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Barriers to Innovation and Public Policy in Sub-Sahara Africa

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Abstract
Countries in sub-Sahara Africa are increasingly becoming aware of the role of Science, Technology and Innovation (STI) in lifting the region from the doldrums of poverty and deprivation. This is necessary if the continent aims to add value to its raw material in order to remain competitive in the global market and at the same time diversify the structure of its economies. This paper aims to explore policies on STI implemented across countries in the region and how these policies have managed to change the status quo and ultimately led to building technological capability economies to enhance the wellbeing of the region.The paper primarily focuses on countries within sub-Sahara Africa excluding North Africa and the Middle East. However, comparisons are occasionally drawn from certain countries in the west and emerging economies.The paper systematically reviews national science, technology and innovation plans of selected countries in sub-Sahara Africa. Other secondary sources included credible journal articles, commentary, webpages, working papers and reports published on the selected countries.Empirical evidence gathered from secondary sources indicate that governments in the region have built public organizations and institutions to support STI. Yet technology-capability indicators available illustrates the results are far from expectation. The paper further discusses the barriers faced by governments in the design and implementation of STI policies that have led to the ensuing situation.In the face of the significant progress in setting up institutional frameworks across countries in the region leading to the adoption of a systemic approach, the ensuing results of STI policies in the region is marginal as evidenced in the indicators. Human and financial resources devoted to them are in shortfall. We admonish countries in the region to take all the necessary steps to develop national evaluation and STI data stand. The success of this approach will be contingent on the region first of all being able to evolve a specific conceptual and methodological tools for monitoring and assessing STI policies. Area of financing STI policies have to be reconsidered. Tax incentives and havens for technology related businesses ought to be given priority to augment already existing instruments such as export-led instruments.
Keywords: Barriers; Sub-Sahara Africa; Policy, Science and Technology and Innovation (STI); Entrepreneurship.

1. Introduction

Sub-Sahara Africa is a region housing over two-thirds of the world's poor and continues to be off-target in achieving the millennium development goals (MDGs) in 2015 (Oxfam, 2014; Puzzanghera, 2014; UN- DESA, 2013). Over the last three decades, policy makers and politicians alike, together with development partners have been trying to find lasting solutions to the plight of the region. Yet the results leave much to be desired, thus calling for further deliberation in dealing with the situation.

When discussing the state of Sub-Sahara Africa, corruption, governance, political instability among others are identified as some of the causes (Forson et al., 2017; Forson et al., 2016; Forson, 2016a). Notwithstanding, issues of diversification that may bring about structural change have not been addressed adequately either in political or academic discourses. Thus, Africa's failure to embrace change and innovation has affected the structure of its economy. Researchers such as Oyelaran-Oyeyinka (2012) and others have described sub-Sahara Africa as a 'latecomer' to demonstrate how sluggish the region has been in embracing technological advancement. To make any meaningful strides would mean there should be a structural change. According to Oyelaran-Oyeyinka (2014) by definition economic structural change is measured by quantifiable structural shift (GDP or employment share of the sector explained by the level of development). This situation includes observable economic transformation, followed by significant changes to the relative contribution of different sectors, in terms of production and factor use. That has not been achieved holistically.

It should however be pointed out that, the process of development is marked by pervasive and widespread market imperfections (Oyelaran-Oyeyinka, 2012). With this in mind, government policies and institutions are to be charged with the task of correcting these imperfections that poses as bottlenecks to national development (Osborne & Gaebler, 1992; Rodrik et al., 2004). Africa, from the preamble has fallen behind because its people, despite their historical abilities in science, have not done this in an organized manner. The more the western

world was able to invent and innovate in the past 300 years, the more "civilized" it became. And as Africa, in comparison, remained closer to nature and was dominated by natural phenomena, the more "primitive" and backward the continent seemed (Moghalu, 2014). The World Bank in its 2009 report of World Development Indicators on innovation had pointed out that the amount of scientific and technical journal articles in Africa was less than 1% (approximately 0.64%). Comparing this figure to what is transpiring in other quarters where the level of innovation is around 36.84%, 24.17%, 2.72% and 3.04% for Europe, East Asia, South Asia and Latin America respectively, then it confirms what has been purported about the region (World Bank, 2009).

The contribution of this article therefore is to explore the efforts enforced by policymakers on science and technology and innovation in sub-Sahara Africa and then have it linked to the technological-capability indicators which will inform readers as to how effective efforts have been in spurring innovation in the region. This has important implication for bringing about desired structural transformation for sustainable development. This is against the backdrop that through innovation, countries such as China, India, South Korea and Malaysia have been able to leverage on its upside benefits and are a leading example.

Consequently, the article is organized into five parts. The first part is the introduction which lays the background to the issue of STI in Africa. The second part explores the concepts of STI policies. The third part of the paper looks at the role of institutions in developing innovation. STI policies of selected countries are explored in section four using STI indicators. The paper ends with conclusions and policy recommendations in section five.

2. Science, Technology and Innovation policies

According to Hadjimanolis and Dickson (2001), the role of science and technology in economic development only came to be appreciated after the Second World War. Specific policies to realize the full of science and technology have since been the fulcrum of national progress, initially in the developed world and later, through the process of gradualism, it's been extended to developing economies (Sagasti, 1989). Yet the application in developing countries such as the ones in sub-Sahara Africa has been almost non-existent till the late 1980s.

Innovation according to researchers such as Sundbo (2003), is combination of knowledge that result in new products, processes, input and output markets, or organization (not only technical innovation) but also organizational and managerial innovations, new markets, new sources of supply, financial innovations, and new combinations (Perlman and Heertje, 1991). To Padilla-Perez and Gaudin (2014), innovation is an interactive and gradual process, based on communication and knowledge exchange. Carayannis et al. (2006) have argued that in a knowledge-based economy, innovation through the creation, diffusion and use of knowledge has become a catalyst in the build up to economic growth. Rycroft and Kash (1999) pointed out that innovation policy is a complex process, not a single product, but as a result of a set of programs and policies, involving institutions.

However, innovation come in different forms and facades. For instance, industrial innovation includes manufacturing, technical design, management and commercial activities used in the marketing of a new (or improved) product or the first commercial use of a new process or equipment (Freeman, 1982). Huang et al. (2007) are of the opinion, the factors required for industrial innovation are in manifold and may include technical knowledge, manpower, market information, financial resources, R&D environments, a domestic market and an international market (Rothwell and Zegveld, 1982). Many researchers (see Barro, 1990; Mcmillan & Rodrik, 2011; Rothwell & Zegveld, 1982) have proven and made a case that indeed, industrial innovation can increase overall economic development. Finding the right measure of innovation has given rise to intellectual argument. Huang et al. (2007) in a quick rebuttal had pointed out that macro measures such as R&D tax credit are not effective and pointless, and that policies must be designed to influence particular economic sectors. Product innovation differs from the generic concept, as it is basically the introduction of new good or service or the significant improvement of existing product with respect to its characteristics and intended use (Ayyagari et al., 2012; Barasa et al., 2017). But Salmenkaita and Salo (2002) disagreed and emphasized that there are no straightforward answers to the question of what should constitute an innovation policy.

According to Padilla-Perez and Gaudin (2014), governments' role as far as innovation system is concern may be in twofold: (1) government generate and disseminate new knowledge through public research centers, universities and enterprises and, (2) government creates and modify institutions that supports state technology innovation (STI). Government achieves this through a host of other policy instruments such as trade policies, public investment, support for small and medium scale enterprises, training and education and regional development.

3. Institutions and Innovation Perspectives

According to Mothe (2004), institutions are the conduit through which ideas are formed and flow, from government labs, firms (small and large), universities, and agencies, providing community services, and developing the notion of what he termed as "constructed advantage".

Institutional development holds the key to innovation and this has been researched extensively by Lundvall

(1992) and in most recently Nelson (2008) and Rasiah et al. (2016). Lall and Teubal (1998) and Lall (1994) had discussed the industrialized the experience of East Asian nations, which sought to emphasize on the importance of coordination between research and development (R&D), training, investment and product development for improved performance. Nelson on the other hand posits that the embedding organizations and institutions actively advance the role of technologies in each industry. In collaborating this assertion, Rasiah et al. (2016) in an attempt to examine the relationship between host-site institutional support, innovation capabilities and exports observed that innovation capabilities is correlated with institutional support, and that it also enjoyed a positive relationship with export.

At the firm level, Barasa et al. (2017) were able to prove that firm-level resources vary depending on the institutional environment and that regional institutional quality positively moderates the effects of the firm-level resources.

Dollar and Kraay (2003) argued that properly designed institutions can stimulate productive behaviors, yet weak institutions often lead to unproductive behaviors (Greif, 2006)). Institutions can reduce transaction costs and uncertainty and ease coordination between economic agents (Alonso & Garcimartin, 2013). Institutional quality encompasses (1) the process by which a government is selected, monitored and replaced (2) a government's capacity to effectively formulate and implement sound policies and (3) the economic and social interactions between citizens and the state are governed (Kaufmann & Mastruzzi, 2013). As such, the institutional environment can influence the propensity of firms to innovate in a variety of ways (North, 1993). For instance, weak enforcement of regulations and the absence of intellectual property rights may hinder innovation. Compared to countries in Latin America, Southeast Asia and Middle East and North Africa, countries in sub-Saharan Africa perform poorly in upholding the rule of law, regulatory quality, control of corruption and government effectiveness (Alence, 2004).

4. STI Policies in Sub-Sahara Africa

4.1. Brief overview of sub-Sahara Africa economies and their technological capabilities

Geographically, Sub-Sahara Africa[i] is the area of the continent located south of the Sahara Desert. When considered politically, it consists of all countries that are fully or partially south of the Sahara without Sudan even though Sudan is at the Eastern portion of the Sahara Desert. This contrasts with North Africa, which is considered a part of the Arab world. As of 2007, the population of Sub-Sahara Africa stood at 800 million. It currently has a population growth rate of 2.3% and the UN predicts a population of nearly 1.5 billion in 2050, making the area highly densely populated. Sub-Sahara Africa is housed to 49 countries and boast of the most linguistic diversity of the world with more than 1000 languages, which is a representation of 1/6 of the world's total[ii].

Table 1: Selected countries in sub-Sahara Africa

	Nigeria	South Africa	Botswana	Ghana	Namibia	Rwanda	Kenya
Population 2017 (million)	181.2	55.01	2.29	28.83	2.53	12.21	49.70
Surface Area (10^3km^2)	924	1 221	582	239	824	26	2 725
GDP per capita 2015 (PPP US dollars)	2 714	5 773	6 361	1 356	4 674	697	1 377
Exports and Imports/GDP 2015	31.02	65.10	114.98	89.78	102.70	na	72.56
Human Development Index[iii] (2015)	0.47	0.66	0.69	0.57	0.64	0.49	0.55

Source: UNESCO (2016) and World Bank development indicators (2010-2016)

Nigeria is the most populous country in the region with over 180 million people and in terms of GDP is the largest economy on the continent. With a total surface area of 923,768 square kilometers, and a per capita income of $2714 (see Table 1). Human development is low in Nigeria (0.47). In general, per capita GDP significantly varies among countries. According to a recent report by the World Bank (2013), growth in Sub-Saharan Africa is recovering, supported by modestly rising commodity prices, strengthening external demand, and the end of drought in a number of countries. Growth in Sub-Saharan Africa is forecast to pick up to 2.6 percent in 2017 and to 3.2 percent in 2018, based on moderately rising commodity prices and reforms to tackle macroeconomic imbalances.

Before analyzing STI policies in the region, a set of technological-capabilities indicators on some selected countries in sub-Sahara Africa are shown Table 2. A conscious attempt is made to compare the indicators of the region with other countries in other regions to illustrate the widening gap. It should be noted the technological-capabilities is classified into two groups: efforts and results. The first group focuses on efforts devoted to strengthen technological-capabilities to bring about desired change, whiles the second tries to quantify advances in technological change owed to the effort that has gone into it.

Table 2: Efforts and Results on selected countries in sub-Sahara Africa

Country/Indicator	Nigeria	South Africa	Mali	Kenya	South Korea	Brazil	United States	Sweden
No. of graduates on ST areas (per 1000 inhabitants)	0.3	0.7	0.11	0.3	na	4.3	5.1	na
ST Personnel (per 1000 inhabitants)					4.9	2.4	4.7	5.0
R&D Expenditure (percentage of GDP)	0.2	0.9	0.66	0.79	3.4	1.09	3.1	3.6
Patent applications by residents (per million inhabitants)	645	5 065	na	53	2745.9	37.7	801.8	2745.9
No. of Scientific Journal Publication	3,653	9,679	64	872	58,844	48,622	412,541	19,361

Source: Author construct based on World Development Indicators and UNESCO indicators. All available online.
Note: ST= Science and Technology, na = not available

On the effort indicators, data on R&D and others have indicated a drastic shift in the effort. Yet, it leaves much to be desired. Broadly speaking, there has been a surge in R&D expenditure as a percentage of GDP in the region. Countries like Ethiopia, Kenya, Mali, Senegal and Ugandan have increased commitment levels from 0.24%-0.61%, 0.36%-0.79%, 0.25%-0.66%, 0.37%-0.54% and 0.37%-0.48% respectively. Focusing more specifically on individual countries in the region, Nigeria plans to join the top 20 most powerful economies in the World by 2020 by attaining a GERD/GDP ratio comparable to that of the 20 leading developed economies (National Council on Vision 2020, 2010). Rwanda have increased investment in R&D to 3% of GDP by 2015. This has given Rwanda a higher GERD/GDP ratio than most developed countries. To buttress the claim that countries in the region are far behind in terms of commitment, the USA, for instance, had a GERD/GDP ratio of 2.7% in 2007 and Germany a ratio of 2.5% (UNESCO, 2015). An action plan for research and innovation covering 2010-2013 was adopted by the Republic of Congo in 2009. It also reiterated the target of devoting 1% of GDP to gross domestic expenditure on research and development (GERD). In other development, South Africa adopted a 10-year plan to foster a knowledge economy, entitled Innovation towards a Knowledge-based Economy. It has five focal thrusts: from farmer to pharma; space science and technology, energy security; global climate change science; and human and social dynamics. More specifically, one-fifth of government spending on R&D in South Africa goes to the engineering sciences (20.9%), ahead of medical and health sciences (15.1%), ICTs (14.0%) and applied science and technology (11.0%), social sciences (9.4%) and agricultural sciences (6.9%). This contrasts with the emphasis on agricultural research in other sub-Saharan countries (UNESCO, 2015). To illustrate further the wide gap between sub-Sahara Africa and global leading countries, United States invests 3.1% of GDP, South Korea 3.4%, and Sweden 3.6% according to credible sources (see Padilla-Perez & Gaudin, 2014; UNESCO, 2016).

The average number of science and technology graduates (per thousand inhabitants) and number of scientific journal publication in sub-Sahara Africa is lesser than what pertains in other regions. Focusing on countries within the region making incursion, the number of graduates in science and technology areas for Nigeria, South Africa and Kenya was less than 1% respectively. These front liners in the region are trailing behind its counterparts in East Asia, South and North America in which Brazil and United States recorded 4.3 and 5.1 per thousand inhabitants respectively. On the number of scientific journal publications, apart from South Africa which published more nine thousand (9,679) journal articles, the other countries in the region (Nigeria - 3563, Mali - 64, and Kenya – 872) were lower than countries such as South Korea (58,844), USA (412,541) and Sweden (19,361) in 2013.

On the results (output) emerging from these efforts, one would argue the region has made modest inroads yet it still lags behind other regions. On internet access, some of the highest connectivity rates in sub-Saharan Africa were recorded in Zimbabwe (10.12% of the population), Sudan (9.08%), South Africa (8.16%), Kenya (7.99%), Cape Verde (6.98%), Nigeria (6.75%) and Senegal (6.62%) (UNESCO, 2016; World Bank, 2013). On patent, the overall outlook showed that there were 8800 patents granted in sub-Sahara Africa in 2015, the least among regions such as Northern America (320,600), Latin America and Caribbean (18,600), Asia (700,400), Europe (165,200), and Oceania (27,500). Finally, the number of scientific publications (per million inhabitants) in sub-Sahara African countries is lower than countries in North America, Asia, Europe and South American. Nigeria and South Africa scored 11.4 and 46.4 per million inhabitants as compared to the global leading countries such as the United States (1276.7) and Sweden (1053.1).

4.2 STI Policies in sub-Sahara Africa

This section explores STI policy instruments already in forced in selected countries in sub-Sahara Africa. It should be noted that these policy instruments are grouped into three key areas: institutional framework, financing, and interaction and diffusion.

Table 3 (appendix) summarizes STI policy instruments on selected countries in sub-Sahara Africa focusing on the areas already mentioned above.

4.2.1 Institutional Framework

A cursory look at the national plans of the various countries in the region have shown that each country has a public organization task with the responsibility of planning, designing and implementation of STI-policies. Ghana, the first country in the region to be independent from colonial rule launched its national science and innovation policy in 2010. The Ministry of Environment, Science and Technology (MEST) is the oversight

agency, but Ghana's science and technology policy is under the office of the president. MEST works with other agencies such as the council for Scientific and Industrial Research (CSIR), the Ghana Atomic Energy Commission (GAEC), the Environmental Protection Agency (EPA) and Town and Country Planning Department whose basic tasks are applied research and development (R&D) in Ghana. Placing Ghana's science and Technology policy right under the office of the president underscores the seriousness with which government attaches to innovation policy (MEST, 2010, 2017).

Unlike Ghana, Zimbabwe's science and technology comes under a unit other than the parent ministry: the Research Council of Zimbabwe (RCZ). The body has an advisory role in areas of science and technology and thus coordinate and monitors research and development in the country (see Ali-Dinar, 2012). The Research Council can establish sectoral Research Councils and Boards. It can also establish, with Government approval, R&D Centres. This core responsibility has enabled the RCZ to establish the Scientific and Industrial Research and Development Centre (SIRDC). This body is being established with some eight R&D sectoral institutes, one of which is microelectronics. Currently SIRDC activities in informatics extend to the processing, acquisition, and dissemination of remote sensing data. This data is instrumental for monitoring environmental degradation, crop forecasting, search for minerals, establishment of road networks and other large projects.

Kenya's commitment to science and technology and innovation is among the oldest on continent and dates back to the 70s. The National Council for Science and Technology (NCST) was established by the Science and Technology Act (Chapter 250) of the Laws of Kenya on 1 July 1977. The Council is therefore the national focal point for science and technology policies and advises the Government through the Ministry of Science and Technology (MST) on all aspects of science and technology and its application for national development. The Act further empowers the Council to appoint standing committees, one of which deals with documentation and information. Series of reforms have had the name of the institutional framework changed to the Kenya National Innovation System (MoHEST, 2008).

Science and technology in Tanzania comes under the National Commission for Science and Technology (NCST) and has its membership among plays in the science and technology system, public sector, technical ministries among others. Its primary role is the coordination of science and technology planning as well as its implementation. Stimulating and performing a catalytic role for indigenous technologies remains it core function (Ali-Dinar, 2012).

Science and technology and innovation policy in Nigeria is championed by the Federal Ministry of Science and Technology (FMST) and supported by the National Science and Technology Act, CAP 276 of 1977 and the FMST Act No 1, 1980 to incorporate the new STI Policy. Yet the first National Science and Technology Policy in Nigeria was produced in 1986 with the policy designed to create harmony in the pursuit of knowledge about the environment through research and development (R&D). Particularly, the policy stressed the need to use science and technology to ensure quality of life for the people (Willie et al., 2016). The policy was reviewed in 1997 to lay more emphasis on coordination and management of Science and technology system, sectoral developments, collaboration and funding (FMST, 2011; National Council on Vision 2020, 2010). However, FMST works with other bodies such as the National Research and Innovation Council (NRIC), which is mat to set national priorities on R&D.

The South African experience is different from its akin economies in the region. The development of science, technology and innovation policy in South Africa has generally followed a similar path to that of most OECD countries in terms of a "*National System of Innovation*" (NSI) approach in which emphasis is laid on innovation as opposed to the generic concept of STI or R&D. It was not until 1996 when a coherent framework on science and technology was developed by the Department of Arts, Culture Science and Technology (DACST) (see DACST, 1996). The NSI approach considers that the flow of knowledge and technologies is also affected by policies of other state departments other than that of science and technology. The coordinating role that the Department of Arts, Culture, Science and Technology (DACST) now Department of Science and Technology (DST) performs and the structured relationship between departments within the NSI facilitates the process of ensuring that issues related to financing, procurement, regulatory, governance, privatization and competition policies are constantly under review in so far as they impact on the innovation process.

4.2.2 Financing

None of the countries under review in sub-Sahara Africa offers tax incentives to specifically promote R&D activities. But in other jurisdiction, there are other policy instruments that can be used for this purpose and are commonly found in the laws and regulations for export-led processing zones (ad-hoc schema for export promotion and attraction of foreign inflows). For instance, in Ghana, there is a free-zone industrial enclave where investors are encouraged to site factories and are given a ten (10) year tax holidays. On mechanism for financing STI development in Ghana, government remains the sole financier, but have encouraged private sector to support the activities of R&D. Other financing mix is also being explored such as tax incentives, encouraging public procurement of products and services from science and technology institutions, formation of venture capital fund administering authority for the commercialization of new technologies from scientific and

technological institutions (MEST, 2017). For instance, the national science and math quiz is an initiative of the private sector (primetime limited) with support from the Ghana education service for secondary schools in Ghana.

According to the first policy plan of South Africa, provision for funding of the activities of NSI have been made. Thus the policy makes provision for innovation fund (DACST, 1996: pp.44), and charges DACST to create mechanism to administer the fund. Managers of the fund were encouraged to draw on the experience of the Support Programme for Industrial Innovation (SPII), the Water Research Commission, the Safety in Mines Research Advisory Committee and the Energy Policy Projects (both supported by the Department of Mineral and Energy Affairs), and the Directorate of Technology Development of the SANDF. To show that firm commitment, there has been a steady increment in government funding of the activities of DST. Thus for the past three years, investment in that area has been increasing from R7.44-billion in 2015-16, and R7.43-billion in 2016-17, it will be hitting R7.56-billion in 2017-18.

Government remains the key funding agency in Zimbabwe, Kenya, Tanzania and Nigeria although other source of funding are being explored to execute the activities of the Research Council of Zimbabwe (RCZ), the National Council for Science and Technology (NCST), National Commission for Science and Technology (NCST) and Federal Ministry of Science and Technology (FMST) respectively. There are also supports from both international and regional bodies such as UNESCO, UNDP, the AU initiatives (the Global Monitoring for Environment and Security (GMES), the Africa union space STI initiative headed by the space working group (SWG), the African union research grant programme, the Kwame Nkrumah scientific awards programme, AU Science, Technology and Innovation Strategy for Africa 2024 (STISA-2024), the EU-Africa cooperation on STI, scientific, technical and research commission (STRC), African scientific research and innovation council (ASRIC), African observatory for science, technology and innovation (AOSTI), the African union biodiversity program, etc.) (DHRST, 2012). Nigeria had indicated it had created a research fund akin to the US National Science Foundation. The fund, the National Science Research, Technology and Innovation Fund is yet to be operational.

4.2.3 Interaction and Diffusion

Virtually all the policy plans of the countries under review have emphasized interaction and diffusion among players in the science and technology agenda. In Ghana, the parent agency for science and technology and innovation (MEST) works with other agencies such as the council for Scientific and Industrial Research (CSIR), the Ghana Atomic Energy Commission (GAEC), the Environmental Protection Agency (EPA) and Town and Country Planning Department whose basic tasks are applied research and development (R&D). Similar attempts is being made in other countries.

In Nigeria, the federal ministry of science and technology interacts and at the same time have diffused its core mandate to parastatals such as the National Board for Technology Incubation (NBTI), the Nigerian Institute of Science Laboratory Technology (NISLT), National Centre for Technology Management (NACETEM), National Office for Technology Acquisition and Promotion (NOTAP), the National Institute of Leather Science and Technology (NILEST) among others.

Several bridging organizations, which bring together efforts by public and private sectors are being created in the region. For instance, the Global Monitoring for Environment and Security (GMES), the Africa union space STI initiative headed by the space working group (SWG), the African union research grant programme, the Kwame Nkrumah scientific awards programme, AU Science, Technology and Innovation Strategy for Africa 2024 (STISA-2024), the EU-Africa cooperation on STI, scientific, technical and research commission (STRC), African scientific research and innovation council (ASRIC), African observatory for science, technology and innovation (AOSTI), the African union biodiversity program, are all being created to deepen the region's innovation to impact on well-being.

4.3 Barriers to design and implement STI policies in sub-Sahara Africa

Previously, the study had described STI policies in force in sub-Sahara Africa. Nevertheless, technological-capability indicators have shown the region still lags behind its compatriots. This section identifies and briefly discusses the barriers that have led to the ensuing status quo. These are barriers faced by governments when designing and implementing STI in Africa.

To begin with, although there appear to be some form of political support in the design of STI policies, the results from the technological-capability indicators have proved otherwise. Thus high-level political support for STI policies is superficial and therefore remains absent. Public organizations charged with the task of science and technology innovation policies (ministries, national council, secretariat, and parastatals) lack the resources and enough leverage to discretionary push their agenda. Moreover, recognition and the role of innovation to stimulate growth remains ambiguous, hence commitment levels being low comparatively. As posited before, countries such as Ethiopia, Kenya, Mali, Senegal and Ugandan despite increment in the commitment levels from 0.24%-0.61%, 0.36%-0.79%, 0.25%-0.66%, 0.37%-0.54% and 0.37%-0.48% of GDP, is still far from

appreciable levels looking at what is being done elsewhere (e.g. US 3.1% of GDP, and Sweden 3.4% of GDP).

In exploring other source of funding for STI in the region, tax incentives seem to be the best option, yet countries in the region are already saddled with the problem of low tax revenue which makes it difficult to implement the policy on tax incentives. This poses as a strong barrier for increased STI public investment. According to figures from the World Bank (2009) tax revenues as a percentage of GDP in the region is low. For instance in Ghana tax revenue accounted for just 14.87% of GDP in 2012, in Nigeria 5.46% in 2008, in South Africa 26.50% in 2012, in Kenya 19.88% in 2012, in Tanzania 13.8% in 2012, in Cameroun 11.2% in 1999 and 12.46% for Angola in 2015 (World Bank, 2013). The implication therefore is that, funds for STI won't be forthcoming as countries are faced with more social issues that needs redress in the short term.

Political instability in the region remains a barrier to the implementation of STI policies. STI programmes do not always survive the entrance of new government. This is a common practice in Africa. New government often over-look policies initiated by its predecessors irrespective of the programmes impact on general wellbeing.

The universities in the region are mainly focused on teaching or basic-science research which has a weaker link to private enterprises. Science and technology institutions that were conceptualized from the outset to be the incubating grounds for entrepreneurs and inventors have taken to offering social science programmes and business administration. For instance, universities such as the Kwame Nkrumah University Science and technology (KNUST) in Ghana, the Federal University of Technology (FUT) in Nigeria, Central university of Technology (CUT) in South Africa have all diluted their programmes by offering more programmes in the arts and social sciences than its pure and applied science programmes which is core to its mandate.

Coordination among public organizations and parastatals in the design and implementation of STI policies is weak. Departments and parastatals often elaborate their strategies but are not fully integrated and coordinated thereby leading to competition among these institutions. This is undoubtedly a barrier to improving the impact of STI policies and developing an efficient use of scant resources.

Financial systems in sub-Sahara Africa are not incentivize enough to support innovation in the region. New entrepreneurs and existing firms hardly get access to financial sector to finance innovation activities. Venture capital are also almost non-existent. The gestation periods for actualizing the full potential of new inventions often takes time, and this is a disincentive for existing financial institutions who are already grabbling with liquidity and solvency risks.

In summary, countries in sub-Sahara Africa are trailing behind when it comes to science and technology and innovation due to the fore-going barriers identified which shares commonalities with what pertains elsewhere: design and implementation failure and political instability (see Woolthuis et al., 2005), weak education systems (Aubert, 2004; Segarra-Blasco et al., 2008), lack of resources (Aubert, 2004), lack of financing mix (Segarra-Blasco et al., 2008) and lack of coordination among public organizations and failure to monitor (Hadjimanolis & Dickson, 2001; Willie et al., 2016).

5. Conclusion and policy recommendation

Sub-Sahara Africa remains the region with the least in the penetration and adoption of STI policies in terms of output. The move has led to the region being described as the "latecomer" in the world of innovation policy. Yet the past three decades has witnessed tremendous strides by policymakers to leverage on the upside benefit of innovation in the region, nevertheless the results have been far from expectation. The present study explores the barriers to the design and implementation of STI policies in the region.

STI policies is being implemented across the continent. Countries in sub-Sahara Africa have established new institutions, while strengthening existing ones in support of STI activities. It should be noted that some policy instruments are clearly widespread in the region whiles others remain untapped. Surprisingly, none of the countries considered have implemented research and development tax incentives or even technology-forecasting exercise yet. For most part of the region, more emphasis is being laid on science and technology as opposed to innovation. The latter focuses on the generation of knowledge for national development without innovation and commercialization except South Africa whose policy plan is aligned with what pertains in the OECD countries. Central governments remain the chief financier of R&D activities, but there is increasing interaction between private sectors and institution of learning. For instance, in Ghana, there is science and math quiz which is organized for science students in secondary schools by primetime limited nationwide which is in the private sector.

Despite the significant progress in setting up institutional frameworks across countries leading to the adoption of a systemic approach, the ensuing results of STI policies in the region is marginal. Human and financial resources devoted to them are in shortfall. The present paper identifies certain factors that have been a stumbling block (barriers) to the design and implementation of STI policies in general but emphasizes these might not be exclusive to the region. Lack of financial and human resources is a barrier to all the countries in sub-Sahara Africa. This study found there is a strong association between STI institutions and policy strength and socioeconomic development. South Africa and Nigeria seem to have the strongest financial and political

commitment to STI policies and the highest per-capita income and socioeconomic indicators (see Table 1). In continuum, pro-activeness of these institutional frameworks (strength), scope of STI policies and resources (financial and human alike) to execute policies vary among countries.

The present paper recommends countries in the region take all the necessary steps to develop national evaluation and STI data stand. The success of this approach will be contingent on the region first of all being able to evolve a specific conceptual and methodological tools for monitoring and assessing STI policies. Area of financing STI policies have to be reconsidered. Tax incentives and havens for technology related businesses ought to be given priority to augment already existing instruments such as export-led instruments.

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APPENDIX

Table 3 **sub-Sahara Africa**: *science, technology and innovation policy*

Policy Instruments	Nigeria	South Africa	Ghana	Kenya	Tanzania
Institutional Framework					
1. National Plan of STI	*	*	*	*	*
2. Evaluating of STI policies					
3. Technology forecast exercise					
4. Administration Organization	*	*	*	*	*
(a) Regional (subnational) STI					
(b) Regional (subnational) STI Organization					
(c) Coordination mechanism among public organizations in charge of STI policies	*	*	*	*	*
5. Public education system: national strategy			*	*	*
(a) Strategy to promote mathematics and sciences in primary and secondary education	*	*	*	*	*
(b) Strategy to promote science and engineering in undergraduates and postgraduate education	*	*	*	*	*
6. Legislative Instruments				*	
Financing					
7. Fiscal incentives					
(a) Specifically designed for R&D expenditures					
8. Direct subsidies for R&D activities					
(a) Competitive funds					
9. Innovation financing					
(a)Public loan guarantees					
(b)Public funds to commercialize innovations					
10. Government Budget (% of GDP)	*	*	*	*	*
Interaction and Diffusion					
11. Programme to interaction among the actors of the innovation system					
(a) Programmes to foster public-private joint research		*			
(b) Programmes to promote personnel exchange and secondments between universities and firms		*		*	
12. Public incubators	*	*			

Source: Author elaboration

Note: Empty cells means policy instruments not available yet

[i] Africa and sub-Sahara Africa are interchangeably used to refer to the same thing.
[ii] Definition of Sub-Sahara Africa adopted from Wikipedia (see http://en.wikipedia.org/wiki/Sub-Saharan_Africa)
[iii]The Human Development Index is a composite index measuring average achievement in three basic dimensions of human development: a long and healthy life, knowledge and a decent standard of living (Cypher & Dietz, 2009; UNDP, 2007).