findings
Financial Development-Life Expectancy Nexus		
Outreville (1999)	57 developing countries (1971 to 2010)	The life expectancy is improved with financial development caused by human capital.
Wei and Wu (2002)		Financial openness does not promote better health.
Hakeem and Oluitan (2012)	South Africa (1965-2005)	The financial development Granger causes human capital.
Nik *et al.* (2013)	Iran (1977-2010)	The negative and significant impact of financial development on human capital is observed.
Akhmat *et al.* (2014)	South Asian Association for Regional Cooperation (SAARC) (1988-2008)	The human capital promoted by financial development improves health condition of the people.
Sehrawat and Giri (2014)	India (1980-2012)	The human capital Granger caused by financial development has the capacity for better quality of life.
Hatemi-J and Shamsuddin (2016)	Bangladesh (1980-2011)	The financial development Granger caused by human capital promotes healthy life of the people.
Alam *et al.* (2016a)	India (1990Q1-2013Q4)	The positive and significant impact of financial development upon life expectancy is reported.
Sehrawat and Giri (2017)	10 major Asian countries (1984-2013)	The financial development adds in human capital that helps in the improvement of life expectancy.
Globalization-Life Expectancy Nexus		
Wei and Wu (2002)		The higher trade openness reduces infant mortality and improves life expectancy.
Levin and Rothman (2006)	130 countries	An increased trade openness reduces infant mortality and malnutrition.
Owen and Wu (2007)	219 countries (1960-1995)	The beneficial effect of trade openness on life expectancy is noticed in poor countries but not for richer countries.
Bussmann (2009)	134 countries (1970-2000)	No significant and positive impact of trade openness on women's health care is observed.
Ovaska and Takashima (2006)	68 countries	The vital role of economic freedom in improving life expectancy for large-sized economies is observed.
Tsai (2007)		Globalization improves human welfare in highly industrialized countries and hampers it in case of developing countries
Papageorgiou *et al.* (2007)	67 countries	An importing medical technology is the key to improve life expectancy.
Bergh and Nilsson (2010)	92 countries (1970-2005)	The insignificant effects of political and social globalization on life expectancy is evident.
Stevens *et al.* (2013)	Developing and developed countries	The positive effect of increased trade openness on human health and welfare was pronounced in lower income countries compared to the developed ones.

Bezuneh and Yiheyis (2014)	37 developing countries	The trade liberalization bears a negative effect on food availability, which in turn shows hampering effects on public health
Herzer (2015)	USA (1960-2011)	The trade openness positively influences health.
Lin *et al.* (2015)	48 developing (1995-2012)	The trade openness is not beneficial towards reducing infant mortality.
Alam *et al.* (2015)	Pakistan (1972-2013)	Both trade openness and FDI both increase life expectancy in the long-run.
Nagel *et al.* (2015)	179 countries (1980-2011)	FDI positively improves population health at lower income and deteriorates it for higher income levels.
Herzer (2017)	74 countries (1960-2010)	The beneficial effects of trade openness on population health is noticed in countries with lower development and less market regulations.
Alam et al. (2016b)	Pakistan (1972-2013)	Both trade openness and foreign direct investment promote life expectancy in Pakistan by increasing population health condition.
Economic Growth-Life Expectancy Linkage		
Acemoglu and Johnson (2007)	47 rich, middle-income and poor countries	The find a negative but statistically insignificant impact of life expectancy on economic growth.
Jaunky (2013)	107 countries	The existence of a U-shaped relationship between – what defines – as life expectancy at birth (health) and economic growth (wealth) is confirmed.
Mahyar (2016)	Iran (1966-2013)	life expectancy is positively and significantly associated with economic growth in Iran.
Hansen and Lønstrup (2015)	35 countries (1900-1940 and 1940-1980)	They reported the negative and significant interrelationship between life expectancy and economic growth.
Alam *et al.* (2016a)	India (1990Q1-2013Q4)	They found the positive and significant effect of economic growth on life expectancy.

[1]This clearly shows that human development is independent of economic status, hence indicating that conditional on income, longer life expectancy has no apparent effect on health satisfaction.

[2]Deaton (2008) also argued that longer life expectancy at birth enables people to do more with their lives which is the best single indicator of population health.

[3]In particular, they advised the Indian government to raise financial investments in order to mitigate poor peoples' education and health expenditures at affordable costs.

[4] Wei and Wu (2002) used trade openness as an indicator of globalization.

[5] Firstly, trade openness may enhance interactions between economies that increase the general flow of knowledge about best health practices and medications especially concerning life-threatening diseases. Secondly, it may open up an opportunity for sound economic policies targeting better health care programs.

[6] As trade-to-GDP ratio is modified significantly from year to year while changes in life expectancy could also evolve dynamically over the years, the methodology of data interpolation for missing observations may not capture efficiently the impact of trade openness on women life expectancy for a large set of the investigated countries.

[7] Except for Ethiopia and Mauritius whereby the datasets span the periods 1981-2012 and 1976-2012 respectively.

[8]The high real economic growth rate (4%), high inflation rate (7.8%) and low life expectancy at birth were the basis of doing empirical assessment for 16 Sub-Saharan countries of the African region (African Economic Outlook 2016; UN 2006).

[9]We chose domestic credit to the private sector as an inclusive measure of financial development following Levin (2000) and Shahbaz *et al.* (2017). This measure refers to financial resource disburses to the private sector via loans, purchases of non-equity securities, trade credit and other accounts receivable that establish a claim for repayment (Boutabba 2014). It further shows the actual level of domestic saving disburses to investors for productive investment ventures, thus reflecting financial development.

[10]The economic globalization index is calculated based on the information on actual flows of trade, FDI and portfolio investment as well as restrictions (import barriers, trade tariffs, and capital account restrictions). Secondly, the social globalization index is constructed based on personal contact (telephone contact, tourism, international migration), information flows (internet usage and news trading), and data upon cultural proximity (number of McDonald's restaurants and number of trades in books). Lastly, the political globalization index is constructed from the number of embassies, membership in international organizations, and participation in U.N. security councils.

[11]The variables are transformed into natural logarithms for econometric consistency and robustness (Shahbaz *et al.* 2016).

[12]Bierens (1997a) unit root test is able to test for stationarity while taking into account inherent nonlinearities, hence testing for structural breaks in the series is not essential as the former – according to Bierens (1997a) – is considered a source of nonlinearity as well.

[13]As the Bierens (1997b) cointegration test is able to test for long-run equilibria even in the presence of nonlinearities, testing for structural breaks in the cointegrating vectors is redundant considering it is also a source of nonlinearity.

[14]Further proof of the theorem can be found in Wang and Phillips (2009).

[15]See Diks and Panchenko (2006) nonparametric procedure for further details.

[16]According to Diks and Wolski (2016), it is possible to include additional conditioning variables in $\{Q\}$ without a noticeable loss in the power of the test.

[17]The robustness of the Bierens (1997a) unit root analysis is checked using the Phillips-Perron test. The estimated results are not presented here but will be available upon request from the authors.

[18]The robustness of the Bierens (1997b) estimates are corroborated by the Nonlinear Autoregressive Distributed Lag (NARDL) bounds test. Results are not presented here but will be available upon request from the authors.

[19]We do not present the results regarding the direction of causality between the right-hand side variables of equation to keep the discussion brief, concise and relevant. Those test results may be obtained upon request by the authors.

[20]Results not presented here but available upon request from the authors.

[21]See: https://www.weforum.org/agenda/2016/05/what-s-the-future-of-economic-growth-in-africa/.

[22]Other studies also examined the determinants of economic growth, human capital, environmental quality (Latif et al., 2018; Park et al., 2018; Wang et al., 2018a; 2018b; Xu et al., 2018).