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Abstract

As part of efforts to change the structure of economies in sub-Sahara Africa from agrarian dominated to a more diversified one that will add value to exports and create more job opportunities, countries in the region have intensified strategies through its regional bloc - the African Union (AU) with its eight sub-regional bodies. Such a feat is only plausible through a concerted approach targeted at achieving sustainable economic growth laden with higher output turnover. This paper therefore takes a critical look at sub-regional governments' intent on the implementation of science, technology and innovation across countries in the ECOWAS by focusing on three policy instruments (institutional framework, financing and diffusion and interaction) and how these instruments have led to building technological capability economies. Empirical evidence gathered from secondary sources indicates among other things that sub-regional governments have invested in the establishment of public institutions to support STI. That notwithstanding existing technology-capability indicators illustrates the results are far from expectation. The paper further discusses the dilemmas sub-regional governments have had to deal with in the design and implementation of STI plans.

Keywords: Dilemmas, Structural Change, Public Policy, ECOWAS; science, technology and innovation (STI), Innovation Financing.

1. Introduction

As part of efforts to change the structure of economies in sub-Sahara Africa from agrarian dominated to a more diversified one that will add value to exports and create more job opportunities, countries in the region have intensified strategies through its regional bloc - the African Union (AU) with its eight sub-regional bodies (AMU, CEN-SAD, COMESA, EAC, ECCAS, ECOWAS, IGAD and SADC) on the adoption of innovation policy (UNECA 2016). One

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of such strategies is the one adopted by the West African sub-regional bloc – Economic Community of West African States[i] (ECOWAS) headquartered in Lagos, Nigeria. The policy on science and technology dubbed '*ECOPOST*', is an integral sub-regional blueprint to 2020 aligned with ECOWAS vision 2020 policy framework. A distinguishing feature of the sub-regional policy is the mechanism for monitoring and evaluation, which is often overlooked in national policies (ECOWAS 2011).

Policy makers and development experts while thinking through the plight of the region have consistently laid emphasis on corruption, governance, political instability, geographical location among others as some of the underlying causes (Forson et al. 2016; Pellegrini 2011; Forson et al. 2015; Forson et al. 2017; Forson 2016a). Nevertheless, Africa's failure to embrace change and innovation seem to have been downplayed and is the reason growth and development remains sluggish. Consequently, scholars such as Oyelaran-Oyeyinka (2012), Moghalu (2014) and Lepage (2017) have collectively described sub-Sahara Africa as a '*latecomer*' to demonstrate how sluggish the region has been in embracing technological advancement (see Barasa et al. 2017). To induce sustained economic output would mean the region would have to adopt a radical and dramatic approach to bring about structural change. In the words of Oyelaran-Oyeyinka (2014), economic structural change by definition is measured by quantifiable structural shift (i.e. GDP or employment share of the sector explained by the level of development). It may include economic transformation that is observable, tinged with significant changes to the relative contribution of the various sectors of the economy particularly in terms of production and factor use. That has not been the case in either sub-Sahara Africa or any of it sub-regional blocs particularly the ECOWAS bloc (Oyelaran-Oyeyinka 2012; Oyelaran-Oyeyinka 2014).

That aside, Oyelaran-Oyeyinka (2012) explains that development is not a spontaneous phenomenon but goes through a process marked by persistent and widespread market imperfections. Therefore, it is governments' responsibility to reinvent and correct these so-called imperfections that poses as bottlenecks to national progress (see Osborne & Gaebler, 1992; Rodrik et al. 2004). Africa lags behind its contemporaries due to its people's inability to leverage on its historical abilities in science, and have failed to manage these abilities in a well-structured manner. In fact the more the so-called '*first world'* was able to discover and invent over the past three centuries, the more '*civilized*' it became. Africa on the other hand, in comparison, have continued to be closer to nature and was subjected by natural occurrences, the more '*primitive*' and backward the continent appeared (Moghalu 2014). In 2009, the World Bank had theorized in its report of World Development Indicators (WDI) on innovation that the amount of scientific and technical journal articles in Africa was approximately 0.64% (less than 1%). This figure when compared with other regions where innovation is around 36.84%, 24.17%, 2.72% and 3.04% for Europe, East Asia, South Asia and Latin America respectively lends credence to the fact of the region being a '*latecomer*' (World Bank 2009). As a consequence, relevant questions such as the following draws concern that calls for redress: (1) what have been the inputs of policy makers in the design and implementation of STI policies in the region particularly in the ECOWAS bloc? (2) How has

innovation been financed in the bloc (3) How has it affected the technological – capability indicators? (4) What are the dilemmas faced by policy makers in the design and implementation of STI policies in the ECOWAS sub-region? These questions and others were addressed in this study.

Thus the contribution of this article therefore is to explore the efforts enforced by policymakers on science, technology and innovation in the ECOWAS sub-region and then have it linked to technological-capability indicators in member states. This approach will bring to the fore how effective governments' efforts have been in spurring innovation among member states. This has important implication for bridging the gap between sub-Sahara Africa and other regions particularly East Asia and Latin America for a desired structural transformation for sustainable economic output. The sub-regional bloc's performance will expose the dilemmas the region have had to contend with in the design and implementation of innovation policies. This is against the backdrop that through appropriate innovation policies, countries in East Asia and South America have transformed their economies (e.g. China, India, South Korea, Brazil, Chile and Malaysia).

The article is organized into six parts. The first part introduces the agenda by laying the background to the issue of STI in Africa in general and introduces the context in the ECOWAS bloc. The second part explores the concepts of public policy and Science, Technology and Innovation (STI). The role of institutions in developing innovation policy is dealt with in section three. Section four focuses on methodology and the type and sources of data used. STI policy plans of selected ECOWAS member states are explored further in section five using STI indicators. Subservient to section five are the dilemmas faced by policymakers in the design and implementation of STI policies among member states. The paper ends with conclusion and policy recommendations in section six.

2. Public Policy and Science, Technology and Innovation (STI)

In the words of Dye (2013) public policy is defined as the actions and inactions of government. These actions and inactions are reactive response to societal challenges created as a result of market failures. It is worth noticing that there is no unifying definition for the concepts science, technology and innovation, but the closest the research community have come is adopting explanation formulated by researchers. Thus Weimer and Vining (1989) are of the view the concept is a representation of the set of actions that governments can take to deal with a range of problems in the intersecting and complementary domains of science, technology and innovation to achieve a clearly defined (national) objective when private incentives provided by free markets systematically perform poorly. STI policies are classified under the following: *vertical (sectoral)*, *horizontal* and *mixed policies*. Sectoral policies reflect government-identified national development priorities. Horizontal STI policies are of generic in nature and thus cut across sectors and bridges sectoral dichotomy by dealing with the shortcomings of vertical policies (UNECA, 2016: p.83).

Sundbo (2003) explains innovation as the blend of knowledge that result in products that are new, processes, input and output markets, or organization including technical ones but also organizational and managerial innovations, new sources of supply, new markets, financial innovations, and new combinations (Perlman and Heertje, 1991). Padilla-Perez and Gaudin (2014) advances that innovation is an interactive and slow process, that hinges on communication and the exchange of knowledge. Carayannis et al. (2006) argues that in a knowledge-based economy, innovation through the creation, dissemination and use of knowledge has become a catalyst in the build up to economic growth. Rycroft and Kash (1999) are of the view that innovation policy is a complex process, not a single product, but as a result of a set of programs and policies, including institutions.

Nonetheless, innovation takes different forms and facades. Therefore innovation is not just hi-tech but expression of creative ideas. According to Lepage (2017), innovation involves 5% hi-tech and 95% imaginary thinking. The other aspect of innovation (industrial innovation) includes manufacturing, management, technical design 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 view that the factors required for industrial innovation are in diverse and may include technical knowledge, manpower, market information, financial resources, research and development (R&D) environments, an international and domestic markets (Rothwell and Zegveld, 1982). Many researchers have proven and made a case that indeed, industrial innovation can increase overall economic development (see Barro, 1990; Mcmillan & Rodrik, 2011; Rothwell & Zegveld, 1982). Finding the right measure of innovation has given rise to intellectual argument. Huang et al. (2007) objected to the assertion of using R&D tax credit as a measure of innovation and pointed out that such macro measures are not effective and pointless, and that policies must be designed to influence particular economic sectors. In a narrow sense, product innovation may differ from the generic concept, as it is basically the introduction of new good or service or the significant improvement of existing product based on its characteristics and intended use (Ayyagari et al. 2012; Barasa et al. 2017). But Salmenkaita and Salo (2002) differed and stressed that there are no straightforward answers to the question of what should constitute an innovation policy.

According to Lundvall et al. (2009), the national system of innovation (NSI) refers to systems that encompass the interactions both within and between organizations, institutions and socio-economic structures, which defines the direction, rate of innovation and technological capability building. National Innovation Policy (NIP) differs from NSI in that , innovation systems are made up of components (e.g. private enterprises, universities, research centers and government among others), and the relationship among them including the role of institutions (Padilla-Perez & Gaudin, 2014). A distinctive feature of NSI is that, the concept does not necessarily suggest a structure designed and built in a formal and conscious manner, but rather includes institutions, organizations and individuals whose interactions determines their overall innovative performance (see Abubarkari et al. 2018: pp.57).

Padilla-Perez and Gaudin (2014) on explicating on governments' role as far as innovation system is concern identified government involvement in two dimensions. The first dimension focuses on how government generate and disseminate new knowledge through public research centers, universities and enterprises. The second dimension focuses on how government creates and modify institutions that supports science, technology innovation (STI). Government achieves this through an avalanche of policy instruments such as trade policies, public investment, and support for small and medium scale enterprises, training and education and regional development.

STI can be studied and grouped through diverse approaches, but three can be inferred from the literature. First, some researchers (Lundvall & Borrás, 2005) are of the view that STI policies have a dual nature (policy instruments to promote specific areas - science, technology or innovation), but their implementation and design should follow a systematic strategy. The second approach proposed by Elder and Georghiou (2007), distinguishes between supply and demand policies that comprise of finance and services support (e.g. tax incentives, support for public research etc.). The third approach distinguishes between linear and non-linear STI policies. Cimoli et al. (2005) explains linear policies as the ones that are either supply-push or demand-pull oriented characterized by a strong governmental role through active policies, by signaling out innovation priorities and providing direct support. The demand-pull on the other hand assign key role to private actors and markets in pushing through and defining main technology and innovation strategies. The non-linear policies are not based on either private technology demand or public technology supply, but rather characterized by adopting a systemic approach to innovation processes (Cimoli et al. 2005). However, these classifications of STI have been criticized. Critics have contended the taxonomy shows inadequacies for studying certain context-based situations and that there is the need for modification. In applying this, Padilla-Perez and Gaudin (2014) classified STI under three key areas: (1) institutional framework and general policies to promote STI (creating public organizations such as secretariats, councils and ministries: developing national, regional and sectoral plans among others), (2) the second group focuses on financing. Public financial support provided through a well-designed R&D tax incentives or incentives indirectly to be used for that purpose, and (3) promoting greater interaction among actors of the system and disseminating technology knowledge.

3. Innovation Policy: *Does the Quality of Institutions Matter*?

In the words of de la Mothe (2004), "institutions are the channel through which ideas are formed and allowed to flow, from government laboratories, firms (both large and small), universities, and agencies, providing community services, and developing the notion of what he called *constructed advantage*" (see Bingab et al. 2018; Bingab et al. 2016; Abubarkari et al. 2018).

The quality of institution is significantly related to how innovation is spurred. There are a number of studies that have looked at the link between these two variants. For instance, scholars such as Lundvall and Borrás (2005) and in most recently Lundvall et al. (2009) and Rasiah et al. (2016) have one way or the other contributed to enrich this discourse. Thus, Rasiah et al. (2016)

theorizing on this purported link have examined the relationship between host-site institutional support, innovation capabilities and exports with the observation that innovation capabilities correlates with institutional support, and that it also enjoys a positive relationship with export.

At the micro level, specifically the firm level, Barasa et al. (2017) demonstrates that firm-level resources may not necessarily be the same depending on the institutional environment and that regional institutional quality positively moderates the effects of the firm-level resources. Moreover a properly designed institution can inspire productive behaviors, although institutions that are frail and dysfunctional may often lead to unproductive behaviors (Greif 2006; Dollar & Kraay 2003). Costs of transaction and uncertainty as well as to ease coordination among agents depends on the facilitating role of institutions which could lead to a drastic reduction in these costs component (Alonso & Garcimartin, 2013). Institutional quality comprises of government's capacity to effectively formulate and implement sound policies; the process by which a government is selected, monitored and replaced and the economic and social interactions between citizens and the state including how they are governed (Kaufmann & Mastruzzi, 2013). Thus the institutional setting can affect the tendency of firms to innovate in a variety of ways (North, 1993). This can be appreciated through this anecdote. Thus weak enforcement of regulations and the absence of intellectual property rights may obstruct entrepreneurial tendency (innovation). Countries in Africa have consistently performed poorly as against its counterparts in the Middle East, Southeast Asia, Latin America and the North Africa in upholding the rule of law, regulatory quality, control of corruption and government effectiveness (Alence 2004; Forson 2016b).

4. Research Methodology

This paper focuses on ECOWAS member states, which makes it a case study research. According to Yin (2009), case study research is an empirical inquiry that explores a contemporary phenomenon in detail and within its real-life context especially when the boundaries between phenomenon and context are not clearly evident. The case study method offers a platform to systematically investigate an event or a set of related events with the specific aim of unfolding and explaining this phenomenon (see Bell, 2004; Berg, 2007).

Following through these explanation, the author systematically reviews STI policy plans among countries in the ECOWAS member states. The data used mostly came from secondary sources that included national policy plans on science, technology and innovation (STI), journal articles, books, working papers, reports and webpages that are credible. The author further subjected the raw data to his intuitive and scholarly judgment for refinement to arrive at the discussed dilemmas to the design and implementation of STI policies.

5. STI Policies in ECOWAS

5.1. Brief overview of ECOWAS economies and their technological capabilities

ECOWAS geographically is the area of the continent located at the western part of Africa. It is an economic union of fifteen countries which collectively occupy an area of 5,114,162 km^2 (1,974,589 sq. mi) and in 2016 had an estimated population of over 350 million. The Union was founded under the treaty of Lagos on 28th May, 1975 with the stated mission of promoting economic integration across the region. In 1993, a revised treaty was signed in Cotonou with a goal of achieving '*collective self-sufficiency*' for its member states. ECOWAS asides it vision of building a full economic and trading union, also serves as a peacekeeping force in the region where member states occasionally send troops to intervene in the bloc's member countries in times of political instability (e.g. Ivory Coast 2003, Liberia in 2003, Genuine-Bissau in 2012, Mali in 2013 and Gambia in 2017).

In 2011, ECOWAS adopted its development blueprint for the next decade, *Vision 2020*, and, to accompany it, a policy on Science, Technology and Innovation (*ECOPOST*) (ECOWAS 2011). According to a statistical report by UNESCO (2016) the bloc has an estimated nominal GDP of $675 billion with a per capita income of $1,985 in 2015. The bloc make use of three official languages: French, English and Portuguese. Morocco had officially requested to join ECOWAS in February 2017. The application was endorsed at the summit of head of states in June 2017 (see Odinkalu, 2017).

<< Insert Table 1>>>

Nigeria is the biggest economy in Africa and doubles as the most populous country in the region with over 180 million people and in terms of GDP is the largest economy among ECOWAS member states. 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). Ivory Coast has the highest HDI (0.81) in the bloc and is placed among group five and Burkina has the least of 0.40.

To analyze STI policies in the member states of ECOWAS sub-region, a set of technological-capabilities indicators on some selected countries are shown in Table 2. The study compares the indicators of the bloc with other countries in other regions to illustrate the widening gap. It should be noted the technological-capabilities is classified into two groups: (1) The first group focuses on efforts devoted to strengthen technological-capabilities to bring about desired change, (2) the second tries to quantify advances in technological change as a result of the effort that has gone into it.

<<< Insert Table 2 >>>

On the effort indicators, data on R&D and others have indicated a drastic shift in the effort. Nevertheless, it leaves much to be desired. Although there has been a surge in R&D expenditure as a percentage of GDP in Africa in general, commitments from ECOWAS member states fell below 1%. Thus in other blocs, countries like Ethiopia, Kenya and Ugandan have increased commitment levels from 0.24%-0.61%, 0.36%-0.79%, and 0.37%-0.48% respectively.

Focusing more specifically on individual countries in the bloc, 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). The Ministry of Higher Education and Scientific Research of Ivory Coast reported that government devoted about 0.13% of its GDP to GERD in 2013. In other development, South Africa, a member of the South African Development Community (SADC) 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 researchers in R&D in the ECOWAS member states remains the lowest. For instance, apart from Ivory Coast and Ghana who had more than 900 inhabitants involved in R&D, the rest had less than 500 inhabitants in research. Yet the performances of the front liners in the sub-region are far behind its counterparts in South and North America in which Brazil and United States which had more than 1.2 million and 128,056 inhabitants committed to research respectively.

On the results (output) emerging from these efforts, one would argue the region has made modest inroads although it still lags behind other regions. On mobile phone subscription (per 100 inhabitants), some of the highest connectivity rates in ECOWAS member states were recorded in Mali (140), Ghana (130), and Ivory Coast (119). On internet connectivity as a percentage of individual per country, Cape Verde scored 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).

5.2 STI Policies in ECOWAS Member States

The study profiles STI policy instruments deployed by selected countries in the ECOWAS bloc. These policy instruments are grouped under three main headings: *institutional framework*, *financing*, and *interaction and diffusion*. Table 3 (appendix) summarizes STI policy instruments of selected countries in the ECOWAS bloc under the headings outlined.

5.2.1 Institutional Framework

The study finds each of the selected countries in the ECOWAS bloc has a public organization tasked with the responsibility of planning, designing and implementing STI plans.

Countries like Ghana 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; MEST 2017). Although there are no incubators to breed innovation and entrepreneurship in Ghana, government has initiated a new program called the National Entrepreneurship and innovation Plan (NEIP). NEIP is a modular program on incubation, industrialization, Youth Enterprise Fund (YEF) and business advisor. It should be noted that before the launch of the national science and innovation policy, there were other policy frameworks designed to deepen efforts at leveraging on the benefits of innovation in Ghana. Some of these policies overlap with the current ones being pushed forward. An extant example is the Ghana Information and Communication Technology for Accelerated Development policy framework (ICT4AD) launch in 2003 (GoG 2003). Within the broader ICT4AD policy framework, the government of Ghana has also adopted a National Telecommunication Policy, Trade policy and Private Sector Development Strategy (PSDS), all with the sole aim of supporting the ICT development agenda. The gains made regarding these policies on innovation are superficial in nature. Having realized this, the Akuffo Addo led government, by a notice of instrument had established a Presidential Advisory Council on Science, Technology and Innovation (PACSTI) at the presidency in Ghana. PACSTI is composed of eminent Ghanaian scientists to keep his government informed on current advances in STI and their relevant application towards national development (Joynews 2019).

Science, technology and innovation policy in Nigeria is directly under 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 collaborates with other agencies such as the National Research and Innovation Council (NRIC), mandated to set national priorities on R&D.

The experience of the Ivory Coast is interesting and worth sharing. Until 2015, the Ivory Coast did not have a dedicated policy for science, technology and innovation (STI), although similar policies were being implemented by the Ministry of Higher Education and Scientific Research (MoHESR). The main planning body was the Directorate General of Scientific Research and Technological Innovation (DGSRTI) and its technical directorate. Forum for consultation and stakeholder dialogue is provided by the Higher Council for Scientific Research and Technological development (MPD, 2012; Van Lill & Gaillard, 2014).

Drawing from the experiences of some of the member states of SADC particularly South African presents a rather different situation from those in the ECOWAS sub-region. The progress

of science, technology and innovation policy in South Africa has generally mimicked similar path of OECD countries in terms of a **"***National System of Innovation*" (NSI) approach in which emphasis is laid on innovation as opposed to the 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.

Note should be taken that, countries such as Mali, Genuine-Bissau, Genuine, Benin Gambia and Togo by being part of the ECOWAS have adopted the bloc's institutional framework-ECOPOST. All member states are to work through the guidelines provided by the policy including developing STI indicators.

5.2.2 Financing

The study further examine the financing approach resorted to by countries within the bloc and finds none of the countries under review offer tax incentives to promote R&D activities. However, similar policy instruments are commonly being used in other jurisdiction. For instance there are laws and regulations for export-led processing zones (ad-hoc schema for export promotion and attraction of foreign inflows). In Ghana and Nigeria, there are free-zone industrial enclaves where investors are encouraged to site factories and are given a ten (10) year tax holidays. On the means of financing STI development in Ghana, government remains the sole financier, but have encouraged private sector to support the activities of R&D. Plans are far advanced to explore other financing channels 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 (GES) for secondary schools in Ghana. In 2017, the Ministry of Business Development launched its flagship program – the National Entrepreneurship and Innovation Plan (NEIP) to provide support (training and funding) for startups and small business using a competitive funding approach (The Presidency - Republic of Ghana 2017).

Government remains the key funding agency in Ivory Coast, Mali, Gambia, Cape Verde and Nigeria although other source of funding are being explored to execute the activities of the institutional frameworks established. Although Ivory Coast does not have an elaborate STI policy plan, funding for the activities of the Directorate General of Scientific Research and Technological Innovation (DGSRTI) and its technical directorate for research and innovation is provided by the National Agricultural Investment Program established in 2010. There is also the Ivorian Fund for

the Development of National Enterprises established in 1999 but the National Fund for Scientific and Technological Research is yet to be establish as its being discussed. 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 (see Van Lill & Gaillard, 2014).

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 program, the Kwame Nkrumah scientific awards program, 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. that provides funding for STI initiatives with the ECOWAS member states (DHRST 2012).

5.2.3 Interaction and Diffusion

Policy plans of selected member states paid much attention to interaction and diffusion among different agents in the science and technology agenda. In Ghana for instance, the parent agency for science, technology and innovation – ministry of environment, science and technology (MEST) works with other sub-agencies such as the Ghana Atomic Energy Commission (GAEC), council for Scientific and Industrial Research (CSIR), 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. In the Ivory Coast, the Directorate General of Scientific Research and Technological Innovation (DGSRTI) and its technical directorate interacts with parastatals and agencies such as the Ivorian Organization for Intellectual Property, Department for the Promotion of Research and Technological Innovation, and the Centre for the Demonstration and Promotion of Technologies.

Other organizations that seek to bridge and bring together efforts by public and private institutions are being created among member states in the bloc. For example, 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 program, the Kwame Nkrumah scientific awards program, 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 (see

Abubarkari et al. 2018). ECOWAS member states are signatories to these bridging organizations and there is coordination among these organizations and the departments and parastatals in the various countries in the ECOWAS member states.

5.3 Dilemmas in the design and implementation of STI policies in the ECOWAS sub-region.

The study had described STI policy plans in force in the ECOWAS states in the previous section. Though technological-capability indicators have shown the bloc still lags behind its compatriots, the study identifies and briefly discusses the dilemmas that have served as a blockade in realizing the bloc's vision on innovation. Indeed these are the obstacles faced by governments when designing and implementing STI policies in the region.

Reviewing the various policy plans of the countries involved gave the impression that although there appear to be some form of political support in the design of STI policies, the results from the technological-capability indicators proved otherwise. Yet this high-level political support seem to be superficial and is latently absent. There are also variation with the establishment of institutional framework and STI plans. Whereas some countries have made inroads by carving a plan on science and technology (e.g. Ghana and Nigeria), the rest have employed an ad-hoc approach in which the framework provided by the AU and the ECOWAS have become a major policy guide. Government agencies charged with the task of science, technology and innovation policy plans have consistently lacked 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. Despite the push by countries such as Ethiopia, Kenya, Mali and Senegal and Ugandan through 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, it can be reasonably observed the region in general and the ECOWAS bloc in particular are 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).

On the alternate source of funding for STI plans in the bloc, the study finds tax incentives to be the best option, although available evidence suggest countries in the region are already burdened with the problem of low tax revenue which makes it a daunting task to implement the policy on tax incentives. This is a major drawback for increased STI public investment. The World Bank (2009) reports that tax revenues as a percentage of GDP in Africa in general is low. For instance in Ghana and Nigeria tax revenue accounted for just 14.87% of GDP and 5.46% in 2008 respectively. This when compared to countries in SADC and EAC member states (South Africa and Angola) had mobilized close to about 26.50%, and 12.46% respectively of its revenue in 2012 from taxes. Kenya and Tanzania as at 2012 had mobilized 19.88%, and 13.8% of its revenue through taxes respectively (World Bank 2013). What this means is that, funds for STI would not be forthcoming as countries are confronted with more social issues that needs redress in the short-term.

Political instability in the region is another dilemma to the implementation of STI policies in the region. STI programs do not stand the test of time owing to the entrant of new government

through the adoption of democracy which is still fragile. This is a common practice in ECOWAS member states. Ivory Coast, Liberia, Sierra Leone, the Gambia, and Mali have over the past years experienced instability that have affected progress made on STI. On the other hand, stable economies such as Ghana and Nigeria have had instances where new governments have over-looked policies initiated by its predecessors irrespective of the programs impact on general welfare.

Institutions of higher learning in the region have mainly focused on teaching or basic-science research which has a weaker link to private enterprises. Science and technology institutions that were established from the outset to be the incubating grounds for entrepreneurs and inventors have taken to offering social science and business related programs. For instance, universities such as the University of Science and Technology of Bamako in Mali, African Higher School of Information Technology and Communication in Ivory Coast, Kwame Nkrumah University of Science and technology (KNUST) in Ghana and the Federal University of Technology (FUT) in Nigeria, have as a matter of fact diluted programs by offering more arts and social sciences than its pure and applied science programs which is core to its mandate. More emphasis are being placed on teaching as opposed to research that would disseminate ideas to spur innovation.

The study also sees coordination among public organizations and parastatals in the design and implementation of STI policies to be weak. Government agencies often elaborate their strategies but are not fully integrated and coordinated thereby leading to unnecessary competition among these institutions. This is undoubtedly a challenge to improving the impact of STI policies and developing an efficient use of scant resources.

In addition to the ones elaborated above, the study finds the activities of financial systems in economies such as Ghana, Nigeria and Sierra Leone to be less incentivized enough to support innovation in the bloc. New entrepreneurs and existing firms hardly get access to financial sector to finance innovation activities. Venture capital are few and even in other jurisdiction 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 faced with liquidity and solvency risks.

Indeed ECOWAS member states and the entire sub-Sahara Africa are seen to be far behind when it comes to STI due to the dilemmas outlined. It should however be emphasized here that the dilemmas presented shares common traits with what pertains in most developing economies and may well be summarized as follows: lack of financing mix (Segarra-Blasco et al. 2008; Forson et al. 2018), design and implementation failure and political instability (see Woolthuis et al. 2005), weak education systems (see Aubert, 2004; Segarra-Blasco et al. 2008), lack of coordination among public organizations and failure to monitor (see Hadjimanolis & Dickson, 2001; Willie et al. 2016) and lack of human resources (see Aubert 2004; Naim 2014).

6. Conclusion and policy recommendation

Sub-Sahara Africa and ECOWAS in particular are the least in the penetration and adoption of STI policies in terms of output. This has prompted scholars in the region to describe Africa as

a '*latecomer*' in the global trend of innovation. Nevertheless, a lot has gone by way of strategies after independence to leverage on the upside benefits of innovation in the region. Yet the results has been far from expectation. This study critically examines the dilemmas to the design and implementation of STI policies in the ECOWAS member states.

Governments in the ECOWAS member states are in the process of implementing STI policies while some have established new institutions, and have strengthened existing ones in support of STI activities. Whiles some policy instruments are clearly widespread in the bloc, others remain untapped. It was startlingly shocking to observe that none of the countries considered have implemented research and development tax incentives or even technology-forecasting exercise. For most part of the bloc, more emphasis is being laid on science and technology as opposed to the innovation. The latter focuses on the generation of knowledge for national development. Among economies considered in Africa, only South Africa has had a plan akin to the ones in the OECD countries. Although governments continue to be the main financier of R&D activities, there are glimpses of interaction between the private sector and institution of higher learning unfolding.

Regardless of the progress made in establishing institutional frameworks among ECOWAS member states which to a large extent has led to the adoption of a systemic approach, the impact does not in any way correspond with the end results given its superficial impact. This is because human and financial resources devoted to these policies are in shortfall. Moreover, challenges associated with the design and implementation of STI policies poses as a threat in advancing the tenets of research. It should be noted further that these factors identified and might not be exclusive to the ECOWAS sub-region but applicable to other developing economies. Lack of financial and human resources is a dilemma to virtually all the countries in ECOWAS. Although there seem to be strong association between STI institutions and policy strength including socioeconomic development, the technological - capability indicators shows more has to be done. 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). Nigeria had initiated a move to have technology fund for its program akin to what pertains in the advanced economies, but the move is yet to be operational. 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.

All necessary steps has to be taken by ECOWAS member states to develop national plans on STI that will address its economic and social challenges irrespective of the one proposed by the regional bloc. Moreover, provision must be made for a national evaluation and STI data stand to augment what is enshrined in the policy brief under the ECOPOST initiative. The success of this approach is contingent on the region first of all being able to evolve specific conceptual and methodological tools for monitoring and assessing STI policies. Alternative source of financing STI policies ought to be reconsidered. Tax incentives and havens for technology related businesses and building of entrepreneurial incubation points on innovation ought to be given priority to augment already existing instruments such as export-led instruments. Governments in the bloc should partner with financial institutions to give priority to enterprises that are into product

innovation such as software or even IT related to address societal challenges. Rolling out a comprehensive universal education to the secondary level across all vocational training centres could ignite and promote innovation and entrepreneurial spirit in the member states.

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TABLES

Table 1: Selected countries in ECOWAS

	Nigeria	Ivory Coast	Mali	Ghana	Senegal	Cape Verde	Burkina Faso
Population 2016 (million)	181.2	23.25	18.13	28.83	15.59	0.53	18.63
Surface Area (km^2)	924	322.5	1 240.2	239	196.7	4.0	273.0
GDP per capita 2014	2 714	1 546	701	1 388	1 067	3 609	725
Growth Rates (annual): 2014	6.3	8.5	7.2	4.0	4.4	1.8	5.0
Human Development Index[ii] (2015)	0.47	0.81	0.69	0.57	0.47	0.65	0.40

Source: (UNESCO 2016)

Table 2: Efforts and Results on selected countries in ECOWAS

Country/Indicator	Nigeria	Ivory Coast	Mali	Ghana	South Korea	Brazil	United States	Sweden
Researchers in R&D (FTE)	38.56	1 269	443	941	345 463	138 653	1.2m	66 643
Technician in R&D (FTE)	12.51	na	342	731	62 155	128 056	na	19 194
R&D Expenditure (percentage of GDP)	0.2	0.13	0.66	0.4	4.3	1.09	3.1	3.6
Patent applications by residents (per million inhabitants)	645	na	na	53	2745.9	37.7	801.8	2745.9
Cellular Mobile telephone subscription (per 100 inhabitants)	82	119	140	130	118	127	118	130
Internet Usage (% of individuals per country)	47.4	21.0	10.3	23.5	89.9	59.1	74.6	90.6
No. of Scientific publication (per million inhabitants)	11.4	427	64.2	6.6	464	187	1276.7	1053.1

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

APPENDIX

Table 3. ***ECOWAS***: *science, technology and innovation policy*

Policy Instruments	Nigeria	Ivory Coast	Ghana	Mali	Cape Verde
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. Program to interact among actors of the innovation system					
(a) Programs to foster public-private joint research	*	*	*		
(b) Programs 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] ECOWAS has a member states of 15 countries. The founding members were Benin, Ivory Coast, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania (succeeded in 2002), Niger, Nigeria, Senegal, Sierra Leone, Togo, and Burkina Faso. Morocco had applied to be a member of ECOWAS.

[ii] The Human Development Index (HDI) is a composite index that measures 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).