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Knowledge-Driven Economic Growth: The Case of Sub-Saharan Africa[1]

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Abstract

The experience of South Korea, India, China and Singapore reveals that developing economies can fasttrack development, leapfrog the stages of development and catch up with advanced economies by putting knowledge capital as the driver of development. If the knowledge economy is therefore an accelerant of development for both advanced and developing economies, it is possible for Sub-Saharan African (SSA) economies to also catch up with advanced economies. It was on this basis that this study assessed the knowledge capacity of SSA and the effect it has on its economic advancement. Given the importance of the interrelatedness among the knowledge economy elements, this study, thus, examined how the interaction effect between the elements of the knowledge economy affects economic growth in 32 SSA countries, for which data were available, over the period of 17 years (1996-2012). Using the System Generalized Method of Moments (SGMM), the study found out that institutions and human capital in SSA mitigate the effect of innovation on economic growth in the region, thus, making it a lean knowledge economy.

Keywords: Economic Growth; Human Capital; ICT; Innovation; Institutions; Knowledge Economy

Introduction

Facilitating sustainable growth and development has been the drive of economies; hence economies are employing effective means to achieve this objective. Recent studies have shown that economies that tap into the knowledge capabilities tend to experience more advancement in their economies as reflected in the quality of their products, production and innovation outcomes. This is in line with the discovery of Solow (1957) and the assertion of Romer (1990, 1994), who validated that economic growth and development can be fasttracked by putting knowledge capital at the centre of development. The experience of South Korea, India, China and Singapore have also revealed that developing economies can fasttrack development as well as leapfrog the stages of development. If knowledge is therefore an accelerant of development for both advanced and developing economies, it can enable Sub-Saharan African (SSA) economies also catch up. It is therefore necessary to examine the knowledge capacity of SSA and the effect it has on its economic advancement. This study, thus, examines these using the volume of knowledge created, as proxied by scientific and technical journal articles. This examination is done without the isolation of the institutional environment in order to assess the true picture of the impact of knowledge on SSA's economic advancement. 32 SSA countries, for which data were available, were examined over the period of 19 years (1996-2014).

Various studies have examined the knowledge economy empirically (Brandt, 2007; Kuo & Yang, 2008; Kooshki and Ismail, 2011; Kaynak and Arslan, 2012; Gabsi and Chkir, 2012, Oluwatobi, Efobi, Olurinola, and Alege, 2015). Many of these studies have examined knowledge economy from various perspectives; however, the methodology for examination has been consistent. These studies framed their examinations on the platform of endogenous growth theory and were consistent with the use of knowledge economy variables. However, indicators used to capture the variables were different across the studies. This difference was as a result of data availability most cases. For instance, number of patents and R & D expenditure have been used as indicators for innovation mostly in studies examining advanced or emerging economies, while studies examining developing economies used the scientific and technical journal articles, high-technology export, number of universities and knowledge-based industries (Asongu, 2013).

Brandt (2007) studied market-driven knowledge creation, as an engine of productivity growth, and how it affects economies of scale and market power. The study agrees with theoretical expectations that increase in knowledge is proportional to R&D spending. R&D spending was used as a measure of innovation in the gross output production function, which was the the basis for its modeling. As emphasized in the study, data limitation impeded the process to correct labour, material inputs and capital for R&D expenditure in order to avoid double counting. Labour may include expenditure on R&D since some staff members work in the R&D department. Also, material inputs as well as physical capital stock, such as machinery, equipment etc. may be used in the R&D process to acquire new knowledge. The study found out that there was no relationship between productivity and average R&D intensity, contrary to theoretical expectations. An explanation for this contradiction could be that the effect of R&D intensity is yet to translate into productivity as well as product and process innovation outcomes. Usually, such R&D efforts still find expression in the development of other outcomes that may not require as much R&D costs (Hall, Mairesse, & Mohnen, 2010; Becker, 2013; Verba, 2015).

Kaynak and Arslan (2012) in their study tested the relationship between the knowledge economy variables and the knowledge economy of the first 19 members of the OECD over the period 2005-2010. The researchers employed the variables identified by the World Bank's (2008) Knowledge Assessment Methodology (KAM), thus, validating the reliability of the variables to capture knowledge economy. The analysis was done in parts using four estimation techniques (general statistics, panel regression analysis, panel cointegration analysis and panel causality tests). Their results confirm that there exists a long run relationship among all the knowledge economy variables given the period of study. It was also found out that knowledge economy variables have a direct relationship with knowledge economy index. These findings, however, may not be reliable given the structure of the model. The explanatory variables used were knowledge economy variables and the dependent variable used was knowledge economy index, which was developed by the World Bank (2008) using data on the knowledge economy variables. This clearly violates the assumptions of ordinary least squares, which was used in the study.

Gabsi and Chkir (2012) examined the impact of domestic and foreign R & D on TFP in the case of 24 developing countries observed over the period 1996 to 2007. To achieve this objective, they conducted an analysis of integration-cointegration panel by employing the Fully Modified Ordinary Least Squares (FMOLS) and the Dynamic Ordinary Least Squares (DOLS). Their results show that stock of foreign R & D, measured by technological spillovers transferred through flow of imports, has a positive effect on TFP with its coefficient (0.02) statistically significant at 0.05 level of significance. On the other hand, the stock of domestic R & D was not statistically significant even though its coefficient (0.33) showed a direct impact on TFP. These results reveal that technology transfer has a direct impact on the economic growth of developing economies, especially the ones where the human capital adapts and integrates foreign technology.

Bhatiasevi (2010) explored the idea of knowledge-driven growth from the comparative view. He studied the growth and development of two developing economies (Malaysia and Thailand) based on knowledge economy. The Malaysian government's initiative to facilitate knowledge-based economy commenced in 1991 while that of Thailand began in 2001, thus giving Malaysia a better head start with respect to ICT infrastucture development, investment in R & D and institutions that facilitates the establishment of a knowledge economy. His result shows that Thailand still lags behind Malaysia. This reflects that economies that want to achieve knowledge-driven growth will have their expectations realized when adequate investments have been made beforehand in the pillars that make the knowledge economy possible. Malaysia's commitment to building a knowledge economy 10 years before Thailand has put her economy far ahead of Thailand. This indicates the benefit of early investment in promoting knowledge-driven economic growth. Other similar studies corrobotate this (Oluwatobi, Olurinola, Atayero, & Ogundipe, 2016).

Tweed and McGregor (2004) adopted an industry-focused approach by studying the impact of knowledge on the development of the biotechnology industry in New Zealand. Their study examined the motivation for innovation and the competencies required for growth in profitability in that industry. The examination is concerned with the little attention given to investment in knowledge development despite the fact that the new economy is dependent on the knowledge capacity of people and modern management that is made of capacities that include knowledge management (Marope, 2005; Batra, 2009; Ahmed, 2016).

Beyond examining the essence of the human capital capacity required to establish an knowledge-based economy, it would be essential to investigate how the diversities of R&D sources, innovation infrastructure, human capital, and academic knowledge affects the performance of the industry responsible for engaging them. The study of Lin (2013)is pertinent in this matter considering that one of the proven structures that facilitate the transition from a natural resource-driven economy to a knowledge and innovation-driven economy is the Triple Helix model. In carrying out his study, he employed the fixed and random effects regression to test his hypotheses over a period of eight years. The Generalized Least Squares (GLS) technique was used to estimate the models. His result confirms that there are merits and demerits in the various R&D sources. This result lines up with the postulations of the open innovation paradigm. However, improving R&D sources after the optimal point would lead to a decline in industrial performance. This result suggests that industries are to diversify their R&D sources as they commit to creating knowledge and generating innovation.

One crucial subject to assess is the readiness of developing economies to beconome knowledge-based economies. The World Bank (2008), though, had come up with a methodology (KAM-Knowledge Assessment Methodology) for such assessment, it was important to examine the application of this. Kurtic and Donlagic (2012) did this by adopting the KAM as a benchmark to measure the readiness of Bosnia and Hercegovina to become knowledge economies. After conducting a survey on a sample of one hundred and fifty enterprises while employing factor analysis as the technique, they discovered that education was a crucial ingredient to achieve the development of a knowledge economy. They also found out that incentives provided by the government will boost economic activities and promote the advancement of the knowledge economy in addition to the significance of ICT infrastructure in enhancing productivity and efficiency.

Afzal and Lawrey (2012) in their study give empirical evidence to order the relevance of knowledge-based economy input factors. This according to them is necessary to grant insight regarding the areas to channel resources and investments so as to become successful knowledge-based economies. Their aim of study was to develop a policy-centred framework of knowledge-based economy as the scope of study. To execute the study they employed the beta coefficient technique, which helps in the ranking of the most vital knowledge-based economy input and output factors. Standardized beta coefficients were also used to evaluate the amount of standard deviations that will be altered by a dependent variable after identifying input and output factors of the knowledge economy. This operation helps to clarify which independent variable has greater impact on the dependent variable in a multiple regression analysis. From their result, Indonesia emerged the weakest in terms of knowledge acquisition, knowledge production and knowledge diffusion. However, Singapore and the Philippines emerged tops. For the weak countries like Indonesia, it was suggested that commitments should be made to improve the effectiveness of the inflow of Foreign Direct Investments (FDI), the optimization of R & D expenditure, increase in post-primary school enrollments and linkages between the University and the Industry to boost the creation and commercialization of knowledge. This study, which is also validated by the findings of other studies, buttresses the important role the institutional environment has to play in facilitating the emergence and development of knowledge-based economies (Hearn and Rooney, 2002; Rooney, Hearn, Mandeville and Joseph, 2003; Birch, Levidow and Papaioannou, 2014).

The literature has therefore provided evidence that knowledge has a role to play in the growth and development process and the level and quality of innovation are outcomes of the engagement of knowledge. Moreover, the quality of human capital and the extent to which they are engaged to create value contribute to the growth process, particularly when the enable environment (in form of quality institutions and infrastructure) are made available (Marginson, 2010; Nilsen and Anelli, 2016; Osabutey and Zhongqi, 2016; Ogundeinde and Ejohwomu, 2016; Laurell and Sandstrom, 2017; Xu, Wu, Minshall and Zhou, 2017). The focus in this study is to find out the extent to which knowledge drives growth in SSA and also establish how close the region is to becoming a knowledge-based economy.

Framework and Methodology

The concept behind this study is based on the postulation that none of the knowledge economy elements can operate in isolation of the other. Institutional arrangements, such as protection of intellectual property rights, promotion of free enterprises and University-Industry collaborations, support human capital development. It is, also, expected that human capital development will enhance the rate of innovation, given that it is a relevant factor in the knowledge production process (Oluwatobi et. al., 2016a; Oluwatobi et. al., 2016b). The expected outcome is economic growth and development.

ICT provides the infrastructure that serves as channels for the easy distribution of knowledge. Hence, basic services such as education, health care, financial services and commercial transactions can be delivered through ICT. All these will increase the volume of innovation and economic activities, thereby affecting economic growth. These explains the concept of knowledge economy in this study.

This study, therefore, designed a framework, called the knowledge economy matrix, to map out whether SSA is a knowledge-based economy, an institutionally-driven emerging knowledge economy, a human capital-driven emerging knowledge economy or a lean knowledge economy. This matrix was designed based on the interaction between institutions and innovations as well as the interaction between human capital and innovation. This framework is presented in Figure 1.

Innovation is a principal indicator of the knowledge economy given that a knowledge-based economy is principally innovation-driven. Thus, it is not out of place to examine the level of knowledge economy by assessing whether the level of innovation is low, moderate or high based on its interaction with human capital and institutions. Further, institutions and human capital are cardinal determinants of innovation. Each of them, thus, interrelate with innovation to determine the level of its impact on economic progress and growth. These informed the design of the knowledge economy matrix. The assumption here is that basic ICT infrastructure is available.

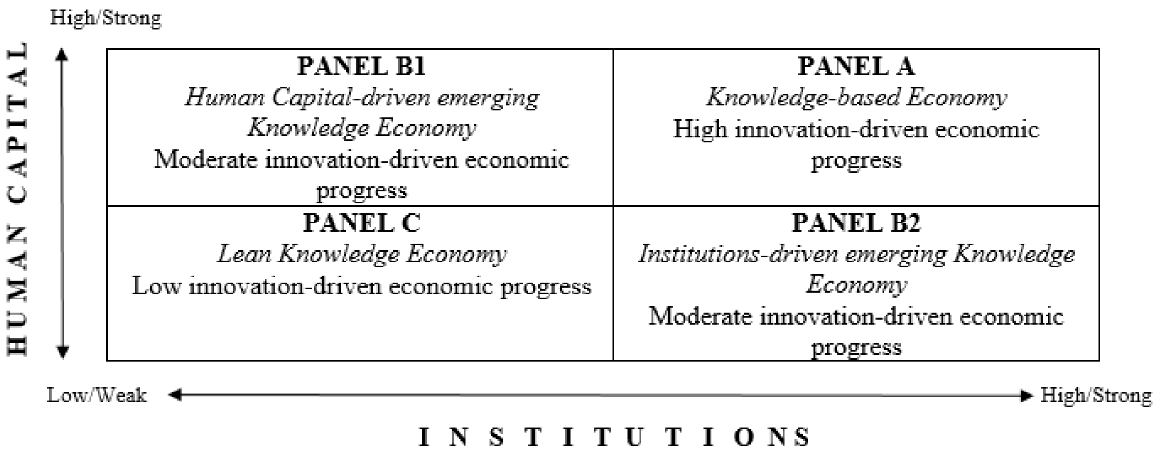

Figure 1: Knowledge Economy Matrix
Source: Author

Panel A, in the matrix, is an ideal knowledge-based economy possessing very strong institutions and highly-skilled human capital. The possible outcome in such economy is innovation-driven economic growth. This economy is characterized by highly creative people cultivated from an enabling environment, which allows them to express their ingenuity and creativity. The institutional environment, here, enables innovation to facilitate economic progress; it allows entrepreneurs to pursue their ideas for profits, protects intellectual property rights, enforces property right laws, procures supporting infrastructure, drives synergies between the University and the Industry, rewards ingenuity, provides access to R&D funds and attracts innovation-centred foreign and local investments. The economy, as defined by *Panel A*, supports R&D activities, absorption of technology, creation of knowledge, and translation of knowledge into usable and commercially viable products. Strong institutions and high level human capital are the factors that engender economic progress, thus, making an economy a knowledge-based economy.

Panel C in the matrix defines an economy characterized by weak institutions and low level of human capital; thus, there is very low innovation outcome leading to less economic progress. This economy enjoys some dimension of economic growth; however, the growth is not mainly as a result of innovation. Usually, a lean knowledge economy depends mostly on the agricultural sector, mining sector and other primary sectors for economic sustenance and growth; thus, it is mainly a natural resource-driven economy. The fact that the economy derives its economic support and sustenance from the primary sector provides less motivation for policy makers to invest in human capital development unlike a knowledge-based economy that needs to invest in human capital necessary to generate innovation-driven economic progress. The lean knowledge economy is characterized by graduate unemployment, underemployment, human capital flight, corruption among policy makers, conflicts, lack of respect for ingenuity, shortage of workers in the R&D sector, and lack of protection of intellectual property rights. Though most of the people in this economy will continue to improve on their competitiveness by continuous training and advancement of their education in order to increase their chances of being employed, they still end up unemployed, underemployed or attracted by other regions with greater opportunities.

Panel B2 captures an economy that is characterized by strong institutions but low human capital capacity; thus, the initial outcome here is a moderate level of innovation with little economic progress. This is termed an emerging knowledge economy possessing the institutional foundation for take-off. This economy, hence, provides a framework, which rewards ingenuity, invests in human capital development, provides opportunities for skilled human capital to be employed, enables the pursuit of enterprise and enforces University-Industry linkages. These motivates the populace to enroll in schools, acquire high level skills and improve on their competitiveness. The availability of strong institutions in this economy will gradually improve the level of human capital until the economy becomes a knowledge-based economy. This, therefore, is an institutionally-driven emerging knowledge economy.

Panel B1 reflects an economy characterized by weak institutions, highly-skilled human capital and consequently a moderate level of innovation and economic progress. This economy emerges a knowledge economy not because of strong institutions but because of the pursuit of personal gain, which drives individuals to improve their competitiveness by improving their level of human capital. Here, the populace takes advantage of the state of existing institutions and takes responsibility for their economic well-being. This economy suffers from the initial economic woes of human capital flight (brain drain), violence, fraud and corruption as a result of weak institutions. However, foreign investors gradually flow into such economy to invest and locate their firms take advantage of available low cost of human capital. The high level of human capital, which also translates into high technology absorption capacity, will influence improvements in the level of institutions. This economy can, therefore, be referred to as a human capital-driven emerging knowledge economy.

Theoretically, this study extends the works of Solow (1957), Romer (1990) and Mankiw, Romer and Weil (1992) by signifying that human capital, innovation, institutions and ICT infrastructure are prominent factors to be considered in the model to capture knowledge economy capacity as well as cater for the non-inclusive gaps of growth. To examine the relationship between knowledge economy and economic growth in SSA, the model is specified implicitly as follows:

$$Y = f(A, K, L, KE, Z) \quad (1)$$

Where Y refers to economic growth, Krefers to capital, Lrefers to labour and $KE$is a vector of the elements of the knowledge economy. Z refers to other factors that can affect economic growth in the model; factors such as knowledge spillovers. The knowledge economy elements include institutions (Ins), innovation (Inn), human capital (HC) and ICT infrastructure (ICT). Hence, the model can further be expanded as:

$$Y = f(K, L, Ins, Inn, HC, ICT) \quad (2)$$

Explicitly, the model is specified as follows based on the theoretical foundation laid by Solow (1957), Mankiw, Romer and Weil (1992) and Romer (1986, 1990, & 1994):

$$Y_{i,t} = A_{i,t}K_{i,t}^{\alpha_2}L_{i,t}^{\alpha_3}e^{\alpha_4 Ins_{i,t}}Inn_{i,t}^{\alpha_5}H_{i,t}^{\alpha_6}ICT_{i,t}^{\alpha_7}\mu_{i,t} \quad (3)$$

μ represents the stochastic error term which indicates that the specified model is an econometric model.

In order to appropriately estimate the model, logarithmic transformation is employed to linearize the model. Thus, the double-log model is presented as:

$$lnY_{i,t} = \alpha_0 + \alpha_1 lnY_{i,t-1} + \alpha_2 lnK_{i,t} + \alpha_3 lnL_{i,t} + \alpha_4 Ins_{i,t} + \alpha_5 lnInn_{i,t} + \alpha_6 lnH_{i,t} + \alpha_7 lnICT_{i,t} + v_{i,t} \quad (4)$$

Where α_0=$lnA_{i,t}$ and $v_{i,t}$= lne

i connotes country while t identifies time.

The model is presented, thus, to signify that it is a dynamic panel model that is required for this study. It is theoretically expected that each of the explanatory variables have a positive relationship with the dependent variable.

Equation 5 depicts innovation as the arrowhead and main driver of economic growth and development in the knowledge economy as validated by the literature. This study, therefore, directs emphasis on innovation as the heart of the knowledge economy and the engine for economic growth.

$$Economic\ growth = f(Innovation) \qquad (5)$$

This, however, does not render the other knowledge economy variables irrelevant given that they affect innovation and are responsible for innovation outcomes. This study therefore examines further the interrelationship between the knowledge economy variables and how it affects economic growth in SSA. The result from the examination provides answers to the second and third specific objective of this study. Examining these relationships demands the specification of an enhanced model, which require the interaction between institutions and innovation as well as between human capital and innovation. These interactions help to ascertain the level of innovation, thus, depicting that innovation is the hub of a knowledge economy.

Equation 4 is, therefore, enhanced to capture the impact of the institutions-innovation interaction and the human capital-innovation interaction. Estimation of these models helps to identify where SSA belongs in the knowledge economy matrix designed in this study.

Equation 6, thus, depicts the model incorporating the interaction between institutions and innovation. This new interactive variable is depicted by $Ins\_Inn_{i,t}$ in equation 6.

$$lnY_{i,t} = \alpha_0 + \alpha_1 lnY_{i,t-1} + \alpha_2 lnK_{i,t} + \alpha_3 lnL_{i,t} + \alpha_4 Ins\_Inn_{i,t} + \alpha_5 Ins_{i,t} + \alpha_6 lnInn_{i,t} + \alpha_7 lnH_{i,t} + \alpha_8 lnICT_{i,t} + v_{i,t} \qquad (6)$$

Results from the estimation of this model reveal whether institutions in SSA have an enhancing effect on the relationship between innovation and economic growth or a mitigating effect. An enhancing effect is a reflection of strong institutions while a mitigating effect is a reflection of weak institutions.

Equation 7 captures the interaction between human capital and innovation as depicted by $lnH\_Inn_{i,t}$. The result from the estimation of this model reveals the impact of human capital.

$$lnY_{i,t} = \alpha_0 + \alpha_1 lnY_{i,t-1} + \alpha_2 lnK_{i,t} + \alpha_3 lnL_{i,t} + \alpha_4 lnH\_Inn_{i,t} + \alpha_5 Ins_{i,t} + \alpha_6 lnInn_{i,t} + \alpha_7 lnICT_{i,t} + v_{i,t} \qquad (7)$$

Thus, it reveals whether human capital has an enhancing effect or a mitigating effect on innovation's impact on economic growth in SSA. An enhancing effect indicates that the level of human capital is high. A mitigating effect indicates that human capital capacity is low.

Table 1: Variables, Data and Source

Variable	*Data Definition*	*Measurement*	*Source*
Economic Growth (Y)	*Log of real GDP*	*US Dollars (US$)*	*WDI 2014*
	GDP Growth rate	*Percentages (%)*	*WDI 2014*
Physical Capital (K)	*Gross Fixed Capital Formation*	*US Dollars (US$)*	*WDI 2014*
Labour (L)	*Labour force participation rate*	*Percentages (%)*	*WDI 2014*
	Population aged 15-64 (percentage of total population)	*Percentages (%)*	*WDI 2014*
Innovation (I)	*Scientific and Technical Journal Articles*	*Units*	*WDI 2014*
	High-technology exports	*US Dollars (US$)*	*WDI 2014*
Human Capital (H)	*Secondary School Enrolment rate*	*Percentages (%)*	*WDI 2014*
	Tertiary Enrolment rate	*Percentages (%)*	*WDI 2014*
Institutions (Ins)	*Regulatory Quality*	*Scale*	*WGI 2014*
	Government Effectiveness	*Scale*	*WGI 2014*
	Rule of Law	*Scale*	*WGI 2014*
	Control of corruption	*Scale*	*WGI 2014*
	Political Stability	*Scale*	*WGI 2014*
	Voice and Accountability	*Scale*	*WGI 2014*
ICT Infrastructure (ICT)	*Mobile subscription (per 100 persons)*	*Units*	*WDI 2014*
	Telephone lines (per 100 persons)	*Units*	*WDI 2014*
	Internet users (per 100 persons)	*Units*	*WDI 2014*
	Internet subscription (per 100 persons)	*Units*	*WDI 2014*
	Internet Servers per one million persons	*Units*	*WDI 2014*
FDI Inflow	*FDI Inflow measured by FDI to GDP ratio*	*Percentages (%)*	*WDI 2014*

Results and Discussion

The knowledge economy indicators were examined in relation to economic growth in SSA. The results (as shown in Tables A2-A5) validate that economic growth is very sensitive to variations in innovation, human capital, institutions and ICT infrastructure. The results also show that SSA economies become more sensitive to higher levels of human capital as they transform to become knowledge-driven economy.

Assessing the knowledge economy indicators and their relationships with economic growth may not be adequate given that the elements of the knowledge economy interrelate; it was therefore, necessary to examine the effect of the interrelationship on economic growth; hence, this study examined how the interaction of knowledge economy elements affects economic growth in SSA. As shown in the analytical framework developed in this study, there are four categories of knowledge economies: First is knowledge-based economy characterized by strong institutions and high level of human capital; second is lean knowledge economy characterized by weak institutions and low level of human capital; third is institutionally-driven emerging knowledge economy characterized by strong institutions and low level of human capital; fourth is human capital-driven emerging knowledge economy characterized by weak institutions and high level of human capital.

The approach adopted in this investigation is based on theoretical underpinnings and validations from literature. Thus, this study, in line with theory and evidence from literature, agrees that innovation is the hub of knowledge economy. This study further agrees with theory and empirical evidence from literature that institutions, human capital and ICT, which are the other elements of knowledge economy, affects innovation. The postulation is based on the ideology that institutions are responsible for the environment that enables or disables innovation. The quality and quantity of human capital also affects the magnitude of contribution innovation makes to economic growth. The argument is that the quantity and quality of innovation outcomes depends on the availability of highly skilled human capital with the capacity for R&D.

Each of the six indicators of institutions were interacted with innovation given its importance in this study. Results of the impact of institutions-innovation interactions on economic growth are, therefore, presented in Table 2. The coefficients of the interacted indicators in model one to model six of Table 2 are small compared to the coefficients of the individual innovation indicator as shown in Table A3. This shows that institutions in SSA mitigate the effect of innovation in SSA. This is an indication of weak institutions in SSA economies.

Table 2: Institutions-Innovation Interactions and Economic Growth (SGMM)

	Dependent Variable: RGDP					
VARIABLES	*1*	*2*	*3*	*4*	*5*	*6*
RGDP (-1)	0.990***	0.969***	0.987***	0.976***	0.982***	0.976***
	(0.0388)	(0.0326)	(0.0270)	(0.0364)	(0.0310)	(0.0373)
GFCF	-0.0541	-0.0575	-0.0583	-0.0614	-0.0487	-0.0558
	(0.0383)	(0.0423)	(0.0433)	(0.0400)	(0.0401)	(0.0423)
$INS_{RQ}\_INN_{S}$	-0.00211					
	(0.00523)					
$INS_{G}\_INN_{S}$		0.00139				
		(0.00350)				
$INS_{C}\_INN_{S}$			-0.00172			
			(0.00331)			
$INS_{RL}\_INN_{S}$				0.000796		
				(0.00490)		
$INS_{PS}\_INN_{S}$					-0.000738	
					(0.00454)	
$INS_{VA}\_INN_{S}$						0.000131
						(0.00484)
HC_{S}	-0.0612**	-0.0683**	-0.0608**	-0.0673**	-0.0557**	-0.0655**
	(0.0270)	(0.0296)	(0.0295)	(0.0267)	(0.0225)	(0.0284)
ICT_{MS}	0.0360***	0.0364***	0.0356***	0.0364***	0.0342***	0.0363***
	(0.00802)	(0.00885)	(0.00910)	(0.00833)	(0.00912)	(0.00908)
Observations	248	248	248	248	248	248
Number of id	31	31	31	31	31	31

Source: Estimated by the Researcher using Stata.

The result indicates that the institutional environment in SSA does not support those activities that promote innovation. Such activities include R&D, University spin-offs, research funding, speedy patenting, reward for ingenuity, freedom of enterprise and expression, life-long learning, competition, protection of intellectual property rights and the enforcement of such laws. This reveals that less attention and support is given to activities that engender innovation outcomes generation as well as increase the stock and use of knowledge for economic growth. This explains the reason for less R&D activities as well as little or no spin-offs from Universities that translate into economic progress in the region.

Research is required to innovate and create knowledge for growth; but, funding is required to fuel the processes involved in research. Lack of it explains why researchers in Universities and research institutes may not be motivated to embark on ground-breaking research that addresses problems peculiar to SSA. This is another indication of the weakness of institutions in the region as validated by the result.

It can also be inferred from the result that researchers in SSA may find it difficult to quickly patent and protect their research findings and output as a result of bureaucratic procedures, costs, and the delays associated with the processes. These institutional glitches can cause researchers, who have invested massively, to lose their efforts to theft and piracy. These institutional glitches and delays involved in patenting and acquisition of rights of ownership may render the research output obsolete by the time the patenting process is concluded. These could weaken the morale of innovators from commitment to R&D.

It can also be inferred from this result that ingenuity of innovators are hardly acknowledged and rewarded in SSA. Rewards are expected to motivate efforts to improve on outcomes. The lack of it, thus, can discourage researchers and innovators in SSA. These institutional setbacks can trigger further human capital flight in the region, since people are likely to migrate to locations they will be rewarded and respected for their human ingenuity and dignity.

The result further indicates the degree to which researchers and entrepreneurs are given the freedom to pursue their ideas and research findings for profits. It can, thus, be inferred that there are some barriers to freedom of enterprise in SSA. Entrepreneurs and researchers may have to register their enterprises before they get the chance to operate; and such registration may involve procedures that take time, cause delays, fuel corruption and discourage the pursuit of enterprise and freedom of expression.

It can be further deduced from the result that intellectual property rights laws may not be enforced. Thus, in the case where research findings are patented, there is limited guarantee that such rights protect from predator firms, which can steal such research ideas and appropriate the ownership without due procedure. Lack of enforcements of intellectual property right laws causes researchers and innovators to have less confidence in the laws; thus, they are not encouraged to contribute to improve on innovation outcomes.

The result also shows that economies in SSA possess institutional environments that discourage lifelong learning, which is required for continuous and growing innovation. Continuous learning is required to keep enhancing the level of human capital needed to create knowledge, innovate and achieve knowledge-driven economic growth. The lack of it, as a result of the institutional enablement, will translate in low innovation outcomes. These findings explain how institutional flaws mitigate the impact of innovation on economic growth in SSA.

Human capital was also interacted with innovation in order to find out how it affects innovation's effect on economic growth in SSA. The results of the estimations are presented in Table 3. The two indicators of human capital were used as shown in the table. The result is a pointer to the role human capital plays in the relationship between innovation and economic growth in SSA. The coefficients of the human capital-innovation interaction are smaller compared to the coefficients of innovation in Table A4. This result reflects the mitigating effect of human capital on the relationship between innovation and economic growth in SSA.

Table 3: Human Capital-Innovation Interactions and Economic Growth (SGMM)

	Dependent Variable: RGDP	
VARIABLES	*1*	*2*
RGDP (-1)	1.014***	1.025***
	(0.0237)	(0.0602)
GFCF	0.00316	0.0358
	(0.0431)	(0.0543)
$HC_S\_INN_S$	-0.00311	
	(0.00341)	
$HC_T\_INN_S$		0.00320
		(0.0128)
INS_{RQ}	-0.000228	-0.0826
	(0.0611)	(0.0522)
ICT_{MS}	0.0110	0.00104
	(0.0201)	(0.0159)
Observations	215	214
Number of id	31	31

Source: Estimated by the Researcher using Stata.

A number of factors responsible are inferred from this result. One of these factors include few opportunities for formal education at the secondary and tertiary level in SSA. This inference does not suggest that there are no opportunities or that there are no substantial opportunities for formal education. It only affirms that the opportunities available may not cater for the growing demand for formal education at the secondary and tertiary level; thus, there is excess of demand of formal education above supply of formal education. Statistics show that only an average of 10 percent of those interested in enrolling for higher education sail through. This gap further deprives many of their capabilities in SSA. This leads to weakened capacity to be involved in R&D activities, thus, mitigating innovation's impact on economic growth in SSA.

It can also be inferred from this result that the mitigating effect of human capital on the relationship between innovation and economic growth in SSA could be as a result of the rising cost of formal education. These rising costs further deprive an increasing amount of individuals interested in enhancing their human capabilities through education. This suggests that the availability of institutes of learning is not sufficient; majority of people in the region should be able to afford it, enroll for it, improve on their human capabilities and be given the chance to express their capabilities to create and contribute to innovation outcomes, which drive economic growth.

The result is also a pointer to the fact that there are limited persons working in the R&D sector; and where there are, they may not be involved in R&D efforts that improve the societies' well-being and contribute to economic growth. The limited amount of persons working in the R&D sector could be as a result of the rising cost of higher education, which is required to cultivate the high-level skills needed to thrive in the R&D sector. The result of the dearth is low innovation outcomes translating into the low impact of innovations on economic growth. One factor that may be responsible for the few workers in the R&D sector is the lack of employment opportunities in the sector. If entrepreneurs are not requesting for innovation outputs to improve on their enterprises, the outcome includes little market and business opportunities.

It can further be deduced from this result that labour force in SSA may be less flexible and less dynamic to the changes in the patterns of demand and changes in technologies; hence, they may not be able to operate effectively. This usually occurs when lifelong learning is not the norm given that it takes continuous learning to be able to respond effectively to dynamics and changes in patterns of demand, technology and the economy at large.

The result also reflects that there is little motivation and less incentives to innovate in the R&D sectors in SSA. Where there is inadequate reward and incentive granted to researchers in Universities or research institutes, they are likely to contribute less, go on strike, or migrate to other sectors of the economy that provide more and better rewards. The global war for talents can further cause SSA to lose its best brains to other regions, thus, causing a shrink in the impact of innovation outcomes on economic growth in the region.

The lack of daring and dynamic entrepreneurs can also contribute to this mitigating effect of human capital on the relationship between innovation and economic growth in SSA. Dynamic entrepreneurs are able to take risks to invest in R&D activities. Where there is the lack of such entrepreneurs, there will likely be little investments and funding of R&D activities to generate innovation outcomes that drive growth. Most entrepreneurs in SSA, however, seem to invest in areas that will enable them yield quick returns unlike R&D activities, whose returns may not be immediate, but rather incur additional costs for experiments and research efforts that may not yield any return.

These are signals for policy makers to invest in improving human capital with higher skills for R&D as well as providing the opportunities as well as the enabling infrastructure and environment for such high-level skills to operate productively. It is also necessary to consider the relationships between those who generate innovation outcomes and those who commercialize innovation outcomes. Mutual relationship between the two will enable learning and focus on marketable innovation outcomes. For instance, a mutual relationship between a University focused on biochemistry research and a fast moving consumer goods' firm will enable such University learn what is needed in the market; hence, that will drive meaningful research. The outcome of such will not only improve the human capital of the researchers involved, but also the students in the University.

This study extended empirical literature further by examining the impact of the interrelationships among the knowledge economy elements on economic growth in SSA. Thus, innovation was interacted with the rest of the knowledge economy variables in order to examine the impact of the interdependence and ascertain what kind of knowledge economy SSA is. The results indicate that SSA is a lean knowledge economy.

Sensitivity Checks

This study investigates the sensitivity of the results to corroborate the robustness checks of the estimated results. The purpose of this was to find out the variations in magnitudes of the knowledge economy variables in relation to the dependent variable. The study therefore employs reports from Economic Complexity Index, Global Competitiveness Index and Global Innovation Index to explore the behaviour of each economy in SSA. From these, extreme cases were identified and exempted so as to validate the estimation results. The Global Competitiveness Report is a report published by the World Economic Forum to present the innovation, productivity and competitive capacities of economies via rankings. It ranks based on 12 pillars which include institutions, infrastructure, macroeconomic stability, health and primary education, higher education and training, goods market efficiency, efficient labour market efficiency, financial market development, technology readiness, market size, business sophistication and innovation. This study has, therefore, the scores and ranking of the Global Competitiveness Report to identify those extreme cases in SSA that can be excluded for sensitivity analysis.

Table 4: Global Competitiveness Ranking

	Score (1-7)	*Rank 2014/15 (out of 144)*	*SSA Rank*
Benin			
Botswana	4.15	74	4
Burkina Faso	3.21	135	23
Burundi	3.09	139	24
Cabo Verde	3.68	114	10
Cameroon	3.66	116	12
Central African Republic			
Comoros			
Cote d'Ivoire	3.67	115	11
Ethiopia	3.6	118	13
Gambia, The	3.53	125	18
Ghana	3.71	111	8
Guinea	2.79	144	25
Kenya	3.93	90	6
Lesotho	3.73	107	7
Madagascar			
Malawi	3.25	132	21
Mali	3.43	128	20
Mauritius	4.52	39	1
Mozambique	3.24	133	22
Namibia	3.96	88	5
Niger			
Nigeria	3.44	127	19
Rwanda	4.27	62	3
Sao Tome and Principe			
Senegal	3.7	112	9
South Africa	4.35	56	2
Swaziland	3.55	123	16
Tanzania	3.57	121	14
Togo			
Uganda	3.56	122	15
Zimbabwe	3.54	124	17

Source: Global Competitiveness Report 2014-2015

Table 4 clearly shows Mauritius, South Africa, Rwanda and Botswana ranked first, second, third and fourth respectively. Out of 7, they scored 4.52, 4.35, 4.27 and 4.15 respectively, while the average score in the region was 3.65. Mauritius and South Africa, which are obviously far from the mean, are extreme cases considered in this study. To further validate the choice of these exemptions, the Global Innovation Index was used to observe the behaviour of the countries.

The Global Innovation Index appreciates the vital role innovation plays as the engine for economic growth; and thus, rates and ranks countries based on their innovation output and the favorability of their environment to enable innovation to drive growth. The report is presented in Table 5.

Table 5: Global Innovation Index 2014

	Score (0-100)	*Global rank (Out of 143)*	*SSA rank*
Benin	24.21	132	28
Botswana	30.87	92	6
Burkina Faso	28.18	109	14
Burundi	22.43	138	30
Cabo Verde	30.09	97	8
Cameroon	27.52	114	17
Cote d'Ivoire	27.02	116	18
Ethiopia	25.36	126	24
Gambia, The	29.03	104	11
Ghana	30.26	96	7
Guinea	20.25	139	31
Kenya	31.85	85	4
Lesotho	27.01	117	19
Madagascar	25.5	124	23
Malawi	27.61	113	16
Mali	26.18	119	20
Mauritius	40.94	40	1
Mozambique	28.52	107	12
Namibia	28.47	108	13
Niger	24.27	131	27
Nigeria	27.79	110	15
Rwanda	29.31	102	10
Sao Tome and Principe			
Senegal	30.06	98	9
South Africa	38.25	53	3
Swaziland	25.33	127	25
Tanzania	25.6	123	22
Togo	17.65	142	32
Uganda	31.14	91	5
Zimbabwe	24.31	130	26

Source: Global Innovation Index 2014

There is a clear indication from the table that Mauritius and South Africa are in the top three in SSA with Mauritius ranking first and South Africa ranking third. Seychelles ranked second, but is not listed among the countries under study. Hence, according to this study, Mauritius and South Africa ranked first and second with scores 40.94 and 38.25 respectively out of 100. Given that the average score in the region is 27.76, the two can be classified as extreme cases. Hence, from Table 4 and Table 5, Mauritius and South Africa had the highest rankings in the region, with portentously larger scores when compared to other economies in the region. It is, therefore, necessary to exclude Mauritius and South Africa and re-examine the relationship between knowledge economy and economic growth in the region based on knowledge economy, the interdependence of its elements and how these affects economic growth in SSA. This is done for the purpose of sensitivity check and improvement on the validity of the results.

SGMM, which is the main estimation technique of this study, was used to estimate the model depicting the relationship between knowledge economy and the interrelationship among its elements as well as their impact on economic growth in SSA, excluding Mauritius and South Africa from the selected SSA countries. The result is presented in Table 6.

The result from the Table is consistent with previous results, thus, validating that the economic growth is sensitive to knowledge economy variables in SSA; it also validates that institutions and human capital in the region are mitigating factors to innovation. This result is consistent with previous results. This is an affirmation that Mauritius and South Africa did not exhibit possible outlier problems in the results estimated.

Table 6: Knowledge Economy in SSA (Excluding Mauritius and South Africa)

	Dependent Variable: RGDP				
VARIABLES	1	2	3	4	5
RGDP (-1)	0.215***	-0.153*	0.160*	0.604	-0.806***
	(0.0813)	(0.0849)	(0.0967)	(0.549)	(0.247)
GFCF	-0.356	-0.694**	-0.376	-0.0347	-0.188
	(0.300)	(0.277)	(0.400)	(0.442)	(1.180)
INN_S	0.785***				
	(0.0828)				
INS_{RQ}	-0.232		-0.0453	-1.161	0.717
	(0.249)		(0.299)	(0.772)	(0.607)
HC_S	0.256*	0.548**		1.335	1.071***
	(0.155)	(0.278)		(0.854)	(0.383)
ICT_{MS}	0.0451	-0.329	-0.298		-0.449*
	(0.0964)	(0.232)	(0.194)		(0.263)
$INS_{RQ}\_INN_S$		0.162***			
		(0.0194)			
$HC_S\_INN_S$			0.216***		
			(0.0171)		
$ICT_{MS}\_INN_S$				0.191**	
				(0.0857)	
$FDI_{KS}\_INN_S$					-0.0813
					(0.0610)
Observations	178	205	177	140	162
Number of year	13	13	13	13	13

Source: Estimated by the Researcher using Stata 12

Models two to five, which reflects the behaviour of the interaction variables, also shows consistency with the previous examination of the interaction variables before the exclusion of Mauritius and South Africa. The coefficient of the institutions-innovation interaction (0.162) is small compared to the coefficient of innovation (0.785) in the table. These results further validates that institutions mitigate the effect of innovation on economic growth in SSA. The coefficient of the human capital-innovation interaction (0.216) is also smaller than the coefficient of innovation in the table; thus, further validating the mitigating effect of human capital on the relationship between innovation and economic growth in SSA.

Summary and Conclusion

These results clearly show that institutions in SSA are weak and the quality of human capital in the region is low. The study also contributes to literature by providing the knowledge economy matrix, which helps to ascertain the knowledge economy status of economies. The result from the study reveals that SSA is a lean knowledge economy, according to the matrix. The study therefore provides policy recommendations to improve the SSA status.

Firstly, incentives should be provided to enable the development of human capital in SSA countries in order to improve the level of human capital. The higher the quality of human capital, the higher the level of innovation. Such incentives will therefore be vital in stimulating an upgrade in the level and quality of innovation in SSA. These incentives can include easy access to higher and technical schools aimed at equipping individuals with the knowledge and expertise to innovate. Other incentives can include free and subsidized education and provisional platforms that allow individuals, lacking the entry requirements, to upgrade their capacity to innovate.

Secondly, incentives that will enable innovation to occur seamlessly beyond education, should be provided. Such incentives include R&D funding, well-equipped laboratories and workshops, and strong interrelationship between research centres and the industry; this will enable researchers and innovators access the real gaps in the industry as well as leverage on their experiences to develop solutions. Beyond enabling innovation in SSA, these incentives will discourage the loss of human capital to advanced economies that attract them at the expense of the development of SSA.

SSA countries can, therefore, invest in the quality of institutions as well as the quality of human capital, so as to upgrade their capacity to stimulate innovation to drive economic advancement.

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Appendix

Table A1: Correlation Matrix of the Independent Variables

	GFCF	L_3	INN_S	INS_{RQ}	HC_S	ICT_{MS}
GFCF	1.0000					
L_3	0.1584	1.0000				
INN_S	-0.0798	0.1012	1.0000			
INS_{RQ}	0.4414	0.4588	0.3062	1.0000		
HC_S	0.2321	0.7519	0.1103	0.4979	1.0000	
ICT_{MS}	0.2959	0.4569	0.0790	0.2198	0.6199	1.0000

Source: Computed by the Author

Table A2: Innovation and Economic Growth in SSA (SGMM)

	Dependent Variable: RGDP		
VARIABLES	*1*	*2*	*3*
RGDP (-1)	0.473***	0.410***	-0.663
	(0.103)	(0.127)	(0.470)
GFCF	0.100	-1.028***	-1.749**
	(0.302)	(0.300)	(0.814)
INN_S	0.960***		
	(0.0913)		
INN_H		0.663***	
		(0.0738)	
INN_{HM}			0.0773
			(0.107)
INS_{RQ}	-0.202	-0.326	1.098
	(0.253)	(0.295)	(0.684)
HC_S	-0.243	0.659*	0.960**
	(0.213)	(0.387)	(0.480)
ICT_{MS}	0.339***	-0.440**	-0.573
	(0.102)	(0.195)	(0.360)
Observations	246	218	217
Number of year	13	13	13

Note: Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Source: Estimated by the Researcher using Stata 12.

Table A3: Institutions and Economic Growth in SSA (SGMM)

	Dependent Variable: RGDP					
VARIABLES	*1*	*2*	*3*	*4*	*5*	*6*
RGDP (-1)	0.473***	0.0200	-0.331**	0.0583**	0.0717**	0.0327
	(0.103)	(0.0315)	(0.136)	(0.0229)	(0.0309)	(0.0354)
GFCF	0.100	-1.099***	-1.629***	-0.620***	-0.459***	-0.713***
	(0.302)	(0.181)	(0.225)	(0.134)	(0.170)	(0.177)
INN_S	0.960***	0.567***	0.343***	0.619***	0.612***	0.616***
	(0.0913)	(0.0231)	(0.122)	(0.0200)	(0.0207)	(0.0242)
INS_{RQ}	-0.202					
	(0.253)					
INS_G		0.291***				
		(0.0822)				
INS_C			0.476***			
			(0.172)			
INS_{RL}				-0.243***		
				(0.0782)		
INS_{PS}					-0.347***	
					(0.108)	
INS_{VA}						-0.157
						(0.146)
HC_S	-0.243	-0.0599	-0.262*	0.0280	-0.0519	0.0406
	(0.213)	(0.0936)	(0.135)	(0.112)	(0.0997)	(0.105)
ICT_{MS}	0.339***	0.160**	0.281***	0.264***	0.292***	0.229***
	(0.102)	(0.0743)	(0.108)	(0.0809)	(0.0837)	(0.0804)
Observations	246	160	157	160	160	160
Number of year	13	13	13	13	13	13

Note: Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Source: Estimated by the Researcher using Stata 12.

Table A4: Human Capital and Economic Growth in SSA (SGMM)

	Dependent Variable: RGDP	
VARIABLES	*1*	*2*
RGDP (-1)	0.473***	0.0952*
	(0.103)	(0.0570)
GFCF	0.100	0.0334
	(0.302)	(0.223)
INN_S	0.960***	0.697***
	(0.0913)	(0.0501)
INS_{RQ}	-0.202	-0.161
	(0.253)	(0.166)
HC_S	-0.243	
	(0.213)	
HC_T		0.501***
		(0.102)
ICT_{MS}	0.339***	-0.181
	(0.102)	(0.118)
Observations	246	213
Number of year	13	13

Note: Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Source: Estimated by the Researcher using Stata 12.

Table A5: ICT and Economic Growth in SSA (SGMM)

	Dependent Variable: RGDP				
VARIABLES	*1*	*2*	*3*	*4*	*5*
RGDP (-1)	0.473***	-0.00570	1.382***	-0.326**	-0.235***
	(0.103)	(0.0474)	(0.393)	(0.141)	(0.0669)
GFCF	0.100	-0.211	2.231***	-1.059***	-1.115**
	(0.302)	(0.237)	(0.560)	(0.263)	(0.443)
INN_S	0.960***	0.636***	1.908***	0.356***	0.518***
	(0.0913)	(0.0457)	(0.366)	(0.102)	(0.0859)
INS_{RQ}	-0.202	-0.0753	-2.635**	0.0187	0.137
	(0.253)	(0.272)	(1.094)	(0.206)	(0.242)
HC_S	-0.243	0.638***	-0.975*	-0.256*	0.0374
	(0.213)	(0.182)	(0.511)	(0.132)	(0.270)
ICT_{MS}	0.339***				
	(0.102)				
ICT_T		-0.205*			
		(0.124)			
ICT_{IS}			1.082***		
			(0.356)		
ICT_{IU}				0.355***	
				(0.0869)	
ICT_{IM}					0.134
					(0.112)
Observations	246	249	74	155	92
Number of year	13	13	9	13	9

Note: Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Source: Estimated by the Researcher using Stata 12.