Country STI profiles

A framework for assessing science, technology and innovation readiness in African countries

United Nations
Economic Commission for Africa

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Abbreviations and acronyms

ECA	Economic Commission for Africa
FAO	Food and Agriculture Organization of the United Nations
GDP	gross domestic product
GII	Global Innovation Index
ICT	information and communication technologies
ITU	International Telecommunication Union
MSMEs	micro, small and medium-sized enterprises
NEPAD	New Partnership for Africa's Development
NIS	national innovation system
NSI	national system of innovation
ODA	overseas development assistance
OECD	Organisation for Economic Co-operation and Development
R&D	research and development
SADC	Southern African Development Community
SME	small and medium-sized enterprises
ST	science and technology
STI	science, technology and innovation
TAI	technology achievement index
TDI	technology deployment index
TFM	technology facilitation mechanism
TFP	total factor productivity
UNCTAD	United Nations Conference on Trade and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
UIS	UNIDO Institute for Statistics
UNIDO	United Nations Industrial Development Organization
WDI	world development indicators

Introduction

1. About the study

An understanding of the nature of economic growth is a central preoccupation of the present report. A pertinent analysis of economic growth is found in the work by Robert J. Gordon, *The Rise and Fall of American Growth*, in which Gordon points out an often forgotten fact: that economic growth is neither steady nor continuous (Gordon, 2016). When growth occurs (or declines), therefore, it is essential that policymakers, researchers and analysts identify the underlying reasons and the sources of such movement. Among the reasons for this is to facilitate the development of new policies, for successful policies to be replicated, including incentives, and for learning and experience sharing to be promoted.

African economies made impressive gains in the first decade of the twenty-first century. These gains changed in demonstrable ways the negative narrative that characterized the continent in the last decades of the twentieth century. Many observers note, however, that the recent positive growth performance does not result in the significant transformation of Africa's economies. They point out that, for growth to result in economic transformation, it must be knowledge-based and innovation-driven, based on evidence from advanced economies and newly industrialized countries. Knowledge-based and innovation-driven economies are economies with sustained investments in science, technology and innovation (STI), and that have the capacity to transform inventions into innovations in order to drive national competitiveness and improve social welfare. Such countries have economic and STI policies integrated as coherent national policies and strategies; their decisions on STI are guided by carefully drafted country STI readiness and assessment reports (including, for example, country STI profiles).

Few African countries prepare an STI profile as a prerequisite to the formulation of STI and industrial policies. There are some instruments that provide some guidance, notably the following: *Frascati Manual 2015* (OECD, 2015); *Oslo Manual* (OECD, 2005); and *Bogota Manual* (Jaramillo, Lugones, Salazar, 2001). The focus of the *Frascati Manual* is research and development, while the *Oslo Manual* focuses on innovation mostly at the firm level. The *Bogota Manual*, derived from the *Oslo Manual*, standardizes the measurement of innovation in Latin American and Caribbean countries. These instruments, however, in spite of recent attempts to make them much more robust, are not very appropriate for African countries for a number of reasons, including the fact that a lot of innovation in Africa takes place in the informal sector — a sector not included in the *Oslo Manual*. Further, Governments are responsible for much of the spending on research and development (R&D) in African countries, a notion at variance with the main premise of the *Frascati Manual*.

There are efforts to make the *Oslo Manual* robust enough for use in African countries. In 2012, the United Nations Educational, Scientific and Cultural Organization (UNESCO) introduced a new instrument, GO-SPIN, to measure STI indicators while the New Partnership for Africa's Development (NEPAD) prepared a biennial African Innovation Outlook to assist policymakers in making sense of the innovation landscape of the continent. The framework and guidelines are the contribution of the Economic Commission for Africa (ECA) to make the effort to provide

Africa's policymakers with the tools to better understand the role that STI plays in economic development and structural transformation in order that they might formulate more appropriate STI policies. The present ECA study was commissioned by the New Technologies and Innovation Section, Special Initiatives Division in late 2013 and was finalized in 2015.

2. Research methodology

The present study is based on an extensive review of literature, and the identification of a set of STI indicators that is applicable to Africa and that also reflects interactions and discussions with key stakeholders. Data were collected from secondary sources and databases, and complemented by a semi-structured questionnaire that was administered to appropriate agencies to collect information on STI policies, programmes and projects.

Data from secondary sources were drawn from published official documents (such as national development plans, budgets, vision documents and policy statements). Statistical databases of United Nations agencies including ECA, UNESCO), United Nations Conference on Trade and Development (UNCTAD), United Nations Industrial Development Organization (UNIDO), and the Food and Agriculture Organization of the United Nations (FAO), were further sources of secondary data. ICT statistics were obtained from the International Telecommunication Union (ITU). The World Bank's World Development Indicators was the source of statistics on general economic performance and data on social indicators.

The analytical framework of the national system of innovation (NSI)[1] provides the theoretical basis for the study. The concept of national innovation systems rests on the premise that understanding the linkages among the actors involved in innovation is key to improving technology performance. Innovation and technical progress are the result of a complex set of relationships among actors producing, distributing and applying various kinds of knowledge (OECD, 1997). The NSI framework allows the flexibility and adaptability necessary to understand how science, technology, and innovation in sectoral, national and regional contexts can be harnessed for social and economic transformation.

In applying the NSI framework to Africa, each of the continent's economies is treated as a learning economy. This approach enables the specific characteristics of each country to be illustrated, together with possible opportunities for technological learning and technological trajectories that could confer economic competitiveness and catch-up advantages. The specific steps undertaken to prepare the guidelines include:

(a) Extensive and in-depth review of literature on STI profiles and their methodological frameworks, with particular reference to African and selected developing countries;

(b) Identifying relevant STI indicators and measurement procedures;

(c) Establishing criteria for the review of STI policies;

(d) Developing criteria for the identification and selection of country STI projects and programmes;

(e) Drafting guidelines or a methodological framework for STI country readiness reports and country STI profiles;

1 The national system of innovation (NSI) framework is generally associated with the work of Chris Freeman, Bent-Åke Lundvall and Richard Nelson who are early writers on the concept.

(f) Drafting and administering questionnaires for data collection on STI policies, projects and programmes;

(g) Selecting two countries to pilot the guidelines;

(h) Organizing an expert group or peer-review meeting on the draft guidelines and the results of the pilot studies;

(i) Finalizing the guidelines based on evidence and lessons learned from the pilot country studies and comments received from the expert group meeting.

The draft methodological framework and the report of the pilot studies in Kenya and Nigeria were presented for review and discussion at an expert group meeting that took place on 23 and 24 June 2014 at ECA, Addis Ababa. The draft report was revised in accordance with comments received at the meeting.

3. Structure of the report

This report comprises the present introduction, that is relevant to the full publication, and three parts, each of which includes a table of contents and list of references. Part I is the review of literature on the strategy for the preparation of the methodological framework for country STI readiness reports. Part II presents the methodological framework for the preparation of country STI readiness reports in Africa. Part III provides an overview of the findings relating to the two pilot studies of the proposed framework in Nigeria and Kenya. A reference list appears for each pilot study.

Early drafts of parts of the report were presented at an ECA expert group meeting.

Part One:
Setting the Scene

This Part of the report sets the scene for the study. It includes a review of relevant literature on the contribution of science technology and innovation to economic growth and the transformation of Africa's economies and discusses various strategies and methodologies for preparing science, technology and innovation readiness reports and profiles. It consists of five sections, beginning with the Introduction.

1. Introduction

African economies have reported impressive rates of economic growth for nearly three decades now. Available data show the rate of growth of gross domestic product (GDP) averaging about 4 per cent per annum between 2000 and 2016.[2] Much of this growth, it must be admitted was driven by a commodity export boom and improvements in macroeconomic management. With the exception of a few countries (e.g. Egypt, Morocco, South Africa and Tunisia), African economies have remained commodity export-based and are limitedly-diversified. In recent times, growth has, decelerated, especially in oil and commodity exporting countries, and in North African countries following the disruptions of the North African Spring. The overall economic climate although not dire, does not inspire as much optimism as it did before. Nor does it invite the unbridled pessimism of the past. Although increasingly fettered by huge shortfalls in foreign exchange earnings, the rest of Africa continues to grow, with real GDP growing at a rate of 4.4 per cent per annum (Leke, 2016).

The deceleration of growth underscores the fragility of Africa's economies and raises questions about securing and reinforcing growth. Many see the solution to the fragility of growth in African countries as lying in industrialization and structural economic transformation. However, the continent is not industrializing and structurally transforming at a rate that provides hope and comfort. Others argue that the slow pace of industrialization and structural transformation can be attributed to the weak science, technology and innovation base of African economies. They argue that Africa will not industrialize in the absence of a careful, purposeful, application of science, technology and innovation for development. Support for this school thought comes from the experience of the industrialized and newly industrialized countries.

But innovation does not take place in a vacuum, in isolation; it is rooted in scientific and technological activities in an economy. Most modern economies invest strategically in science, technology and innovation. These investments, if properly governed, build and expand technological capability of local firms for global reach. A prerequisite for success on this score, evidence suggests, is that macroeconomic and overall development policies, notably industrial policies, must be seamlessly integrated with STI policies. Such integration must be founded on the structure of the economy and the STI capacity and capability of the country. Efforts along these lines have just begun in most African countries, due in large part to a lack of knowledge about innovation in most countries, and also due to countries not allocating significant resources to scientific research and development to elicit taxpayer interest and demand for accountability.

Preparation of a national science, technology and innovation profile on a regular basis can be a corrective to this problem. Hence, the primary objective of this report is to advance

2 See various issues of the ECA flagship publication, ***Economic Report on Africa***.

a framework for preparing national STI readiness reports or STI profiles in African countries to provide the requisite baseline data or up-to-date information on the context, scope, nature and appropriateness of investments in STI as an important input into policy development.

This first part of this report is structured as follows: section 2 briefly examines the global experience on the contribution of science, technology and innovation to economic growth; section 3 discusses the transformation of African economies and the role of national systems of innovation; section 4 presents an overview of STI profiles in three separate but related contexts of developed countries, developing countries and African economies; and the concluding section lays the foundation for the preparation of the methodological framework for STI profiles of African countries.

2. Contribution of science, technology and innovation to economic growth

Why do countries differ in their growth rates and living standards? Theoretical and empirical economics literature on the sources of economic growth identify two broad sources of growth: factor accumulation and factor productivity. Factor accumulation (more labour, more capital) can explain a significant part of the differences in the growth rates puzzle, but it cannot explain differences in long-term sustained growth. The explanation for that lies in factor productivity growth, in technology and innovation.

Historical experience provides irrefutable evidence that achieving a sustained improvement in living standards is based on the extent to which nations develop their science and technology[3] capabilities and that continued prosperity depends on the degree to which they continue to do so. Based on that evidence, the United Nations underscores the importance of knowledge accumulation, science, technology and innovation in national development by identifying technology and innovation as one of the three means of implementation of the Sustainable Development Goals and of the outcomes of recent United Nations summits, including the Paris Agreement on climate change and the United Nations Conference on Sustainable Development. The effective development and management of knowledge assets is essential for any nation aspiring to remain competitive in the global market place. Firms and individuals with more knowledge perform better, and earn more, than those with limited

3 See, for example, J.S. Gordon *An Empire of Wealth: The Epic History of American Economic Power*. Harper Collins: New York, 2005); Morris, I. Acemoglu, D. and J. Robinson *Why Nations Fail*. Crown Publishers: New York, 2012; Gordon R.S. *The Rise and Fall of American Growth*, Princeton: Princeton University Press: Princeton, 2016); and Morris, I. *Why the West Still Rules-For Now*. (Farrar, Straus, Giroux: New York, 2010).

knowledge. This central role of knowledge in development informs the increasing commitment to research and development, training, education and other intangible investments observed in most economies, in particular the developed ones.

Many developing countries have not always managed their economies or their growth prospects well. However, the end of the Cold War in 1991[4] and the successful transition of the erstwhile planned economies of Eastern and Central Europe[5] to thriving market economies, and the emergence of China, presented new models of success from which developing countries could learn. Hitherto, the "Asian tigers" economies of Hong Kong, Special Administrative Region of China; Taiwan Province of China; the Republic of Korea; and Singapore had emerged as pace-setters in economic growth and technological catch-up (Perez and Soete, 1988; Kim, 1997; Mathews and Cho, 2000; Malerba and Nelson, 2012) and were frequently presented as models for developing countries in general and African countries in particular. Although the East Asian tiger economies continue to serve that role, a major criticism was that their growth was driven by factor accumulation, instead of growth in total factor productivity (TFP) (or technical progress), unlike the growth experience of the industrialized economies.[6]

The experiences of the developed and emerging economies lend credence to the proposition that investment in research and development (R&D), knowledge, science and technology is crucial for sustained economic growth. China and the Republic of Korea illustrate this point well: China has transitioned from a low to middle income country and the Republic of Korea from a middle to a high income country, largely on the basis of technological catch-up and the building of globally competitive industries with strong export performance.

Both China and the Republic of Korea achieved success through a combination of factors, the most important of which are political will and leadership. A national consensus in both countries on the importance of research and development (R&D) created a conducive environment for rapid increases in R&D expenditure by all stakeholders. As a consequence, R&D intensity[7] increased in both countries at a rapid clip. The Republic of Korea reached the R&D intensity of advanced industrialized economies in the 1990s and has since surpassed them. In 2014, the Republic of Korea spent 4.29 per cent of its GDP on R&D, outstripping Israel (4.11 per cent), the European Union (1.9 per cent) and China (2.1 per cent).[8] The Republic of Korea has consistently increased public and private investment in research[9] and research infrastructure and has systematically borrowed and learned from overseas through licensing and other channels, institution and capacity-building.

The cumulative outcome of these efforts is that the Republic of Korea is today among the world's leading industrialized and technology-driven and focused economies. Figure I.I below presents the evidence. In China, science, technology and innovation grew

4 The end of the Cold War is usually dated as the year the Soviet Union ceased to exist and broke up into 15 independent States.

5 These are former countries of the Soviet bloc and successor States of the Soviet Union.

6 See, for example, Lau, L.J and J. Park (2003) *The Sources of East Asian Economic Growth Revisited*. Available at: www.stanford.edu/~ljlau/RecentWork/030921.pdf; and Young, A. (1994). Lessons from the East Asian NICs: A contrarian view, *European Economic Review*, vol. 38, pp. 964-973.

7 R&D intensity is defined as expenditures on research and technology expressed as a percentage of gross domestic product of a country.

8 Bartzokas, A. Country Review Korea UNU-Merit. Available at: http://ec.europa.eu/invest-in-research/pdf/download_en/korea.pdf accessed 23 February 2017.

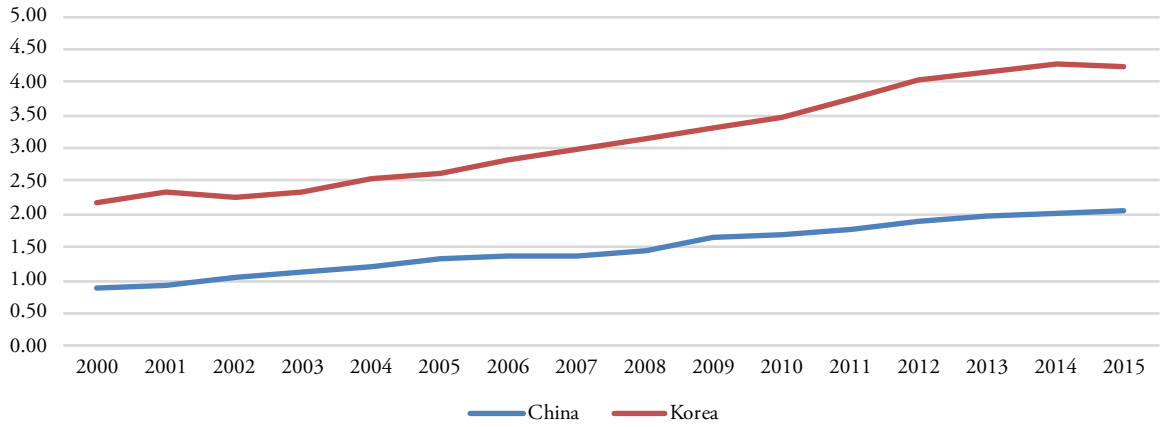
9 The Republic of Korea aims to increase its R&D investment to 5 percent of GDP by the end of 2017. It spends more R&D as a percentage of GDP than any country in the world. See **www.nature.com/news/why-south-korea-is-the-world-s-biggest-investor-in-research-1.19997**.

very rapidly (from an already strong base) in the 1990s and 2000s, having been identified by Deng Xiaoping in 1978 as the key to the country's modernization.[10] China's R&D intensity has doubled since the late 1990s, rising from less than 1 per cent in 2000 to slightly above 2 per cent in 2014. And it is expected to continue to grow as China seeks to play a more visible leadership role in world affairs (Zastrow, 2016).

Globalization has also, by improving access to the global stock of knowledge and technologies, driven the contribution of science, technology and innovation to economic growth and development. Knowledge is a global public good. Nations with mechanisms to leverage the globally available pool of knowledge and to produce new knowledge for a global market to innovate have profited, while nations unable to do so have been increasingly left behind.[11] As noted above, both China and the Republic of Korea took full advantage of the opportunities presented by globalization to harness science, technology and innovation to improve the global competitiveness of their economies.

Understanding the pathways through which science, technology and innovation contribute to economic growth has been a major preoccupation of economists. Several theories have been advanced. But two broad theoretical approaches dominate: Solow's neoclassical theory of exogenous long-term growth, and the endogenous growth theory of Paul Romer and others. The empirical implementation of these theories captures technical progress through multi-factor productivity growth.[12] Prior to Solow's work, the prevailing view among economists was that factor accumulation, namely capital accumulation, was the major determinant of growth. However, Solow's pioneering work of 1957 empirically identified capital accumulation as accounting for only a quarter of observed growth in the

Figure I.I:
R & D expenditure in China and the Republic of Korea (percentage of gross domestic product), 2000-2015



Source: OECD data (see https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm).

10 See McGregor, J. China's drive for 'indigenous innovation': a web of industrial policies" (n.d.). Available at: www.uschamber.com/sites/default/files/legacy/reports/100728chinareport_0.pdf.

11 For a detailed discussion of the effects of globalization on the contribution of science, technology and innovation to development, see, for example, Roberts (2003).

12 OECD observes that more rapid multi-factor productivity growth is generally due to improved managerial practices, organizational change and, most importantly, to smarter and more innovative ways of producing goods and services. (2000, p. 2).

economy of the United States of America. In his analysis, Solow attributed the shortfall to a residual factor which was interpreted as "technical change".

Solow's work inspired a rich body of work on the economics of technological change and the development of increasingly more sophisticated models.[13] Recent studies emphasize the role of human capital and knowledge spillovers in economic growth. Lucas (1988) modelled human capital with constant rather than diminishing returns, thus offering useful insights into the critical role of a highly skilled workforce for long-term growth. Romer (1986) endogenized technical change in the growth model by introducing knowledge spillovers, a modification which has had far-reaching implications for how scholars think about economic growth today and for policy.

Schumpeter (1949), presents the importance of technological innovation in a more elemental form. He demonstrated that the process of innovation by entrepreneurs disrupts and destroys existing production processes, replacing them with new and superior processes (creative destruction). Similarly, new and superior products often displace well-established products from the market. Economic growth is accordingly determined by the micro processes and the innovative capacity of firms. Neo-Schumpeterian economists have demonstrated that an economy enjoys improved growth performance when it has a higher rate of start-up of new and innovative firms. This arises from the constant replacement of former innovators with new ones through the process of creative destruction. Their models use the concept of technological frontiers to distinguish between a "frontier innovation" where a company (or region or country) leapfrogs the best technology available and "imitation" innovation involving the reverse engineering of existing technological innovations.

Newly industrializing and emerging economies are often characterized by technological activities aiming at sectoral catch-up with a global technology frontier representing the stock of global technological knowledge available to innovators in all sectors of all countries (Coad and Reid, 2012, p.5; Malerba and Nelson, 2012). Implicit in this distinction, and also in the broader "creative destruction" concept, is the need to improve on the R&D intensity of an innovating economy – this is especially true, in the case of developing countries, of adaptive R&D. Moreover, if developing economies were to either catch up (imitation innovation), or to push back the frontier of innovation (frontier innovation) this would require significant investments in human capital which would in turn foster the innovative capacities of diverse economic agents contributing to growth.

The growth trajectory of most emerging economies[14] has demonstrated the possibility and importance for latecomers in the global economy to make every effort to catch up. The noun "catch-up" has its origin in the macroeconomic explanation of economic convergence.[15] It is used to explain the extent to which the growth in per capita income of different countries lags significantly behind the frontier at the start of a time period enabled them to "catch up" with the leading countries in that category by the end of the period (Malerba and Nelson 2012). The literature is rich with different reasons why some developing economies have been able to catch up, while others are still lagging behind. Malerba

13 See, for example, N. Gregory Mankiw, David Romer and David N. Weil. A contribution to the empirics of economic growth, *The Quarterly Journal of Economics*, vol. 107, No. 2, pp. 407–437.

14 Also known as "emerging markets", examples include the BRICS States (Brazil, the Russian Federation, India, China and South Africa), as well as the MIKT countries (Mexico, Indonesia, the Republic of Korea and Turkey).

15 See Barro (1990) and Barro and Salai-Martin (1995) for an explanation of economic convergence.

and Nelson (2012) identified four common elements required for technological catch-up across different sectors, a) firms' learning capabilities, b) access to foreign knowledge, c) skilled human capital, and d) active government policy.

3. Transforming Africa's economies

3.1 Vital importance of economic transformation

Structural economic transformation is one of the "consensus" buzzwords in current discourses on Africa's future. Structural transformation, a process defined by increases in productivity, technological capability, economic diversification, and international competitiveness that support rapid, sustained and shared growth in employment and incomes (Ogbu and others, 2012) is vital for improving social welfare and the competitiveness of nations. In recent times, many analysts, international development organizations, African Governments and informed citizenry have asserted that the region's economies are yet to go through the process of structural economic transformation.[16]. These assertions are contrary to available evidence. They ignore the enormous transformations that have taken place on the continent since 1960.[17] Clearly, African economies are transforming but they are not transforming fast enough.[18]

Economic transformation involves change over time in the sectoral composition of output, patterns of employment and skills mix, and the knowledge intensity of production and consumption patterns. Evidence of transformational growth are found in sustained long-term improvements in key development indicators such as: real per capita income; the proportional contributions of industry and its manufacturing and service subsectors; the ratio of average labour productivity in non-agriculture to agriculture. On the other side of the equation, there will be observed a long-term decline in the share of agriculture in GDP and the employment share of agriculture in total employment. Annex I lists selected countries that have experienced economic transformation.

Economies that are structurally transformed tend to be associated with steady, sustained economic growth rates, relatively low growth volatility and a higher capacity to create jobs. These attributes help significantly to reduce

16 For example, *African Transformation Report* (ATR) 2014 "Growth with Depth" was premised on the determination that "African economies need more than growth if they are to transform." Other recent reports focused on African structural transformation include Lopes et al "Macroeconomic Policy Framework for Africa's Structural Transformation}, the African Development Bank's "At the Center of Africa's Transformation" and ECA *Economic Report on Africa 2013: Making the Most of Africa's Commodities: industrializing for Growth, Jobs and Economic Transformation*.

17 See Maria Enache, Ejaz Ghani, Stephen O'Connell. *Structural transformation in Africa: a historical view*. Policy Research Working Paper. No. 7743. World Bank, Washington, D.C., 2016. Available at: https://openknowledge.worldbank.org/handle/10986/24824 License: CC BY 3.0 IGO.

18 Nwuke, K. Rethinking the transformation of African economies in light of new evidence. ECA, 2013.

an economy's vulnerability to external shocks, providing a stronger basis for maintaining macroeconomic stability and establishing an enhanced capacity for smoother economic adjustment. Lower volatility also reduces uncertainty and makes macroeconomic management less difficult (ECA, 2011). However, whether growth will eventually be associated with structural change, and will consequently lead to economic transformation is, still a matter of debate. Key elements of this debate focus on the role of investments, debt stock and debt service ratio; governance (in general) and the strength of institutions; human capital development; agricultural productivity insofar as agriculture is the primary sector in countries with economies that are yet to structurally transform. The higher the agricultural productivity, the stronger the likelihood of structural transformation.

According to ECA (2011), Africa's transformation experience shows that, despite the diversity of country experiences, the performance of many African economies was indistinguishable from the performance of similarly situated countries or similarly endowed economies in other regions of the world between the early 1960s and the early 1970s. Divergence in performance between African countries and other developing regions emerged in the wake of the oil price shock of 1973. Economic growth in Africa generally declined from 2000–2007 before recovery began. Nonetheless, Africa's growth has remained fragile, the economies are still largely monocultural and therefore very vulnerable to shocks. The continent's inability to harness its abundant natural resources and endowments for economic development remains problematic. Some blame ineffective policies and lack of technological capability. Others blame conflicts (including ethnic and sectarian conflicts), colonial legacy, asymmetrical and unfair deals with the rest of the world, weak national institutions, and poor governance. Still other analysts blame all the above listed factors and more.

3.2 Structural change and economic diversification

As noted earlier, African countries have consistently posted strong economic growth figures in the recent past (see figure I.II below). In spite of stagnation and reversals in North Africa (due to the disruptions of the Arab Spring) and the group of oil exporting countries, growth remains strong in a majority of countries. However, there is consensus that the basis of Africa's growth remains narrow and that African countries need to further diversify their production and exports to reduce their susceptibility to shocks, to provide employment opportunities, to further enhance growth and competitiveness and to boost their integration into the global economy.[19] In the light of this, there is fervent interest amid African policymakers in the potential role of industrial policy and science, technology and innovation policy.

In general, economies become structurally transformed and diversified through a process whereby an increasing range of economic outputs is produced through the diversification of markets for exports or the diversification of income sources away from domestic economic activities (that is, through income from overseas investment). Different countries have different reasons for diversifying their economies. In that regard, Zhang (2003) identifies the following five rationales for economic diversification:

(a) Trends in terms of trade;

(b) Price instability in primary commodity markets;

19 See various issues of the ECA flagship publications, *Economic Report on Africa* and *Assessing Regional Integration in Africa*.

(c) Depletion of mineral resources;

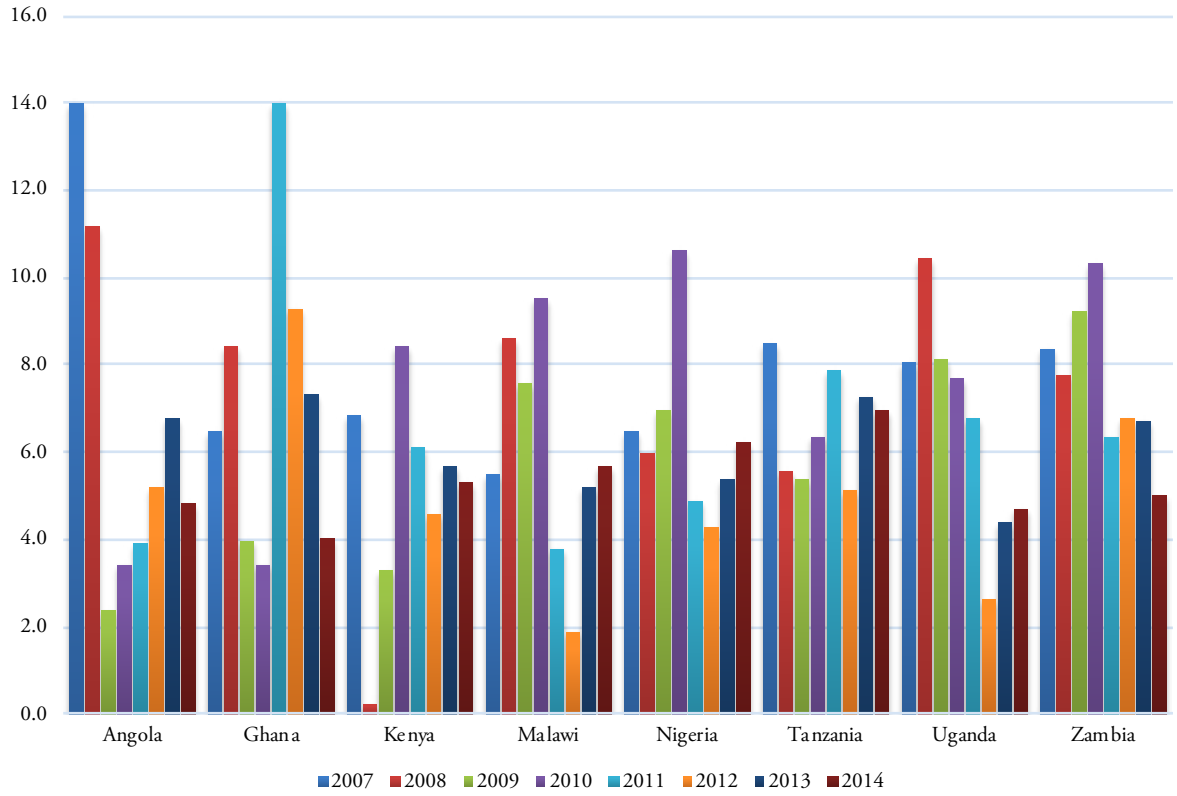
(d) Economies of scale and external economies, especially those associated with manufacturing;

(e) Reduction of portfolio risk.

A 2011 report issued by the United Nations identified five major determinants of economic diversification. They are: governance; the role of the private sector; natural resources; the broader international framework; and institutional capacity and human resources. It also highlighted the following three major challenges to diversification of Africa's economies: constraints on specialization; the lack of international opportunities; and trade barriers.

Overall, economies that are well diversified enjoy a number of advantages, including: an increase in trade activities; reduced vulnerability to external shocks; improved capital and labour productivity; and enhanced regional economic integration. These advantages, in addition to better public financial management, can help to reduce poverty while also stimulating economic and social development. Economic diversification remains elusive for most countries of the continent even though a significant number of them have in place policies to diversify the economy. This

Figure I.II
Real gross domestic product growth rates in selected African countries, 2007-2014



Source: African Economic Outlook (2017) (Table 2 Real GDP growth 2007-2017. Available at: http://www.africaneconomicoutlook.org/en/statistics).

Note: the growth rates for 2015, 2016 and 2017 are not included since they are estimates and projections.

limits the scope for the application of science, technology and innovation.

3.3 National systems of innovation and competitiveness of African economies

In his book, *The Competitive Advantage of Nations*,[20] Michael Porter argued that national welfare will increasingly depend not on the comparative advantage of nations but on their competitive advantage and that competition will occur not just between firms and organizations but between nations, states and regions.[21] He also identified scientific and technological infrastructure as one of the determinants of the competitiveness of nations. This means, therefore, that one of the loci of innovation is the nation.

The concept of National Innovation System (NIS) as a framework for studying and understanding the competitiveness of nations is proposed by Lundvall (1992), Nelson (1993) and OECD (1997). The definition of this concept is not settled.[22] Adeoti (2007) summarizes some of the most influential definitions of the concept as can be seen in table I.1. Box I.1 presents the features of an NSI. Innovation underpins not just the competitiveness of firms but of nations, which provide the space for firms to interact and innovate. Economic development occurs as a result of interactions among institutions that can be identified within a State. The firm as the centre of innovative activities does not act in isolation, and lacks the capacity to innovate without the benefit of knowledge resources accessible from other agents in the nation.

R&D activities and institutional arrangements for policy intervention ensuring that knowledge generation and use provide structural transformation and economic change are crucial to any national system of innovation. R&D in the public and private sectors is considered a major source of economically productive knowledge or technological knowledge. In this context, the mainstream neoclassical assumption of technological change as a shift in the production function (Jones, 1975) gives way to the actual identification of technological change as endogenous to the production system.

NSI is both a production system and a system that enables the generation and use of innovation in every sector of the economy. Unlike most economic frameworks which stress the importance of maximizing output from scarce resources, NSI focuses on innovation processes. It distinguishes innovation from research as measured in terms of scientific and technical outputs. The emphasis of NSI is that innovation is neither research nor science and technology, but is rather the application of all types of knowledge to achieve desired social and economic outcomes. This knowledge may be acquired through learning, research or experience, but until it is applied for social and economic gains it cannot be considered as innovation. These processes of learning and acquiring knowledge are interactive, often requiring extensive links among different sources of knowledge (Hall and Sulaiman, 2007).

20 Porter, Michael. *The Competitive Advantage of Nations* (The Free Press: New York, 1990).

21 See Michael Porter. The competitive advantage of nations, states and regions (2011). Available at http://www.hbs.edu/faculty/Publication%20Files/2011-0707_Malaysia_vcon_b3574e10-758b-483f-b6c5-f7439d7c58e9.pdf.

22 The discourse on NSI presented in this subsection draws largely from Adeoti (2007) and Adeoti and Olubamiwa (2009).

Table I.1
Definitions of NSI and the nature of innovation in focus

Definitions of NSI	Nature of innovation in focus
"… the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman, 1987).	» Technology new to the firm » Technology new to the world » Technology as artefact
"… the elements and relationships which interact in the production, diffusion and use of new, and economically useful knowledge …. and are either located within or rooted inside the borders of a nation State" (Lundvall, 1992).	» Technology new to the world » Technology as knowledge resources
"… the set of institutions whose interactions determine the innovative performance of national firms" (Nelson and Rosenberg, 1993).	» Innovation at firm level
"… the national system of innovation is constituted by the institutions and economic structures affecting the rate and direction of technological change in the society" (Edquist and Lundvall, 1993).	» Rate and direction of technological change
"… a national system of innovation is the system of interacting private and public firms (either large or small), universities, and government agencies aiming at the production of science and technology within national borders. Interaction among these units may be technical, commercial, legal, social, and financial, in as much as the goal of the interaction is the development, protection, financing or regulation of new science and technology" (Niosi and others, 1993).	» Production and use of new science and technology » Technology new to the world » Technology as artefact » Technology as knowledge resources
"… the national institutions, their incentive structures and their competences, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country" (Patel and Pavitt, 1994).	» Technological learning
"… that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provide the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies" (Metcalfe, 1995)	» Technology new to the world » Innovation process » Technology as artefact » Technology as knowledge resources

Sources: Adeoti (2007) and Niosi (2002).

As indicated previously, the main objective of NSI is to generate and use innovation for economic development. Thus NSI may be viewed as an integrated system of economic and institutional agents directly promoting the generation and use of innovation in a national economy. Generally speaking, the elements of NSI identified by Lundvall (1992) and Adeoti (2002) include the following:

- Internal organization of firms
- Inter-firm relationships
- Role of the public sector
- Institutional set-up of the financial sector
- R&D intensity and R&D organization
- Education and training

These elements suggest that institutional settings are very important in shaping the processes (e.g. interacting, learning, knowledge sharing) that are critical for innovation. In this respect the NSI framework does not

Box I.1

Common features of the national systems of innovation framework

- The firm is the core of the national systems of innovation (NSI) framework: it is the place where factor combinations take place, and is also the centre of innovative activities.
- System view of innovation: networks and feedback among agents, network economies.
- A kiss between demand and supply of R&D: NSI emphasis on the generation and use of technological knowledge makes demand for R&D an important issue alongside R&D programmes and projects.
- Innovation as the engine of growth
- Institutions matter for system effectiveness in interaction among economic actors
- Market not always sufficient for innovation to happen, so policy matters
- Learning is essential (by doing, using and interaction modes)
- Knowledge-based and technology-driven development
- Co-evolutionary processes, the system is dynamic

Source: Adeoti (2007).

limit institutions only to bodies such as enterprises, research institutes and governmental and non-governmental organizations. It also embraces the new institutional economics definition of institutions as sets of common habits or norms, routines, practices, rules and laws that regulate the relationships and interactions between individual agents and groups (Edquist, 1997; North, 1997; Parto, 2005). When the elements of NSI are well developed, the firm which is regarded as the core or centre of NSI becomes more innovative, and the impact of innovation as the engine of economic growth and technological progress is widespread. The structural transformation becomes evident and the international competitiveness of national and local firms begins to thrive (Kim, 1997; Mytelka, 1998; Lall, 2001; Muchie and others, 2003; Lall and Pietrobelli, 2005).

The NSI framework has continued to gain prominence in the analyses of the determinants of technological innovation (Goel and others, 2004). On the one hand it has been extended to analyse regional systems of innovation (Freeman, 1995; Edquist, 1997), while on the other hand it has been reduced to analysing sectoral systems of innovation (Malerba, 2002; Hall, 2005). Of interest to this study is the application of NSI to sectors that are considered crucial for growth and poverty reduction.

The World Bank (2004) asserts that the ultimate objective of a well-functioning innovation system is to serve the needs of the economy by achieving the full integration of the science and technology (S&T) infrastructure with the production base, by increasing private sector participation in innovation and technology development, and by developing strong linkages between industry, universities and research institutions. While advising on the conditions under which the opportunities inherent in a functioning NSI framework can be tapped to strengthen the competitiveness of economies, the World Bank states that NSI is effective only to the extent that its different elements work in harmony. A multi-pronged structure must be built to support innovation delivery from the birth of an idea to its ultimate commercialization; and the economic environment should be conducive to entrepreneurship, with well-established key national policies that include intellectual property rights protection and an appropriate system of standards and quality assurance. Other

key features of NSI identified by the World Bank include a functioning framework for the generation of new ideas by research institutions, universities and private firms, as well as for industry using the research products; the availability of financing for enterprises to use, adapt and develop new technologies; and the existence of a framework to support the establishment and sustainability of knowledge-based firms (World Bank 2004).

In NSI, successful innovation often depends on the firm combining a range of capabilities, including its capacity to access finance, its understanding of market needs, recruiting highly-skilled staff, and establishing effective interactions with other actors. Some firms are, however, deterred from engagement in innovation because of the difficulties involved, and remain locked into established routines. Other firms do try to innovate and invest in formal or informal R&D, but may fail to bring new products or processes to market because they are unable to overcome barriers to innovation (D'Este and others, 2012).

Recognizing the role of institutions in NSI, Oyelaran-Oyeyinka and McCormick (2007) assert that the framework for a system of innovation is essentially undergirded by the theory of institutions. According to them, institutions are necessary for innovation for two reasons. First, the innovation process is characterized by considerable uncertainty. For example, institutions provide stability by regulating the actions of individuals and enforcing contractual obligations. Second, the creation, validation and distribution of learning and knowledge, which are prerequisites of economic change, are mediated by institutions. These institutions operate in such areas as R&D, finance and investment, intellectual property rights and patent laws.

Arocena and Sutz, (2000) and Cassiolato and others (2003), observe that the nature of innovation systems in developing countries differs markedly from those in developed countries. Less developed countries are characterized by a deficient socioeconomic infrastructure, weaker institutional frameworks and low levels of interaction. According to them, formal institutional, legal and regulatory frameworks are generally weakly developed and usually have less reliable enforcement mechanisms. The composition of sectors tends to be different and less diversified, with simple consumer goods (in food and clothing) being central in local manufacturing with a high degree of dependence on imported manufactured goods (Szogs and others, 2009).

Arocena and Sutz (2000) and Bertelsen and Müller (2003) also present the characterization of the nature of innovation systems in developing countries as typified by low levels of interaction among firms, as well as among different types of organizations (e.g. firms, universities and technology service providers). The limited numbers of innovative enterprises are often isolated, and suffer from few upstream and downstream linkages in the value chain. According to Bertelsen and Müller (2003) informality in business networks dominated by micro-enterprises and small-scale agricultural production is another key distinctive feature of innovation systems in less developed countries.

Na-Allaha and Muchie (2010) identify attributes found in the institutions of each country that has succeeded in strengthening innovation capabilities. Two of these key attributes are: the roles of the government, and the evolutionary history of NSI. They state that, through its control over regulatory instruments like monetary and fiscal policies, property rights law, patent systems, antitrust legislation, tax laws and others, the State is perceived to be capable of creating conditions needed to trigger private-public interaction and to launch new knowledge activities. In their view, these catalytic roles are also played through endeavours such as trade

agreement negotiations and investment promotions. They concluded that, in one way or another, the government represents the one actor in the innovation network that is ideally placed to change the direction of innovation in the land. As far as the evolutionary history of NSI is concerned, Na-Allaha and Muchie[23] posit that each national innovation system has its own history and specificities that set it apart from others. Some aspects of these specificities, according to them, have been put forward in models of sectoral systems of innovation to explain the varying capabilities of NSI to impact positively on sector-specific outcomes. They also observed that an accident of history which triggers a path-dependent developmental process in a specific sector can also account for the different outcomes achieved by different nations.

Countries at different stages of development toward a knowledge-based economy have begun to realize that they need to build on their competitive advantages. It is generally agreed that the competitive advantage of both developed and developing economies depends largely on how advanced their systems of innovation are and also on how well they have engendered coherence and interactions that spur knowledge flows and interactive learning. Guennif and Ramani (2011) are of the view that, by using the NSI framework, we can explore why, at certain points in time, countries with similar resource structures and investment patterns have had different trajectories in accumulating industrial capabilities. In this regard the World Bank (2004) notes that, even in the more traditional agricultural and manufacturing sectors, knowledge (about crop varieties, new markets, and innovative production processes) is becoming more easily and rapidly accessible on a global basis, thus increasing its competitive value. For the more sophisticated economies, the World Bank continues, the next step in enhancing their competitiveness lies in creating an environment conducive to the translation of concepts and new ideas into real products. This undoubtedly requires both a market reorientation and a well-functioning national innovation system, together with the integration of R&D institutions, universities and the private business sector.

Many years ago, the argument about the opportunities for countries that innovate was taken to the international level. It has been strongly argued that, if a firm within a country innovates and successfully exports its innovation, it stands a chance of enjoying an export monopoly until imitators come into its line of business. Earlier in the literature, Posner (1961) notes that the capacity of foreign demand to adjust faster than foreign supply is what allows for this monopoly. In the context of international competition, the key factor is the ability of foreign demand to adapt more quickly than supply from a foreign country, which for a time gives to that first mover country the competitive advantage. Sooner or later one might expect this monopoly to be erased by imitation (Kim, 1997; Garcia-Torres, 2007). As Posner (1961) argues, it is the time lag[24] between international demand and the domestic supply that allows a country to be more competitive.

According to Garcia-Torres (2007), a new twist to the effects of international demand on NSI suggests that international demand serves as a more reliable source of information. The recognition of new international needs spurs the country to take advantage of the international market through the creation of either a new product, or of a new niche within an existing market. Perez (1985, 1988) stressed that successful innovations should incorporate thinking about the new technological

23 Op cit.

24 For more on the time lag effect, at least in the context of technical change and international trade, see Hufbauer (1970) or, more generally, Dosi and others (1990).

paradigm and domestic demand. The example of the competition between the United States of America and Japan in the copier machine industry provided by Porter (1990) demonstrated that the Japanese discovered a new demand segment that could be met by small machines, and accordingly developed a new marketing strategy.

Dalum (1992) took a different perspective while attempting to examine the different export specialization patterns of 21 countries of the Organization of Economic Cooperation and Development (OECD) and how their export specialization affects the performance of NSI. Dalum tacitly attributed to international demand greater importance than to domestic demand, and tries to explain why different systems arrive at different specialization patterns within a sectoral distribution of exports. According to him, even though all countries have access to international trade, they specialize in different sectors. According to Dalum, the reasons for such specialization may be historical or cultural. Thus, according to him, the specialization of national capacity stimulates international demand.

On the supply side, UNCTAD (2003) indicated that efforts to bring some supply-related factors into focus have been limited. It further argued that insights from available studies reveal that the pervasiveness of structural weaknesses in virtually all sectors of beneficiaries' economies makes it difficult for domestic producers to derive maximum benefit from market access preferences. These weaknesses are usually thought of in terms of critical deficiencies in the supply of business support and physical and institutional infrastructures. While Guennif and Ramani (2011) agree that this will undoubtedly explain some of the problems associated with export responses, they believe that it is not a sufficient explanation. Their position is that "the issue of capacity to supply must move beyond these basics to accommodating the fact that it is the social absorption capability of an economy which finds expression in the incumbent systems of innovation that matter" (Guennif and Ramani, 2011).

4. Science, technology and innovation profiles

4.1 What are Science. technology and innovation profiles?

Science, Technology and innovation profiles (STI profiles) present analytical snapshots of the state of investments, strategies and skill used to develop the STI base of a particular country or region. STI profiling captures the trend in STI investments in an economy, and assesses its capacity for achieving competitive advantage and robust growth, given the STI outlay and prospects. It provides information on the resources – physical, human and financial – devoted to strengthening the STI performance of an economy. Such profiles are critical in providing government, civil society groups, development agencies and other relevant development stakeholders with the

information needed to understand the state of the national innovation system. They are indicators that inform policy decisions. Such indicators can be used for monitoring and benchmarking systems, for foresight analysis, or for evaluating projects.

OECD (2012) affirms the critical role of STI in economic transformation, and identifies three main functions of STI profiles. First, they articulate the government's vision regarding the contribution of STI to their country's social and economic development. Second, they set priorities for public investment in STI and identify the focus of government reforms (e.g. university research funding and evaluation systems). Third, the development of these strategies can engage stakeholders ranging from the research community, funding agencies, business and civil society, to regional and local governments in policymaking and implementation. In some cases national strategies outline the specific policy instruments to be used to meet a set of goals or objectives. In others, they serve as visionary guides for various stakeholders.

Hence, it can be deduced from these three main functions that the preparation of country STI profiles or STI readiness reports is crucial for realizing the objectives of economic and social transformation. Such profiles guide governments on the strategies needed to attract relevant players to build an effective STI framework for economic competitiveness. Initially, STI profiles were prominent only among the OECD countries, but in recent times there have been impressive efforts and commitments among emerging and developing economies in building such profiles for their nascent economies. For instance, emerging economies like Brazil, China and India now have a long-term STI framework targeted towards their economic development. In addition, middle-income countries such as Argentina, Colombia and Viet Nam have developed strategies to diversify their economies and mobilize innovative resources to improve their competitiveness.

4.2 STI profiles and measurement

Moving to a knowledge-based and innovation-driven economy requires a deep understanding of how knowledge is generated, exploited and diffused towards improved economic growth and development. In order to achieve this, it is important to have better measures of STI. Colecchia (2006) observed that, at the ministerial-level meeting of the OECD Committee for Scientific and Technological Policy, 29-30 January 2004, ministers confirmed the need "to develop a new generation of indicators which can measure innovative performance and other related output of a knowledge-based economy" with special attention to "the data required for the assessment, monitoring and policy making purposes". Beyond the promotion of the appropriate environment for the invention, diffusion and commercialization of scientific outputs, which has been the preoccupation of many a Ministry of Industry or Science and Technology, there is also a growing interest from central bankers and Ministries of Finance wanting to better understand how innovation creates value in the form of productivity and profits, while also contributing to the valuation of enterprises, ultimately leading to the growth, productivity, and competitiveness of economies.

For over 50 years OECD has constantly developed indicators to monitor the movement in STI. The indicators are frequently reviewed to capture changing trends in the composition of STI profiles. An initiative to develop a methodological framework for measuring STI started in 1957. OECD was subsequently formed in 1961, with its Directorate for Scientific Affairs holding a conference in 1962 to more systematically address the problems of measuring R&D. The conference resulted

in the so-called Frascati Manual.[25] Since then, the limitations of some of the key indicators – particularly intensity – in measuring R&D have been identified, and efforts at addressing them have deepened. The most notable of these limitations is the fact that the scope of such indicators was too narrow to capture the complex system of different innovation inputs and outputs. To overcome these limitations a mix of indicators has been used to broaden the scope of the Frascati Manual (OECD (2015). Some of these indicators cover areas such as intangible investment in STI, patents, bibliometrics and measures of innovation through direct surveys and surveys of firm performance. Colecchia (2006) provides a more comprehensive list of these indicators. Some key indicators are presented in box I.2.

It is important to note that a variety of different indicators have been used to analyse STI investments among countries and continents. Some of the indicators apply across-the-board, while others depend on the level of technological development of the country or region. Other factors that inform the development of an STI model are the industrial, social and cultural setting at the national or regional level. For example, NEPAD (2005) observed that the driving force in developing innovation indicators in Africa differs from that in industrialized countries. African countries can develop their technological innovation capabilities by harnessing the vast knowledge locked in its informal sector, tapping from the wealth embedded in indigenous knowledge, leveraging the biodiversity and biotechnology assets in the continent, and deploying information and communications technologies. For these reasons it has been argued that the methodological approach to assessing STI trends among different economic groups or entities should consider the uniqueness of each economy.

It is also critical to have a national or regional systems approach to building a framework for STI indicators. Such an approach would capture indicators on actors (individual agents, governments, business enterprises and educational institutions involved in R&D) acting within the cultural and physical environment; activities promoting science, technology and innovation; and linkages facilitating the development of a robust national system of innovation and outcomes of such innovative efforts.

Most of the STI indicators in use in African countries are adapted from the OECD framework on STI measurement. According to Cozzens and others (2007), prominent among this set of indicators are public and private investment in R&D; the R&D intensity of nations (R&D as a proportion of GDP), and industries (R&D as a proportion of sales); high tech exports; output and employment in low, medium- and high-technology industries; patents, trademarks and designs; the proportion of population with secondary and tertiary education; the number of S&T graduates; new products to the market and the firms; level of ICT expenditures and several other ICT-related indicators such as internet hosts and broadband penetration). These indicators shape and constrain policy formulation by providing a set of common standard terms, concepts and measures of performance that are easily translated into policy objectives and targets.

Other indicators that have been used to capture STI trends include foreign direct investment as a percentage of GDP, firm-level technology absorption, the United Nations Development Programme (UNDP) 2001 technology achievement index, the number of institutions providing vocational and technical training, the number of researchers in R&D, researchers in R&D per million of the population, the science and engineering enrolment

25 The *Frascati Manual* was a proposed standard practice for surveys of R&D.

Box I.2

Definition of selected key indicators for measuring STI

Intellectual property: An innovative work whose exclusive right to the inventor could be legally protected.

Intangible investments in STI: These are investments with no easily-quantified physical properties. They usually take the form of intellectual property.

Patent: The sole right granted by a government to an inventor to market an invention for a period of time. It is a form of intellectual property that encourages innovative efforts among entrepreneurs.

Bibliometrics: It is a set of methods to quantitatively analyse academic literature.[1] It could be used to measure the number and quality of scientific and technical journal articles in an economy.

Public and private investment in R&D: This shows the outlay of money and other resources on R&D by both government and private firms.

R&D intensity of nations: This is the proportion of a country's GDP that is spent on R&D.

R&D intensity of industries: This estimates an industry's R&D spending (e.g. in knowledge and technology search efforts) as a proportion of its sales.

High-tech industries: Industries that use the most advanced technologies available to manufacture goods or provide services.

High-tech exports: These are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments and electrical machinery.[2]

Output and employment in high- and medium-tech industries: This captures total production and the proportion of the labour force absorbed by high- and medium-tech industries in an economy.

FDI as a percentage of GDP: The share of FDI in GDP. It captures knowledge spillover from developed to developing economies.

Technology absorption: An economy or enterprise's capacity and readiness to use the most advanced technology available for productive purposes.

Technology achievement index (TAI): It is used by the UNDP to measure how well a country is creating and diffusing technology and building a human skills base, reflecting its capacity to participate in the technological innovations of the network age.[3]

Royalty: The percentage of income accruing to inventors from the sales of their inventions.

License fee: The amount paid or other terms that needed to be fulfilled before access to intellectual property can be granted.

1 See http://en.wikipedia.org/wiki/Bibliometrics.
2 See http://data.worldbank.org/indicator/TX.VAL.TECH.CD.
3 See http://www.insme.org/glossary/technology-achievement-index-tai.

ratio(percentage of tertiary level students), scientific and technical journal articles per million of the population, the percentage of imported technologies used in domestic markets, and royalty and license fee payments.

The technology achievement index (TAI) is defined by Desai and others (2001) and the UNDP (2001) as a function of four indices that include technology creation, human skills, the diffusion of recent innovation and the diffusion of old innovation. Evidence suggests the vital importance of capacity to deploy technologies in Africa, since R&D capabilities for new technology creation are weak. This reality recommends an understanding of strategies to acquire existing technologies that may either be new to the world or may be new only to the country adopting them. This will involve technology adaptation and absorption

as an important component of technology deployment. Thus, instead of computing a TAI for African countries, we propose that a technology deployment index (TDI) would be more relevant. This would be defined as a function of four indices comprising technology adaptation, human skills, diffusion of recent innovation and diffusion of old innovation.

4.3 Overview of country STI profiles

4.3.1 Developed countries

Most developed countries have well-structured and regularly reviewed STI policies which have often contributed to shape their remarkable growth performance and transformation. Since the mid-1990s most OECD countries have ratcheted up investments in knowledge accumulation relative to investments in machinery and equipment. This trend is also observable in other developed countries. An important measure of government support to STI is the Government Budget Appropriations or Outlays on Research and Development (GBAORD) as a percentage of total government expenditure. Recent evidence for 200-2015 suggests a flattening of GBAORD in most OECD countries except in countries such as Germany, Korea, Portugal and Switzerland which are spending more on R&D[26]. For example, in 2016, GBAORD was 1.38 per cent in the EU-28, a decrease from the 1.5 per cent recorded in 2009[27]. Countries are reducing R&D expenditures in response to continued pressure on public finances.

Another indicator related to GBAORD for measuring progress in STI profiles is R&D expenditure as a share of GDP (or R&D intensity). The EU and the United States of America have an R&D intensity target of 3 per cent

Table I.2
R&D intensity, 2004 and 2014, European Union and selected countries

	2004	2014
European Union	1.76	2.03
Sweden	3.39	3.16
Finland	3.31	3.17
Denmark	2.42	3.08
Germany	2.42	2.84
Austria	2.17	2.99
France	2.09	2.26
Belgium	1.81	2.46
Netherlands	1.81	1.97
Slovenia		2.39
Switzerland	2.68	2.96
Japan	3.13	3.47*
Russia	1.15	1.19
South Korea	2.68	4.15*
USA	2.49	2.81*

* Based on 2013 data

Source: R&D expenditure in the European Union was stable at slightly over 2 per cent of GDP in 2014. Available at: http://ec.europa.eu/eurostat/documents/2995521/7092226/9-30112015-AP-EN.pdf/29eeaa3d-29c8-496d-9302-77056be6d586.

26 See OECD Science, Technology and Innovation Outlook 2016 at https://www.innovationpolicyplatform.org/system/files/STIO%20Key%20messages_0.pdf.

27 See http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tsc00007&plugin=1.

for 2020. Japan's R&D intensity is, however, more ambitious at 4 per cent. In 2014, R&D intensity in the European Union stood at 2.03 per cent. This is still below the 3 per cent target for the Europe 2020 strategy. Table I.2 presents R&D intensity for the period 2004 and 2014 for the European Union, a subset of European Union member States, and some non- European Union member States. The table shows Japan, the Republic of Korea, Switzerland, and the United States of America outperforming the European Union in both years. The leading European Union countries, defined here as countries with R&D intensity above the European Union average are Denmark, Finland and Sweden.

The impressive R&D intensity performance of Scandinavia and South Korea is generally attributed to the knowledge-intensive bias of their economies and to political will. These countries have several hot-spot clusters in key technologies at a European and world scale, in particular in ICT, environment, materials, energy, security and food and agriculture (EC, 2013, p. 88).

In addition to R&D intensity, the OECD (2012)[28] identified other STI policy trends among developed countries, as follows:

(a) Exploring other sources of growth and competitiveness: OECD countries are leveraging STI to sustain vibrant economic growth. Countries such as the USA, Germany and the Republic of Korea are investing in the areas of green growth and green innovation. Countries not at the cutting-edge of innovation are focusing on strengthening their institutions and business environment to gain a competitive edge.

(b) Deliberate targeting of strategic technologies/sectors: In addition to developing technologies like nanotechnology, biotechnology and information and communications technologies, other areas of focus in developed countries (particularly amongst OECD members) have been in some strategic technologies and sectors, including traditional ones (e.g. agriculture) and services. Industrial policies have also been expanded to cover wider innovation policies.

(c) Leveraging challenges: Many OECD countries have exploited global challenges such as climate change and energy security to increase their public investment in STI. Some of these countries – Denmark, Germany and the Republic of Korea – are encouraging green growth. Germany, Italy and Japan are working on their health and demographic challenges as a means of fostering innovative growth.

(d) Promoting demand-side innovation policies: Along with supply-side innovation policies, emphasis has also been placed on demand-side innovation and diffusion policies. A good example is the research and innovation policy guidelines of the Finnish Research Council, which include specifications for demand-side approaches. However, aligning demand- and supply-side innovation polices remains a challenge, as does the evaluation of such measures.

(e) Bridging the inequality gap: STI policies and strategies have in recent decades been used to bridge the gap between the haves and the have-nots among OECD and non-OECD countries. Examples of such policy strategies are Poland's national cohesion strategy, Ireland's strategy for science, technology

28 See OECD Science, Technology and Industry Outlook 2012.

and innovation and Portugal's national strategic reference framework.

(f) Encouraging basic research and improving skills: Efforts are being intensified in most developed economies towards building human capital through huge investment in education and research. Leading countries in basic research are striving to maintain their position while transitional economies are granting more autonomy to universities in allocating their public funds in order to catch up. Countries such as Japan, the Netherlands, the United Kingdom and the United States of America have intensified efforts to make the outcome of research more inclusive through assessment, evaluation and improved priority-setting. Deliberate attempts to make the results of research more widely available are also on the increase. Pursuant to this, countries have updated the guidelines and operations for granting intellectual property rights at universities and public research institutions. Moreover, access to publicly funded research data is improving. Also, policies to improve human resources in science and technology, to encourage international mobility, to reduce gender gaps and to attract foreign talent remain high priorities in the national STI strategies of OECD countries.

(g) Business support: Support for business innovation focuses on improving framework conditions, streamlining business innovation programmes and expanding indirect funding instruments such as R&D tax credits. At the same time, given the critical role of the business sector in addressing challenges such as energy and the environment, much public support for business innovation is being directed towards public-private partnerships and improving links between public and private research through instruments such as innovation vouchers[29] and cluster policies[30].Improving conditions for entrepreneurship and the supply of risk capital, especially for small and medium-sized enterprises, remains an important focus of business innovation support policies. Finally, evaluation, not only of public research, but also of business support schemes is becoming more important in the light of fiscal consolidation and the need to adapt policies to the rapidly changing nature of innovation.

4.3.2 Developing countries

The challenges of global competition have elevated the issues of bridging the technological divide between developed and developing nations to a position of prominence in development policy debates. Some developing countries, notably Korea, Singapore, and China have demonstrated their capacity to deploy technology and to innovate in their bid to achieve sustained and inclusive growth and to catch up with the more advanced economies of the West. In this they follow very closely the example of Japan[31] (Freeman, 1987; Matthew and Cho, 2000; Malerba and Nelson, 2012).

Data on R&D intensity in most developing countries reveal that there are marked differences between the emerging economies

29 An innovation voucher is an initiative that provides funding and other supports for businesses wanting to explore ways of improving their competitiveness and productivity.

30 Cluster policies are policies promoting economic development within a cluster by improving the competitiveness of one or several specific business sectors.

31 The concept of first and second-tier newly industrializing economies became popular during the so-called "East Asian Miracle." The first-tier economies are Hong Kong, the Republic of Korea, the Taiwan Province of China and Singapore, while the second-tier economies are Indonesia, Malaysia and Thailand.

and other developing countries, particularly the least developed countries[32]. East Asian and South-East Asian regions dominate in R&D intensity, with China posting the largest share. In 2010, China had the third largest R&D investments in the world after Japan and the United States of America (OECD, 2011). However, in 2015, China's position declined by one eighth, with R&D intensity of 2.067 per cent — well below the OECD average of 2.380 per cent.[33] Table I.3 shows the trend in R&D investments by developed and developing countries, with some specific country examples from 2002 to 2015. Data are not often available for developing and African countries but the few available give an indication of direction. India and South Africa are yet to reach the target of spending 1 per cent of their GDP on R&D. The least developed countries as a group spend less than a quarter of a per cent of their GDP on R&D.

Another important indicator for characterizing the STI profile of a country is the number of published scientific and journal articles. Figures I.III presents the trend in the number of scientific and journal articles published in least developed countries and a range of developing countries. The least developed countries did not demonstrate any significant improvement in the number of scientific and journal articles published between 2005 and 2014. While this result could be an artefact of the data and/or a reflection of alleged unwillingness of the editors of major scientific journals to publish research emanating from developing countries, it could also be a reflection of the low level of their R&D activities, poor R&D infrastructure and weak human capacity. Among developing countries, China has registered a stellar performance in journal publications (which is also reflected in the increasing number of patents issued to Chinese). South Africa was the best performing African country during the period under review.

Other mechanisms have also been put in place by countries – particularly the emerging economies – to ensure the development of science and technology capabilities. Countries are putting a high premium on building their technological absorptive and adaptive capacity through technical collaboration activities. With the assistance of some development agencies, there are heightened efforts

Table I.3
R&D expenditure as percentage of GDP, selected regions and countries 2002-2015

Year	2002	2007	2009	2011	2012	2013	2014	2015
Developed countries	2.22	2.24	2.32	n.a.	n.a.	n.a.	n.a.	n.a.
Developing countries (excluding least developed countries)	0.83	0.99	1.11	n.a.	n.a.	n.a.	n.a.	n.a.
Least developed countries (LDCs)	0.22	0.2	0.2	0.23*	n.a.	0.24*	n.a.	n.a.
Brazil	0.98	1.1	1.12	1.14	1.13	1.2	1.17	n.a.
China	1.07	1.4	1.7	1.78	1.91	1.99	2.02	2.07
India	0.71	0.81	0.84	0.83	n.a.	n.a.	n.a.	0.63
South Africa	n.a.	0.88	0.83	0.74	0.73	0.72	n.a.	n.a.

n.a. - not available

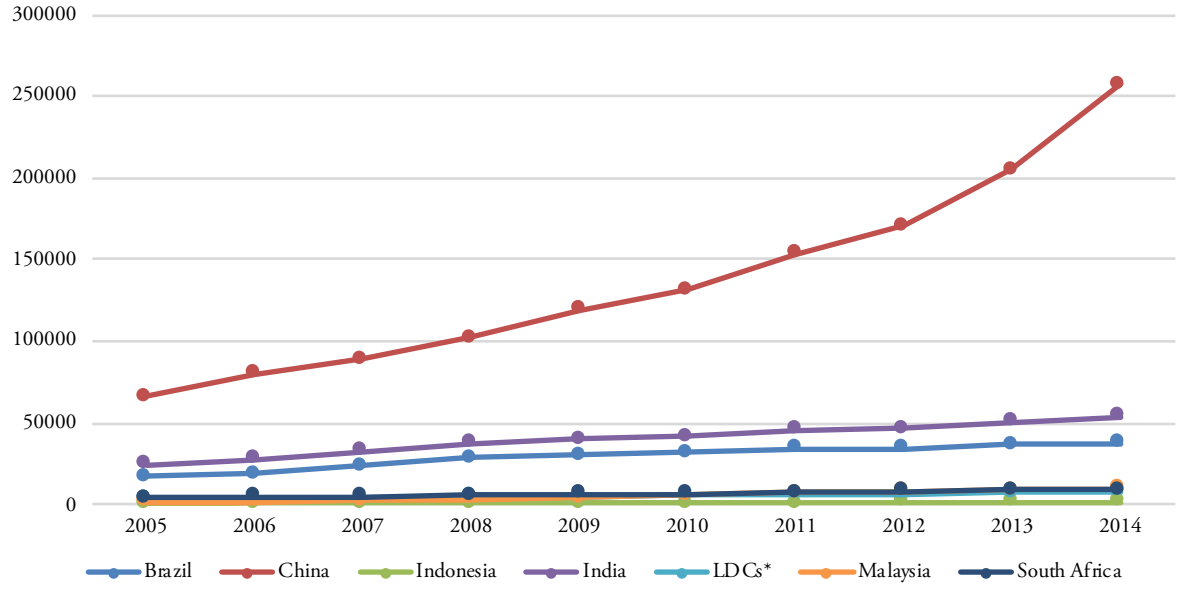
Source: UNESCO Institute for Statistics 2017 and * are from UNESCO report 2016

32 A least developed country is a country that, according to the United Nations, exhibits the lowest indicators of socioeconomic development, as demonstrated by UN Human Development Index ratings of all countries in the world. (http://en.wikipedia.org/wiki/Least_developed_country).

33 OECD (2017) Gross domestic spending on R&D (indicator) doi 10.1787/d8b068b4-en (accessed on 08 August 2017) available at https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm.

Figure I.III

Trends in the number of scientific and journal articles published in selected developing countries, 2005-2014



Source: UNESCO Science report towards 2030 (p. 778, Table s 8).

to boost South-South cooperation in order to enhance technological capabilities among South-South countries. Examples of such initiatives and cooperation include:

(a) **Programmes of international organizations to support South-South technological collaboration:** Over the years, development organizations have contributed to building the STI base of many developing countries. Such programmes include the United Nations Environment Programme (UNEP) South-South cooperation exchange mechanism, designed to promote environmental capacity-building and technology support activities in developing countries and regions of the South. Also, the UNDP South-South Global Assets and Technological Exchange (SS-GATE) is a virtual and physical platform where entrepreneurs in developing countries can interact and obtain needed technology, assets and finance in a secure environment.[34]

(b) **The Delhi declaration:** This declaration stressed the need to promote science and technology and related knowledge exchange among the country members of the BRICS group – viz., Brazil, Russian Federation, India, China and South Africa. The priority areas in the declaration are food, pharmaceuticals, health and energy, as well as basic research in emerging interdisciplinary fields such as nanotechnology, biotechnology and advanced material science.[35]

(c) **The India-Brazil-South Africa dialogue forum:** This is an informal arrangement or policy initiative geared towards improving the technological potential of like-minded States. The focuses of the cooperation are: to share information on best practices in technology transfer and to jointly consider intellectual property rights issues related to the protection of biodiversity and traditional knowledge; and to promote networking among their

34 See http://ssc.undp.org/content/ssc/services/expo/2013/the_expo/global_assets_tech_exchange.html.

35 See BRICS Summit, Delhi Declaration, Council for foreign Relations. http://www.cfr.org/brazil/brics-summit-delhi-declaration/p27805.

R&D institutions in order to strengthen and further develop the trilateral science and technology relationship.[36]

(d) Istanbul Programme of Action: This was the outcome of the fourth United Nations Conference on the Least Developed Countries, held in May 2011. The Programme identifies the lack of a robust STI framework as the major cause of poor development in these countries. It was recognized that their production processes mainly rely on mostly obsolete technologies, and that there is therefore a need for critical assistance in the areas of STI development and investment. The Programme therefore calls for the establishment of a technological bank and supporting mechanisms for STI. These should focus on improving the scientific research and innovation base of the least developed countries, enabling network among researchers and research institutions and facilitating access to critical technologies (UNCTAD, 2012, pp. 59-60).

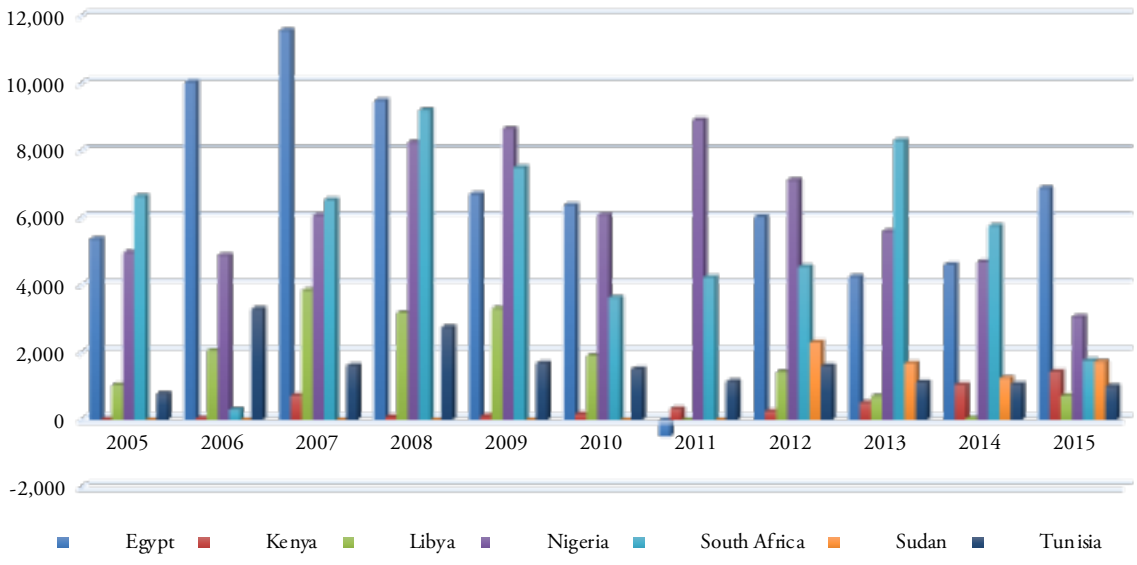
4.3.3 African countries

Generally speaking, African countries have a varied history of preparing STI readiness reports or STI profiles. Foreign direct investment (FDI) inflows have over the years played a vital role as a driver of innovation and technology transfer on the continent. FDI is therefore crucial to the STI profiles of African economies. As shown in figure I.IV, FDI inflows generally increased from 2005 to 2008, but declined from 2009. The decline in FDI inflows observed for some countries from 2009 onwards could be a result of the unfriendly investment climate caused by terrorist activities and political instability in a few countries as well as more favourable policy changes in other countries and regions.

In addition to FDI inflows, some recent initiatives likely to have an impact the STI profiles and improve country STI readiness include:

(a) Agenda 2063, which contains an explicit recognition of the vital importance of technological progress for economic

Figure I.IV
Foreign direct investment inflows, selected African countries, 2005-2015 (in millions of United States dollars)



Source: UNCTAD, FDI online database (2017).

36 See http://www.dfa.gov.za/docs/2004/ibsa0305a.htm.

transformation. Agenda 2063 is underpinned by the African Union's Science, Technology and Innovation Strategy for Africa 2024 (STISA-2024), the successor strategy to the African science and technology consolidated plan of action. STISA-2024, a ten-year plan adopted in 2014, has four main pillars: (a) infrastructure development; (b) initiatives by the regional economic communities,[37] and (c) technical competencies; innovation and entrepreneurship; and enabling environment; and (d) the United Nations Sustainable Development Goals, which specifically mention innovation in Goal 9 and in Goal 17 identifies technology and innovation as one of the means of implementation. The General Assembly resolution 70/1 endorsed the outcome of the Addis Ababa Action Agenda of the third International Conference on Financing for Development on the establishment of technology facilitation mechanism (TFM) to support countries to access the technology that they need to achieve the SDGs. The TFM consists of a United Nations Inter-Agency Task Team (IATT), a ten-member Advisory Panel appointed by the Secretary-General, an online platform and an annual STI forum convened by the Economic and Social Council (ECOSOC).

5. Towards a methodological framework for country STI readiness reports

The preceding sections of this report suggest that few African countries have articulated or are implementing a framework for monitoring progress in science, technology and innovation as a national priority.[38] A number of countries have STI policies (ECA, 2017). As discussed in another ECA report (2016), there are also country-level vision documents and subregional STI strategies. Some regional economic communities, such as the East African Community, have created an independent STI governing organ while others, such as SADC are integrating their industrialisation and STI strategies and policies. Most of these strategies and policies do however lack a coherent and well-articulated strategy for investments in STI, especially at the country level. Since economic and social well-being are to a great extent determined by country level policies, it is argued in this report that country level economic and STI policies, because they are crucial to economic growth and competitiveness, should be seamlessly integrated with economic, industrial policies, the aim being to create conditions conducive to the promotion of knowledge-based and innovation-driven

37 See ECA. *Innovation, Competitiveness and Regional Integration: Assessing Regional Integration in Africa VII* (Addis Ababa, 2017) for a detailed discussion of regional initiatives as well as national policies.

38 South Africa and Algeria, unlike most African countries, have robust systems for monitoring and evaluating progress in STI. Many others have STI policies that are seldom assessed and reported on.

African economies. For such policies to succeed, country STI readiness reports are necessary for understanding the scope, context, pathways and prospects for investments in STI. The methodological framework for the preparation of country STI readiness reports is envisaged as a critical instrument or guide for development policy analysts and other development stakeholders interested in profiling African economies in terms of sustained growth and competitiveness.

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Part Two: Methodological framework for country science, technology and innovation readiness reports in Africa

1. Introduction

As explained in Part One of the present report, country STI readiness reports are analytical snapshots that capture an economy's trend in STI investments, and assess its capacity for achieving competitive advantage and robust growth, given the STI outlay and prospects. For the preparation of country STI readiness reports, methodological approaches often include a review of economic and innovation performance within a short- to medium-term timeframe; the identification of STI initiatives that are critical for sustained growth and economic competitiveness; and suggestions for policy reform and actions that would enable the harnessing of STI resources to achieve improved growth performance and global competitiveness. The national system of innovation framework has been applied as the theoretical guide for STI readiness assessments, and helps to map the inputs, output and outcomes of innovation activities within a country. As illustrated by the OECD (2012), the application of the NSI framework for the preparation of country STI readiness reports involves analysis of the four major components of NSI which can be characterized as the pillars of country STI readiness. These include:

(a) STI actors' competences and capacity to innovate;

(b) STI actors' interactions;

(c) Human resources for innovation;

(d) STI policy governance.

Applying this approach to African economies requires considerable caution because of the relatively weak technological capability of African countries and the different institutional contexts that determine economic performance. Significant points of divergence in the methodological approach applicable to African economies should consider the preponderance of technological adaptation in Africa and the vital importance of poverty reduction. As learning economies, African countries are characterized by technology deployment activities (technology applications new to firms, but not necessarily new to the world, such as green technologies); the diversification of the economy through value-addition for agricultural and other primary commodities; informal sector economy technology applications (innovation in informal settings); human resources development and capacity for technology acquisition; and strengthening institutional capacity for technology policy management.

A methodological framework is essentially an outline of the guideline for accomplishing a task or defined goals. The task in view for the methodological framework in this paper is a toolkit or blueprint for organizing the preparation of country STI readiness reports for African countries. The guidelines described in this paper accordingly present the criteria and activities required in five domains that include:

(a) Criteria for the review of country economic and innovative performance;

(b) Selected/relevant STI indicators and measurement procedures;

(c) Criteria for the review of country STI policies;

(d) Criteria for the identification and review of STI initiatives;

(e) Mode of reporting country STI readiness.

2. Criteria for the review of economic and innovation performance

This is a restricted situation analysis of economic and innovative performance within a short-term to medium-term framework of two-five years. Questions to be answered include:

(a) Where is the country coming from in terms of its economic and innovative performance in recent years?

(b) How has the country harnessed resource endowments for economic development?

(c) What are the trends in the structural composition of the economy? Is there any evidence of structural change?

(d) Is the economy growing? Is growth accompanied by economic transformation? Is there any evidence of poverty reduction, job creation, and tendency towards greening the economy?

(e) What are the contributions of the informal sector to economic performance?

(f) What are the nature, trend and composition of investments, and how have they contributed to the achievement of performance levels?

(g) What are the current levels of achievement in economic progress and innovation?

(h) How competitive is the economy in local, regional and global contexts?

(i) How is economic and innovative performance rated when compared with and benchmarked against selected African countries and emerging economies such as Brazil, China, India, Indonesia, Malaysia and Mexico?

(j) What are the new economic and technological opportunities which can benefit these countries?

The review should be concise, deep, precise, and focused on macroeconomic management, sectoral performances, drivers of and barriers to economic growth and competitiveness, and the analysis of economic transformation potential and prospects. Sectoral specificities should be identified, and the role of new technologies in sectoral performance should be tracked. The elements of the NSI framework in developing countries as identified by Adeoti (2002) should be applied to guide the discourse. These elements include:

- Internal organization of firms
- Inter-firm relationships
- Role of the public sector
- Institutional set-up of the financial sector
- R&D intensity and R&D organization
- Education and training

3. STI indicators and measurement procedures

Measuring science and technology development activities is crucial for planning investments in STI and STI's role as a major driver of economic transformation. STI indicators applied to measure scientific activities and their impacts are mainly based on the work of OECD. In this methodological framework an attempt should be made to adapt some of these existing STI indicators to suit the African context. Where possible, new and more appropriate indicators for African countries would be developed. The STI indicators would be divided into two categories, namely input indicators and output indicators. STI input indicators are those that measure the resource inputs for science and technology activities, while STI output indicators are those that measure the results of science and technology activities. The extent of STI output achieved determines the economic and/or social impacts of investments in science and technology activities. The ultimate goal of STI investments is to generate the knowledge and innovation that are required for sustained growth and economic transformation.

For each African country, tables II.1 and II.2 present the STI input and output indicators respectively along with their definition, measurement procedure and interpretation and likely data sources for each indicator.

Table II.1
STI input indicators

Indicator	Definition	Measurement and interpretation	Data source(s)
R&D intensity of country	This is a country's total expenditure on R&D as a proportion of GDP	Measured as expenditure on R&D divided by country's GDP	World Development Indicators (WDI); UNESCO Institute for Statistics (UIS)
R&D intensity of industries	This estimates an industry's R&D spending (e.g. in knowledge and technology search efforts) as a proportion of its sales	It is calculated as total expenditure on R&D divided by industry's total output. This indicator monitors resources devoted to improving the industry's innovative and technological capacity. At the firm level, it is calculated as expenditure on R&D in a firm divided by the firm's total output	National statistical bureaux; UIS; national R&D survey data
Govt. budget appropriations or outlays on R&D (GBAORD)	Share of total budget assigned to R&D	This is measured in terms of the proportion of the R&D budget in the total budget. It describes government investment in R&D activities	National budget offices and websites
Public investment in R&D	This is the outlay of investment in R&D from national budgets and other publicly financed development partners such as the World Bank, African Development Bank, UKAID/ DfID, USAID, and SIDA.	This is measured as a country's total expenditure on R&D financed from national government budgets and overseas development assistance (ODA)	National budget offices; WDI; UIS; national statistical bureaux
Private investment in R&D	This is the outlay of investment in R&D by private firms	This is calculated as expenditure on R&D by local and foreign firms operating in the country	National statistical bureaux
Education expenditure as proportion of GDP	Proportion of total GDP spent on education	It is measured as total expenditure on education as a proportion of GDP	WDI; UIS; UNDP human development indicators same as for human development index later in article
No. of institutions providing technical and vocational training	These are institutions established to train young professionals in technical and vocational skills	This is obtained through official records of the national board on technical training or through field surveys	Ministry of Education/National Board for Technical and Vocational Education of countries
No. of researchers in R&D	These are professionals engaged in the conception or creation of new knowledge, products, processes, methods, organizations, and markets in a country	This is obtained from relevant documents that reveal the number of people employed in knowledge-based institutions. It may also include the number of research officers employed in the private sector. It shows the number of people doing research for the development of a country	UIS; Ministry of Education; national university commission of countries; Ministry of National Planning; national statistical bureaux
No. of researchers in R&D per million of the population	This is the number of professionals engaged in the conception or creation of new knowledge, products, processes, methods, organisations, and markets in each million of the population	It measures the number of researchers in a country in each million of the population	UIS; Ministry of Education; national university commission of countries; Ministry of National Planning; national statistical bureaux

Indicator	Definition	Measurement and interpretation	Data source(s)
Science and engineering enrolment ratio (per cent of tertiary level students)	This is the proportion of students enrolled in science and engineering courses in tertiary educational institutions in terms of total tertiary education students' enrolment	This is the ratio of students enrolled in science and engineering to the total number of students in a country's tertiary institutions. The ratio provides insight into students studying science and engineering courses in tertiary institutions	UIS; Ministry of Education; national university commission of countries; Ministry of National Planning; national statistical bureaux
Level of ICT expenditure by public sector	This is the total outlay of investment in ICT by the public sector	This is measured as public sector expenditure on ICT as a proportion of total public sector expenditure.	National Ministry in charge of ICT; Ministry of Science and Technology; Ministry of National Planning; national budget office
Level of ICT expenditure by private sector	This is the total outlay of investment in ICT by the private sector	This is measured as private sector expenditure on ICT as a proportion of total private sector expenditure	National Ministry in charge of ICT; industry association; national R&D survey data; national innovation survey data
Total investment in renewable energy technologies	This is the total outlay of investment in renewable energy technologies by a country	This is measured as the cost of renewable energy technology assets created by a country. It reveals the intensity of investment in renewable energy technologies in the total country's investment	National energy departments, councils and commissions; International Energy Agency (IEA)
Technology achievement index (TAI)	This is a measure of how well a country is creating and diffusing technology, and building a human skill base for economic growth and development. It reflects the country's capacity to participate in the technological innovations of the network age	This is measured as $\mathrm{TAI} = \frac{TC + RI + OI + HS}{4}$ Where TAI is the technology achievement index based on the linear averaging method, TC is a technology creation index, RI is an index of the diffusion of recent innovations, OI is an index of the diffusion of old innovations, and HS is an index of human skills	UIS; UNDP Human Development Report
Technology deployment index (TDI)	This index measures how well a country is deploying existing technology and building a human skills base for economic growth and development. African countries are relatively weak in technology creation and are therefore expected to take advantage of deploying existing technologies for rapidly increasing productivity and economic competitiveness	This is a new indicator computed with the developing economies in focus. It is created by replacing a technology creation index with a technology adaptation index in the computation of TAI. Annex II shows how TDI is calculated $\mathrm{TDI}_{GM} = (TA \times RI \times OI \times HS)^{1/4}$ Where TDI_{GM} is the technological deployment index based on the geometric mean aggregation method, TA is the technology adaptation index, RI is an index of the diffusion of recent innovations, OI is an index of the diffusion of old innovations, and HS is an index of human skills	UIS; WDI; Human Development Report

Table II.2
STI output indicators

Indicator	Definition	Measurement/Interpretation	Data Source(s)
Proportion of population with secondary and tertiary education	This is the ratio of the number of persons in the total population, regardless of age, who have received a secondary or tertiary education	This is the sum of the number of persons with only secondary level education and persons with tertiary level education, as a proportion of the total population	National population commissions; national educational regulatory authorities; Ministry of Education; national statistical bureaux; WDI
No. of S&T graduates	This is defined as the number of graduates with a tertiary level qualification in the disciplines of science, technology, engineering, and mathematics	This statistic is obtained from relevant documents that emanate from agencies or commissions regulating higher education in a country	National University Commission of Countries; national statistical bureaux; WDI
Low, medium and high tech exports	This is the value of exports with low, medium and high R&D intensity	This is measured as the ratio of low, medium and high tech exports to total exports	National statistical bureaux; UNIDO industrial statistics; UNCTAD statistics; national innovation survey data
Output of low, medium and high tech industries	This is the value of total production coming from low, medium and high tech industries in an economy	This is measured as the ratio of the output of low, medium and high tech industries to total industrial output	National statistical bureaux; UNIDO industrial statistics; UNCTAD statistics; national innovation survey data
Employment in low, medium and high tech industries	This is the proportion of the labour force absorbed by low, medium and high tech industries in an economy	This is calculated as the ratio of employment in low, medium and high tech industries to total employment in the industrial sector	National statistical bureaux; national innovation survey data; WDI
Patents, trademarks and designs	Number of patents, trademarks, and designs registered by scientists, engineers and other inventors in an economy	For patents, this is measured as the total number registered in the national patent office, the United States Patent Office or the European Patent Office. Trademarks and copyrights are measured in terms of the numbers registered by national copyright and trademark offices	National statistical bureaux; WIPO database; national patent offices; United States Patent Office; European Patent Office; national trademark and copyright offices
Scientific and technical journal articles per million of population	This refers to the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology and earth and space sciences	Total number of scientific and technical journal articles as a proportion of each million of the population	UIS; national statistical bureaux; UNCTAD statistics

4. Criteria for the review of country STI policies

Science, technology and innovation policies have local, regional and global dimensions. The local specificities of African economies underscore the need to critically examine the relevance and applicability of global and international STI policy frameworks. Nonetheless, there is an emerging consensus that the national system of innovation (NSI) framework could be a firm basis for the articulation of STI policies in developing countries, serving as a potent instrument for reforms aimed at fostering economic transformation. The NSI framework involves a dynamic process of interactions among economic and social actors in the generation and use of technological innovation. Policymaking is a process, and the process to a great extent determines the value that can be derived from the policy while it is being implemented. The review of STI policies should adopt this view, thus clearly highlighting the STI policy processes and providing historical clues on how the policy regime has evolved. The following questions should be addressed by the review:

(a) What are the institutions responsible for STI policies and what have been the changes in these institutions? What are the factors driving the transformation of the policy institutions?

(b) How and to what extent? Has the policy process engaged critical stakeholders or actors interested in STI investments? To what extent has the private sector been involved in the STI policy process?

(c) What has been the relationship between the local and international dimensions of STI policies? How has conflict, if any, been resolved?

(d) Are there policies promoting the use of indigenous knowledge? How have such policies been applied in recent years?

(e) How and to what extent? Have STI policies been integrated into sectoral policies, and what impact has this had on sectoral development?

(f) Are there policies on science-society linkages, university-industry linkages, and the promotion of science education? What have been the outcomes of these policies?

(g) Are there policies on new orientations aimed at promoting applications of green technologies?

(h) What roles do STI policies play in the country's industrial policy or industrialization strategy? Are there clearly defined innovation policies that adequately link STI and economic policies?

(i) To what extent have STI policies promoted technological learning, possibly enabling opportunities for economic and technological catch-up?

5. Criteria for the identification and review of STI initiatives

STI initiatives that would be analysed include projects and programmes aimed at improving the country's science base, as well as local technological capability and the country's capacity to compete in the global marketplace. The review of economic and innovation performance should provide insights into the major STI initiatives. For a robust discussion of these initiatives, it would be necessary to identify a few of them as case studies to be presented in boxes or illustrated in figures depicting their contributions to improving the innovation capacity of economic agents. The following four questions should guide the identification of suitable STI projects and programmes:

(a) Does the initiative involve a network of actors, including demand for the product or a process generated by the initiative?

(b) Are there private sector involvements in the initiative that mostly encourage public sector contributions?

(c) Are public sector contributions tailored towards addressing challenges that could not be otherwise addressed because the outcomes are in the public good?

(d) Does the initiative include a well-defined programme of technology acquisition with measurable targets and milestones for performance evaluation?

While some initiatives may be fully identified and described by desk research involving a review of project and programme documents available in the public domain, others would require a country-level survey of STI policymakers and other stakeholders as key informants. In this respect, the survey of STI projects and programmes should use a semi-structured questionnaire such as that shown in annex III. The survey respondents should include:

- One high-level official of the national agency responsible for STI policymaking (such as the Director or Permanent Secretary)
- The president or chair of a national industry association
- One high-level official of a non-governmental organization with an interest in STI policy advocacy

At least three completed questionnaires would be required for a robust identification and analysis of country STI initiatives in each country.

6. Reporting country STI readiness

The main objective of country STI readiness reports is to present analytical snapshots of the state of the STI investments and strategies used in developing the country STI base. The ensuing STI profiling will, as much as possible, provide information on the resources – physical, human and financial – devoted to strengthening the STI performance of the economy.

The criteria specified in sections two to five of this guideline are the methodological instruments for the assessment of country STI readiness. The drafting of a country STI readiness report would start with a review of country economic background and STI status. This would include an analysis of economic and innovation performance, a review of STI policies, and an analysis of the economic and institutional determinants of the state of STI investments. The subsequent sections of the report would examine the national STI ecosystem with the aim of identifying the drivers of, and barriers to, new STI investment opportunities that can foster economic and technological catch-up; and recommendations would be made on the industrial and innovation policies required for economic and social transformation.

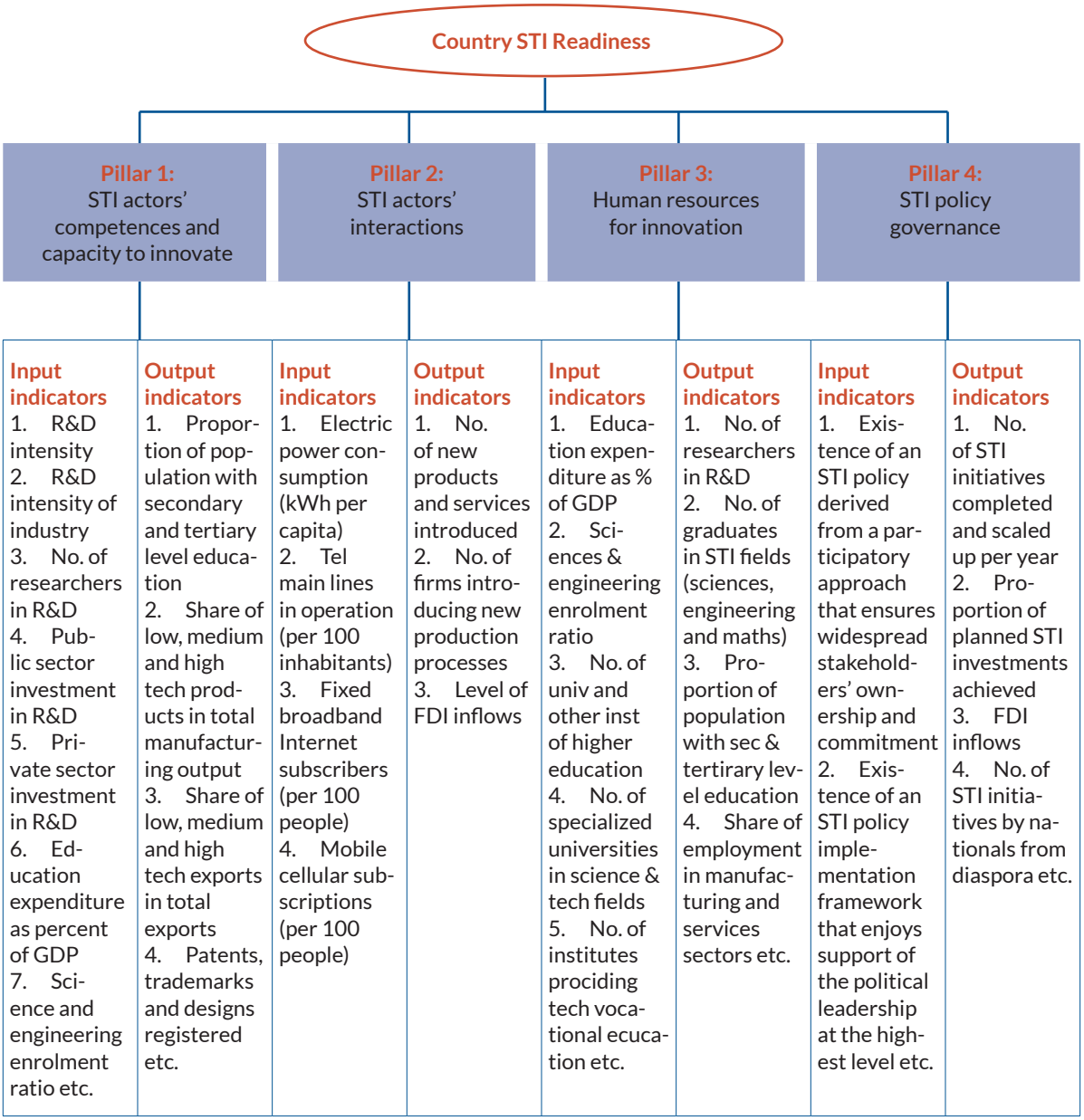
The STI readiness analysis will adopt the analytical framework of the national system of innovation. The application of the NSI framework is premised on the important role of government intervention in setting priorities for the STI investments and the interactions required among the critical stakeholders involved in STI investment activities. The NSI has been defined in various ways, and table I.1 in Part I of this report presents its common definitions, along with the nature and types of innovation in focus within NSI. The broad framework of NSI can be characterized by four components (OECD, 2012) that may be regarded as pillars of the country STI profiles. These pillars STI readiness include STI actors' competences and capacity to innovate; STI actors' interactions; human resources for innovation; and STI policy governance. The country STI readiness report should therefore be written with the four pillars forming the main chapters after the introductory chapters on economic background and STI status.

For each of the four pillars input and output indicators would be drawn from table II.1 and table II.2, respectively. Additional indicators may be added as necessary to adequately reflect each country's specificities. It is also important to note that the classification of input and output indicators may not be absolute, and that an indicator may sometimes be applicable for more than one pillar of country STI readiness. For example, while "researchers in R&D" is an input indicator for pillar 1 (STI actors' competences and capacity to innovate), it is also an output indicator for pillar 3 (human resources for innovation). Figure II.I presents the pillars of country STI readiness, together with our proposed input and output indicators for the pillars.

For African countries, the challenge of the availability of reliable data and the relatively low level of technological awareness and competence make quantitative expression and analysis difficult for some of the observed trends in STI investments and innovation performance. Nevertheless, comparative analyses would be conducted which benchmark

Figure II. I

Pillars of country STI readiness and their input and output indicators



performance with other developing countries with significant achievements in using STI for industrialization and economic competitiveness, to provide insights into the state of national STI readiness. These benchmark countries will often include developing countries that have achieved remarkable levels of economic transformation in recent decades. Examples would include Brazil, China, India, Indonesia, Malaysia and Mexico. A few OECD countries (e.g. the Republic of Korea and Singapore) which have rapidly transformed into developed countries in recent decades may also present some opportunities for performance benchmarking in some sectors. Moreover, a few African countries (e.g. Botswana, Mauritius, Rwanda and South Africa) may also present opportunities for benchmarking in particular sectors where they have done remarkably well in innovative performance and international competitiveness.

The pillars of country STI readiness, their definitions, input and output indicators, and possible adaptations to suit the African context, are presented below:

(a) STI actors' competences and capacity to innovate

This should identify the major STI actors within the national context and the competences that have enabled them to play significant roles in the economy. This should include the analysis of the science base and the structure of investments in scientific activities that can be illustrated by public sector research institutions (including universities), as well as by evidence of direct and indirect private sector investments in scientific activities and business R&D and innovation activities. The review should also provide appreciable historical clues on how competence development and innovation performance are linked, and on the processes that drive or constrain technological learning. As learning economies, African countries' capacity to innovate using local resource endowments should be a major focus of the analysis. The determinants of sectoral productivities should be identified, and the role of government interventions in promoting industrial productivity and business innovations should be traced in order to highlight sectoral priorities that are critical for economic growth and industrial competitiveness. The informal sector actors' competences and capacity to innovate would provide a specifically African context for technological acquisition and adaptation capabilities. This will facilitate a demonstration of the extent to which "imitation innovation" has contributed to improving indigenous knowledge, inclusive innovation and possible products and process upgrading.

From the above, the input indicators of STI actors' competences and capacity to innovate include:

- R&D intensity
- R&D intensity of industry
- Public sector investment in R&D
- Private sector investment in R&D
- Educational expenditure as a percentage of GDP
- Science and engineering enrolment ratio
- ICT expenditure (public and private) as a percentage of GDP
- Level of investment in renewable energy technologies
- Case studies of indigenous knowledge in the informal sector

The output indicators of STI actors' competences and capacity to innovate should include:

- Proportion of population with secondary and tertiary level education
- Proportion of low, medium and high technology products in total manufacturing output
- Proportion of low, medium and high technology exports in total exports
- Patents, trademarks and designs registered (or applied for, if data about registrations is not available)
- Scientific and technical journal articles per million of the population
- New technology products introduced
- Process improvements introduced

(b) STI actors' interactions

Empirical evidence suggests that interaction among STI actors in Africa is relatively weak (Adeoti, 2002; Muchie and others, 2003, Kruss and others, 2012). A major focus of the analysis of the STI actors' interactions should aim at identifying factors promoting interaction, barriers to interaction and new opportunities for interaction. This will involve the analysis of networks for new technologies such as biotechnologies, ICTs and nanotechnologies, the nexus between indigenous knowledge and modern science, and clusters, knowledge flows and constraints on the commercialization of public research results. The mismatch between African knowledge institutions such as universities and research institutes and formal sector industrial establishments, as well as the social milieu or cultural barriers to interactions among actors, and the challenges associated with subcontracting activities would be analysed to provide insights on how to promote both science-industry interactions and industrial backward/forward linkages. Also important would be the environmental impacts of interactions among economic actors. The extent to which investments in STI have enabled the greening of industry and other tendencies towards a green economy would also be analysed.

A major determinant of STI actors' interaction is the state of critical STI infrastructure, especially in the power and ICT sectors. Hence, input indicators of STI actors' interaction would be infrastructure-related and may include:

- Electric power consumption (kWh per capita)
- Telephone main lines in operation (per 100 inhabitants)
- Fixed broadband Internet subscribers (per 100 people)
- Mobile cellular subscriptions (per 100 people)

Isolating specific indicators to measure the outputs of STI actors' interaction is difficult because interaction is the major mechanism by which innovation and learning take place in a national system of innovation. Output indicators in this respect would essentially be new goods and services or new production processes that have emerged from such interaction and its associated learning effects. For developing countries these new goods, services and production processes may not necessarily be new to the world, but are certainly new to the context and the environment from which they have emerged. Effective interactions among STI actors would also contribute to an improved business climate, and hence to the likelihood of foreign direct investment inflow. The output indicators would thus include:

- Number of new products and services introduced
- Number of firms introducing new production processes
- Level of FDI inflows

It is important to note that most of these indicators of STI actors' interaction are usually captured by innovation surveys.

(c) Human resources for innovation

Human capital is critical for the efficient functioning of the national system of innovation. The skills level of the available human resources should be analysed to determine their innovative capacity. This will involve an analysis of education and training systems, employment and lifelong learning and innovation culture. The predominance of technological learning in the three modes signified by doing, using and interaction would be discussed with a

focus on how investments in STI can promote the most beneficial mode of learning. For African countries a major issue would be how investments in STI can contribute to job creation at a pace that would make the impact of economic growth evident in the economic empowerment of the poor and other vulnerable segments of the population.

The input indicators for human resources for innovation would include:

- Educational expenditure as a percentage of GDP
- Science and engineering enrolment ratio
- Proportion of industry workers who undergo training programmes
- Number of firms with facilities for in-house training or training schools

The output indicators for human resources for innovation would include:

- Number of researchers in R&D
- Number of graduates in STI fields (sciences, engineering and mathematics)
- Proportion of population with tertiary level education
- Proportion of population with secondary level education
- Proportion of employment in the manufacturing and service sectors
- Employment in low, medium and high technology industries
- Number of patent applications

(d) STI policy governance

This should present an analysis of the STI policy institutions and governance structures at the national and, where possible, also at sub-national and sectoral levels. African economies are characterized by relatively weak institutions. The analysis should therefore aim principally at identifying what could be done to strengthen the governance structure and the institutional capacity for science, technology and innovation policy management. This will broaden the social dimension of the analyses to examine the risks of government failures; the role of supra-State, subnational, quasi-State and non-State actors; and the possible influence of multi-level and multi-actor governance. The intersections between the functions and operations of existing STI policy management institutions should be examined with the aim of suggesting how improvements in functions can be achieved.

The input indicators for the assessment of STI policy governance would include:

- Existence of an STI policy derived from a participatory approach ensuring widespread stakeholder ownership and commitment
- Existence of an STI policy implementation framework enjoying the support of the political leadership at the highest level
- Proportion of personnel with science, engineering and professional management qualifications in STI management institutions
- Number of training institutions in science and technology policy management
- Number of memorandums of understanding or technical collaboration agreements between STI management institutions and international development partners

The output indicators for the assessment of STI policy governance would include:

- Number of STI initiatives completed and scaled up per year
- Proportion of planned STI investments achieved
- Foreign direct investment inflows
- Number of STI initiatives by nationals from the diaspora
- Number of endowments in STI fields in educational institutions

It is important to note that data for most of the input and output indicators for STI policy governance can be obtained only by direct national surveys and interviews of high-level policymakers.

Based on the foregoing, box II.1 presents a suggested outline for a country STI readiness report. The outline should be treated as a flexible guide that would require modification to suit the specific country context.

Box II.1
Outline of country STI readiness report

1. Review of economic and innovation performance

1.1 Economic growth performance

- Trends in GDP, GDP per capita, growth rates and drivers of growth, growth prospects, etc.
- Macroeconomic management
- Growth and employment

1.2 Private and public sector investments

1.3 Structure of the economy

- Production structure and economic diversification
- Sectoral distribution of GDP
- Employment distribution
- Performance of MSMEs, backward and forward linkages

1.4 Export performance

- Technological sophistication of exports and imports
- Export commodities

1.5 Trends in foreign direct investment

- FDI inflows: trends and sources
- Technological spillovers, incidence/possibilities

1.6 Informal sector performance

- Inclusive innovation
- Indigenous knowledge

1.7 Ecosystem and environmental innovation

- New technology applications for pollution control and prevention
- Renewable energy technology applications

Box II.1, cont.

Outline of country STI readiness report

2. Review of STI policies

2.1 Features of STI policy

2.2 Local and international dimensions of STI policy

2.3 Sectoral policies and their impacts

2.4 Industrial policy and industrialization strategy

3. STI actors' competences and capacity to innovate

3.1 Science base and structure of investments in scientific activities

3.2 Business R&D and innovation activities

3.3 Technological learning experiences and opportunities

4. STI actors' interactions

4.1 Factors promoting interaction and innovation opportunities

4.2 Barriers to interaction

4.3 Clusters and knowledge flows

5. Human resources for innovation

5.1 Education and training systems

5.2 Employment, skills and lifelong learning

5.3 Inclusive innovation and innovation culture

6. STI policy governance

6.1 STI policy institutions and governance structure

6.2 Roles of multi-level and multi-actor governance

7. STI investment profiles and prospects

7.1 STI investments, innovation performance and prospects of economic transformation

7.2 Business environment and competitiveness: local competition; regional competition; international competition

7.3 Benchmarking against selected African countries and emerging economies such as Brazil, China, India, Indonesia, Malaysia and Mexico

Annexes

Annex I: Technology deployment index: measuring country technology absorption capacity

While considerable efforts have been expended on measuring STI performance among developed economies, the measurement approaches often do not take into consideration the specificities of less developed African economies. One of these approaches is the technology achievement index (TAI), which is a composite index used by the United Nations Development Programme (UNDP) to reflect a country's capacity for technology creation and diffusion, and for building a human skills base and participation in the technological innovation activities of the modern knowledge economies. The TAI accordingly focuses on four dimensions of technological capacity: the creation of technology, the diffusion of recent innovations, the diffusion of old innovations and human skills.[39] The composite index helps a country to situate itself relative to others, especially those farther ahead. Many elements make up a country's technological achievement, but an overall assessment is more easily made based on a single composite measure rather than on dozens of different measures. Like other composite indices such as the UN Human Development Index**,** Desai and others (2001) explained that the TAI is intended to be used as a starting point for an overall assessment of technology performance, which would be followed up by examining different indicators of technology performance in greater detail.

Although the appropriateness of composite indicators for arriving at informed policy conclusions is continuously debated, it is still recognized as an important tool for cross country comparisons of progress in important social and economic variables. The OECD (2008) highlighted some drawbacks of composite indicators, including:

- Tendency to send misleading messages if the indicators are poorly formulated
- Arriving at simplistic policy conclusions
- Process of formulating the indicators may lack transparency or statistical and conceptual principles
- Indicators may be incorrectly used to support desired policy
- Lack of transparency may also disguise serious failings in the system, making corrective efforts difficult
- Difficulty in measuring important variables could lead to the omission of vital indicators and the formulation of inappropriate policies

39 http://www.insme.org/glossary/technology-achievement-index-tai.

However, when composite indicators are properly formulated, OECD (2008) identified the following benefits:

- Ability to summarize complex, multi-dimensional realities with a view to supporting policymakers
- Easier to interpret than explaining individual indicators
- Progress of countries can be assessed over time
- Issues of country performance and progress can be placed at the centre of the policy arena
- Helps to develop and underpin narratives for lay and literate audiences
- Enables users to compare complex dimensions effectively

The TAI adequately captures the objective for which it was developed: evaluating progress made by developed countries and middle income developing countries towards the achievement of technological goals. However, it fails to address the fundamental technological realities, prospects and challenges within developing countries (particularly African economies). This limits its application in most developing countries. For instance, while technological diffusion (both old and new) and the development of human skills are crucial for both medium- and long-term "catching-up" by African countries, technological creation might not be appropriate or relevant because most countries in Africa lack the R&D capacity required for the much-desired leapfrogging towards technological frontiers.

Moreover, the indicators (the number of patents granted to residents per capita and receipts of royalties and license fees from abroad per capita) that are used in the TAI to calculate the technology creation index are insignificant in most African countries. As shown in table II.A1 for patent applications, the few possible exceptions are Egypt, Morocco and South Africa. This suggests that substantial technology creation in African countries is still grossly lacking. In spite of this, there is evidence showing that innovative activities which might not be represented by these indicators are going on in African countries. This weakness in the TAI was clearly stated in its development. Desai and others (2001) noted that the availability of data played a vital role in the choice of indicators for estimating the TAI, and that limitations in data must be taken into account when interpreting TAI values and rankings. Some countries may have undervalued innovations because patent records and royalty payments are the only systematically collected data on technological innovation, and omit valuable but non-commercialized innovations such as those occurring in the informal sector and in indigenous knowledge systems.

Table II.A1

Patent applications by selected countries (2003-2016)

Origin	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Africa	3404	3616	3966	2359	3258	3442	3243	3475	4747	5120	4359	6302	5843	8830
Angola	NA	NA	NA	NA	NA	NA	1	NA	4	1	3	2	4	3
Egypt	505	405	457	44	647	551	547	684	728	796	760	883	836	1052
Ghana	2	1	4	1	3	1	3	1	NA	3	21	5	NA	117
Kenya	37	39	40	54	52	67	56	81	160	143	181	160	179	202
Morocco	10	112	146	180	211	196	150	183	192	211	354	368	308	263
Nigeria	4	3	6	3	6	4	22	40	81	52	64	11	60	13
Sierra Leone	4	4	2	1	1	NA	NA	NA	2	1	NA	3	1	NA
South Africa	1540	1802	2109	1913	2063	2099	1964	1996	1763	1688	2211	2317	2076	4087
Togo		48	32							32		51		170
Tunisia	46	56	62	86	98	105	126	126	152	190	218	176	218	270
Uganda	6	12	3	11	7	NA	NA	1	2	4	10	7	11	17
Zambia	20	2	5	4	20	26	9	5	4	8	14	15	1	1
Brazil	4451	4814	4920	4969	5393	5521	5420	5735	6359	6603	6848	6712	6554	7208
China	58757	69017	97948	129290	161308	204268	241434	308326	436170	561408	734096	837817	1010448	1257202
India	5370	6728	8028	9434	10529	11546	11939	14869	15896	18202	20908	22445	23946	25795
Republic of Korea	112754	136438	162694	173301	176336	173496	170233	178654	187747	203836	223527	230553	238045	233625

NA – Not Available.

Source: WIPO statistics database (2017).

Apart from the fact that patent applications and receipts of royalties and licenses (as a measure of technology creation) are generally poor in Africa, investments in STI which would translate into knowledge and technological creation are also inadequate. For instance, AfDB (2013)[40] observed that, while Africa accounts for 13.4 per cent of the world's population, it produces only 1.1 per cent of the world's scientific knowledge. The report identified low investment in research and development as the main reason for this poor performance.

From the foregoing it emerges that estimating technology creation for many African countries using the TAI formula is practically impossible. Moreover, calculating the TAI for African countries would not provide an index that underscores the uniqueness of their economies. Most African economies are more involved in adapting already existing technologies than in creating new ones. A majority of R&D investments, both at firm and national level, are accordingly focused on adapting existing technologies (mainly imported) for productive activities in the economies. This necessitates the proposal of a modified TAI index considering the technological adaptation index, which is more relevant than a technological creation index in such cases. Besides, in adapting already existing technologies, a premium should be placed on the inputs needed to modify existing technologies, rather than on their outcomes and achievements.

Whereas the TAI focuses on outcomes and achievements rather than on effort and inputs, we propose for Africa a more relevant technological deployment index (TDI). A TDI would need to use indicators that depict the effort and inputs used in adaptive R&D. Such efforts would include the "formalization" of indigenous knowledge to address the individuality of each African economy, the restructuring of tertiary institutions' curricula to build the adaptive potentials of graduates for existing technologies, and the strategic importation of capital goods to promote industrialization and industrial competitiveness.

Another major methodological flaw in the TAI as identified by Srijit and others (2013) is the use of the linear averaging (LA) method in its calculation. The basic assumption underlying the LA approach is the perfect substitutability of its indicators. This assumption means that a differential improvement (or increment) in one indicator at any value can be substituted for or neutralized by an equal differential decline (or decrement) in another indicator at any other value. This assumption is understandable when used in the case of the same parameters, as when rice that is produced in different plots of land is added up to calculate the yield per unit of land. Linear averaging accordingly essentially proceeds along one-dimensional lines by treating as the same or similar the parameters of different dimensions, which are in principle perfectly substitutable. By using linear averaging in the construction of the TAI, it is assumed that technology creation and the diffusion of old and new innovations, and human skills are perfectly substitutable (Srijit and others, 2013).

Hence, adopting a variant of the methodology used in developing the TAI, we propose that the technology deployment index would, like the TAI, cover the following four dimensions: technology adaptation, the diffusion of recent innovations, the diffusion of old innovations, and human skills. The indices for the diffusion of recent innovations and the diffusion of old innovations and human skills are the same as those used in calculating the TAI. However, the technology adaptation index would be calculated using R&D intensity and imports of capital goods.

40 http://www.afdb.org/en/news-and-events/article/afdb-approves-us-45-million-grant-for-creation-of-pan-african-university-for-science-technology-and-innovation-12155/.

The choice of R&D intensity and capital goods imports for computing the technology adaptation index is informed by at least two factors. First, as shown in table II.A2, imports of capital goods by most African countries have increased since the start of the millennium. Africa is the only region that spends ten times more on imports of capital goods than it earns from the export of similar goods. This reveals that Africa is not a major producer of capital goods. Moreover, the structure of Africa's exports has remained largely unchanged over the past two decades. This implies that African countries' adoption of already existing technologies for production activities has consistently increased over that period. On the other hand, Asia has joined Europe as a net exporter of capital goods, while exports of capital goods from Latin America and the Caribbean have grown at the same speed as those from Asia (a threefold increase) (United Nations, 2010).

Table II.A2
Imports of capital goods by selected African countries

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Algeria	1,432	1,678	2,144	2,643	3,489	3,583	3,540	4,381	5,684	6,812	6,917	7,215	6,029	7,360	9,152	8,874
Egypt	na	na	na	na	na	na	na	na	6,201	5,853	5,801	5,280	5,598	6,490	6,460	7,264
Ethiopia	194	235	236	395	447	690	777	1,097	1,493	1,462	1,477	1,440	1,958	2,538	3,239	4,125
Gambia	na	na	7	9	13	21	23	26	18	18	12	24	27	14	20	na
Kenya	414	439	336	364	505	580	777	1,067	1,473	1,446	1,869	na	na	2,262	na	na
Morocco	1,739	1,401	1,462	1,841	2,365	2,668	2,908	3,793	5,056	4,441	4,120	4,085	3,990	3,952	3,705	3,062
Nigeria	851	1,096	1,815	2,676	na	na	5,235	5,463	6,280	5,241	6,999	7,508	5,194	5,948	7,888	na
Senegal	155	168	190	201	260	309	391	424	629	531	459	534	602	624	639	721
South Africa	5,089	4,749	5,007	6,326	8,500	10,000	12,307	14,088	15,322	11,286	13,778	17,270	17,275	17,866	16,253	13,314
Tunisia	1,177	1,293	1,176	1,315	1,499	1,494	1,621	1,976	2,534	2,587	2,824	2,704	2,462	2,404	2,533	2,040
Tanzania	228	308	264	299	347	411	639	666	928	1,012	948	1,356	1,216	867	1,273	1,176

na – Not available

Source: Comtrade database, 2017

Secondly, in most cases, firms engage in R&D to adapt these technologies to suit the production environment of their country. Corroborating the need for adaptive R&D, UNCTAD (2012) noted that a country can generally import capital goods while it is able to pay for them. However, what remains important for productivity growth is the extent to which such imports are effectively channelled into generating future income. This relates to how firms and sectors are able to adapt and use the technologies included in these imports to generate productivity growth.

Whereas the TAI aggregated all economies in its technology creation estimation,[41] two important distinctions were made in calculating their TDI. First, countries are grouped into net exporters or importers of capital goods. Only net importers are included in developing the technology adaptation index. This distinction is crucial, as net exporters are assumed not to be involved in any significant technology adaptation efforts. It also provides an intuitive basis for measuring adaptation progress and making comparisons among similar economies.[42] The second distinction is that the R&D intensities observed in the different countries are not interpreted in the same way for net exporters and net importers of capital goods. For net exporters, R&D intensity is interpreted as research efforts for technology creation. On the other hand, R&D intensity for net importers of capital goods is intuitively assumed to mean research efforts aiming at technology adaptation. Moreover, since available information and data (particularly patent applications) in African countries suggest that there have been few or no efforts to create technology, data on R&D intensity in these countries could be interpreted to mean adaptive R&D.

Model specification for technology deployment index (TDI)

Taking into consideration the limitations of the linear averaging (LA) approach of the TAI, the TDI would be estimated using the more recent geometric mean aggregation method. The geometric mean does not allow for perfect substitutability, gives higher importance to the dimension with lower performance, and penalizes unbalanced development.[43]

The TDI has four dimensions, each of which consists of two indicators. It recognizes that there are other variables that could be included in measuring technology adaptation.[44] However, the choice of only two indicators is mainly due to the unavailability of data. The non-measurability of some other indicators that could otherwise have been used in calculating technology adaptation is also an important limitation of the TDI.

We apply the methodology used in developing the UN Human Development Index in the model specification for the TDI. The values of the different indicators are normalized to a scale from 0 to 1 using goalposts, in such a manner that an indicator value that is equal to the upper goalpost will be normalized to 1, while a value to the lower goalpost will be normalized to 0. The indices are normalized using the general formula:

41 No clear distinctions were made between developed and developing economies and net exporters or importers of technology. Hence, the TAI calculation assumes that all countries are similar in their priorities for technology investments and achievements.

42 That is, economies that belong to the same net importing group.

43 The geometric mean approach was recently adopted in 2010 in the 20th anniversary edition of the UN Human Development Report. For more discussion on the geometric mean see Gidwitz and others (2010); Herrero and others (2010); and Kovacevic and Aguna (2010).

44 For instance, the extent to which indigenous knowledge is used in technology adaptation, and the natural and man-made assets facilitating adaptation and the investment environment.

$$\text{Index} = \frac{\text{actual value}_i - \text{observed minimum value}_j}{\text{observed maximum value}_k - \text{observed minimum value}_j}$$

where index = index of the indicators in each dimension

actual value_i = value observed for the country of interest

indicator_j = minimum value observed for a given indicator across countries

indicator_k = maximum value observed for a given indicator across countries

Technology adaptation index (TAI): this is measured by the R&D intensity of countries and imports of capital goods by countries.

$$\text{R\& D intensity index} = \frac{\text{R\& D intensity}_i - \text{R\& D intensity}_j}{\text{R\& D intensity}_k - \text{R\& D intensity}_j}$$

$$\text{Imports of capital goods index} = \frac{\text{capital goods import}_i - \text{capital goods import}_j}{\text{capital goods import}_k - \text{capital goods import}_j}$$

Diffusion of recent innovations index: this is measured by the number of Internet hosts per capita and the proportion of high-and medium-technology exports in total goods.

$$\text{Internet host index} = \frac{\text{internet host}_i - \text{internet host}_j}{\text{internet host}_k - \text{internet host}_j}$$

$$\text{High - technology and medium - technology index} = \frac{\text{High - technology and medium - technology}_i - \text{High - technology and medium - technology}_j}{\text{High - technology and medium - technology}_k - \text{High - technology and medium - technology}_j}$$

$$\text{Diffusion of recent innovations index } (RI) = \frac{\text{Internet host index} + \text{high-technology and medium-technology index}}{2}$$

Diffusion of the old innovations index: this is measured by telephones (mainline and cellular) per capita and electricity consumption per capita.

$$\text{Telephony index} = \frac{\text{log telephones}_i - \text{log telephones}_j}{\text{log telephones}_k - \text{log telephones}_j}$$

$$\text{Electricity index} = \frac{\text{log electricity per capita}_i - \text{log electricity per capita}_j}{\text{log electricity per capita}_k - \text{log electricity per capita}_j}$$

$$\text{Diffusion of old innovations index (OI)} = \frac{\text{Telephony index} + \text{Electricity index}}{2}$$

Human skills index: This is measured by the mean years of schooling in the population for those aged 15 and older, and the gross tertiary science enrolment ratio.

$$\text{Mean years of schooling index} = \frac{\text{Mean years of schooling}_{i} - \text{Mean years of schooling}_{j}}{\text{Mean years of schooling}_{k} - \text{Mean years of schooling}_{j}}$$

$$\text{Gross tertiary science enrolment index} = \frac{\text{Gross tertiary science enrolment}_{i} - \text{Gross tertiary science enrolment}_{j}}{\text{Gross tertiary science enrolment}_{k} - \text{Gross tertiary science enrolment}_{j}}$$

$$\text{Human skills index (HS)} = \frac{\text{Mean years of schooling index} + \text{Gross tertiary science enrolment index}}{2}$$

Technology deployment index (TDI): TDI is computed as the geometric mean of the four indices calculated above. TDI is thus given as follows:

$$\text{TDI} = \left(\text{TA x RI x OI x HS}\right)^{1/4}$$

Annex II: Questionnaire for the survey of country STI projects and programmes

United Nations
Economic Commission for Africa

Country science, technology and innovation readiness/profiles

Questionnaire on STI projects and programmes

This questionnaire is designed to collect data/information on science, technology and innovation (STI) projects and programmes in ..... (*country*). Data/information obtained through this questionnaire is to be kept confidential and used only for research and the preparation of country STI readiness reports/profiles. The main objective of the country STI readiness report is to review country level economic and innovation performance with a view to providing insights on the nature and scope of investments in STI that are required for economic growth and competitiveness. The following are guides for the completion of the questionnaire:

1. Only one questionnaire is to be completed by the respondent institution or agency

2. Please return the completed questionnaire before ..... (*date*). The completed questionnaire should be submitted by email to ..... (email of country STI readiness report's team leader).

3. The questionnaire should be completed by the following categories of institutions involved in STI development and/or investment:

(a) Institution responsible for science, technology and innovation (STI) policy or STI statistics (e.g. Ministry of Science and Technology, Ministry of Research and Higher Education, National S&T Council, or a similar organization).

(b) National industry association;

(c) Non-governmental organization(s) with an interest in STI policy advocacy.

4. Data reported in this questionnaire should cover all major STI projects and programmes that you know of in your country. If this is not the case, please indicate which information has not been supplied, with an explanation, using the space provided for comments.

Section A: Respondent information

1. Family name (surname): .....
2. First name: .....
3. Gender (male/female): .....
4. Job title (or position): .....
5. Department, division or sector: .....
6. Name of organization: .....
7. Address: .....
8. City/town: .....
9. Postal code: .....
10. Telephone: .....
11. Mobile telephone line: .....
12. E-mail: .....
13. Institutional website: .....

Section B: General information

1. Type of institution (*tick only one option*)

- ☐ Public organization (national government ministry, department or agency)
- ☐ Research council
- ☐ Higher education
- ☐ Private enterprise
- ☐ Private non-profit
- ☐ Other (describe):

2. Primary activities of the institution *(tick **all** that apply)*:

- ☐ STI policy
- ☐ Research and development
- ☐ Higher education
- ☐ Technology promotion and transfer
- ☐ S&T services
- ☐ STI collaboration with foreign partners
- ☐ Official statistics
- ☐ Other (describe):

3. Does your institution periodically publish STI statistics or indicators?Yes No

(If yes, please attach to an email or post copies of your most recent STI publications.)

4. Principal responsibility of your institution regarding STI statistics *(select only one option)*:

- ☐ National coordination
- ☐ Sectoral coordination

Section C: STI policy

1. Does your country have an STI policy?Yes No

2. If yes, when was it adopted or launched? .....

3. Is the policy the first such policy or a revision of a previous policy?

☐ First policy ☐ Revised policy

4. State the main objectives or goals of your STI policy:

.....

.....

.....

.....

.....

5. What is the institutional framework for STI policy implementation?

☐ Implementation by existing government agencies *(provide names)*:

.....

☐ Implementation through private sector involvement *(provide names of key private sector agents)*:

.....

☐ Implementation through involvement of foreign partners *(provide names of key foreign partners)*:

.....

☐ Implementation through collaborative efforts of agents in public and private sectors *(provide names of key agents collaborating)*:

.....

☐ Other*(describe)*:

.....

6. What are the main drivers of STI policy implementation? (*tick **all** that apply*):

- ☐ Achieving sustainable economic growth and competitiveness
- ☐ Improving labour markets for the STI workforce
- ☐ Enhancing interaction between science and society
- ☐ Improving interaction between universities and other research institutions and industry
- ☐ Government support for STI investments (e.g. R&D tax incentives, venture capital, endowment of chairs for research)
- ☐ Prioritization of global competition (desire to make local firms globally competitive)
- ☐ Desire to upgrade technology and improve local technological capability
- ☐ Poverty reduction, disease prevention and social inclusion
- ☐ Environmental protection and conservation
- ☐ Promotion of diffusion of renewable energy technologies
- ☐ Promotion of greening of industry and green growth
- ☐ International scientific collaboration and broadening of countries' access to science and technology
- ☐ Comparative advantage conferred by indigenous knowledge
- ☐ Other, please specify

.....

7. What are the main obstacles or barriers to STI policy implementation? (*tick **all** that apply*):

- ☐ Weak infrastructure for R&D
- ☐ Poor funding of R&D activities
- ☐ Low level of R&D skills
- ☐ Lack of good governance
- ☐ Lack of political will for policy implementation
- ☐ Lack of interaction between researchers and industrialists
- ☐ Inherent weakness of STI policy
- ☐ Inadequate stakeholder participation in the preparation of STI policy
- ☐ The absence of relevant indicators for monitoring and evaluating STI policy implementation performance
- ☐ Other, please specify

.....

8. What were the key achievements of STI policy implementation in the past four years?

.....

.....

.....

.....

.....

.....

9. What were the main success factors?

.....

.....

.....

.....

.....

.....

10. In order of your rating of the level of success achieved, list the key STI projects and programmes implemented in the past four years.

.....

.....

.....

.....

.....

.....

Section D: STI projects and programmes

Complete the form below for four important STI initiatives (i.e. projects and programmes) implemented in your country in the past four years. (***Please attach or send any publication or documentation that may provide additional information on your responses or descriptions***).

Item	Description
Project or programme name	
1. Start date or year	
2. Status (ongoing or completed)	
3. Project/programme objectives	
4. Sectoral focus of project/programme	
5. Stakeholders involved	
6. Type of technology involved (indigenous, local, foreign, mixed – describe the nature)	
7. Source of technical skills involved (mainly local, mainly foreign, equally local and foreign)	
8. Source of technology equipment/artefact (mainly local, mainly foreign, equally local and foreign)	
9. Source of finance (public, private, both public and private)	
10. Type(s) of innovation generated (process, product, organizational, marketing)	
11. Type of market involved or society engaged	
12. Linkages and interactions (informal-formal sectors, foreign-local, MSMEs-large firms, research-industry)	
13. Energy source (conventional non-renewable, renewable energy technology)	
14. Learning opportunities and prospects for up-scaling	
15. Project or programme outcomes (economic and social impacts: job creation, wealth creation, greening)	

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Part Three: Policy research report

III.A – Pilot study —Nigeria[45]

Science, technology and innovation readiness/STI profile: Nigeria[46]

1. Review of economic and innovation performance

1.1 Introduction

Nigeria is the most populous country in Africa, with an estimated population of 194 million people in 2017.[47] It is classified as the largest economy in Africa, with an estimated GDP of more than $400 billion in 2016.[48] With a total land area of about 924,000 km^2, Nigeria is the thirty-second largest country in the world. It also has a long coastline spanning 853 km. Nigeria's land mass is irrigated by several rivers and streams providing opportunities for economic activities that require freshwater. About 1.4 per cent of Nigeria's land mass is covered by rivers/streams and natural and man-made reservoirs. Vegetation stretches from mangrove and rain forests in the south to the Guinea savanna in the middle belts, and the Sudan and Sahel savannah in the north. In recent decades the encroachment of the Sahara Desert in the north, and gully erosion due to intensive rains, especially in the southeast, have posed significant economic and social challenges. Nonetheless, Nigeria is adjudged to be a country rich in biodiversity, and with an ecological makeup that confers significant economic advantages.

The economy is still mainly agrarian and dominated by subsistence agriculture. The agricultural sector is the largest employer of labour, accounting for about 24 percent of GDP in 2016[49]. Crude oil and natural gas although accounting for about 10 per cent of GDP, dominate export earnings, accounting for 95 per cent of foreign exchange earnings and 85 percent of government revenue in 2012.

Although it recorded very impressive rates of economic growth from the beginning of the millennium, the Nigerian economy contracted significantly in late 2015 and growth rate fell into negative territory for five consecutive quarters. Growth has resumed and Nigeria has exited recession. According to data made available by the National Bureau of Statistics (NBS), the economy grew by 1.4 per cent year-on-year in the Third Quarter of 2017. Resumption of growth has been attributed to three main factors: improved availability of foreign currency to finance raw materials imports; increased public spending, and higher oil production.

Adeoti and others (2010), identify five distinct periods in the macroeconomic performance

45 This pilot study was prepared by John Adeoti, Odunayo Adebayo and Augustine Osigwe of the Nigerian Institute of Social and Economic Research (NISER), Ibadan, Nigeria. It was revised and updated by the New Technologies and Innovation Section, ECA.

46 The data in this section may not be current. Where possible and available more up-to-date data have been used in the analysis.

47 http://countrymeters.info/en/Nigeria.

48 IMF Nigeria Portal

http://nigeria.opendataforafrica.org/tbocwag/gdp-by-country-statistics-from-imf-1980-2022?country=Nigeria.

49 Central Bank of Nigeria as reported in the Vanguard Newspaper of 12 April 2016 available at https://www.vanguardngr.com/2016/04/agric-accounts-24-gdp-says-cbn/.

of Nigeria, each reflecting significant shifts in economic management:

- Immediate post-independence period starting from 1960 to the advent of the first military government in 1966;
- Post-civil-war oil economy starting from the end of the 30-month civil war in 1970 to the military's handover of government to civilians in 1979;
- Transition to economic austerity that emerged in the second republic, and the subsequent adoption of the World Bank/IMF led economic structural adjustment programme (SAP) in 1986;
- The era of SAP and guided economic liberalization starting from 1986 to the advent of the new democratic dispensation in1999;
- The policy of further economic liberalization starting from 1999, resulting in emergent macroeconomic stability in recent years.

Table IIIA.1, consistent with this periodization, shows the key performance indicators of the Nigerian economy in a historical perspective from 1960 to the present (in the light of presently available data).[50] The period from 1960 to 1979 generally witnessed rapid industrial growth, largely due to import-substituting industrialisation aided by the oil economy. While the growth rate of value-added manufacturing soared in the 1960s and 1970s, the 1980s were a period of industrial decline. Manufacturing value-added growth, which was 46.9 per cent in 1979, declined to minus 3.9 per cent in 1986, reflecting the de-industrialization phenomenon which was widespread in sub-Saharan Africa (Jalilian and others, 2000).

Economic decline was halted and reversed at the beginning of the 1990s following a rigorous and vigorous implementation of policies to structurally adjust the economy. By 1999 the growth rate of value-added manufacturing had improved to 2.1 per cent; it further improved to 9.6 per cent and 7.9 per cent in 2005 and 2009 respectively. However, in spite of improvements in the growth rate of value-added manufacturing, the manufacturing sector remained relatively small, accounting for only 2.9 per cent and 4.0 per cent of GDP in 2005 and 2009 respectively. It rose to 9.75 per cent in 2014 and declined marginally to 9.53 in 2015[51].

Table IIIA.1 also demonstrates that the economy has been very dependent on the import of manufactured goods, while the export of manufactured goods has remained relatively small. The two major components of manufactured imports are: consumer goods and capital goods imports. Consumer goods imports, when disaggregated, show the imported basic manufactured goods that Nigeria could import-substitute. Three factors help explain the rise in the proportion of manufactured goods in merchandise imports: the rising middle class with a taste for imported commodities; trade liberalization; and the lack of competitiveness of the Nigerian manufacturing sector. The manufactured exports are composed largely of agro-food consumer products and intermediate products which signify that Nigerian manufacturing is mainly low technology.

50 1960 was the year of political independence; 1966 was the year of the first military adventure into political governance; 1970 was the end of the civil war; 1979 was the beginning of the second attempt at democratic governance; 1986 was the year of the introduction of the World Bank/IMF economic structural adjustment programme, and 1999 was the beginning of the current democratic dispensation.

51 World Bank World Development Indicators available at http://data.trendeconomy.com/dataviewer/wb/wbd/wdi?ref_area=NGA&series=NV_IND_MANF_ZS.

Of particular note is the influence of oil revenue on the Nigerian economy. The post war economy was dominated by the oil economy, arising from the unprecedented increase in the price of crude oil in the international market, especially in the early and late 1970s. The oil boom enabled an expansion in infrastructure and public sector investment in large-scale manufacturing concerns, most of which were aimed at achieving import substitution of foreign consumer goods and consumer durables. As reported by NBS (2009), oil exports as a percentage of total exports rose from 58 per cent in 1970 to 83 per cent in 1973, and to about 90 per cent or more in subsequent years. Similarly, oil revenue as a percentage of total government revenue rose from 26 per cent in 1970 to 54 per cent in 1972, and to 60 per cent or more in subsequent years. According to the NBS, in 2016, petroleum exports revenue represented over 90 per cent of total exports revenue.

The oil economy was characterized by the phenomenon referred to by economists as "Dutch disease", signified by the appreciation of the Nigerian naira and the diversion of productive resources away from agriculture in particular into commercial activities that thrived on trade in imported manufactured goods. Moreover, a rapid expansion of State expenditure took place without a systematic framework for prioritizing the allocation of public expenditures.

The first National Development Plan (1962-1968) was Nigeria's first attempt at a comprehensive and integrated economic development blueprint.[52] This was succeeded by three subsequent development plans for the periods 1970-1974, 1975-1980, and 1981-1985. In 1985, Nigeria, against a backdrop of serious economic decline, organized a national debate on whether the country should accept a US$2.4 billion loan from the International Monetary Fund (IMF). The debate showed Nigerians overwhelmingly opposed to the loan leading the government of the day to cancel efforts to obtain the IMF loan and to instead impose a raft of tough home-grown economic structural adjustment policies (SAP) with the objective promoting economic efficiency and private sector development as a basis for improving prospects for long-term growth. These policies resulted in the resumption of growth, with the economy growing at 5 per cent on average per annum between 1986 and 1992.[53]

As reported by Sackey (2011), the SAP was effectively implemented up to 1988, and by the beginning of the 1990s had transited into a regime of three-year rolling plans[54], which in the late 1990s were reduced to only annual plans or annual budgeting. The return to democratic governance in the early 2000s revived the planning tradition by launching the First National Economic Empowerment and Development Strategy (NEEDS, 2004-2006); the Second National Economic Empowerment and Development Strategy (2007-2009); and the Nigeria Vision 20:2020, which has a broad objective of economic transformation that aims to result in Nigeria becoming the twentieth largest world economy by the year 2020.

52 Previous colonial plans were the ten-year plan of 1946, and the 1955-1960 plan. As reported by Bevan and others (1999), these plans were regarded as grossly deficient as instruments of development, and were reminiscent of shopping lists for government departments.

53 See World Bank (1994) Nigeria Structural Adjustment Programme: Policies, Implementation, Impact at http://documents.worldbank.org/curated/en/959091468775569769/pdf/multi0page.pdf.

54 There were only two three-year rolling plans: the first, for 1990-1992; and the second, for 1993-1995.

Table IIIA. 1

Nigeria's key economic performance indicators, 1999 – 2016

Economic performance indicators	1999	2005	2010	2011	2012	2013	2014	2015	2016
GDP (constant 2010 US$) (in billion USD)	149.52	260.52	369.06	387.10	403.67	425.44	452.28	464.28	457.13
GDP growth (annual %)	0.47	3.44	7.84	4.89	4.28	5.39	6.31	2.65	-1.54
GDP per capita (constant 2010 US$)	1253.05	1875.03	2327.32	2376.64	2412.86	2475.95	2563.09	2562.52	2457.81
Manufactures imports (% of merchandise imports)	66.56	n/a	86.45	54.03	72.00	57.32	64.11	n/a	n/a
Manufactures exports (% of merchandise exports)	0.60	n/a	6.69	2.55	2.87	3.39	6.45	n/a	n/a
Manufacturing, value added (% of GDP)	4.73	2.83	6.55	7.19	7.79	9.03	9.75	9.53	8.76
Manufacturing, value added (annual % growth)	3.44	9.61	7.57	17.82	13.46	21.80	14.72	-1.46	-4.32
Agriculture, value added (% of GDP)	35.31	32.76	23.89	22.29	22.05	21.00	20.24	20.86	21.18
Agriculture, value added (annual % growth)	5.29	7.06	5.82	2.92	6.70	2.94	4.27	3.72	4.11
Services, etc., value added (% of GDP)	26.84	23.74	50.79	49.36	50.63	52.97	54.82	58.76	60.36
Services, etc., value added (annual % growth)	3.38	11.10	12.40	4.90	3.97	8.38	6.85	4.78	-0.82

Source: World Development Indicators database (2017)

1.2 Economic growth performance

The macroeconomic performance of Nigeria, summarized in tables IIIA.2 and IIIA.3, was generally unimpressive in the 1980s and 1990s. Economic performance in the first decades of the 2000s improved remarkably, as is shown by significant improvements in GDP, GDP per capita, private and public consumption ratios, domestic savings, and the debt to GDP ratio. Remittances also became an important source of foreign exchange inflows. Nigeria's population growth rate has, according to the World Bank, stabilized around 2.6 per cent since 1983.[55] The stabilization of the population growth rate may be due to a number of factors, including reductions in infant and under-five mortality rates, a successful advocacy campaign for family planning and a significant improvement in the education of young girls.

As noted earlier, Nigeria's economy contracted in the early 1980s although growth resumed from about 1986. But generally, this period was characterized by widespread unemployment, a decline in industrial production, capital flight, exchange rate volatility, and decline in human capital stock, especially through the emigration of highly skilled professionals and scientists. Rapid growth resumed in the late 1990s and remained reasonably high (at 7.4% p.a. in 2014) until the country went into a recession in 2015. The consequence of the resumption of growth was a gradual rise of real per capita income from $300 in 1999 to $3,221 in 2014 before falling to $2175 in 2016.[56] A key feature of macroeconomic management is the location of economic policy and reform under the purview of an economic management team that reports directly to the President.

55 https://data.worldbank.org/indicator/SP.POP.GROW.

56 https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=CN-NG&year_low_desc=false.

Table IIIA.2

Trends in Nigeria's macroeconomic indicators

Macroeconomic indicators	1980	1985	1990	1995	2000	2005	2010	2012	2015
GDP (constant 2010 US$) (billion)	143.77	124.54	130.94	134.23	157.47	260.52	369.06	403.67	464.28
Population, total (million)	73.70	83.90	95.62	108.42	122.88	139.61	159.42	168.24	182.20
GDP per capita (constant 2010 US$)	1950.80	1484.31	1369.44	1238.00	1281.56	1866.01	2314.96	2399.33	2548.17
GDP per capita index (1980=100)	100.00	76.09	70.20	63.46	65.69	95.65	118.67	122.99	130.62
Private consumption (% of GDP)	n/a	67.04	62.95	69.08	52.55	75.16	66.12	58.39	77.96
Public consumption (% of GDP)	n/a	12.73	4.96	12.09	8.34	6.81	8.71	8.20	6.69
Gross domestic investment (% of GDP)	n/a	11.36	14.43	7.08	7.03	5.47	17.29	14.91	15.49
Private (% of GDP)									
Public (% of GDP)									
Gross domestic savings (% of GDP)	n/a	20.23	32.09	18.84	39.11	18.03	25.17	33.41	15.36
Exports of goods and services (% of GDP)	29.38	17.39	35.34	35.76	51.73	31.66	25.26	31.44	10.66
Imports of goods and services (% of GDP)	19.20	8.51	17.69	24.01	19.65	19.09	17.39	12.94	10.79
AID (million USD)	34.40	31.71	255.08	210.96	173.70	6408.81	2057.80	1911.66	_
AID per capita	0.47	0.38	2.67	1.95	1.41	45.90	12.91	11.36	_
AID (% of GDP)	0.00	0.00	0.01	0.01	0.00	0.06	0.01	0.00	_
Remittances, (billion USD)	0.03	0.07	0.14	0.30	0.54	0.42	0.69	1.21	1.56
Debt service (% of exports of goods, services and primary income)	1.81	28.32	22.25	14.05	8.21	15.41	0.36	0.25	n/a

Source: WDI (2017)

Table IIIA.3
Nigeria's macroeconomic indicators (average annual growth rates)

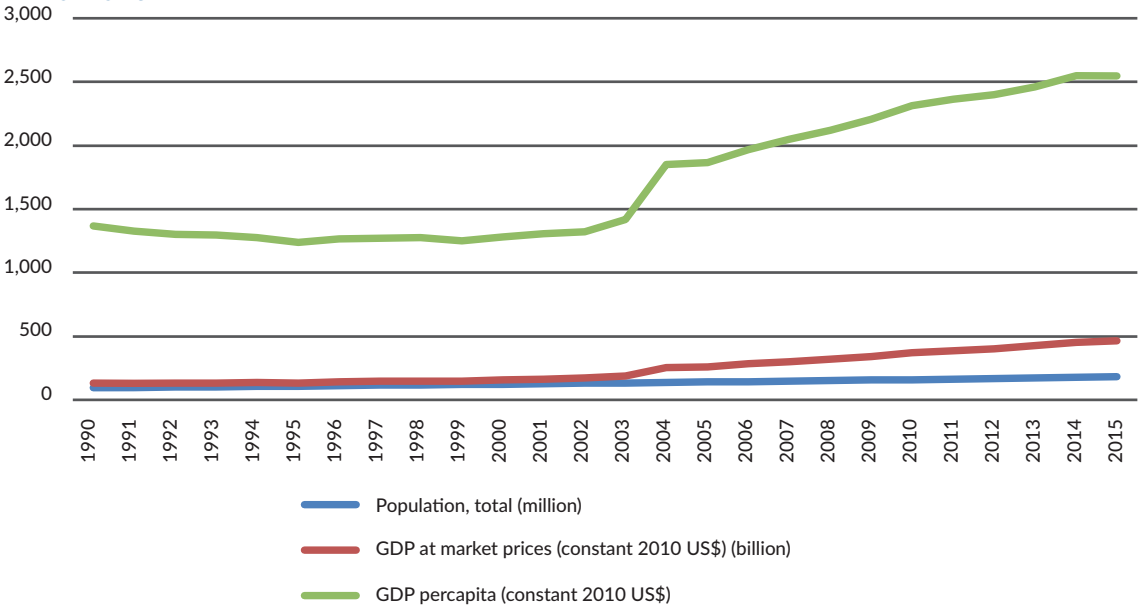
Macroeconomic indicators	1980-1984	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2012
GDP (in constant US$ 2005)	-5.31%	-1.37%	0.70%	2.75%	2.58%	4.26%	5.22%
Population, total	2.63%	2.66%	2.55%	2.53%	10.23%	1.55%	2.72%
GDP per capita (in constant US$ 2005)	-7.74%	-3.93%	-1.80%	0.21%	10.48%	18.71%	2.43%
GDP per capita index (1980=100)	-7.74%	-3.93%	-1.80%	0.21%	10.48%	18.71%	2.43%
Private consumption	4.87%	-3.97%	0.80%	2.43%	-3.11%	24.60%	2.86%
Public consumption	-2.38%	-16.64%	51.18%	-7.47%	4.08%	11.66%	-7.09%
Gross domestic investment	-20.56%	3.99%	-5.75%	0.51%	-9.32%	2.45%	-2.07%
Private*							
Public*							
Gross domestic savings	-9.27%	25.32%	-13.58%	206.76%	-11.64%	15.22%	0.16%
Resource balance**							
Exports of goods and services	-13.63%	39.05%	-7.50%	1.22%	10.32%	-2.54%	-4.02%
Imports of goods and services	-15.43%	19.99%	2.47%	2.02%	40.29%	3.47%	-5.01%
Aid	1.55%	91.40%	-5.34%	-7.07%	-7.94%	-33.33%	6.03%
Remittances	50.93%	46.12%	11.17%	0.35%	-8.55%	6.08%	13.00%
External debt	98.23%	18.53%	-1.40%	-9.63%	22.30%	6.08%	8.08%
Debt services	-12.82%	70.42%	457.57%	21.30%	22.30%	6.08%	1.36%

Source: WDI (2017).

* = Not Available

Figure IIIA.I

Trends in gross domestic product, population and gross domestic product per capita, 1990-2015



Sources: World Development Indicators 2017.

Table IIIA.4 shows the sectoral distribution of growth rates in 2015 and 2016 as an illustration of sources of growth in recent years. While growth has flattened and is sometimes negative in the oil and gas sector, the non-oil sectors have witnessed a considerable surge in growth. As in many other African countries (see ECA, 2013), the primary sector comprising agriculture and solid minerals is an important source of growth in Nigeria. The ongoing reform in the agricultural and solid mineral sectors has resulted in improved rates of growth in agriculture, and in the solid minerals sector. More pronounced growth rates are also recorded in the tertiary sector, notably in telecommunications and post, wholesale and retail trade and hotel and restaurants. Building and construction and real estate sectors have also experienced a considerable boom. In effect, the Nigerian economy has experienced dynamic growth and unprecedented change in recent years, signifying that economic management and reform during that period have impacted favourably on sustained growth and emergent economic diversification.

Table IIIA.4
Sectoral growth summary for 2015 and 2016

	2015				2016			
Sectors	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Agriculture	4.7	3.49	3.46	3.48	3.09	4.53	4.54	4.03
Mining and quarrying	-7.91	-6.62	1.13	-8.05	-2.96	-17.19	-21.64	-12.04
Crude petroleum and natural gas *	-0.15	-6.79	1.06	-8.28	-1.89	-17.48	-22.01	-12.38
Manufacturing	-0.70	-3.82	-1.75	0.38	-7.00	-3.36	-4.38	-2.54
Information and communication	9.49	6.26	5.27	4.21	4.07	1.35	1.11	1.38
Finance and insurance	9.01	6.41	6.57	6.41	-11.28	-10.82	2.64	2.68
trade	6.47	5.07	4.40	4.69	2.02	-0.03	-1.38	-1.44
construction	11.17	6.42	-0.11	-0.35	-5.37	-6.28	-6.13	-6.03
Hotels and restaurants	26.66	-8.97	-5.42	-3.55	-7.41	-6.39	-4.88	-2.74
Real estate	3.08	2.97	2.06	0.79	-4.69	-5.27	-7.37	-9.27
Real GDP growth rate (at 2010 constant price)	3.96	2.35	2.84	2.11	-0.36	-2.06	-2.24	-1.30

Note: * Crude petroleum and natural gas growth rate is subset of Mining and quarrying.
Source: Nigerian Gross Domestic Product Report (Q4 2016) table 5.

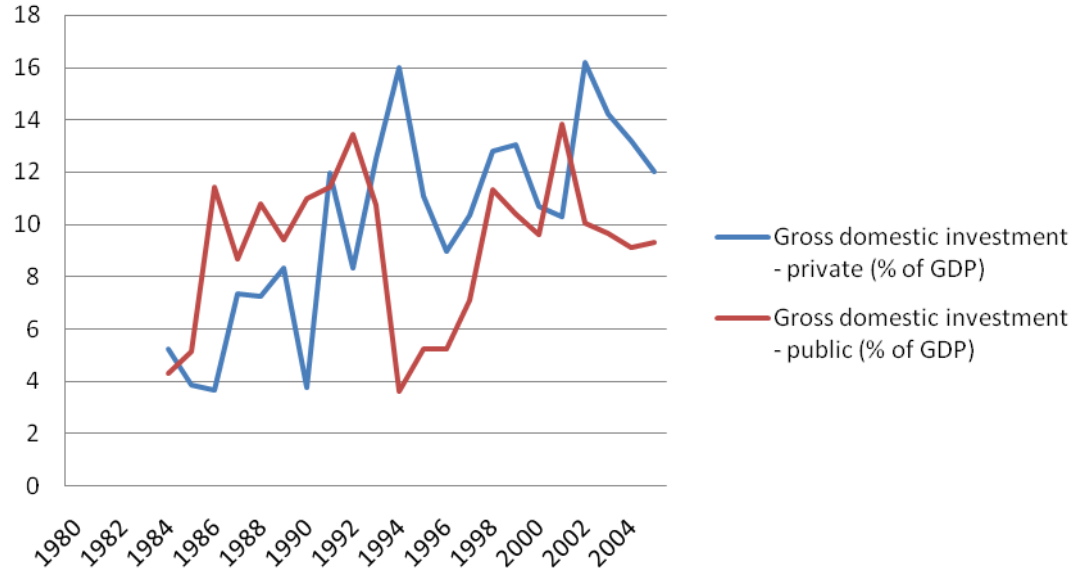
1.3 Private and public investments

As shown in figure IIIA.II, the trend in public and private investment has been highly volatile reflecting different shocks (both external and internal) to the economy. As noted earlier, the five-year development planning framework was abandoned for rolling plans in the late 1980s. Because the rolling plans were not based on a long-term vision for the economy, they were accordingly subject to frequent changes that perhaps account for the volatile nature of both public and private investment. Investment was largely public investment from the 1980s until the early 1990s. Private investment increased sharply in the early 1990s, and declined for a while in the mid-1990s, but exceeded public investment for most of the period between the early 1990s and 2005.

Public investment has also been increasing since 1995, with a slight decline between 2000 and 2005. It should be noted that the decline in both private and public investment between 2000 and 2005 is only in terms of proportion of GDP, and that the current value of private and public investments increased over the same period. Because the proportion of investment as a percentage of GDP was decreasing, and was not increasing as fast as GDP, the growth in consumption accordingly dominated investment growth in the renewed economic development of the 2000s. Such growth cannot engender structural change because of its weak productive base and its notable tendency to consume foreign goods and services.

Figure IIIA.II

Trend in private and public gross domestic investment, 1980 to 2004 (% GDP)



Sources: WDI (2010).

1.4 Structure of the economy

1.4.1 Production and economic diversification

The sectoral composition of GDP is shown in table IIIA.5 for the years 2012-2016.[57] The service sector is the largest sector of the Nigerian economy for the period under review. This is followed by industry which until 2016 when it was superseded by agriculture. The decline in industry probably reflects the difficulty that industry had in importing raw materials and other inputs due to a scarcity of foreign exchange in 2015 and 2016. followed by industry until Services is was higher than that of agriculture and manufacturing. The increase in agriculture could be due to better weather conditions and increase in domestic production as more people substituted out of high-priced imports. The agricultural sector has accounted for a significant proportion of economic growth since the mid-2000s. However, while the proportion of agriculture and services increased, the proportion of manufacturing continued its decline. Much impetus is needed to push through reforms that will rapidly increase the pace of growth in the non-oil sector, especially agriculture, including agro-processing and manufacturing.

The failure of industry to expand raises serious concerns about innovation since innovation is largely found in manufacturing. In such a situation, it is unlikely that new technologies or technological changes will emerge that enable the significant upgrading of products and processes. As evidenced by the limited data available on the technological classification of Nigerian manufacturing in table IIIA.5, manufacturing was mainly resource-based and at a low technological level in the 1990s. We do not have evidence indicative of any changes. In effect, economic growth would therefore be limited, and structural change would hardly take place.

The classification of manufacturing activities for 1980, 1991 and 1996 that is shown in table IIIA.5 is based on Lall's technology

57 National Bureau of Statistics (2017), *Nigeria Gross Domestic Product Report 2016.*

Table IIIA.5
Structure of production

	2012	2013	2014	2015	2016
Sectoral composition (% value-added)					
Agriculture*	23.91	23.33	22.90	23.11	24.43
Industry*	25.61	24.81	24.93	23.71	22.02
Services*	50.48	51.86	52.16	53.18	53.56
Technological classification of production of manufacturing activities in % (Lall/UNIDO, 2009)		**1980**	**1991**	**1996**	
High tech		2.86	5.38	6.70	
Medium tech		41.34	23.76	34.80	
Low tech		19.30	53.64	26.39	
Resource based		39.37	22.60	38.80	

Source: UNIDO INDSTAT 2 (technology classification); * Data from NBS (2017).

classification of industrial activities as presented in the UNIDO *2009 Industrial Development Report*. The data indicate that, although the proportion of manufacturing that is high technology is relatively very small, it increased gradually, from about 2 per cent in 1980 to about 7 per cent in 1996. Though there are no data to assess the trend in recent years, this would suggest that the Nigerian manufacturing industry, given the right incentives, is capable of manufacturing high technology products.

In particular, the Nigerian oil and gas industry has been a major focal point of foreign investment since the mid-1980s, with considerable efforts having also gone into attempts at making solid minerals[58] exploitation a major source of foreign exchange. In the oil and gas sector there have been calls for improvements in local content through value addition and the engagement of local oil services companies. Nevertheless, technological spillover from the oil and gas industry to other sectors is still very limited or hardly visible. The lack of mastery of the basic technology in the oil industry, after nearly 60 years of oil exploration and production in Nigeria, points to institutional weakness and inherent obstacles to efforts aimed at the transformation of the sector. The Petroleum University and the Petroleum Technology Development Fund (PTDF)[59] have been set up specifically for this purpose. The National Office for Technology Acquisition and Promotion is promoting technology acquisition by Nigerians in this industry. It was in recognition of this that the Local Content Act 2010[60] was enacted by the Government of Nigeria.

58 The solid minerals industry accounts for not more than 1 per cent of GDP and is still largely at a primary level, while value is added mainly through the processing of crude minerals into semi-crude forms. The only exception is perhaps the mining of limestone for cement production, which has resulted in an extensive cement industry led by the Dangote Group's investment in cement production in the 2000s. The combined production capacity of Dangote cement plants in Nigeria was estimated to be 20 million tons per annum in 2012 (http://www.dangote-group.com/ourbrands/cement.aspx accessed 29 February 2012).

59 The PTDF was established by PTDF Act No 25 of 1973 as a fund for the purpose of training and educating Nigerians in the oil and gas industry.

60 The Local Content Act 2010, signed into law in April 2010, aimed at achieving significant participation of Nigerians in the upstream petroleum industry through skills upgrading and forward and backward linkages involving Nigerian companies.

1.4.2 Employment distribution[61]

Figure IIIA.III shows the trend in the sectoral distribution of employment from 1980 to 2008. In the early 1980s there was more employment in manufacturing than in services. Manufacturing employment has, however, been declining since the mid-1980s, while growth in employment in the service sector experienced a major boom after the end of the 1990s. The increases recorded in employment in the service sector were mainly driven by the liberalization of the telecommunications sector in the late 1990s and the subsequent licensing of the telecommunications companies that have been providing GSM services since 2001. As reported by Adeoti and Adeoti (2008), the boom in the telecommunications sector had considerable impact on small businesses that previously had no access to fixed line telephones. The improvement in business activities, especially in the informal sector of the economy, together with recharge card and cell phone distributors and agents, were major contributors to the observed increases in employment in the decade of the 2000s. By 2010 there were 1.05 million active wired lines and 87.29 million digital mobile lines in Nigeria (CBN, 2010).

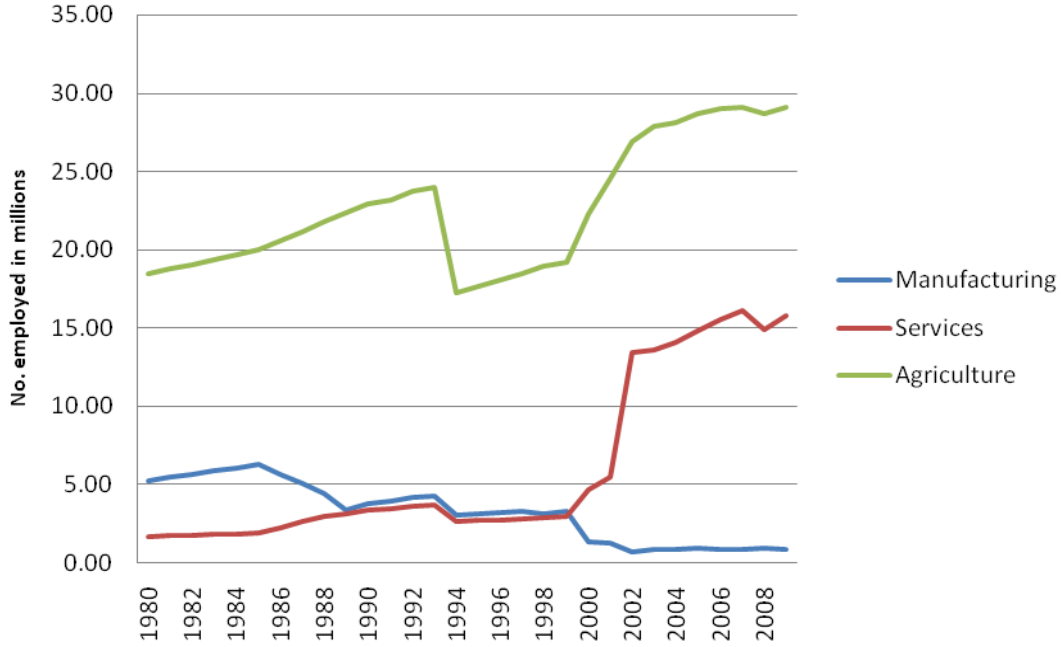
In spite of the growth in the service sector the agricultural sector has, however, remained the major employment sector. There has been gradual growth in employment in the sector except for the economic shock of the early 1990s, which might have been attributable to the political crisis of the early 1990s, which disrupted much economic activity in both urban and rural areas.

The persistent decline in manufacturing employment and the increase in agricultural employment further confirm that the process of structural change has not begun. There is no evidence of capital deepening in the Nigerian manufacturing industry because declining manufacturing employment is not an outcome of the application of new or improved manufacturing technologies. Moreover, the agricultural sector is also not known for its significant application of new technologies to bring about an appreciable change in the composition and quality of agricultural output. The shrinking manufacturing sector could accordingly neither add value to agricultural products nor expand the scope of the technological upgrading needed for structural change. Agriculture is the employer of last resort, and is mostly unsophisticated, small-scale subsistence farming.

61 Employment statistics in Nigeria is very inadequate. This data used here are the latest available at the time of this report.

Figure IIIA.III

Trends in sectoral distribution of employment, 1980 to 2008



Sources: WDI (2010).

1.5 Export performance

As shown in table IIIA.6, the decade of the 2000s witnessed an increase in the proportion of manufactured exports in total exports, from 0.22 per cent of total mercantile exports in 2000 to almost 4 per cent of total exports in 2009. Primary exports as a proportion of total exports were about 99 per cent in 1991, and nearly 100 per cent in 2000. Manufactured exports were accordingly negligible in the last decade of the twentieth century. The economic recovery of the first decade of the twenty-first century apparently accounted for the decline in the proportion of primary exports in total exports to about 96 per cent of total exports in 2009. This was possibly an indication of emergent structural change. Its extent was, however, so marginal and fragile because it was neither driven by a strong economic policy that could engender the required technological innovation nor sustained by the investments required for economic diversification.

Table IIIA.6 also shows that the proportion of the top five exports and the proportion of the top ten exports peaked in 2000 at 99.8 per cent and 99.88 per cent of total exports respectively. This structure changed in 2009, with the top five exports and the top ten exports having proportions of 94.84 per cent and 96.82 per cent of total exports respectively. This revealed that non-oil exports were increasing. The challenge for economic policy is to foster an increase in the pace of this emergent growth in non-oil exports.

It is also important to note that Nigeria is, historically speaking, not recorded as having exported services. But two service industry subsectors are emerging very strongly: financial services, currently limited to banking, and the movie industry. A few of the very strong Nigerian banks now have subsidiaries outside Nigeria. The entertainment industry is also noteworthy in this respect. Nigeria's film industry, Nollywood, has achieved considerable international recognition, and has established a strong presence in African countries.

Harnessing the resources of the Nigerian entertainment industry to promote tourism is, however, still a challenge.

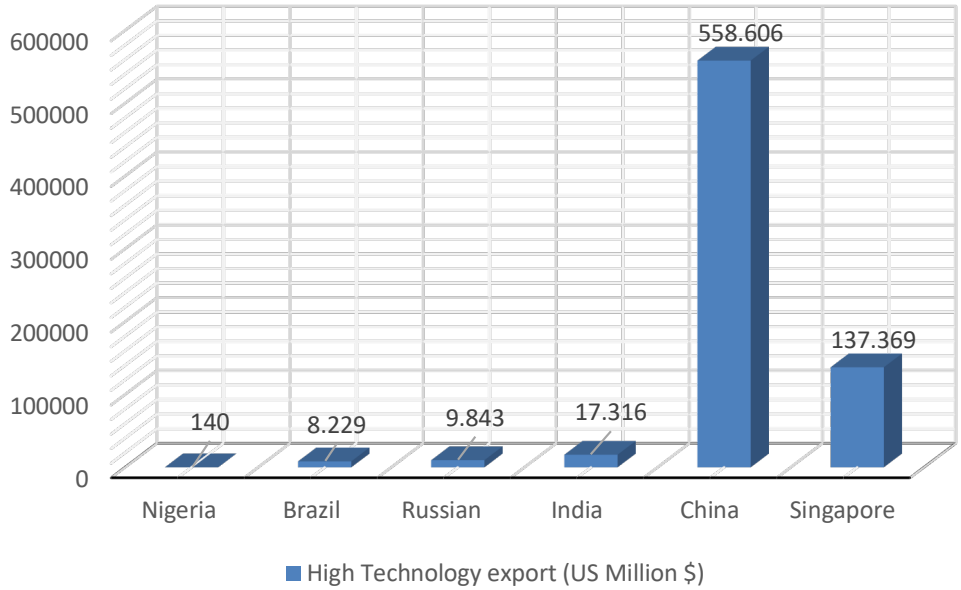
1.5.1 Technological sophistication of exports and imports

High-technology exports from Nigeria, comprising products with high R&D intensity as in sectors such as aerospace, computers, pharmaceuticals, scientific instruments and electrical machinery, have been relatively low. For instance, a comparison of Nigeria with the BRICS countries and other economies in terms of high-technology exports in 2012 shows that Nigeria is lagging far behind emerging market economies in Asia and Latin America. As indicated in figure IIIA.IV, Nigeria received a total sum of $140 million from high-technology exports in 2012, compared to Brazil, which received $8.229 million, China – $558,606 million, India – $17,316 million, the Russian Federation – $9,843 million and Singapore– $137,369 million. Similarly, Nigeria underperformed BRICS countries in terms of high technology exports in 2014 as shown in Figure IIIA.V. In that year, high technology exports accounted for only 2.1 per cent of Nigeria's manufactured exports while for Brazil, China, India, the Russian Federation and Singapore it accounted for 10.6 per cent, 25.4 per cent, 8.6 per cent, 11.5 per cent, and 47.2 per cent respectively.

For Nigeria to achieve a significant improvement in high-technology exports, increased efficiency and productivity are required. Hence it is pertinent that a host of factors, including innovation, technology, skills acquisition and quality infrastructure and availability of stable power supply, need to be in place to drive production.

Figure IIIA.VI illustrates the technological sophistication of exports based on the classification of exports into high, medium and low technology and resource-based exports, in accordance with categories developed by Lall (2009). The evidence shows that Nigeria is yet to emerge as an exporter of high technology products even though there is a perceptible movement in that direction. In 2009, high

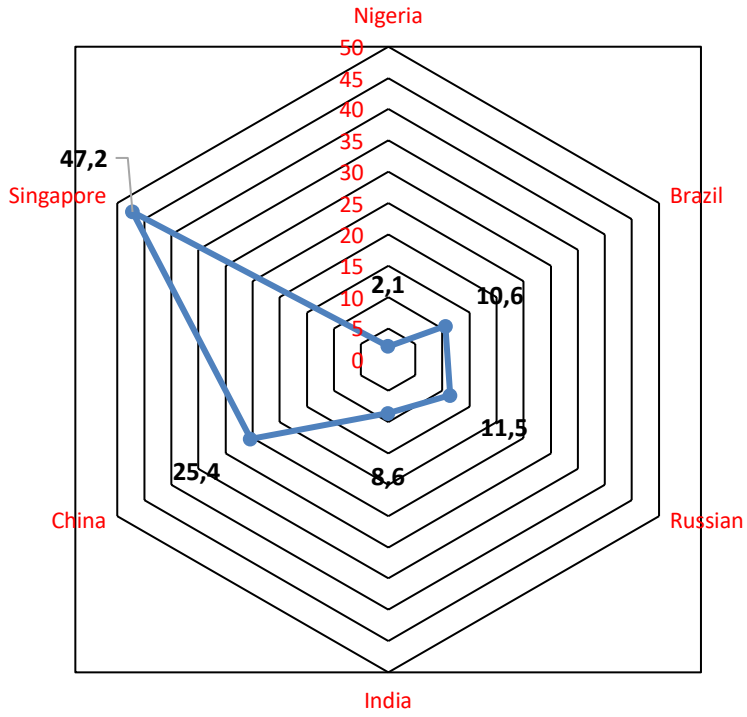
Figure IIIA.IV
High-technology exports in 2012 (in millions of United States dollars)



Source: World Development Indicators 2017.

Figure IIIA.V

High-technology exports as percentage of manufactured exports in 2014



Source: World Development Indicators 2017.

technology represented just 0.17 per cent of total exports and remained so in 2014. Both medium and low technology exports existed in 1991 and 2000, with both improving significantly to about 3.2 per cent of total exports in 2014. The export of resource-based manufactured goods followed a similar trend, but was less pronounced. The export of manufactured goods of all classifications fell from 1991 to 2000 and improved from 2000 to 2014.

The foregoing notwithstanding, it is imperative to stress that the first decade of the 21st century experienced a slight improvement in the performance of manufacturing exports. For example, table IIIA.6 indicates that the proportion of manufactured exports in total world exports of manufactured goods attained an unprecedented high level of 0.02 per cent of total world exports in 2009. Contrasting slightly with exports (see figure IIIA. VII), the composition of imports by end-use did not show any significant change between 1990 and 2014.

As shown in Figure IIIA.VII, the share of raw materials in total imports decreased from

Table IIIA.6

Sector composition of merchandise exports and export diversification

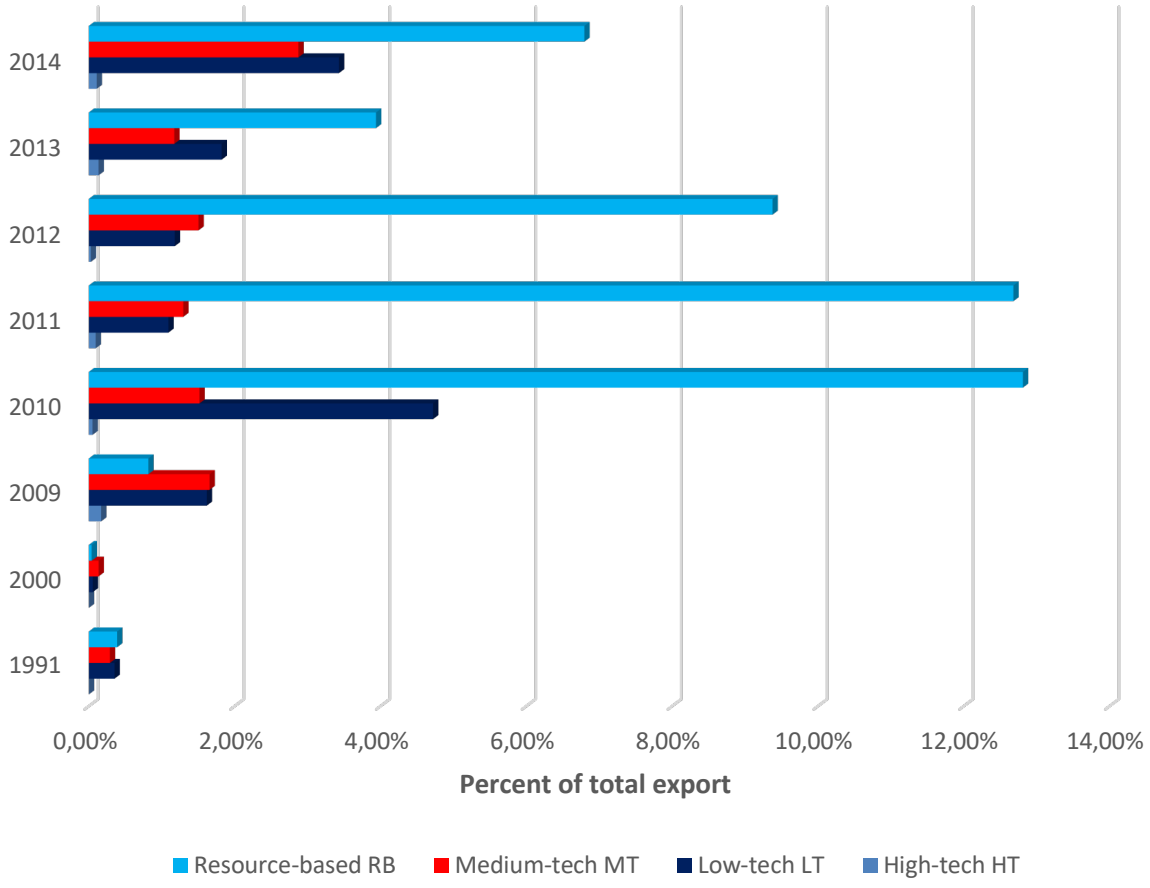
Sector composition of merchandise exports (% primary, manufacturing)	1991	2000	2009
Primary (including oil &gas)	98.96%	99.78%	96.10%
Manufacturing	1.04%	0.22%	3.90%
Proportion of manufactured goods in total world exports	0.0028%	0.0083%	0.02%

Export diversification			
Proportion of top 5 exports	98.70%	99.80%	94.84%
Proportion of top 10 exports	99.38%	99.88%	96.82%

Source: United Nations Comtrade SITC 2, digit 3.

Figure IIIA.VI

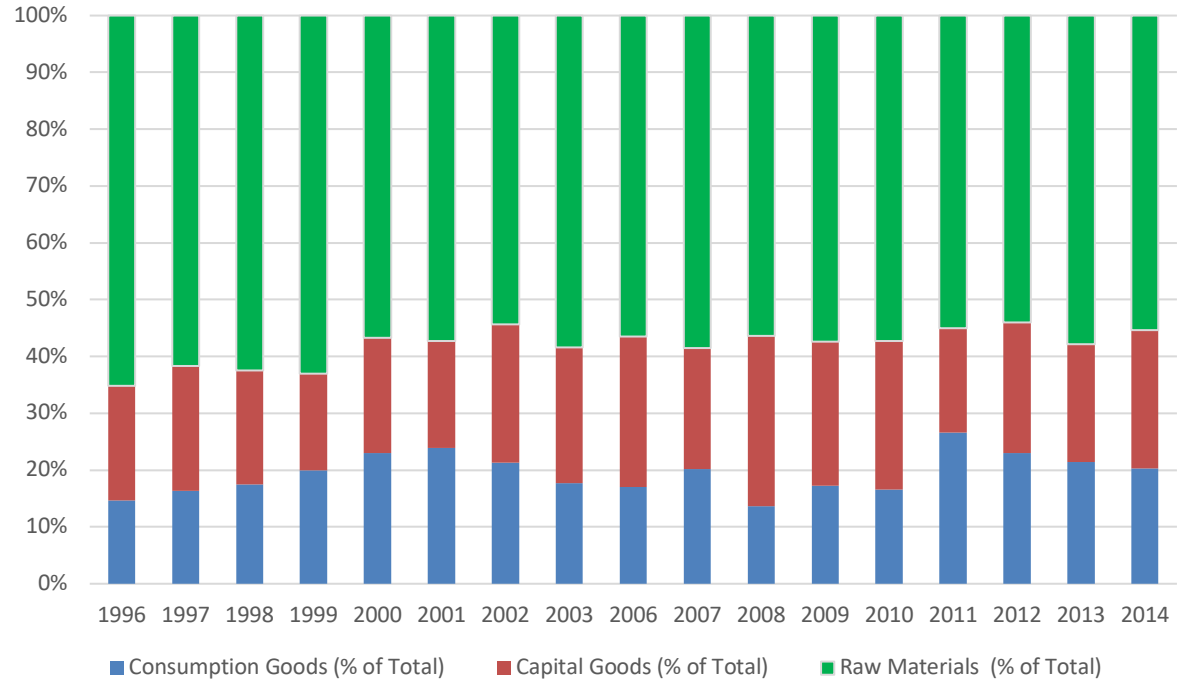
Technology classification of exports



Source: United Nations Comtrade.2017.

Figure IIIA.VII

Composition of imports by end-use, 1996 to 2014 (per cent of total imports)



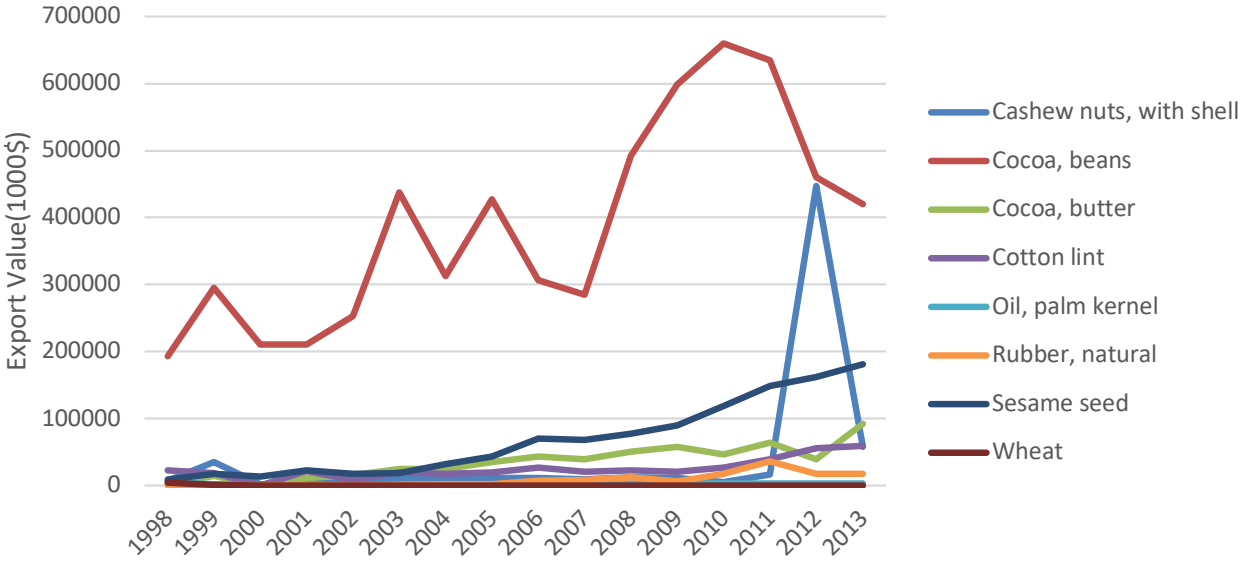
Source: UN Comtrade 2017.

about 65 per cent in 1996 to nearly 55 per cent in 2014 suggesting gradual progress in local content substitution Worrying is the fact that the proportion of capital goods in total imports remained steady at about 20 per cent during the period under review. The near lack of movement in the proportion of imported capital goods suggests low investment in the manufacturing sector and portends a limited scope for structural change because firms' limited access to new machinery and equipment implies a low capacity for technological upgrading and low value addition.

1.5.2 Export commodities

As mentioned earlier, Nigeria's exports consist mainly of oil and non-oil products. Oil exports account for the larger proportion of the country's total exports. Nigeria is the eighth largest world exporter of crude oil, and its natural gas reserves are ninth in the world. Efforts are currently underway to diversify the country's export base to non-oil exports. The major agricultural export commodities are as shown in figure IIIA.VIII, which indicates that cocoa beans remain the foremost agricultural export commodity. Sesame is the second most important export commodity. Other important major agricultural exports are cocoa butter, cotton lint, wheat bran, rubber and cashew nuts, while palm kernel is the least important. In 2013 about 47 per cent of total non-oil exports were accounted for by agriculture, and this trend has been improving.

Figure IIIA.VIII
Major agricultural export commodities of Nigeria



Source: FAOSTAT (2017).

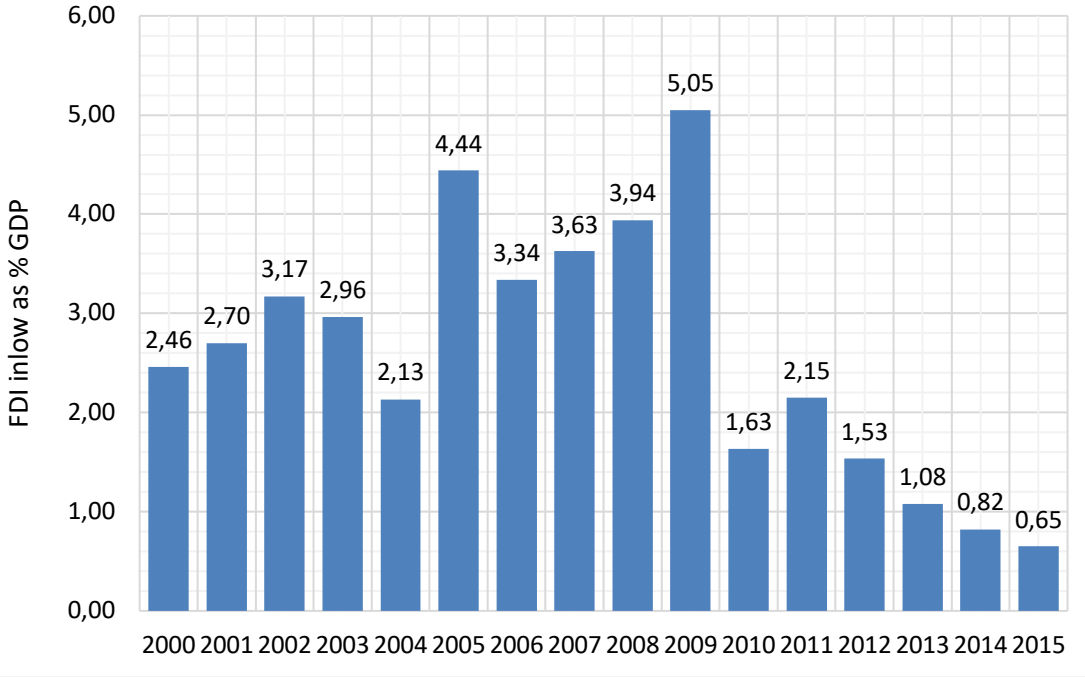
1.6. Foreign direct investments and technology spillovers

Figure IIIA.IX presents foreign direct investment (FDI) net inflows as a percentage of GDP in Nigeria from 2000 to 2015. On average, from 2000 to 2015 FDI net inflow was 3.3 per cent of GDP. Within the above-mentioned period, FDI net inflows had their lowest contribution of 0.65 percentage of GDP in 2015, and had the highest contribution of 5.07 per cent in 2009. According to Corporate Nigeria (2011), Nigeria's most important sources of FDI have traditionally been the home countries of the oil majors. The United States, present in Nigeria's oil sector through Chevron, Texaco and Exxon Mobil, had investment stock of $3.4 billion in Nigeria in 2008. The United Kingdom, one of the host countries of Shell, is another key FDI partner – its FDI into Nigeria accounts for about 20per cent of Nigeria's total foreign investment. As China seeks to expand its trade relationships with Africa, it is becoming one of Nigeria's most important sources of FDI. Nigeria is China's second largest trading partner in Africa, after South Africa. From $3 billion in 2003, China's direct investment in Nigeria is reported to now be worth around $6 billion (or 8.8 per cent of total Chinese FDI in Africa in 2010).[62] The oil and gas sector receives 75 per cent of China's FDI in Nigeria. Other significant sources of FDI include Brazil, France, Italy, the Netherlands and South Africa.

Nigeria is a leading destination of FDI inflow into Africa. According to WIR (2013), in sub-Saharan Africa Nigeria had the highest FDI inflows in 2011 and 2012. The trend in oil and non-oil FDI inflow from 2009 to 2016 is shown in figure IIIA.X. There was very little if any FDI into Nigeria's oil and gas sector between 1999 and 2003 for a variety of reasons including problematic joint venture agreements. However, the situation began to change in 2003. In 2004 the proportion of FDI in the oil and gas sector rose sharply, from 23 per cent of total FDI in 2003 to 90 per cent of total FDI in 2004. The explanation for this lies in the upsurge of Chinese investment in Nigeria's upstream petroleum sector and the massive investment by multinational

62 Standard Chartered (2012) Beyond Trade: China-Africa Investment trends available at https://www.sc.com/en/resources/global-en/pdf/Research/Beyond_trade_China-Africa_investment_trends.pdf.

Figure IIIA.IX
Nigeria FDI net inflows, 2000 to 2015 (per cent of GDP)



Source: WDI (2017).

companies in the Nigerian oil and gas sector.[63] But it has fallen since then. The oil and gas sector employs state-of-the art technologies, and is continuously seeking to master relatively new technologies and to exploit this advantage to improve the efficiency and timely delivery of products. However, this is also a source of concern: The oil industry remains largely an enclave industry although progress is being made local provision of services and fabrication of parts. But opportunities for growth and expansion exist, especially if the Government fast-tracks the implementation of the recently passed Petroleum Industry Bill, which aims to implement major reforms ensuring that the oil and gas sector is integrated with other productive sectors.

While it is widely believed that subsidiaries of multinational companies bring new technologies, skills, marketing expertise and novel management techniques from their parents into host countries, these knowledge resources may also be leaked to indigenous companies through various channels (see Dutse, 2008, and UNCTAD, 2009). In Nigeria, empirical evidence on the spillover effect arising from FDI inflow has been mixed. Recent studies have shown that multinational subsidiaries' technological behaviour, and in some cases the technological capabilities of local firms have had a significant bearing on the magnitude of such spillover effects (see, for example, Dutse, 2011). In this study of Nigeria, Dutse found positive and robust relationships between the intensity of FDI in technological capabilities vis-à-vis FDI-related technology spillover. The results of his study also show that investments in R&D and the acquisition of licensed technologies are the main drivers of spillovers, with subsidiaries contributing more to the process than indigenous firms.

63 For example, the liquefied natural gas (LNG) project has attracted huge FDI in recent years. The plant is one of the largest in the world, and has become one of the leading international exporters of LNG.

Figure IIIA.X A

Proportions of oil and non-oil FDI, 1999-2006

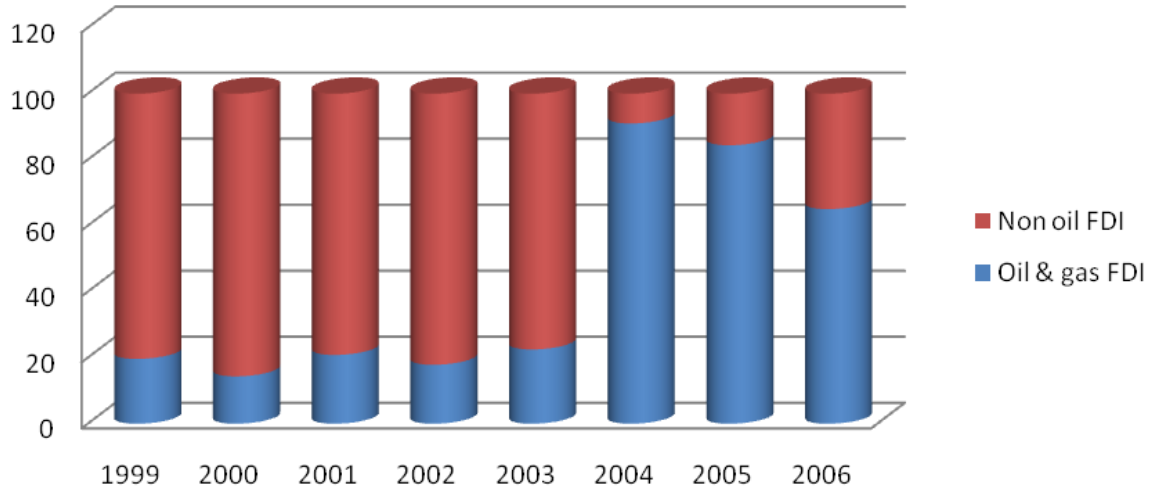
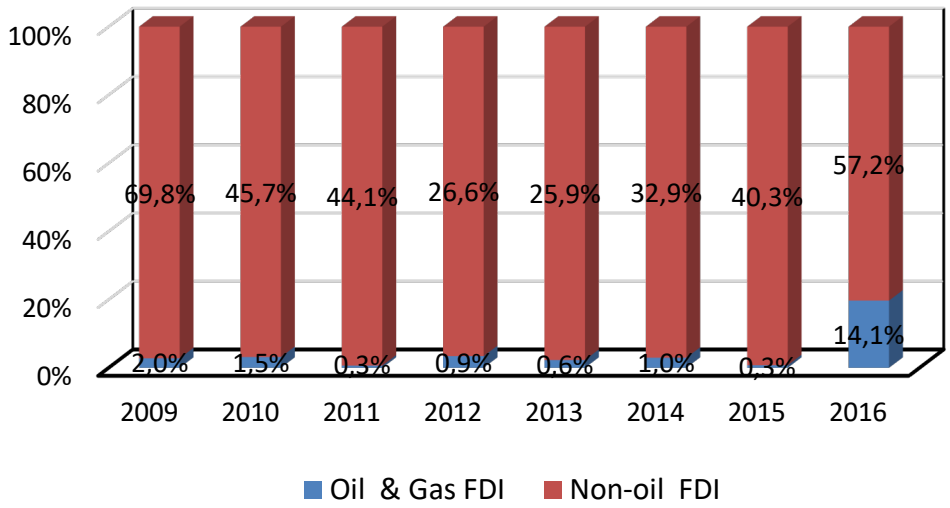


Figure IIIA.X B

Proportions of oil and non-oil FDI, 2009-2016



Source: NIPC 2016.

1.7. Informal sector performance

The Nigerian informal sector economy comprises a range of activities. These include several small-scale and unregistered sole-proprietor businesses and, in some instances, joint-partnership businesses which can be found in both rural and urban settlements across the country. According to NBS (2012) the informal sector contributes about 60 per cent of Nigeria's GDP[64]. As in many other developing countries, the sector is considered crucial to job creation, as – if agriculture is included – it accounts for about 90 per cent of jobs in Nigeria. Ogbuabor and Malaolu (2013) established empirically that, since 1970, the size of the Nigerian informal economy has hovered between 53.6 and 77.2 per cent

64 Estimates vary from 41 per cent on the low end to 60 per cent on the high end.

of GDP, and that the average size of the informal economy was about 64.6 per cent of GDP. Specifically, the results indicate that the informal sector was about three-quarters of GDP in 2010. Furthermore, they showed that unemployment, tax burden, government regulation and inflation are the most important factors promoting the informal sector in Nigeria.

The informal sector has the possibility of promoting inclusive and frugal innovation, generally defined as "innovation that is community-based and tailored to address the needs of poor and marginalized populations". Inclusive innovation is often not an outcome of formal or traditional R&D investments. It has been severally described in terms of concepts such as "innovation in informal settings", "innovation below the radar", and "social innovation" (Kaplinsky, 2011; Cozzens and Sutz, 2012; Lizuka, 2013). As explained by Mashelkar (2013), inclusive innovation can be either technology-led or non-technological, or it can be a combination of both; and it leads to affordable access to quality goods and services, thus creating improved livelihood opportunities for excluded populations, notably at the bottom of the income distribution pyramid.

Nigeria's informal sector is richly endowed with talented entrepreneurs who are actively engaged in various types of indigenous technologies that foster inclusive innovation. These technologies are often found in indigenous industries which include the production of pots from clay and aluminium metal scraps, textile making, cloth weaving, bronze casting, leather tanning, and the like, in various parts of the country. The indigenous knowledge supporting these industries is generally passed on from generation to generation, and is accordingly a tradition that is producing specific products in specific locations. As observed by NACETEM (2008), the method of indigenous knowledge transmission and skills acquisition is largely through observation and apprenticeship. These pockets of indigenous technologies could be a platform for promoting innovation that would ensure that the benefit of current growth is shared among marginalized and vulnerable populations.

Another dimension of inclusive innovation can be environmental innovation or eco-innovation, which enables more efficient resource use, less pollution, and environmentally friendly production and consumption patterns in the informal sector economy. Beyond this, environmental innovation is important for both formal and informal sector economies, and results from eco-efficient technologies and products, or from organizational changes/practices that directly or indirectly promote environmentally friendly products and production processes.

2. Review of science, technology and innovation policies

2.1 Evolution of Science Technology and Innovation policy-making in Nigeria

Ever since Nigeria became an independent country, each government has acknowledged the important role of science and technology (S&T) in industrialization and economic development. The Federal Ministry of Science and Technology (FMST) first established by an Act of the National Assembly in 1980 is responsible for STI policy making in Nigeria. A coherent national science and technology policy was first promulgated in 1986 the broad aim of which was to harmonize the sector in order that S&T could be used to power the economy and to create a better quality of life for the Nigerian people. The policy was subsequently reviewed in 1997, 2003 and 2005. The 1997 review provided more emphasis on the coordination and management of the S&T, as well as on sectoral developments, collaboration and funding. The 2003 review incorporated a programmatic approach to policy formulation, while that of 2005 stressed economic development initiatives, institutional governance and Nigeria's research and development agenda, as well as funding mechanisms, intellectual property and STI infrastructure development.

A further and more elaborate review of the S&T policy was undertaken in 2012 based on a participatory approach involving several development policy stakeholders in both the public and private sectors. What emerged from this review is a national policy on science, technology and innovation with emphasis on how the national system of innovation could be promoted and strengthened. Box IIIA.1 presents the vision, mission and objectives of the 2012 Nigeria National Policy on Science, Technology and Innovation. The policy recognizes that success in commerce and industry, agriculture, arts and culture, traditional and orthodox medicine, meteorology, and other critical sectors depends on the nation's capacity to harness STI. The policy identifies STI as the key to achieving the transformational agenda of the country as set out in Nigeria's Vision 20:2020.

Nigeria's 2012 STI Policy

The 2012 STI policy covers a number of areas including: human capital development, agriculture, industrial growth, health, environment, energy, banking and finance, information and communications technologies, women and youth empowerment, job creation, tourism, trade, science acculturation, natural resources management, building and construction, national security, nuclear science and technology, sports and recreation, diplomacy and transport management. The STI policy seeks to send a signal to the scientific community in both the public and private sectors, namely that research and other scientific activities should focus on faster, sustainable and inclusive development of the population. Specifically, the 2012 STI policy is designed to provide a strong platform for science, technology and innovation engagements with the private sector, for the purpose of promoting sound citizen-centred economic transformation. The 2012 STI policy aims to resolve by practical means the long-standing disconnect between economic planning and science and technology enhancing skills for applications of science and technology. It places strong

emphasis on innovation and aims to create a robust national system of innovation by strengthening structures for the coordination, promotion and management of interactions within the system.The STI policy reflects an effort on the part of Nigeria to demonstrate renewed commitment to ensure that its R&D efforts enhance new business development, encourage employment generation and wealth creation through the growth of small and medium-sized enterprises. Other key elements of the policy include: making careers in science, research and innovation attractive enough for talented and bright Nigerians; establishing world-class infrastructure for R&D for gaining global leadership in some select frontier areas of science; and linking the contributions of science, research and innovation systems with the inclusive economic growth agenda, and combines the priorities of excellence and relevance;

The policy supports the creation and maintenance of an up-to-date, reliable and accessible database of Nigeria's STI human and material resources, as well as of the activities needed for sound economic planning and policymaking. A key highlight of the policy is that it established the National Research and Innovation Council (NRIC) with the President as its chair, thus elevating STI policy implementation to a level where the highest political commitment can be realized. NRIC is responsible for setting national priorities on R&D, setting directions to coordinate STI activities, including R&D, in line with national priorities,

Box IIIA.1
Nigeria's STI policy vision, mission and objectives

STI policy vision: "By 2020, it is hoped that Nigeria will have a large, strong, diversified, sustainable and competitive economy that effectively harnesses the talents and energies of its people and responsibly exploits its natural endowments to guarantee a high standard of living and quality of life to its citizens".

STI policy mission: "Evolving a nation that harnesses, develops and utilizes STI to build a large, strong, diversified, sustainable and competitive economy that guarantees a high standard of living and quality of life to its citizens".

The *specific objectives* are to:

(a) Facilitate the acquisition of knowledge to adapt, utilize, replicate and diffuse technologies for the growth of small and medium-sized enterprises, agricultural development, food security, power generation and poverty reduction;

(b) Support the establishment and strengthening of organizations, institutions and structures for the effective coordination and management of STI activities within a robust national innovation system;

(c) Encourage and promote the creation of innovative enterprises making use of Nigeria's indigenous knowledge and technology to produce marketable goods and services;

(d) Support mechanisms to harness, promote, commercialize and diffuse locally developed technologies for the production of globally competitive goods and services that intensively use Nigeria's raw materials;

(e) Facilitate and support the creation and maintenance of an up-to-date, reliable and accessible database on Nigeria's STI resources and activities;

(f) Promote activities for effective STI communication about and the inculcation of an STI culture in Nigerian society;

(g) Create and sustain reliable mechanisms for the adequate funding of STI activities in Nigeria;

(h) Initiate, support and strengthen strategic bilateral and multilateral cooperation in scientific, technological and innovation activities across all sectors of the economy.

Source: FMST (2012).

and establishing new research institutes and strengthening existing ones as is deemed necessary, and facilitating fund-raising activities to support innovative activities in areas of national needs and priorities.

The Nigerian STI policy serves as a national guide, not only for the Federal Ministry of Science and Technology (FMST) and its agencies, but also as platform for collaboration among the agencies of the 36 states of Nigeria. The policy considers the FMST to be a service ministry of the Government, and accordingly empowered it to interact with all relevant agencies and organizations promoting the application of STI in all sectors of the economy.

As indicated earlier, the 2012 STI policy was developed in an inclusive, participatory manner. Consultative meetings were held with various stakeholders across the length and breadth of the country, as well as with international development partners[65]. The participatory approach to the design of the policy heightened awareness of STI, and provided opportunities for various actors to articulate their views and make inputs into the new policy. The approach also promoted the collective ownership of the policy by all stakeholders.

2.2. Sectoral STI policies and industrialization strategy

The STI policy recognizes the need to prioritize strategies geared towards the generation, acquisition, storage, application and diffusion of S&T knowledge for national development. To this end, its objective is to foster demand-driven and sectorally innovative R&D activities, at the level of R&D institutions and firms. Pursuant to this, the policy identified the following five industrialization-related strategies:

- Ensuring that R&D activities are directed towards the development of appropriate technologies for the production of industrial goods and services in small, medium, and large-scale firms;
- Developing local capacity for the design and production of machine tools and spare parts for rapid industrial growth and development;
- Fostering interactions among universities and higher education research institutions, industries and investors, to generate innovations;
- Ensuring value-addition to the nation's natural resources for industrial development;
- Fostering the development of technological entrepreneurs to facilitate innovation.

In all, 19 specific sectoral strategies are included in the STI policy. These sectors are agriculture, water resources, biotechnology, health, energy, environment, mines and materials, ferrous, non-ferrous and chemical technologies, information and communications technology, space and investment, industry, new and emerging technologies, raw materials and manufacturing, defence and national security, transportation, youth, sports and tourism, works, land, housing and urban development, wood resources and science laboratory technology. These strategies are at various stages of implementation.

However, it is not yet possible to ascertain whether these STI policy strategies are producing the expected results. In addition to the STI policy, the Nigerian Agricultural Transformation Agenda (ATA), the Nigeria Industrial Revolution Plan (NIRP) and the National Enterprise Development Programme (NEDEP) are recent sectoral policies aimed at transforming

65 The World Bank and the UNDP provided financial and technical support for the development of the policy.

the agricultural and manufacturing sectors into sectors of relatively high productivity and sources of employment generation.

NIRP was promulgated in January 2014, as a five-year plan aimed at rapidly building industrial capacity and improving industrial competitiveness of the country. It's target is to increase manufacturing's contribution to GDP from the 2013 estimate of 4 per cent to 6 per cent by 2015, and to above 10 per cent by 2017. NIRP is based on the desire to drive a process of intense industrialization, based on the structure of the economy, focusing on sectors where Nigeria has a comparative advantage – such as the agro-allied sectors; metals and solid minerals related sectors; oil and gas-related industries; as well as construction, light manufacturing and services. The criteria used for selecting the focus sector groups are: existing skills and installed capacity, natural resource endowments, a competitive cost base, labour intensity, potential for linkages with other industries, local and regional demand and ability to export to developed markets.

To achieve its objectives, NIRP stresses the vital importance of addressing the numerous impediments to the growth in the non-oil sector. These impediments include the high cost of funding and the lack of long-term finance for industry; inadequate infrastructure, especially poor electric power infrastructure; low industrial skills; the lack of linkage between research and industry; the relatively poor investment climate; constraints on product standards; and the lack of patronage of local industrial products. Implementation of NIRP is expected to result in job creation, economic and revenue diversification, import substitution, export diversification and a broadened government tax base. Nigeria's strengths in terms of actualizing its industrial policy goals include abundant raw materials, its strategic location in the Gulf of Guinea, its large domestic market, abundant labour and international political clout.

For effective and sustainable industrial development, backward and forward linkage of the industrial subsectors is a necessity. To this effect, the Ministry of Industry, Trade and Investment designed the National Enterprise Development Programme (NEDEP) to accelerate the growth of micro, small and medium-sized enterprises (MSMEs). NEDEP is expected to create an average of one million jobs per year. NIRP and NEDEP are composite industrial strategies that are being simultaneously implemented to leverage necessary synergy in the two strategies. For example, NEDEP will work in line with NIRP to address the issue of the availability of affordable finance by leveraging off the NIRP plan to increase early stage funding by reforming the venture capital and private equity environment. Through this approach, NEDEP will be able to create an enabling environment for greenfield investments, especially in high-potential MSMEs.

Furthermore, NEDEP aims to ensure that MSMEs undergird the supply chain of all priority sectors of NIRP. Through NEDEP, large private sector industries will identify the areas in their supply and value chains that can be filled by MSMEs. The capacity of these MSMEs is expected to be strengthened through the NEDEP framework and its private sector training and capacity-building activities.

3. STI actors' competences and capacity to innovate

3.1 Science base and structure of investments in scientific activities

Compared to emerging economies, Nigeria's science base is relatively weak. Investments in scientific activities have been mainly in the educational system and public sector research institutions. The structure of these investments is difficult to determine due to data constraints on most of the identified input and output indicators of STI actors' competences and capacity to innovate. However, a few indicators such as R&D intensity and education expenditure provide some clues to Nigeria's STI readiness when compared with other economies as shown in figure IIIA. XI. Nigeria's education expenditure as a proportion of GDP in 2012 is the lowest among comparable countries. The next country, China, recorded educational expenditure of 1.8 per cent of GDP in 2012, while Nigeria had only 0.9 per cent.

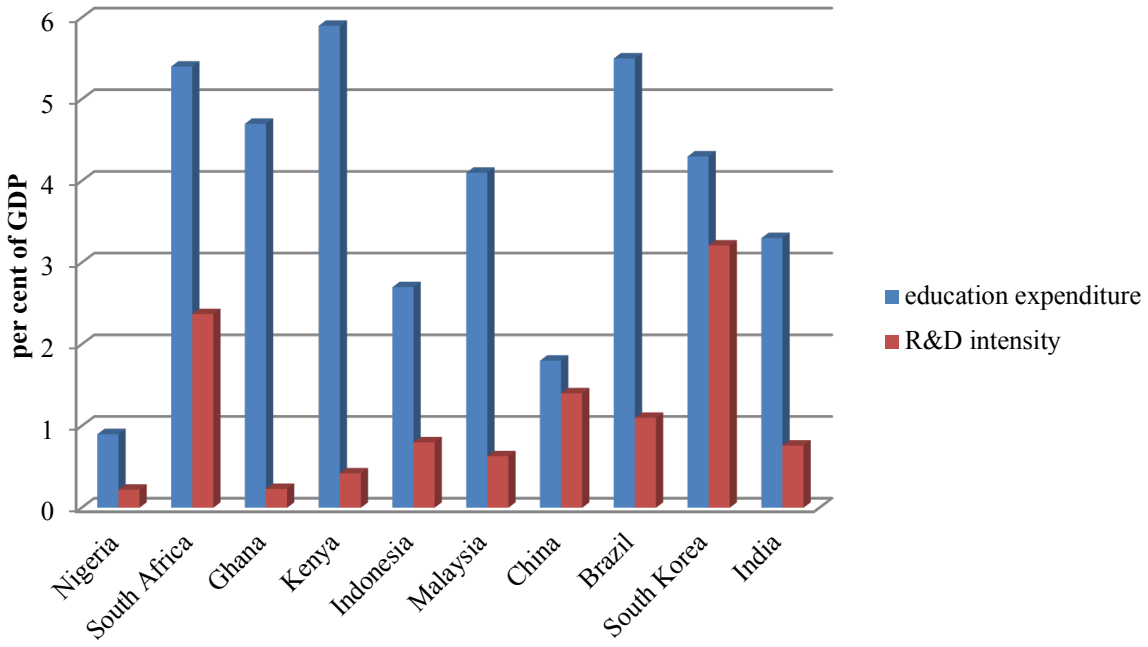
Data for selected countries show that Nigeria and most of the emerging economies have not significantly changed the amount spent on education as a proportion of GDP since the beginning of the new millennium. That said, however, in the case of Nigeria and most other African countries, it may be argued that, since their economies have been growing appreciably, educational expenditure has also been growing reasonably. Still, if Nigeria's economy is to derive a significant benefit from knowledge, it would have to substantially increase the pace of investment in education, to further strengthen the knowledge base and its ability to power and diversify the sources of growth.

Figure IIIA.XI also shows that Nigeria's R&D intensity. Considered against the BRICS -Brazil, Russia, India, China and South Africa, a club that Nigeria aspires to be a member of, Nigeria performs very poorly. Nigeria's low R&D intensity is a major impediment to improving its science base and increasing investment in technology and innovation activities. It also constrains opportunities for knowledge accumulation, knowledge discovery; and capacity-building for technology adaptation and innovation. Nonetheless, Nigeria has made significant efforts at improving R&D intensity, as the evidence discussed elsewhere in this report shows. However, it would have to more than double the current level of R&D intensity and consistently increase it at a rate not lower than the average observed among a cluster of much better performing emerging economies if it is to compete with the BRICS and other emerging economies.

Other input indicators of STI actors' competence and capacity to innovate, which can help to explain the science base and structure of investment in scientific activities in Nigeria, include public sector investment in R&D, private sector investment in R&D, the science and engineering enrolment ratio, the number of universities and other institutions of higher education, the number of specialized universities in science and technology fields and the number of public sector research institutions.

The relevant output indicators of STI actors' competence and capacity for innovation include the proportion of the population with secondary and tertiary level education; the share of low, medium and high technology products in total manufacturing output and

Figure IIIA.XI
Educational expenditure and R&D intensity of selected countries in 2012



Source: WDI (2013).

in total exports; and the number of patents registered. These input and output indicators should be discussed in a full report on Nigeria's STI readiness that will hopefully follow this pilot study.

3.2 Business R&D and innovation activities

The state of the science base and the structure of investments in STI would determine the capacity of firms to conduct R&D on their own or in partnership with public sector research and development institutions. The global business environment is laden with uncertainties that threaten the growth of small businesses in developing countries. The survival and longevity of small businesses increasingly depends not just on local relevance but also on their capacity for R&D, in whatever form, and however modest. Though recent data on business R&D are not available for Nigeria and many other African countries, previous research provide evidence that business R&D in Nigeria is rare for small-sized enterprises, and there are only anecdotal cases of local R&D in medium- and large-sized enterprises (Adeoti and others, 2010). A good illustration of local business R&D is the case of Zinox Technologies Limited, as presented in box IIIA.2.

A recent report by Adeoti and others (2014) on the role of universities' interaction with external social partners for inclusive innovation also revealed that businesses in the informal sector economy have no R&D base, and that R&D in universities directly affects businesses in the informal sector only in the case of a few specialized projects, often with donor support. Improving business R&D and innovation activities can improve STI actors' competences and capacity to innovate in the following ways:

- Discovering new products (goods and services), processes, and methods and enhancing existing products and processes;
- Encouraging STI actors to implement the desired innovations and activities through practical learning, by doing, using and interacting with others;
- Developing new market expansion techniques and strategies with the support of publicly-financed research done in partnership with the business community;
- Developing ways of generating revenue to fund actors' capacity-building activities.

3.3 Technological learning experiences and opportunities

Technological learning experiences and opportunities are often highlighted in case studies carried out during an innovation survey or a deliberate survey done as part of a country STI readiness study. For this pilot study, technological learning experiences are illustrated with data provided by two leading firms in the Nigerian computer industry, Omatek Computers PLC and Zinox Technologies Limited. The two firms have in recent years demonstrated that, given the right incentives, Nigeria is capable of manufacturing high technology products. The two firms are known to have benefited from an official governmental policy encouraging public agencies to use their products during the first term of the Government of President Olusegun Obasanjo. The products and accessories of the two firms accordingly enjoyed widespread patronage from public and private sector agencies in Nigeria. Box IIIA.3 describes the emergence and features of technological learning which have accompanied the advances of Omatek Computers in recent years.

Box IIIA.2
Zinox Technologies Ltd

Zinox Technologies Ltd. was launched in 2001 by a team of IT professionals for the local production of computers. Zinox engages in significant research and development as part of its core operations, from where products designed for the local markets are conceived, and innovative and customer-centric packages and products are designed, particularly for the African market. Zinox is the first original equipment manufacturer (OEM) in West Africa to market internationally certified branded computers. It was also the first computer company in the world to incorporate the Nigerian currency on its keyboard; and it aims to develop other digital solutions in areas other than computer manufacturing. Zinox has initiated strategic investments in leading ICT companies, and has made major investments in Technology Distributions Ltd, Task Systems Ltd, AfriHub LLC, and Zinox Telecommunications Ltd.

Source: FMCI (2010).

Box IIIA.3
Omatek Computers PLC

Omatek Computers was established in 2000 by its mother company, Omatek Ventures Ltd, which has been in existence since 1986 as a computer training business, and a marketer and distributor of branded computers and accessories. By 1990 the company had, through learning in sales and strategic partnerships, become a major re-seller for Compaq, IBM, ACER and Apple, among other internationally recognized computer brands. As a result of the high sales volumes achieved, the company was appointed a premium partner for Compaq, and a senior partner for IBM, Apple and Microsoft for turnovers in excess of $1 million annually. In 1993 Omatek Ventures set up its first factory for the local assembly of computers from completely knocked down parts. This introduced another major opportunity for learning through imitation.

Omatek Computers is a joint venture project of Omatek Ventures Ltd and two local banks, Zenith Bank and Guaranty Trust Bank. The company aims to make computers cheaper and more affordable in Africa and to assist governments to bridge the digital divide across the continent. Product development was facilitated by learning through regular feedback from users of Omatek products. The company's products include fully-built desktop PCs, notebooks, casings and speakers. It is also involved in the assembly of OEM brands for both local and foreign builders. The company uses technology from China, India and Singapore to implement OEM initiatives promoted by Intel and Microsoft.

The company has succeeded in building a strong international market profile for itself and its products, receiving more than 18 awards signifying the wide acceptance of its products. The company is the first computer firm to be listed on the Nigerian Stock Exchange, and has grown into a group of companies, establishing subsidiaries to strengthen its operations. Omatek Ventures PLC is now a holding company, with subsidiaries including Omatek Computers Ltd, Omatek Computers (Ghana) Ltd, Omatek Ventures (Ghana) Ltd, Omatek Engineering Services Ltd, and Omatek Ventures Distribution Ltd.

Source: FMCI (2010).

4. STI actors' interactions

4.1 Factors promoting interaction and innovation opportunities

Factors that promote interactions among STI actors are related to technology infrastructure. For developing countries, critical among these are the following:

- Electric power consumption (kWh per capita)
- Telephone main lines in operation (per 100 inhabitants)
- Fixed broadband Internet subscribers (per 100 people)
- Mobile cellular subscriptions (per 100 people)

As shown in table IIIA.7, with the exception of fixed broadband Internet subscriptions, Nigeria lags behind many countries on infrastructure support for interaction among STI actors. although it reported considerable improvements in mobile telephone line subscriptions and broadband Internet subscriptions. Growth of broadband Internet subscriptions is still relatively constrained by infrastructure deficits and price. Nigeria is also performs poorly in terms of electric power consumption per capita.

Table IIIA.7
Trends in infrastructure-related indicators of STI actors' interaction

	Electric power consumption (kWh per capita)					Fixed telephone subscriptions (per 100 people)					Mobile cellular subscriptions (per 100 people)					Fixed broadband subscriptions (per 100 people)				
	2000	2005	2010	2012	2016	2000	2005	2010	2012	2016	2000	2005	2010	2012	2016	2000	2005	2010	2012	2016
Brazil	1891.97	2007.28	2361.06	2485.59	n.a	17.64	21.32	21.41	22.09	20.15	0.06	1.73	7.17	9.53	12.88	13.23	46.12	100.07	123.81	117.54
China	992.94	1782.31	2943.59	3474.99	n.a	11.29	26.52	21.65	20.23	14.72	0.00	2.83	9.29	12.74	22.99	6.64	29.77	63.17	80.87	97.25
Ghana	332.02	245.85	280.51	345.70	n.a	1.12	1.49	1.13	1.11	0.89	n.a	0.01	0.21	0.26	0.31	0.69	13.34	71.14	99.55	135.80
India	394.96	469.45	642.11	724.79	n.a	3.08	4.39	2.85	2.45	1.84	n.a	0.12	0.89	1.19	1.41	0.34	7.88	61.10	68.46	85.17
Indonesia	390.37	499.72	634.18	732.10	n.a	3.15	5.96	16.88	15.26	4.12	0.00	0.05	0.94	1.20	2.00	1.73	20.69	87.12	113.29	147.66
Kenya	106.10	130.21	150.28	152.84	n.a	0.93	0.80	0.92	0.58	0.15	n.a	0.01	0.02	0.12	0.33	0.41	12.79	60.38	70.41	80.44
Korea, Rep.	5906.96	7796.31	9716.13	10305.33	n.a	54.58	49.08	57.60	60.26	55.20	8.17	25.03	34.70	36.54	40.47	56.59	78.72	102.45	107.35	120.68
Malaysia	2748.08	2877.23	4159.64	4323.35	n.a	19.96	17.01	16.40	15.73	15.51	n.a	1.88	7.46	10.01	8.72	22.09	76.17	120.44	141.67	140.80
Nigeria	74.45	129.26	136.36	156.73	n.a	0.45	0.88	0.66	0.25	0.08	n.a	0.00	0.06	0.01	0.06	0.02	13.38	55.05	67.41	82.98
South Africa	4503.77	4547.65	4510.22	4352.39	n.a	10.85	10.03	9.42	9.15	8.07	n.a	0.34	1.44	2.09	2.05	18.24	69.56	97.65	129.05	147.13

Source: WDI (2018).

Figure IIIA.XII compares Nigeria's electric power consumption against Indonesia, Brazil, China and India. Nigeria consumes less electric power than all countries. It is particularly noteworthy that while per capita electric power consumption increased in all four comparator countries, it actually stagnated in Nigeria.

Hence, Nigeria needs up investment in power infrastructure to raise per capita electric power consumption. This is an urgent imperative if it is to promote interaction among STI actors. It will also need to increase investments in broadband infrastructure and continue to make improvements in mobile cellular infrastructure.

The outputs of interactions among STI actors are innovations or mechanisms generating innovation. These could be identified from the trend observed in the following key indicators:

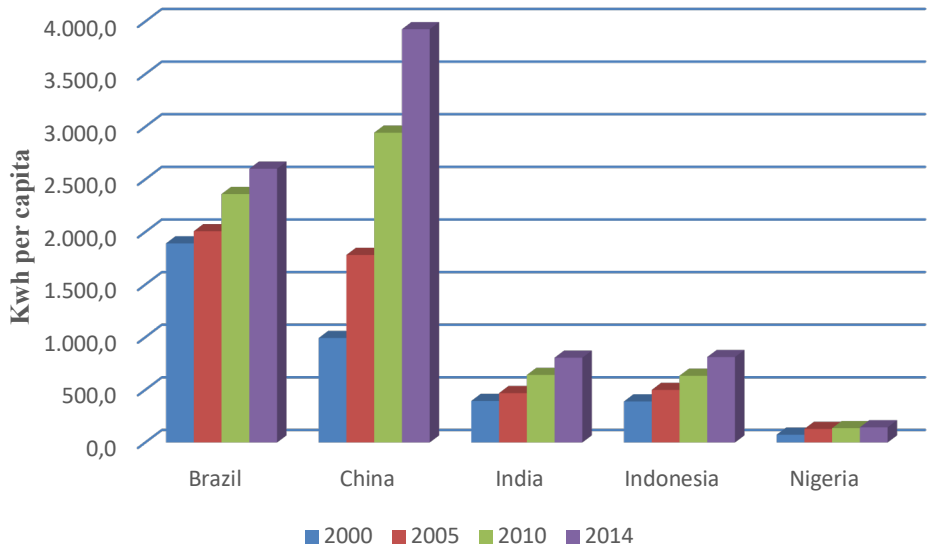
» Number of new products and services introduced

» Number of firms introducing new production processes

» Level of FDI inflows

The first two indicators can be tracked in an innovation survey while the third can be tracked through various reports and sources, including reports by the Nigeria National Bureau of Statistics, the IMF and the World Bank. Data on FDI inflows indicate that Nigeria has been among the top destinations of FDI inflows in Africa in recent years. For example, figure IIIA.XIII shows that Nigeria's FDI inflows surpassed those of South Africa in 2015 and compared fairly well with those of Malaysia, an emerging economy. Decomposition of the FDI inflows by sector shows

Figure IIIA.XII
Electric power consumption for selected countries (kWh per capita)



Source: WDI (2017).

that FDI inflow into Nigeria is mainly concentrated in the oil and gas sector, a sector still largely dominated by foreign technology in terms of capital and skills/expertise. Hence, FDI inflows may accordingly not be an accurate reflection of interactions that generate significant technological spillovers across the Nigerian economy.

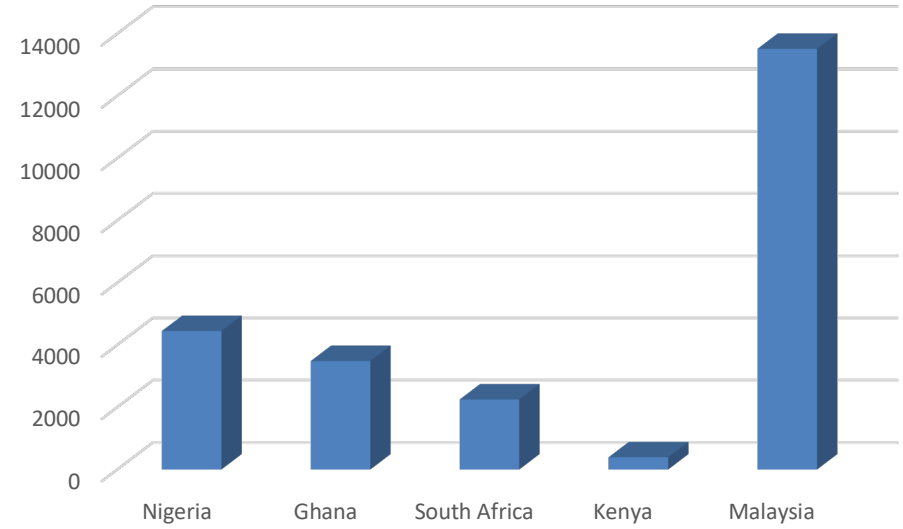
Nevertheless, evidence emerging from ongoing efforts to diversify the Nigerian economy suggest that FDI inflows into the agricultural and manufacturing sectors are improving, and can be viewed as a product of interactions among major STI actors. The 2012 Nigeria STI policy and the new Nigeria Industrial Revolution Plan launched in January 2014 strongly emphasize the importance of a national system of innovation, with interactions among STI actors as a major strategic element.

4.2 Barriers to interaction among actors in the innovation system

The national system of innovation (NSI) recognizes that flows of technology and information among people, enterprises and institutions are important for the innovation process. Innovation and technology development are the result of a multifaceted set of relationships among actors in the system, which often includes enterprises, universities, research institutes, policymakers, civil society organizations and others. The network of key STI actors may be viewed as a system guided by a framework of knowledge demand and supply with a certain output of innovation. Innovation in this context may be either technological or non-technological, given the broad definition of innovation as including technological, organizational, social and marketing innovations.

Barriers to interactions constitute a major challenge to the evolution of NSI in many African countries, and result in underachievement in the areas of industrialization and economic competitiveness. Adeoti and others (2010) and the Nigeria Industrial Revolution Plan (2014), identify the following factors, amongst other things, as barriers to STI actors' interaction in Nigeria:

Figure IIIA.XIII
FDI inflows of selected countries in 2015



Source: WDI (2017).

(a) Lack of sectoral priorities for the promotion of innovation, and poor inter-sectoral linkages inhibiting value-chain development;

(b) Lack of adequate and effective policy on research-industry linkages;

(c) Weak intellectual property rights regime;

(d) Inadequacy of the plan's fund for STI activities;

(e) Weak and fragile management of innovation infrastructure (special economic zones and export processing zones, regional technological/innovation parks and specialized research centres);

(f) Lack of appropriate incentives capable of channelling FDI toward knowledge-intensive and non-traditional industries;

(g) Low investment in the skills required for industrial production and innovation activities.

Emerging economies with globally competitive industrial sectors have effectively addressed similar challenges at various stages of their economic development. Nigeria's current STI policy and the Nigeria Industrial Revolution Plan are designed to tackle these barriers to innovation. It is yet to be seen whether or not the STI policy and the plan will be backed by sufficient political will for effective implementation. Commitments providing positive signals have been made at a very high policy level. This is exemplified by the Nigerian President's decision personally to serve as the chair of the National Research and Innovation Council (NRIC) as specified by the 2012 STI policy. With this and other remarkable efforts, especially by high officials of critical STI agencies (e.g. the ministries of industry, trade and investment; communications technology; agriculture and rural development; and science and technology), Nigeria appears to have substantially overcome the attitudinal obstacle to removing barriers to STI actors' interaction.

4.3 Clusters and knowledge flows

Nigeria promotes a number of schemes to improve clusters and knowledge flows from public sector research to the private sector for purposes of commercialization. These include the Innovation and University Linkage Division of the National Universities Commission (NUC) and NIRP - Nigeria's new National Industrial Revolution Plan. Moreover, small and medium-sized enterprise (SME) clusters exist in various parts of Nigeria, some of which have grown organically over the years.

The adoption of NIRP and NEDEP in 2014, suggests that a national consensus appears to have emerged on the vital importance of promoting SME clusters as strategic loci for industrial development and innovation. Examples of existing clusters that are supported by NIRP and NEDEP are industrial export processing zones created by official industrial policy and some private sector led clusters that were established with little or no official government policy support. Some of the current private sector-led SME clusters include:

- Shoe manufacture and garment making at Aba
- An auto spare parts cluster at Nnewi
- The Otigba computer village in Ikeja, an emergent IT innovation valley
- The Sokoto leather works, rated as of world class

Knowledge flows within clusters provide opportunities for interaction among STI actors, taking advantage of the agglomeration economies that characterise industrial clusters. Some of the SME clusters are already recognized as emergent innovative clusters (e.g. Otigba Computer Village and the Nnewi Auto Spare Parts Cluster. Sokoto locational advantage, if combined with relevant knowledge and skills could result in the emergence of a leading global innovation hub for leather technology. They could serve as nodes for innovation activities from which sectoral innovation systems can be grown for the benefit of the entire economy. Although Nigeria's STI readiness as indicated by clusters and knowledge flows may at present be regarded as being still at infancy, current efforts aimed at supporting and strengthening the SME clusters portend great hope of significant improvement in Nigeria's STI readiness through SME cluster development.

5. Human resources for science, technology and innovation

5.1 Education and training systems

Education and training systems are important subsystems of national systems of innovation. In industrialized countries, apart from defence R&D activities, the private sector plays critical roles in R&D activities in the generation of innovation. However, in a developing economy the public sector plays the dominant role,

especially through the network of higher educational institutions and public sector research institutes. Large firms which are better placed (by their apparent resource advantage) to carry out R&D in the private sector are in many cases subsidiaries of multinational enterprises which concentrate R&D activities either in their home countries or in other industrial countries. For a developing country, the higher education system is therefore an important element of the NSI that determines the nature, quality and extent of R&D capabilities that exist for generating innovation.

The higher education sector has been the fastest growing segment of the Nigerian educational system in recent years[66]. Higher education institutions in Nigeria include universities, polytechnics and colleges of technology, colleges of education, and specialized institutions such as colleges of agriculture, nursing and administration. The university sector comprises conventional universities and specialized universities. Conventional universities constitute the majority, and offer courses in pure and applied sciences, as well as in the social sciences and humanities; while specialized universities include agricultural universities (concentrating in agricultural sciences), medical universities (concentrating in medicine and allied fields), and science and technology universities (concentrating in engineering and other technology-related fields). The polytechnics provide advanced vocational and technical training in engineering disciplines, while colleges of education train professional teachers (Adesina, 2005)[67].

Until recently, the vast majority of universities in Nigeria have been owned by state and federal governments. In 1932 the British Government established Yaba Higher College in Lagos as the first higher educational institution in Nigeria. The University of Ibadan was established in 1948 as a college of the University of London, and thus became the first university in Nigeria. By 1962 Nigerian higher education consisted of three regional universities and two federal universities. Over the years, the drive for more investment in higher education, a growing youth population and the fiscal space created by increased revenues from oil exports led to the establishment of more universities at state and federal levels. The private sector emerged in the 1990s to become a major actor in the provision of higher education in the country. tertiary education with the establishment of private universities

Table IIIA.8
Expansion and ownership of Nigerian universities 1960-2017

Year	Types of ownership			Total
	Federal	State	Private	
1960	1	1	-	2
1965	2	3	-	5
1975	5	-	-	5
1999	24	25	3	52
2009	27	30	36	93
2012	37	37	50	124
2017	40	44	68	152

Source: National Universities Commission (2017).

66 Nwuke, K., 2005, 'Emerging Prometheus: Private Provision of Higher Education in Africa', Scholar (Journal of the Academic Staff Union of Nigerian Universities), September 2005.

67 There is a network of Law Schools and the Armed Forces own a couple of universities with focus on science, technology and innovation. Unlike the Israeli military, the Nigerian military has not been a seedbed of innovations, innovators and start-ups.

Table IIIA. 9

Selected indicators of human resources for innovation in 2015 or latest

Countries	Government expenditure on education, total (% of GDP)	School enrolment, secondary (% gross)	School enrolment, tertiary (% gross)	Researchers in R&D (per million people)	Patent applications, residents
Brazil	5.95*	99.65	50.60	698****	4,641
China	n.a	95.03**	45.35	1176.58	968,252
Ghana	6.16*	60.32***	16.07***	38.68****	14.00***
India	3.84**	73.98	26.88	215.85	12,579
Indonesia	3.58	87.30	23.30	n.a	1058
Kenya	5.27	57.84^^^	4.04^^^	321^^	137
Korea Republic	6.05*	102.75	19.78*	437.06**	889
Malaysia	4.98	84.97	42.37	2261.44	1,272
Nigeria	n.a	56.18**	10.17^	n.a	50**
South Africa	6.05*	102.75	19.78*	437.06**	889

Source: WDI (2018).

Note: * 2014 data ** 2013 data *** 2016 data **** 2010 data n.a - not available

^ 2011 (UNESCO, UIS 2018) ^^ 2010 (African Innovation outlook II, 2014)

^^^ 2009 data (OECD data; see http://uis.unesco.org/en/country/ke?theme=education-and-literacy).

and polytechnics. The first private university was established in 1999, and by 2012 Nigeria had 50 privately owned universities rising to 68 in 2017.

Overall, as shown in table IIIA.8, the number of universities in Nigeria rose from one in 1960 to 52 in 1999 and 152 in 2017 of which 40 are owned and controlled by the Federal Government, 44 are owned by state governments, and 68 are owned by private sector entities, including faith-based organizations, communities, corporations and individuals.

In spite of Nigeria's growing investment in higher education and training, the indicators of human resources in innovation presented in table IIIA.9 suggest that the outcomes of Nigeria's education investments poor and not very competitive when compared against those of emerging economies of Asia and Latin America. While Nigeria is estimated to have only 10 per cent of gross school enrolment in tertiary educational institutions, Indonesia has 23.3 per cent, Malaysia 42.4 per cent, India 26.9 per cent, and Brazil 50.6 per cent. For secondary school enrolment, Nigeria's enrolment of only 55.7[68] per cent of gross school enrolment lags behind all other selected countries in table IIIA.9. The outcome of Nigeria's relatively low investment in education and training as a principal means of building the skills base for human resources in innovation is reflected in the data on the number of researchers in R&D per million of the population and the number of patent applications. As shown in table IIIA.9, while Nigeria had only about 39[69] R&D researchers per million population in 2009, Malaysia had 2261, India had 216 and Brazil had 698.

The number of patent applications in Nigeria is also one of the lowest among comparable countries. Improving Nigeria's STI readiness would thus require a great increase in educational expenditure and schools' enrolment at all levels, along with a significant improvement in the quality of education and training

68 In 2013, according to the World Bank.

69 AU-NEPAD (2010) African Innovation Outlook, NEPAD, Pretoria.

delivered at universities and other institutions with a mandate for education and training.

5.2 Employment, skills and lifelong learning

In the traditional Nigerian setting, education was seen as an immediate pathway into society and a preparation for adulthood. Lifelong learning is envisioned within the context of the larger society after graduation from the regular school system. However, contemporary educational practices in Nigeria have not consistently encouraged key aspects of lifelong learning, which include vocational, non-formal and informal learning. To bridge this gap, Nigeria's new National Policy on

Box IIIA.4

Upgrading the technological capability of automechanics through interaction between the University of Ibadan and a private sector agent

Interaction for skills upgrading and technological capability

The interaction between the University of Ibadan and MAG BEN Automobile Technology* is a case of innovation, skills upgrading and technology transfer in a marginalized community. The interaction aims at addressing livelihood problems triggered by advances in global technology development. The interaction, which is private sector-led, fits neatly into the new vision of the University of Ibadan, which is to contribute to societal development. The innovation is supported by the Distance Learning Centre of the university, which is one of the interface structures that have been established pursuant to the university's new vision and mission statement. The livelihood problem associated with automechanics as informal sector artisans has to do with their inability to repair modern high technology motor vehicles.

MAG BEN initiated an engagement with the University of Ibadan with the purpose of bridging the gap between automechanics and modern automobiles in Nigeria; and to authenticate certificates issued from programmes of MAG BEN Technology. The interaction with the university was facilitated through an interface structure of the university. This interface structure includes the DLC and the Department of Mechanical Engineering in the Faculty of Technology.

The interaction involves the transfer of technological skills to automechanics to enhance their ability to repair the high-tech vehicles which currently abound in Nigeria. The university provided the administrative and theoretical support for the interaction, while MAG BEN provided the practical aspect of the interaction.

Knowledge flows, skills and innovation outcomes of the interaction.

The knowledge flows, skills and innovation emanating from the automechanics' programme occur in three areas:

1. Technical knowledge: technical skills in the area of use of auto-scanner and Launch** in the diagnosis of automobiles. Innovation outcomes include technological innovation resulting from knowledge transfer, and the acquisition and use of new equipment (the Launch and the auto-scanner – the major diagnostic equipment for modern automobiles).
2. Entrepreneurial skills: skills in the areas of book-keeping, customer relations and fund generation from cooperative societies and microfinance institutions. Entrepreneurial innovation is thus achieved through the course on entrepreneurial training.
3. Workshop process skills which incorporate workshop management, work ethics, self-esteem, efficiency and productivity. This produces process innovation covering areas of workshop management.

**. MAG BEN Automobile Technology is a private sector organization established in 2009 that specializes in the training of local automechanics in the repair of high-tech vehicles.*

*** Launch X431 GDS is an auto diagnostic tool like the scanner, but with more diagnostic sensitivity than the ordinary scanner.*

Source: Adeoti and others (2014).

Education strives to make education more accessible, throughout life, and to a wider population through e-learning, adult education, continuous learning, and nomadic and vocational education. The major mechanism for this in the Nigerian educational system is the National Open University of Nigeria (NOUN).

Although NOUN was established to promote lifelong learning, its achievements have so far demonstrated no apparent or remarkable difference from what is achieved from the regular university system. A good illustration of skills upgrading and lifelong learning is the case of interaction between the University of Ibadan and a private sector agent that has enabled skills upgrading and the improved technological capability of automechanics in southwest Nigeria. The case study as reported by Adeoti and others (2014) is presented in box IIIA.4.

5.3 Inclusive innovation and innovation culture

An inclusive innovation and innovation culture that relates to human resources for innovation can be illustrated by case studies emanating from the innovation survey or Country STI readiness study. The case study presented in box IIIA.4 is a good example of inclusive innovation among artisans because the innovation generated contributed significantly to improving the livelihood conditions of the community of informal sector artisans belonging to marginalized segments of the urban population. From published sources the Global Innovation Index Report also provides important clues on inclusive innovation and innovation culture.

Nigeria ranked 120 out of 142 countries on the 2013 Global Innovation Index (GII), which measured countries' innovation capabilities and how they drove economic growth and prosperity (GII, 2013). The report shows that Nigeria scored 26.6 per cent, a two-point improvement over 2012, when it scored 24.6 and was ranked 123rd out of 142 countries. These scores do not in any way suggest an appreciable innovation culture among Nigerians. The scores in relation to different criteria were gloomy. For instance, under institutions (political stability, government effectiveness and press freedom, amongst other things), it was placed 129th; under human capital and research it was ranked 140th; and it was placed 133rd under infrastructure. Furthermore, Nigeria was ranked 134th under business sophistication, 114th under knowledge and technology output, and 74th under creative output. On the African continent Nigeria was placed 19th in terms of GII, whereas Mauritius, South Africa and Uganda took the first, second and third positions respectively.

The report advises that underperforming countries, including Nigeria, can boost their innovation capabilities by developing hubs in which large companies whose business goals are aligned with the objectives of the innovation hub can play a key catalytic role. Enterprise champions, including State-owned enterprises, family-owned conglomerates and multinational corporations can be the critical drivers of innovation hub activities. These enterprise champions can facilitate the building of hub capabilities and their talent pools by stimulating innovation and by helping to bridge the gap between research and commercial success. Two good examples of enterprise champions in Nigeria are the Dangote Conglomerate in cement, oil and gas, and an array of consumer products; and the Heirs Holdings in the power sector and financial services.

6. STI policy governance

6.1 STI policy institutions and governance structure

The governance of STI - the roles that various actors in the innovation system play, the rules that govern the actors, and the process by which decisions concerning STI are made - matters for national wealth creation, productivity and competitiveness. Nigeria, like most countries, recognizes the importance of a governance structure for STI readiness and has, like many other countries, struggled to create an appropriate STI governance structure for the country.

According to the NBS (2012) the first attempt to coordinate scientific research in Nigeria was in 1970, with the establishment of the Nigerian Council for Science and Technology (NCST). It was charged with the responsibility of ranking national priorities in scientific research and coordinating and supervising both basic and applied research activities in the country. Two other subsidiary councils, namely the Agricultural Research Council and the Industrial Research Council were established in 1971, while the Medical Research Council and the Natural Science Research Council of Nigeria were created in 1972 and 1973 respectively to assist NCST in specific areas. Throughout the six years of the existence of NCST there were various complaints concerning its relevance to the economic development of the country.

In January 1977 the National Science and Technology Development Agency (NSTDA) was created to replace NCST. NSTDA was charged with responsibility for the promotion and development of science and technology "including initiation of policy in relation to scientific research and technology". The body was given full control of all government-owned research institutes in the country. The sustained call for the review of the national machinery for managing science and technology (to ensure that scientific research was made relevant to economic development in Nigeria), led to the creation of a fully-fledged Federal Ministry of Science and Technology (FMST) in 1980 by Act No. 1 of 1980 headed by a minister at Cabinet rank. The newly created Ministry took over the responsibilities of the NSTDA, with five professional departments: Science and Technology Planning, Agricultural Science, Industrial Science and Energy, Medical and Natural Science, and Technology Transfer and Science Education.

The tasks of the abolished research councils were reassigned to appropriate departments within the ministry which were now to advise the minister, in addition to initiating and implementing technology policies suitable to the sectors or subsectors in their charge. Each research institute retained its governing board, with responsibility to screen proposals and budgets before they were sent to the ministry. However, in 1984 the FMST was merged with the Federal Ministry of Education to form a Ministry of Education, Science & Technology, whose Science and Technology arm was to be coordinated by a director. Towards the end of 1985 the Ministry of Science and Technology demerged and resumed its autonomy. Then in 1992, the Ministry was scrapped and its responsibilities assigned to the Ministry of Industry & Technology, and a newly created agency called the National Agency for Science and Engineering Infrastructure (NASENI). The research institutes in the defunct Ministry of Science and Technology were moved to their sectoral ministries. The Ministry was re-established in 1993 and has been in existence since then. It supervises Nigeria's more than 17

research and development institutions and is responsible for the development and supervision of the implementation of the national STI policy. It also interfaces with sub-national jurisdictions on their STI policies, strategies and plans.

From the foregoing it is evident that Nigeria has struggled to find a stable institutional framework for STI governance. The chequered history of the FMST did not provide a conducive environment for incremental growth, capacity development, and policy stability and continuity. Nigeria adopted a new STI policy 2012 STI replacing the policy adopted in 1986. The new STI acknowledges that the lack of a long-term commitment to STI has been a major impediment to Nigeria's economic development. The 2012 policy advocates the need to accord to STI a central role in national economic planning and development by establishing both an effective institutional framework and linkages at various levels within NSI. Under the new policy, the following institutions were created to strengthen the governance of STI in the country: a) National Research and Innovation Council (NRIC)[70] chaired by the president of the Federation; b) State Science Technology and Innovation Council (SSTIC) chaired by the governor at the State level; and b) National Council on science, technology and innovation (NCSTI) chaired by the Minister[71].

The new STI policy thus recognizes that the effectiveness of an STI governance structure depends on leadership, effective coordination and adequate resources for all STI activities within the national system of innovation. To enhance the effective coordination, direction and management of STI activities in Nigeria, it is essential to establish and strengthen the institutions and governance structures that are needed to provide sound STI administration, good governance and quality leadership at all levels of government. Good governance creates a platform for inclusiveness, ownership, sustainability and inter-agency collaboration among key actors and stakeholders.

To ensure good governance of the STI system, the Nigerian STI policy outlines the following strategies:

(a) Create a governance structure that is inclusive and broadly-based;

(b) Reconstitute boards and committees to reflect the intent and directions of current policy;

(c) Create specific roles to avoid role duplication and confusion;

(d) Establish an appropriate legal framework for effective organizational management and control;

(e) Strengthen states' ministries of S&T and FMST as the coordinating institutions for all STI activities in the country;

(f) Establish appropriate departments or structures in the FMST and states' ministries of S&T to facilitate linkages among FMST, related ministries, agencies, research institutions and industries;

(g) Strengthen the National Research Development and Coordinating Council (NRDCC) to coordinate R&D activities and promote linkages and collaborations among relevant institutions as well as with the private sector;

(h) Encourage all S&T institutions, as well as public and private sectors, to carry out programmes and activities that are consistent with the national STI policy;

70 Membership of the NRIC includes the private sector.

71 For a full discussion, see the 2012 Nigeria STI policy available at *http://scienceandtech.gov.ng*.

(i) Carry out mandatory periodic evaluation and monitoring of the performance of the national system of innovation;

(j) Ensure the establishment of appropriate STI ministries and policy organs at state and local government levels;

(k) Establish other relevant STI research institutions to fast-track sustainable development.

These STI governance strategies are good, but would require the active involvement of private sector agents to ensure both effectiveness and a demand-driven STI investment and innovation culture.

6.2 Roles of multi-level and multi-actor governance

With its large population, Nigeria is very important to the overall development of the African continent. The persistent challenge of poverty has made support from development partners a critical component of strategies for mobilizing the requisite technical and financial resources necessary for the implementation of development projects and programmes. Table IIIA.10 presents the list of development partners in Nigeria and their activities. It has been noted that Africa's attainment of the Millennium Development Goals by 2015 depended to a large extent on Nigeria's success in reducing poverty (NPC 2004; World Bank and DFID, 2005). This line of thinking explains the presence of several bilateral, multilateral and donor agencies in Nigeria whose sole aim is to assist the country tackle the many development challenges it faces.

Policy formulation and analyses in Nigeria generally take place within government ministries, departments and agencies. In developing its policies and strategies, Nigeria has often consulted internationally through relationships with development partners. For instance, UNESCO was actively involved as an agency of the United Nations system in revising Nigeria's STI policy (UNESCO, 2010). Development partners have supported initiatives aimed at addressing Nigeria's development challenges. They have accepted the Nigeria Vision 2020 (NV2020) as the basis of all support for sustainable development in Nigeria. Fundamental to the Nigeria Vision are two broad objectives – optimizing human and natural resources to achieve rapid economic growth, and translating that growth into equitable social development for all citizens.

While development partners support the mechanisms shown in table IIIA.10 that are aimed at inclusive development, only the World Bank and some United Nations bodies (in particular UNESCO) support instruments and activities that are directly involved in the promotion of investments in science, technology and innovation. Support from other development partners can also, directly or indirectly, contribute to the development of the human capital that is required for a national system of innovation. Nevertheless, UNESCO support for STI investments is especially invaluable for the knowledge generation and learning that are critical for innovation. Overall, the role of development partners in STI governance has been largely restricted to policy support.

At a subnational level, the 2012 STI policy envisages an STI governance structure that emulates the federal STI institutional structure at a state level, and to some extent at the local government level. Since STI policy is a federal government policy, it is yet to be seen how states and local governments will comply, since there is no constitutional or legal framework compelling state and local governments to adopt the policies of the federal government.

Table IIIA.10
Development partners in Nigeria and their activities

Development partner	Areas of interest or activities
1. African Development Bank (ADB)	» Water and sanitation » Health systems development project » Community-based poverty reduction project
2. Canadian International Development Agency (CIDA)	» Poverty reduction » Primary health care » Roll back malaria » HIV/AIDS
3. United States Agency for International Development (USAID)	» Governing justly and democratically » Investing in people through health and education » Enhancing economic growth and trade » Improving peace and security
4. Department for International Development (DFID)	» Promote good governance at the national, state and local government levels in Nigeria » Primary education especially for young girls » HIV/AIDS project » Family planning
5. European Union (EU)	» Economic governance » Democracy » Micro projects-health, credits, etc.
6. World Bank Group	» Community-based urban development » Health system support » HIV/AIDS project » Education support system » Community development project » Universal basic education
7. United Nations (UN)	» Governance » Productive sector » Health services » Education, science and technology » HIV/AIDS

Source: Adapted from Moughalu (2004).

7. STI investment profiles and prospects

Most developed countries have well-structured and regularly reviewed STI policies and profiles which have shaped their remarkable economic transformation experiences. Since the mid-1990s, most OECD economies have increasingly concentrated investments on knowledge accumulation rather than on machinery and equipment. The trend in other developed and emerging developing economies also show significant improvements in the different indices of STI profiles.

African countries and Africa's development partners cannot ignore the vital importance of monitoring progress in country STI profiles if new technologies are to drive and steer Africa's growth along a transformative path marked by sustained growth, global competitiveness, poverty reduction, inclusiveness and environmental sustainability. This pilot study on Nigeria's STI readiness provides some insights into the state of STI profiles, their contributions to economic growth and competitiveness, and

pathways to ensuring that investments in STI result in real wealth creation, poverty reduction, and the greening of Nigerian production and consumption patterns.

From the analysis provided in this report, there are at least 12 elements of a strategy for improving Nigeria's STI profile. They include:

(a) An immediate increase in investments in R&D that is more than double the current levels and that is subsequently increased to an annual level not lower than the average of the BRICS countries;

(b) The state of business R&D and innovation activities in Nigeria is relatively weak. Policy support for business R&D is accordingly critical for Nigeria to improve her STI readiness;

(c) Increase investment in infrastructure, including research infrastructures. With the exception of fixed broadband Internet subscriptions, infrastructure support for interaction involving STI actors is inadequate or weak. For Nigeria to promote interaction among STI actors, improving investments in power infrastructure to raise power consumption levels must be a major component of STI investments. Also crucial are investment in broadband infrastructure and further improvements to the mobile cellular infrastructure;

(d) Nigeria has a few SME clusters already recognised as rising innovation clusters (e.g. the Otigba computer village and the Nnewi auto spare parts cluster). These clusters could serve as nodes for innovation activities from which sectoral innovation systems can be grown and scaled up across the entire country. Although Nigeria's STI readiness as indicated by clusters and knowledge flows may at present be regarded as still in its infancy, current efforts aimed at supporting and strengthening the SME clusters present great hope of a significant improvement in Nigeria's STI readiness through SME cluster development;

(e) In spite of Nigeria's increased investment in higher education and training, the indicators of human resources in innovation suggest that the outcomes of Nigeria's education investments are below the threshold that can make its STI profile compare with those of the competitive and emerging economies of Asia and Latin America. Improving Nigeria's STI readiness would thus require a significant increase in education expenditure and school enrolments at all levels, along with adequate improvement in the quality of education and training delivered at universities and other institutions with a mandate for education and training;

(f) Skills upgrading and lifelong learning in the informal sector economy can be promoted through interactions between knowledge institutions and private sector agents. Such interactions can result in significant technological and organizational innovations capable of raising the STI profile of the informal sector economy;

(g) Nigeria can improve its innovation capabilities by developing hubs in which large companies can play a key role as catalysts in line with their core businesses. Enterprise champions including State-owned enterprises, family-owned conglomerates and multinational corporations, can be the critical drivers of innovation hub activities. These enterprise champions can facilitate the building of hub capabilities and their talent pools by stimulating innovation and by helping to bridge the gap between research and commercial success;

(h) There is need to stabilize the institutional framework for STI governance in the

country. An effective STI governance structure depends on leadership, coordination and adequate resourcing for all STI activities within the national system of innovation. To enhance the effective coordination, direction and management of STI activities in Nigeria, it is essential to strengthen the institutions and governance structures required to provide sound STI administration, good governance and quality leadership at all levels of government. Good governance creates a platform for inclusiveness, ownership and sustainability and inter-agency collaboration among key actors and stakeholders;

(i) While development partner support mechanisms are generally aimed at inclusive development, only the World Bank and certain United Nations bodies (in particular) support instruments and activities that are directly involved in the promotion of investment in science, technology and innovation. Overall, the role of development partners in STI governance has until now been largely restricted to policy support;

(j) At the sub-national level the 2012 STI policy envisages an STI governance structure that replicates the federal STI institutional structure at the state level, and to some extent at the local government level. Since STI policy is a federal government policy, it is yet to be seen how states and local governments will comply, as there is no constitutional or legal framework compelling state and local governments to adopt the policies of the federal government;

(k) The pursuit of technology acquisition should form the core of economic, industrial and STI policies. The industrial competitiveness of the organized private sector and the technological upgrading of the burgeoning informal sector economy cannot be realized without a reorientation that seeks to build local technological capability through upgrading locally available technology and skills and experimenting with foreign knowledge in a bid to improve the competitiveness of local industries;

(l) Learning from countries that have successfully transformed their economies would be of great help in understanding what needs to be done to make investments in STI a major driver of economic development and transformation.

The recent launch of NIRP, NEDEP, NRIC and the establishment of the NIRP Presidential Advisory Group and the National Micro, Small and Medium Enterprise Council are indications of resoluteness and political will to industrialize.[72] Such a demonstration of resoluteness and political will has characterized the leadership approach of most countries that have successfully transformed their economies. This new approach should be brought to bear on the strategies for improving Nigeria's STI investment profiles. These strategies should include:

- A drive towards a knowledge-based and innovation-driven economy
- Upgrading and strengthening institutions for industrial and STI policies
- Sustained investments in R&D
- Promoting entrepreneurship and innovative firms

72 The NIRP Presidential Advisory Group is expected to work directly with the President in an advisory role, and NRIC would be chaired by the President and includes ministers responsible for relevant sectors and STI as members; while the National Micro, Small and Medium Enterprise Council will be chaired by the Vice-President.

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1. Review of economic and innovation performance

1.1 Introduction

Kenya, with a population of approximately 45 million, is on the East African sub-continent. The economy is predominantly market-based and is one of the largest economies in the Eastern and Central African region, with a GDP estimated at $70.8 billion in 2016.[74] The country has a total area of 583,000 km^2, and is generally perceived as Eastern and Central Africa's hub for financial, communications and transportation services. The country's climate ranges from tropical to temperate, depending on altitude. The Kenya Economic Report (2013) presents the agricultural sector as the mainstay of the country's economy, which presently accounts for about 26 per cent of Kenya's GDP and 65 per cent of its total exports.

The agricultural sector has been a key driver of economic growth in Kenya for the last four decades, and is the main source of livelihood for the almost 80 per cent of Kenya's population living in rural areas. The sector accounts for 18 per cent and 60 per cent of formal and total employment, respectively. Kenya's main export products are tea, horticultural products and coffee. The country's export profile is largely primary agricultural products, thus making it vulnerable to exogenous shocks such as unfavourable weather conditions and price volatility in the commodities' export market. Although the Kenyan economy is largely dependent on agriculture, according to official statistics, only 20 per cent of its land area is suitable for crop cultivation. This underscores the importance of developing non-farm employment-generating activities in both the urban and rural areas of the country. However, the performance of the Kenyan manufacturing sector has been poor, recording a downward trend since 2008. Manufacturing added value, which was 12.29 per cent of GDP in 2008, declined to 10.56 per cent of GDP in 2012 (WDI, 2013).

The tourism potential of the country has also been greatly exploited for improved economic performances.[75] The country is endowed with a wide array of wilderness, coast, mountains, forests, lakes, deserts and cities which make for attractive tourist centres for both citizens and foreigners. Moreover, the rich cultural heritage of the different counties is also another tourist attraction. These rich cultural diversities provide an opportunity for each county to market its own cultural heritage,

73 This pilot study was prepared by John Adeoti, Odunayo Adebayo and Augustine Osigwe of the Nigerian Institute of Social and Economic Research (NISER), Ibadan, Nigeria. It was revised and updated by the New Technologies and Innovation Section, ECA.

74 Based on World Bank data from 2012 (WDI, 2013).

75 The tourism sector went into a dip in 2012 because of 2013 election anxieties in the market, the rising cost of flying to Kenya and decreasing passenger numbers, as well as because of high taxes and negative publicity in international media about poor security along the Kenyan coast (Kenya Economic Report, 2013).

even though some counties are better endowed than others.

Kenya has been considerably penetrated by information and communications technologies (ICTs), particularly in its service sector. Prominent among these are the M-Farm and M-Pesa, which are innovative approaches to facilitating farming and banking activities in the country respectively. This penetration has introduced a new and more efficient dimension to service delivery in the country and has narrowed the information and public/private services gap that typically exists between rural and urban populations.

The Kenyan economy has passed through three distinct economic phases since the country's independence in 1963. Immediately after independence, the country experimented with an import substitution industrialization (ISI) strategy. The thrusts of ISI were to ensure the rapid growth of industry, to ease balance of payment pressures, to increase domestic control of the economy and also to generate employment. While the ISI regime saw the manufacturing sector growing at an average rate of 8 per cent annually, its stringent checks[76] on competition from foreign firms led to inefficiencies in the local manufacturing sector, hindering the development of a globally competitive industrial base. Also, the small size of the local market constituted a setback to achieving the goals of ISI, since the industrialization strategy was biased in favour of the local market, with its limited potential to absorb firms' products. The major consequence of this, as shown in table IIIB.1, was the start of de-industrialization as indicated by the unimpressive minus 4.3 annual percentage decline in value-added manufacturing in 1970.

The failure of the ISI to achieve a robust macroeconomic environment for the country led to the adoption of the World Bank-IMF-led economic structural adjustment programme (SAP) of the early 1980s. The SAP was intended to address the structural rigidities, price instability and macroeconomic imbalances that had become embedded in the economy, leading to poor service delivery by the public sector. The adoption of the SAP was to encourage a more competitive industrial base engendering employment creation and export expansion. Whereas the SAP reduced tariffs and attempted to remove price controls, it also exposed local manufacturing firms to intense international competition, leading to the collapse of most industries.[77] The SAP accordingly failed to actualize Kenya's macroeconomic objectives.

By 1993 the SAP had to make way for the export-oriented industrialization strategy, which offered incentives aimed at encouraging industries to produce for export. The main objectives of the export-led industrial sector reform programmes were to improve efficiency, stimulate private investment and increase the sector's foreign exchange earnings. The export orientation policy was accompanied by trade liberalization measures which were also aimed at encouraging production for exports. The liberal trade regime included the removal of quantitative restrictions, tariff reductions and export promotion, as well as the establishment of a more flexible exchange rate regime (Kenya's Ministry of Industrialization, 2011).

As observed by the Kenyan Economic Report (2013), the economy is now on a path to strong recovery, and its medium-term prospects are positive, predicated on a smooth transition to a devolved governance system and the continuing implementation of the

76 These include quantitative restrictions, import licensing, foreign exchange controls, high tariffs on competing imports and overvalued exchange rates.

77 The previously booming textile industry of Kenya was most hard hit by the liberalization policy.

reform agenda outlined in the Medium Term Plans[78] and Vision 2030, as well as on regional stability and security, favourable weather conditions and a stable global economic environment. Table IIIB.1 shows the key performance indicators of the Kenyan economy in an historical perspective from 1960 to 2012.

78 The first Medium Term Plan (MTP) (2008-2012) was geared towards national healing and reconciliation, as well as rapid economic reconstruction to reverse the damage and setbacks the country suffered following the December 2007 general elections. The theme of the Second MTP (2013-2017), launched in October 2013 is: Transforming Kenya: Pathway to Devolution, Socio-economic Development, Equity and National Unity. The Government intends to achieve the second MTP by implementing targeted interventions for the faster provision of benefits to Kenyans.

Table IIIB.1
Kenya's key economic performance indicators

Economic performance indicators	1970	1980	1990	2000	2005	2010	2011	2012	2013	2014	2015
GDP at market prices (constant 2010 US$, billions)	6.76	14.61	21.77	26.20	31.32	40.00	42.44	44.38	46.90	49.41	52.20
GDP growth (annual %)	-4.66	5.59	4.19	0.60	5.91	8.40	6.11	4.55	5.69	5.33	5.65
GDP per capita (constant 2010 US$)	601.07	898.12	928.32	843.34	886.11	991.85	1024.73	1043.12	1073.50	1101.23	1133.46
Manufactures exports (% of merchandise exports)	n.a	12.13	29.25	20.79	31.91	34.67	n.a	n.a	36.86	n.a	n.a
Manufactures imports (% of merchandise imports)	n.a	55.89	65.52	59.58	64.30	62.75	n.a	n.a	61.61	n.a	n.a
Manufacturing, value added (% of GDP)	11.98	12.84	11.72	11.62	11.82	12.62	13.08	12.26	11.72	11.07	11.36
Manufacturing, value added (annual % growth)	-4.32	5.24	5.23	0.68	4.66	4.50	7.24	-0.56	5.60	3.20	3.46
Agriculture, value added (% of GDP)	33.29	32.59	29.52	32.36	27.20	27.83	29.27	29.09	29.48	30.25	32.94
Agriculture, value added (annual % growth)	-7.87	1.07	3.47	-1.28	6.91	10.06	2.35	2.95	5.45	3.49	5.63
Services, etc., value added (% of GDP)	46.87	46.56	51.44	50.72	53.71	51.38	49.68	50.20	50.60	50.42	47.54
Services, etc., value added (annual % growth)	-3.34	5.53	4.48	1.88	4.59	7.30	6.09	4.73	5.36	5.76	5.52

Notes: n.a = not available.

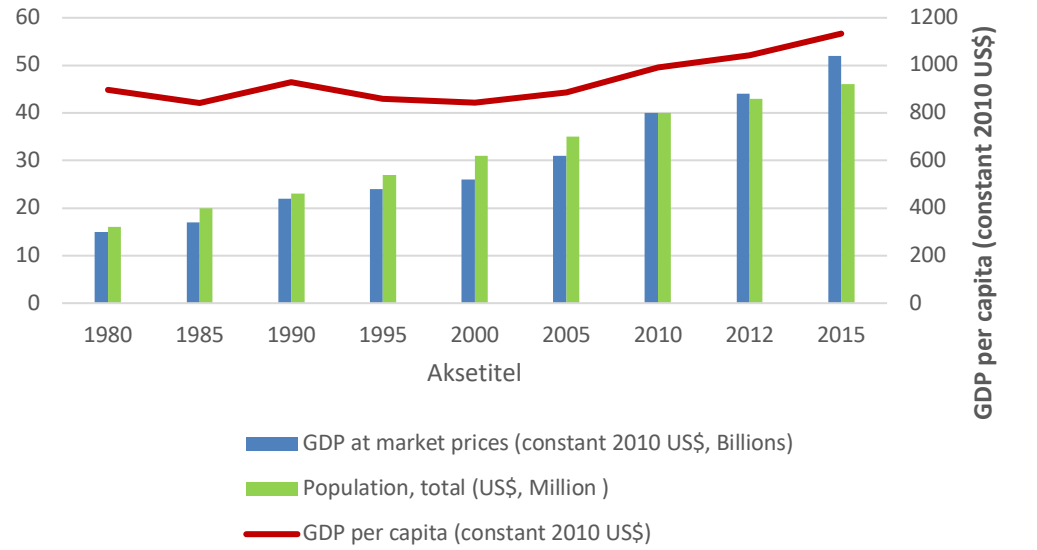
Source: WDI (2017).

1.2 Economic growth performance

More recently economic growth in Kenya has relied mainly on the private sector's ability to explore opportunities in new areas of growth such as horticulture and ICT. The Kenyan Government is, however, focusing on building a strong public-private partnership for the achievement of Vision 2030[79] and the implementation of planned infrastructure projects aiming to transform Kenya into a middle-income economy (AfDB, 2008). While these efforts have yielded positive results in economic growth performance, more proactive policies will be required to achieve the ambitious economic objective of becoming a middle-income economy.

As shown in figure IIIB.1, the last decade witnessed only a moderate annual increase in Kenya's real GDP and GDP per capita. While the formal sector economy has significantly improved its performance, the informal sector has remained the major employer of labour. The low level of human capital in informal economic activities has had a direct negative impact on average labour productivity – output per worker – and an indirect impact on GDP per capita. However, efforts are being intensified to create more decent jobs and to enhance the human capital base in the country.

Figure IIIB.I
Real GDP (in billions of United States dollars) and GDP per capita (1980-2015)



Source: WDI (2017).

79 The vision is a drive to ensure that Kenya becomes a globally competitive and prosperous nation with a high quality of life by 2030. This is intended to be achieved in three main areas: economic, social and political. The vision document aims to maintain sustained economic growth of 10 per cent per annum over the next 25 years, to achieve a just and cohesive society enjoying equitable social development in a clean and secure environment, and to engage in an issue-based, people-centred, result-oriented and accountable democratic political system.

Table IIIB.2
Trends in Kenya's macroeconomic indicators

Macroeconomic indicators	1980	1985	1990	1995	2000	2005	2010	2012	2015
GDP in constant 2005 US$ (billions)	14.6	16.5	21.8	23.6	26.2	31.3	40.0	44.4	52.2
Population, total (millions)	16.3	19.7	23.4	27.4	31.1	35.3	40.3	42.5	46.1
GDP per capita (constant 2005 US$)	898.1	841.7	928.3	860.4	843.3	886.1	991.9	1043.1	1133.5
Gross fixed capital formation* (% of GDP)	8.2	10.7	10.9	13.5	7.5	16.2	n.a	n.a	n.a
Export of goods and services (% of GDP)	29.5	25.3	25.7	32.6	21.6	28.5	20.7	19.8	15.8
Import of goods and services (% of GDP)	35.9	30.1	31.3	39.2	31.7	36.0	33.6	35.4	29.0
Aid US$ (millions)>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	n.a
Aid (% of GDP)	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	n.a
Aid per capita (US$)	24.3	21.7	50.4	26.7	16.5	21.5	40.3	62.4	n.a
Remittances (US$ millions)^	27.7	66.0	139.3	298.3	537.9	425.0	685.8	1211.0	1560.4
External debt (% of GDP)*	48.1	70.6	86.0	83.8	48.9	34.6	22.2	23.7	30.4
Debt services (% of export of goods and services)	12.1	28.8	28.6	20.7	17.3	9.4	4.1	4.8	n.a

Note: Aid represents Net official development assistance and official aid received (current US$)

Remittance = Personal remittances, received (current US$)

Gross domestic investment = Gross capital formation

Debt services = Debt service (PPG and IMF only, per cent of exports of goods, services and primary income)

Source: WDI (2017).

Table IIIB.3

Kenya's macroeconomic indicators (average annual growth rates)

Macroeconomic indicators	1980-1984	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
GDP (constant 2005 US$)	1.72	5.25	0.73	2.12	2.58	3.56	4.70
Population, total	3.29	3.06	2.70	2.14	2.17	2.22	2.25
GDP per capita (constant 2005 US$)	-1.35	1.90	-1.73	-0.02	0.37	1.21	2.21
Gross fixed capital formation	-4.04	10.42	-4.76	0.79	4.65	19.11	14.63
Exports of goods and services	-1.87	-1.79	8.83	-7.22	4.65	-5.95	-3.61
(% of GDP)							
Imports of goods and services	-2.14	-0.02	1.85	-6.02	0.72	-2.86	0.38
(% of GDP)							
Aid (% of GDP)	28.06	0.00	3.64	0.30	-8.97	-4.96	7.38
Remittances	20.95	7.00	-0.28	8.94	-6.03	9.72	22.02
External debt (% of GDP)	4.39	0.76	4.42	-7.75	-2.27	-6.65	4.64
Debt servicing	20.33	1.23	-8.12	-7.42	-11.49	-9.81	7.78
(% of export of goods and services)							

Source: WDI (2017).

Tables IIIB.2 and IIIB.3 present the macroeconomic performance of the Kenyan economy. The growth in national output has significantly outpaced the population growth rate in recent years, hence the sustained growth in GDP per capita. Although imports of goods and services have been higher than exports of goods and services, the deficit has been covered by significant inflows of aid and remittances. The country's poor export performance compared to imports is reflected in the balance of trade deficit recorded in recent years as shown in figure IIIB.2. The main Kenyan export commodities are low-value primary products, while imports are mainly in non-food industrial supplies, fuel and lubricants and other capital equipment that is of high value.

The key sectors that account for Kenyan economic growth in recent years are financial intermediation, tourism, construction and agriculture. The GDP growth rate increased from an average of 2.6 per cent in the late 1990s to an average of 4.3 per cent between 2010 and 2012. This impressive growth performance was, however, halted in 2008, when the rate plummeted to 1.53 per cent, although it subsequently continued on its upward trend. The sharp decline observed in 2008 resulted from a number of shocks including political unrest that attended the 2007 Kenyan general election, the global financial crisis that severely affected Kenya's exports[80] and high international oil prices. Others factors responsible for retarded growth in the late 2000s include poor climatic conditions with their adverse impact on agriculture and hydro-power generation, and security threats which took their toll on the tourism sector.

It is noteworthy that, since 2009, Kenya's economy has not only resumed its positive growth path, but that the drivers of growth have also been broadly based. Each of the core sectors and subsectors experienced a significant improvement in its contribution to the country's growth. The World Bank (2013) reported that in 2012 agricultural output grew by 3.8 per cent, more than twice its growth in 2011. To accelerate the pace of growth in the agricultural sector, the Government is undertaking important reforms in the sector. According to KIPPRA (2013), these reforms include legal and institutional changes, the increased allocation of resources towards irrigation, and improved access to inputs, especially fertilizer and seeds.

It was also reported by the World Bank (2013) that Kenyan industrial output increased by 2.9 per cent and 1.6 per cent in 2011 and 2012, respectively. As shown in table IIIB.4, the industrial sector has accounted for over 15 per cent of GDP since the beginning of the century. This sector comprises mining and quarrying, manufacturing, electricity and water supply and construction. Manufacturing is the largest industrial subsector in Kenya. Its average contribution to growth has declined marginally on average in the past decade, accounting for about 10 per cent GDP in 2012. The trend in the distribution of value added by sectors as shown in table IIIB.4 indicates that there has been no structural change in the Kenyan economy in the past decade. This can be explained by limited value addition and economic diversification, the high cost of inputs and dependence on imported intermediate products.

The mining subsector holds great potential to improve economic growth in Kenya. The recent discovery of oil, coal and other minerals and their responsible exploration could launch the country into a new and vibrant growth trajectory. According to KIPPRA (2013), the responsible exploration of newly discovered mineral resources could take account of issues such as land use and the proper

80 The eurozone is Kenya's largest trading partner.

Table IIIB.4
Distribution of Kenya's added value, by sector, 2000 to 2015 (% of GDP)

Year	Agriculture	Industry	Manufacturing	Services
2000	32.36	16.92	11.62	50.72
2001	31.33	17.22	11.00	51.45
2002	29.13	17.41	11.07	53.46
2003	29.03	17.58	10.92	53.40
2004	28.04	18.23	11.25	53.73
2005	27.20	19.09	11.82	53.71
2006	23.16	21.88	14.32	54.97
2007	23.27	21.82	14.46	54.92
2008	24.92	20.87	13.58	54.21
2009	26.14	20.98	13.39	52.87
2010	27.83	20.79	12.62	51.38
2011	29.27	21.04	13.08	49.68
2012	29.09	20.71	12.26	50.20
2013	29.48	19.92	11.72	50.60
2014	30.25	19.33	11.07	50.42
2015	32.94	19.52	11.36	47.54

Source: WDI 2017.

allocation of financial benefits between national and county governments, as well as of the communalities and linkages between the natural resources sector and other sectors of the economy, in order to promote both forward and backward linkages.

The prudent macroeconomic policy embarked upon by the Central Bank of Kenya (CBK) in 2011 yielded some positive results. The drastic increase in the inflation rate[81] from 4.0 per cent in 2010 to over 14 per cent in 2011 prompted CBK to adopt a tight monetary position. To achieve a single-digit inflation rate, the central bank rate was increased from 6.25 per cent in November 2011 to 18 per cent in December 2011. The bank rate was eased to 13 per cent by the end of 2012 after a substantial improvement in the country's inflation rate. As expected, the inflation rate declined to 9.3 per cent in 2012 and further down to 5.7 per cent in 2013 (KNBS, 2014). The exchange rate was also stabilized, allowing for a gradual easing of monetary policy. The decline in the inflation rate was broadly-based, affecting all income groups, although its impact was felt most among the upper and lower income groups. However, this policy choice resulted in a drop in economic activities in 2012, as a result of low domestic demand arising from the high cost of capital.

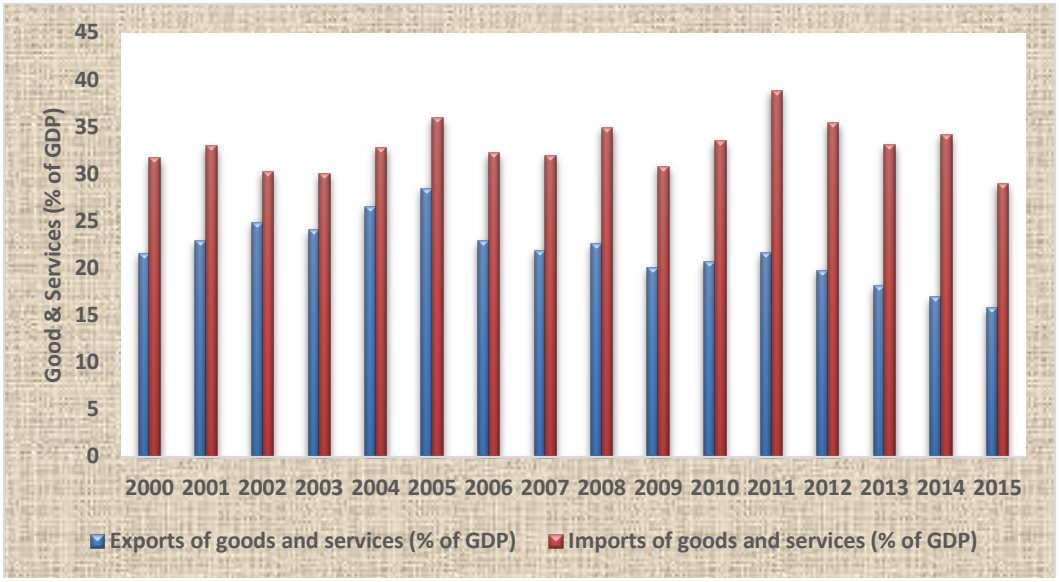
Kenya also maintained relatively effective fiscal discipline despite pressure from external shocks and political uncertainty due to national elections in 2013. The total revenue collected increased compared to the previous year, and government expenditure was largely in line with budgetary priorities. However, the public debt to GDP ratio exceeded the 45 per cent ceiling set out in the debt management strategy. Nevertheless, the most recent debt sustainability analysis by the IMF shows that Kenya continues to face a low risk of external debt distress (IMF, 2013).

Kenya continues to face an unemployment problem arising from the rapidly expanding

81 Owing largely to high international oil prices, drought conditions and exchange rate depreciation.

Figure IIIB.II

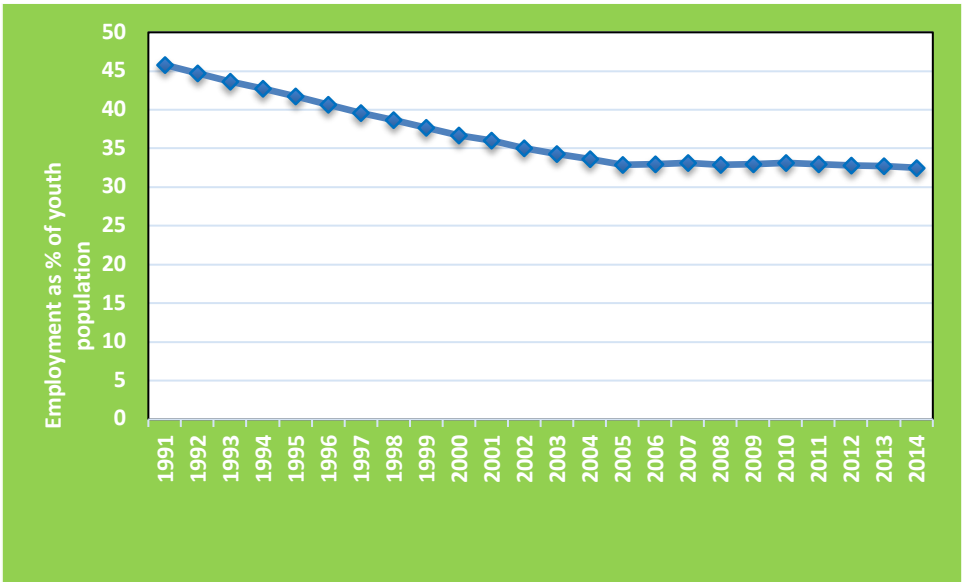
Exports and imports of goods and services, 2000 to 2015 (% of GDP)



Source: WDI 2017.

Figure IIIB.III

Employment to population ratio in Kenya (15-24 years)



Source: WDI (2017).

youth population in both rural and urban centres. For instance, figure IIIB.III reveals that the employment to population ratio has consistently declined in Kenya since the early 1990s for the age bracket 15 to 24 years. The desire of the growing youth population to free themselves economically from their parents, and to improve their work opportunities while also achieving their ambition to have a family has often been frustrated.

The UNDP (2013) also observed that, in 2005 and 2006, because of the rapidly expanding population of young people due to

fast population growth, people aged between 15 and 34 comprised two thirds of the population of working age (15–64), with many facing the hardships of unemployment. While population growth has been declining, it is still high, and the number of people aged 15 to 34 years will accordingly continue for several decades to grow faster than the adult working-age population. Kenya's population dynamics underscore the importance of further reducing fertility rates through education targeting young girls and the encouragement of family planning measures.

1.3 Structure of the economy

Within the context of the African continent the Kenyan economy is considered to be relatively well diversified. It does, however, rely mainly on traditional sectors such as agriculture and tourism, making it susceptible to both internal and external shocks. The tourism sector, for instance, was negatively affected by the 2007/08 political crises in the country and the global financial crisis. Similarly, the recent unpredictable weather conditions resulted in a decline in agricultural output, with all its effects on the country's food security. The emerging trend towards private sector participation in broadening the country's productive and economic base, particularly in the service sector, can greatly strengthen the economy's capacity to absorb shocks.

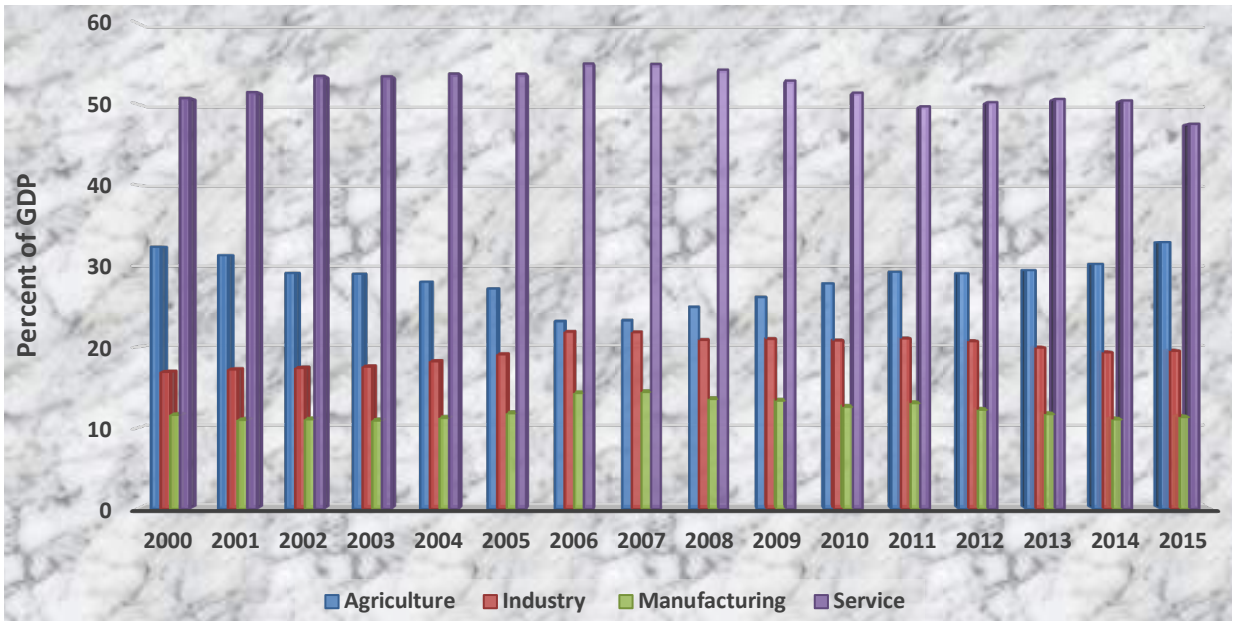
Tea is the most important cash crop in Kenya, and there has been tremendous growth in horticulture. Long distances to markets and high air-freight costs have, however, been an impediment to expansion in both the tea and horticulture sectors. The service sector has also been quite strong. Kenya's strategic location between the Indian Ocean and the regional hinterland affords it many opportunities for trade and investment, although the usefulness of this location needs a good transportation network if its potential is to be fully realized. Continuing problems related to infrastructure are especially pronounced, particularly with respect to the crucially important transportation and energy sectors (OECD/United Nations, 2011).

The advantage conferred by Kenya's geographical location is being continuously exploited to diversify its economy. In boosting telecommunications, the Seacom project was embraced by the country. Seacom is a 17,000 km underwater fibre-optic cable linking Southern and East Africa to global networks via India and Europe. The project has considerable potential to expand broadband services; to enhance local industries' connectedness to international markets; and to encourage improved service delivery in education, health and other public sectors. Moreover, it could enhance Kenya's technological competitiveness by facilitating improvements in scientific and technological research. This would speed up the technological catching-up process, especially through the creation of ICT hubs. The low-cost advantage of the project offers an opportunity for the wider use of mobile phone and Internet technologies in the African sub-regions.

The Seacom project, three quarters of which is owned by Africans, clearly spells out the crucial role of regional integration and cooperation in technology deployment and the exploitation of economies of scale. Kenya hosts a submarine terminal station for Seacom, and has undertaken a similar project, the East African Marine Systems (TEAMS), to connect Kenya to the United Arab Emirates. Kenya plans to take advantage of both Seacom and TEAMS to boost its business process outsourcing and call-centre businesses, both fledgling but highly promising activities (OECD/United Nations, 2011).

The trend in the sectoral distribution of GDP confirms the role that agriculture and service industries, in particular tourism, can continue

Figure IIIB.IV
Sectoral distribution of GDP in Kenya, 2000 to 2015



Source: WDI (2017).

to play in the Kenyan economy. Figure IIIB. IV presents the trends in the structure of the Kenyan economy since the beginning of the millennium. The structure of the country's economy has been dominated by agricultural and services outputs. While services and agriculture respectively contributed 55 and 27 per cent of GDP in 2012, industry and manufacturing contributed only 18 and 10 per cent respectively. Overall, the services sector continues to dominate, while the manufacturing sector consistently retains its last position. This reveals that Kenya has not experienced any significant structural change in recent years. The pattern of growth has remained basically unchanged. The essentially unchanged sectoral distribution of GDP also implies that the country's economy is still predominantly traditional, and based on agriculture, and has not to a significant extent used new technologies which are frequently being deployed outside Kenya in industry and manufacturing.

1.4 Technological sophistication of production

As stated earlier, production activities in Kenya are more prominent in the agricultural and service sectors. Boosting the production of food and cash crops for local consumption and export opportunities accordingly remains a priority in the Kenyan development agenda. The private sector is also contributing to the achievement of this objective. Hence, efforts are being made to adopt innovative approaches to agricultural practices. For all major crops produced in the country, there have been concerted attempts to use state-of-the-art technology in production. This is more pronounced in the type of inputs that are being used (particularly seeds and other planting materials) than in the use of technological applications during value addition and the marketing of final products. For example, Mignouna and others (2010) have observed that research and development initiatives with substantial participation of the private sector have been undertaken in western Kenya to transfer to farmers a new technology in maize production resulting in Imazapyr-resistant

maize. Similarly, the adoption of improved varieties of tea seedlings is increasing in Kenya's tea production subsector. The World Bank (2011) also stressed the high level of penetration of ICTs in Kenya's agricultural system. An example of the application of ICTs in the Kenyan agricultural sector is M-Farm, a mobile service established in 2010 that aims to improve Kenya's agricultural sector by connecting farmers with one another.

Kenya's service sector is also experiencing significant technological transformation through the adoption of ICTs. The application of ICTs has facilitated service delivery in the financial services subsector, as reflected in the upsurge of mobile banking services in the country. This was made possible through the introduction of M-PESA in 2007. It is operated by Safaricom, and allows users to transfer money through their mobile phones without having to register or qualify for a bank account. The educational system in the country is also being restructured to encourage the use of ICTs. The use of e-learning facilities at all levels of education is gaining prominence, and the dissemination of national examination test scores is being done by the Ministry of Education through the mobile phone.

A major technological initiative aimed at improving economic performance is the modernization of the Kenyan oil refinery at Mombasa. As stated in the Kenya Vision 2030, the installation of a thermal cracker technology is envisaged, to make its products competitive with imported products.

The foregoing demonstrates that Kenya's application of improved technology has mainly been in the primary sector (agriculture and extractive) and to some extent in the service sector. The manufacturing sector has generally lagged behind in the application or deployment of new technologies. It is dominated by low value-addition activities, especially in the food and agricultural processing industry. The production of medium- and high-tech products in the country is relatively unimpressive, especially when compared with emerging economies such as Brazil, China, India, Malaysia and South Africa.

1.5 Export performance

While Kenya's export performance to all continents has increased since 2008, it is clear from table IIIB.6 that its manufactured exports have not been able to penetrate the advanced economies of Europe and North America to a significant extent. Kenya trades more with its neighbours in East Africa than it trades with the rest of Africa and the world. The United Republic of Tanzania and Uganda – two East African countries – are the two major destinations for Kenya's exports followed by Europe. This suggests that exports of goods and services from Kenya might not have been competitive enough to gain wider acceptance in developed economies. It could also imply that there have been unfavourable trade policies and regimes and natural obstacles[82] which constitute major trade barriers between the Kenyan economy and western markets.

This increasing interregional trade between Kenya and other States of the East African Community (EAC) could confer the advantage of cushioning the effects on those countries of the economic distress in developed economies. Kenya has consistently taken advantage of regional cooperation within East Africa to boost its export performance. For example, Kenya's exports to the EAC in 2012 accounted for 53.8 per cent of its total exports to Africa and 26.1 per cent of its total exports to the world. In 2012 Uganda continued to be Kenya's leading export destination, absorbing 13.02 per cent of total Kenyan world exports;

82 For instance, long distances to markets and high air-freight costs.

Table IIIB.5
Value of Kenya's total exports by destination, 2008-2015 (KSh million)

Region	2008	2009	2010	2011	2012	2013	2014	2015*
Europe	99,146	99,879	109,296	134,317	124,910	122,243	131,712	132,925
North America	21,291	18,367	23,669	26,871	27,915	30,922	39,521	41,880
Africa	148,397	148,446	173,628	245,949	224,251	199,366	192,804	201,907
Asia	52,896	54,995	76,701	90,539	99,585	99,206	89,554	117,276
Australia and Oceania	603	793	756	998	1,813	2,844	3,182	2,538

* Provisional
Sources: Table 7.9: Export Value by Country of Destination, 2008- 2015, Kenya Statistical Abstract 2016.
See: http://www.knbs.or.ke/index.php?option=com_ phocadownload&view=category&id=106&Itemid=1177#.

the United Republic of Tanzania was second (8.9 per cent) and Rwanda was tenth (3.1 per cent) (KNBS, 2013).

However, beginning in 2012 the proportion of Kenya's exports to Uganda and other EAC countries began to decline. For example in 2012, Kenya's total exports to EAC countries declined from KSh 137.2 billion ($1.61 billion) in 2011 to KSh 134.9 billion ($1.59 billion) in 2012. Of these exports, Uganda accounted for 50 per cent, followed by the United Republic of Tanzania (34 per cent), Rwanda (12 per cent) and Burundi (4 per cent) (KNBS, 2013). This trend has continued, driven in part by the increasing competitiveness of the other EAC countries, export destination diversification by Kenya and domestic policy problems in Kenya.

Another important regional trade arrangement in which Kenya plays an active role is the Common Market for Eastern and Southern Africa (COMESA). Since the launch of COMESA free trade agreement in 2000,[83] Kenya's trade in the region increased from KSh 57 billion ($670 million) to KSh 236.8 billion ($2.7 billion) by 2012. Through Kenya's steadfast implementation of COMESA programmes, COMESA countries have become Kenya's leading export destinations, accounting for approximately 73 per cent of total exports to Africa and 33 per cent of total exports to the world in 2012. Kenya's exports to COMESA, however, decreased slightly in 2012, from $2.14 billion in 2011 to $2.06 billion (Kenya Economic Report, 2013).

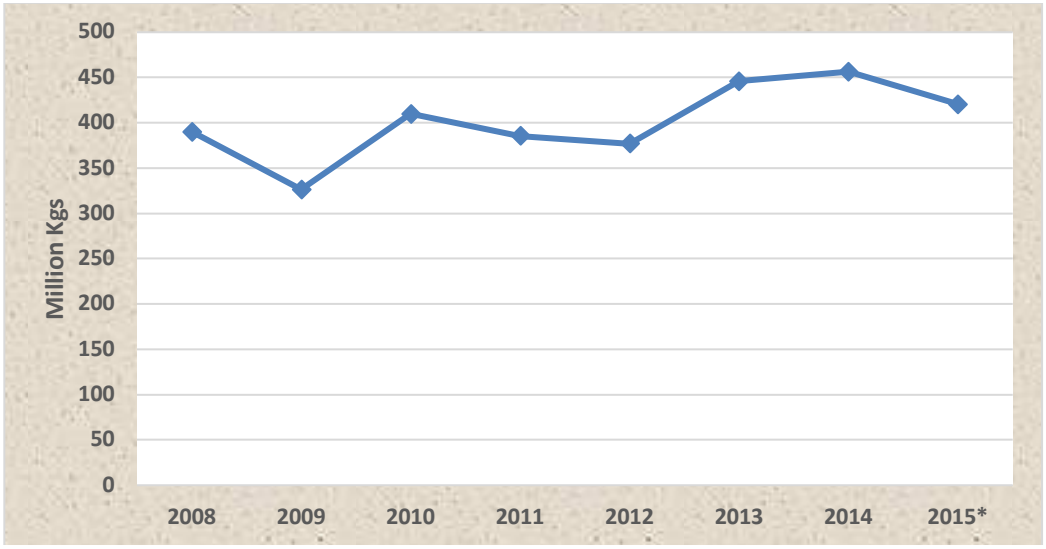
Kenya's exports are primarily in agricultural products, with tea, horticulture and coffee making up the largest proportion of exports. The agricultural sector accounts for 65 per cent of Kenya's total exports, and has been a key driver of economic growth in the last four decades. However, the sector's contribution to growth was adversely affected in 2012 due to adverse weather conditions that impacted negatively on the production of tea, a major export commodity. Nevertheless, the effects of harsh weather conditions on the agricultural sector's contribution to GDP were mitigated by the recovery of tea and coffee exports due to improved governance in the bodies running these industries and improved prices in the international markets. Figure IIIB.V shows the fluctuating performance of_Kenya's tea exports[84] since 2008. Exports peaked in 2014 but declined close to 2008 level in 2015.

83 The treaty establishing COMESA was signed on 5 November 1993 in Kampala, Uganda.

84 According to the annual report of the Tea Board of Kenya 2010/2011, the main export destinations for Kenyan tea are Egypt (21 per cent), Pakistan (18 per cent), the United Kingdom (13 per cent), the Russian Federation (10 per cent) and the Sudan (8 per cent).

Figure IIIB.V

Kenyan tea exports, 2008-2015 (quantity in millions of kg)



Source: Table 7.6: Quantities of Principal Commodities, 2008 - 2015

See: http://www.knbs.or.ke/index.php?option=com_phocadownload&view=category&id =106&Itemid=1177#.

Moreover, the global financial crisis did not have any major impact on the tea, horticultural and coffee exports due to the resilience of these subsectors. Government incentives[85] in coffee production and trade have encouraged positive growth in the crop's contribution to GDP and export. The horticultural subsector has also received an impressive boost, with flowers, fruit and vegetables making up the largest proportion of exports.

Kenya aims to intensify efforts take advantage of preferential access to the United States of America, provided through the African Growth and Opportunity Act (AGOA)[86], to export significant amounts of textiles and apparels. So far, Kenya's exports to the US market under AGOA have been marginal and its performance lags behind those of Southern African countries such as Angola and South Africa (Kenya Economic Report, 2013).

High-technology exports from Kenya still lag behind those of most emerging economies. Table IIIB.6 shows high-technology exports[87] (per cent of manufactured exports) from Kenya and some other economies. The table reveals that Kenya's high-technology exports perform better than those of Egypt, but underperform those of some other emerging economies: Kenya is second-to-last on the table.

To boost its high-technology export performance, Kenya's Vision 2030 document aims at using STI to ensure that it progresses from the production of low-tech to medium-tech and high-tech outputs. It is expected that STI will be mainstreamed in all sectors of the

85 These incentives include writing off debts owed to the Government by cooperative societies; setting up a Coffee Development Fund; allowing direct sales as opposed to auctions; training cooperative societies' staff in good governance; reviewing the Coffee Act; and reducing the number of licenses that millers, marketers and warehouses have to acquire.

86 AGOA is a trade arrangement that allows African countries to export textiles and garments duty-free to the United States of America, without import quota restrictions.

87 Two notable high-tech innovations are currently being exported from Kenya – M-PESA and Ushahidi, a non-profit platform for crowdsourcing information during disasters. M-Farm – a service that gives farmers access to market prices – is another potential high-tech export which Kenya could export to other developing countries (the Economist, August 25, 2012).

Table IIIB.6

High-technology exports (per cent of manufactured exports)

Year	Kenya	South Africa	Egypt	Brazil	China	Malaysia
1994	3.4	4.9	0.4	4.6	8.3	44.3
1995	3.6	5.7	0.5	4.9	10.4	46.1
1996	4.0	5.7	0.6	6.2	12.4	44.4
1997	4.4	7.5	0.3	7.5	13.1	49.0
1998	4.5	8.7	0.2	9.4	15.4	54.9
1999	3.3	7.1	0.3	13.2	17.2	58.9
2000	3.9	7.0	0.3	18.7	19.0	59.6
2001	4.9	6.5	0.9	19.2	21.0	58.1
2002	10.6	5.2	0.8	16.5	23.7	58.2
2003	3.6	4.8	0.5	12.0	27.4	58.9
2004	3.2	5.5	0.6	11.6	30.1	55.7
2005	2.9	6.7	0.4	12.8	30.8	54.6
2006	3.2	6.5	0.6	12.1	30.5	53.8
2007	5.5	5.6	0.2	11.9	26.7	52.3
2008	4.2	5.1	1.0	11.6	25.6	39.9
2009	5.3	5.4	0.8	13.2	27.5	46.6
2010	5.7	4.6	0.9	11.2	27.5	44.5
2011	..	5.0	1.0	9.7	25.8	43.4
2012	..	5.4	0.6	10.5	26.3	43.7
2013	3.8	5.5	0.5	9.6	27.0	43.6
2014	..	5.9	1.3	10.6	25.4	43.9
2015	..	5.9	0.8	12.3	25.8	42.8

Source: WDI (2017).

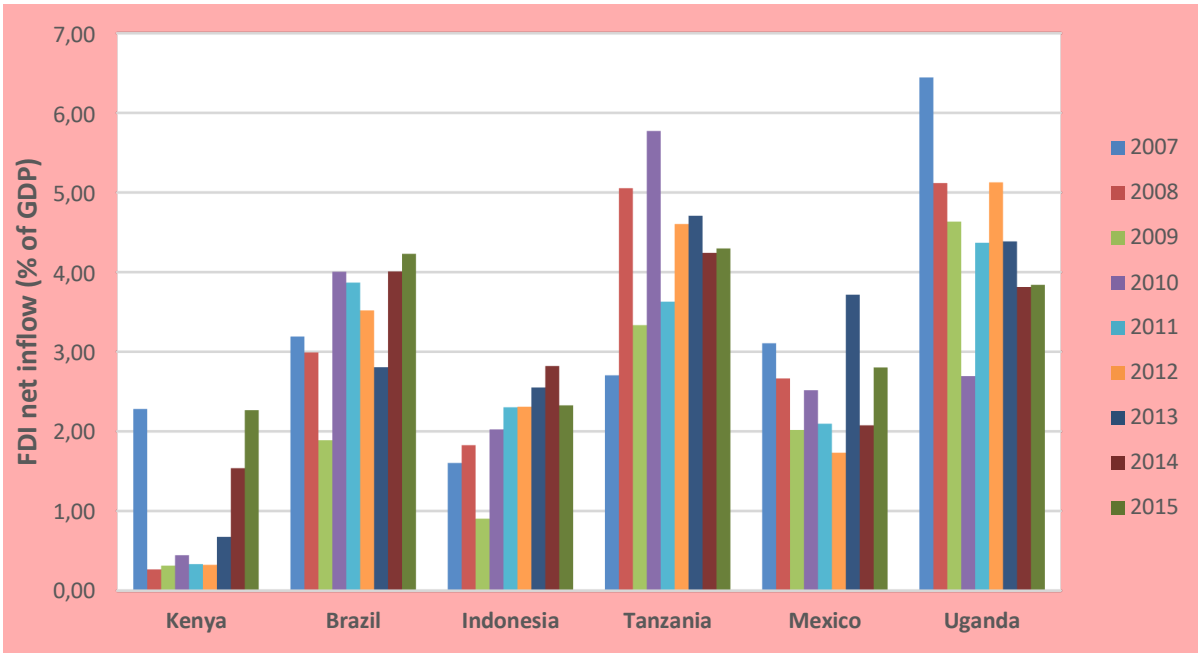
economy through carefully targeted investments in high growth activities, technological learning, the improvement of skills and quantitative increases in STI human resources. This will create a strong base for enhanced efficiency, sustained growth and the promotion of value addition in goods and services.

1.6 Foreign direct investment and technological spillovers

Foreign direct investment plays an important role in enhancing growth and development in developing economies. FDI inflow provides capital for investments, creates employment opportunities, and can serve as a very useful tool in the transfer of state-of-the-art technologies from technologically advanced economies to developing economies. FDI inflows into Kenya have fluctuated for much of its recent history. Figure IIIB.VI presents trends in FDI inflows into Kenya between 2007 and 2015. along with data from two of Kenya's East African neighbours and some emerging economies. The Figure shows that Kenya underperformed relative to her East African neighbours during the period under review. Similarly, Kenya underperformed relative to the selected emerging economies such as Brazil, Indonesia and Mexico during the period, reinforcing the inference that the post-election crisis of 2007-2008 (and possibly combined with the global financial crisis of 2008) had an adverse impact on net FDI inflows into the country.

Nyamwange (2009) identified the main sources of Kenyan FDI inflow as including China, Germany, India, and the United Kingdom. He

Figure IIIB.VI
Foreign direct investment net inflows, 2007 to 2015 (% of GDP)



Source: WDI, 2017.

also noted that the Government has implemented a number of reforms to encourage FDI inflows into the country. Some of these incentives include abolishing exports and import licensing; rationalizing and reducing import tariffs; revoking all export duties and current account restrictions; and removing restrictions on borrowing by both foreign and domestic companies.

1.7 Informal sector performance

Like most African economies, Kenya's is characterized by large informal sector activities. However, while formal sector activities are monitored by relevant governmental agencies, the informal sector operates in harsh economic environments, mostly unprotected by well-formulated legal frameworks and lacking access to basic facilities that can improve effectiveness and efficiency.

The history of informal sector economic activities in Kenya dates back to the pre-colonial era, when artisans engaged in skilled craft and bustling trade with port cities throughout Africa and the Middle East. This trade introduced new cultural ideas incorporated into wood-carving, architecture and even the Swahili language. These traditions are still sustained until today even in large cities like Mombasa and Nairobi, although a sizeable portion of the country's economic activities takes place in informal settings. Steve (2010) noted that informal artisans who engage in the production of goods are known as the *jua kali* sector (from the Swahili for "hot sun") and have established entire ecosystems of production, from scrap sourcing to repair. He argues that, although the Kenyan Government dismisses the informal sector as anti-development, backward or illegal, the sector has continued to expand and, in the face of a sluggish formal sector, contributes over 90 per cent of new jobs annually.

Nevertheless, the Government has maintained its traditional approach of attracting foreign direct investment to create large

industrial estates, absorbing only the remaining 10 per cent of new workers. In 2007, Vision 2030, an initiative of the Government of Kenya announced a plan to develop targeted economic zones around the country, to generate 10 per cent annual growth in GDP. Without mentioning the informal sector, the plan focused on the following formal industries: tourism, agriculture, manufacturing, trade, information technology and financial services. So far the targets have not been met, in part due to violence following the highly contested 2007 elections, but also because the strategy has viewed the nation as a node in the global economy without considering the development of its internal talent and resources in the informal sector.

It has been observed that Kenya is not adequately exploiting the opportunities provided by its informal sector. In particular, the informal sector creates an avenue for absorbing the teeming population of the unemployed. However, the unavailability of enough capital to enable entrepreneurs to formalize and scale up their operations is a major hindrance to increased productivity in the sector (Kinyanjui, 2008).

Most informal sector activities in Kenya operate in the form of clusters. McCormick and others (2003) identified four main types of cluster in Kenya: the diversified industrial cluster; the subcontractor cluster; the market town (distribution) cluster; and the specialized petty commodity cluster.[88] Diversified industrial and subcontractor clusters are predominantly located within major cities and are vertical forms of specialization, while market town clusters and specialized petty commodity clusters are horizontal forms of specialization. In Nairobi a well-developed cluster might specialize in auto repairs or metalwork, with businesses engaged in a variety of activities related to that sector. Peripheral clusters on the outskirts of the city or in smaller cities like Mombasa and Kisumu might be less specialized, relying on larger clusters for raw materials and parts. Rural clusters mostly trade in goods produced in other areas, as well as in the localized exchange of so-called "petty commodities," a term coined by Frederick Engels to describe simple products produced by craftsmen.

The majority of the skills used in Kenya's informal sector are acquired in the formal economy. The interactions of indigenous entrepreneurs and African engineers with foreigners, most especially in Indian-run enterprises, built the human capital of indigenous workers. During such interactions the engineers acquired skills in operating some of the capital goods used in production. After disengaging from foreign-owned enterprises, local entrepreneurs start up their own businesses in an informal setting by applying the skills acquired. These indigenous entrepreneurs also used native workers who are also trained in similar skills; there are accordingly trickle down effects or knowledge spillovers resulting in skills acquisition. The quality of such training is, however, often compromised down the line, owing largely to limited or poor machinery or over-specialization arising from limited capital and human resources. King (1996) substantiated this by claiming that, because of a dearth of tools, it is said that the typical ratio in an African workshop is one man working to five men cleaning. Indeed, because the issue of skills is intrinsically linked to the availability

88 Diversified industrial clusters comprise enterprises producing a range of products for a specific sector, and compete with large businesses by shifting between production for local, national and international markets. The subcontractor cluster is defined by the narrow vertical and horizontal specialization of individual enterprises within the cluster, with most enterprises linked to one or a few large ones located inside or outside the cluster (Pedersen, 1994). Market town clusters include enterprises which are horizontally specialized among and within sectors. It is dominated by retailers and producers supplying local consumers, who are often in direct competition with large enterprises. Specialized petty commodity clusters include enterprises that specialize horizontally, mainly producing, but also retailing directly to low income consumers.

of capital goods, it is difficult to decouple the two.

With adequate incentives, activities in the informal sector could attain the level of import substitution. Such incentives would include relief from import duties on raw materials, tax concessions for entrepreneurs willing to create jobs, and an overhaul of infrastructural facilities in the country. There is also a need for stronger linkages among micro and small enterprises, formal enterprises and educational institutions (Kinyanjui, 2008). It has also been stressed that the informal sector would benefit significantly if there was more effective interaction with stakeholders outside the sector. This should include an inclusive form of growth linking the informal economy with universities' and research institutes' technological inventions. Tapping the wealth of resources locked up in indigenous knowledge is also a crucial dimension of efforts to make the informal sector's output more competitive.

1.8 Inclusive innovation and growth performance

The vital importance of ensuring a growth pattern ensuring an improved livelihood for all has gained currency in Kenya. Applying STI to foster inclusive innovation in Kenya started in the banking sector in 2007 with the introduction of M-Pesa. M-Pesa employs ICT to transfer money through SMS text messages. This mobile money transfer technology is accessible at strategic locations across the country through an agent known as Safaricom (a Kenyan mobile operator). The barrier created by the widely dispersed population – with no easy access to commercial banks or deposit-taking institutions – is now breaking down because of this. Inhabitants living in the remotest parts of the country can now seamlessly and efficiently engage in money transfer transactions. The sender goes to agents who credits their mobile accounts in exchange for cash and send an SMS to the recipients that allows them to withdraw money from an agent located in their neighbourhood. The success recorded by M-Pesa is attributed mainly to its monopoly, supported by the State, enjoyed in its first seven years of existence. Many start-ups at Pivot East[89] use M-Pesa as a base for their business. One team streamlined the payment of school fees through the service by helping institutions and parents to keep track of upcoming and late deposits. Another offered an electronic version of Kenya's popular informal savings groups.

Not only does this mobile banking, once virtually an underground activity, appear in the full light of day, participating in the formal economy where it is recognized, it has also been proven that consumers at the "bottom of the pyramid", so to speak, far from being unproductive social assistance recipients, are capable of opting for technologies and boosting growth. A joint study by the World Bank, the London Business School and the Deloitte firm shows that, whenever 10 mobile phones are added to a population of 100 Africans, the country's GDP grows at a rate between 0.6 and 1.2 per cent.[90]

Since 2010 Nairobi has also had a place called the iHub, where local ICT experts gather and exchange ideas. The iHub has expanded to include a consulting arm, a research department and an incubation space called M-Lab, which supports start-ups that are developing mobile applications.

In order to facilitate farmers' access to market information, the M-Farm technology has been widely deployed in Kenya. M-Farm is

89 PIVOT East is an innovative startup competition geared towards nurturing the growth of ICT talent in East Africa.
90 http://www.paristechreview.com/2013/12/06/mobile-banking-kenya.

an SMS and web-based application focused on reducing or eliminating weaknesses in the value chain. It disseminates targeted agricultural information via SMS to small-scale and marginal farmers in Kenya. Through the platform, which uses the short code 3535, farmers are able to get real-time price information on different products at different markets and locations. This enables them to bargain with buyers, and gives them negotiating power. The platform also aggregates farmers' needs and connects them with farm input suppliers. The platform solves the challenges previously faced by farmers when accessing market information. M-Farm gives farmers a voice by connecting them with each other in a virtual space. There are currently about 2,000 farmers across the country who are enjoying this facility.

To promote entrepreneurship among farmers, Kenya's agricultural sector is participating in Agri-Hub – an online platform that facilitates exchange between Agri-ProFocus[91] professionals, their Kenyan partners and other stakeholders. Agri-ProFocus Kenya is a growing network of farmers' organisations, non-governmental organizations, financial and research institutes, private and public sector actors and Netherlands and other international development agencies. The platform stimulates the enhancement of farmer entrepreneurship in Kenya.

2. Review of science, technology and innovation policies

2.1 Features of Kenyan STI policy

Kenya has a well-structured STI policy and strategy framework. The framework derives mainly from the long-term policy document enshrined in the country's Vision 2030. Since 2003 the country has experimented with the Economic Recovery Strategy for Wealth and Employment Creation (ERSWEC), which is essentially a five-year medium term plan aimed at addressing economic growth and poverty alleviation challenges in the country. However, it does not include a comprehensive blueprint to deal with issues of global competitiveness and the general improvement in the quality of life of citizens. There was therefore a need for a policy document or strategy that takes a holistic view of economic growth and development within the global context. Kenya Vision 2030[92]has this basic element, and also explicitly articulates the role of science, technology and innovation in the country's economic development. The vision conceives the role of STI in the context of the knowledge required for creating an innovation-driven economy that is able to meet the competitive challenges of the global economy.

91 A partnership that promotes farmers' entrepreneurship in developing countries.

92 The vision envisaged that the long-term plan will yield an average GDP growth rate of over 10 per cent per annum; create a just and cohesive society with equitable social development, in a clean and secure environment; and a democratic political system that nurtures issue-based politics, respects the rule of law, and protects all the rights and freedoms of every individual in society.

In this respect the vision document identified the four key elements that are necessary for the effective exploitation of knowledge. These are: an economic and institutional regime that provides incentives for the efficient use of existing knowledge, the creation of new knowledge and the flourishing of entrepreneurship, an educated and skilled population that can create, share and use knowledge effectively, a dynamic information and communications infrastructure that can facilitate knowledge exchange, and an effective innovation system (i.e. a network of research centres, universities, think tanks, private enterprises and community groups) that can tap into the growing stock of global knowledge, assimilating and adapting it to local needs, while creating new knowledge and technologies as appropriate.

Kenya's STI policy is essentially a component of its Vision 2030, and is contained in section 2.6 of the vision document. The primary goal of developing an STI policy and strategy document in Kenya is to move the economy into a knowledge-based one and to ensure that the recent improvement in GDP growth translates to productivity growth. The vision, mission and objectives of the STI policy are presented in box IIIB.1. The policy and strategy document also emphasizes the need to decouple economic growth from environmental damage. It recognizes the fact that most of the growth experienced in the country in recent years has been fuelled by the exploitation of natural resources, with little application of frontier technology promoting the sustainable use of natural resources. This has constrained the natural environment with its adverse impact on the national demographic profile and the status of public health, while also posing serious questions about governance. To achieve a sustainable growth path that exerts little pressure on the environment, it is accordingly expected that STI would be deployed into productive activities. As explained in the vision document, the national system of innovation forms the basis for managing the deployment of STI resources, and NSI would be used to foster interactions between institutions, sectors and individuals in the economy who are deemed to be stakeholders in the drive towards the creation, adoption or adaptation and deployment of knowledge for sustainable economic growth and development.

2.2 Local and international dimensions of the STI policy

The STI policy and strategy document in Kenya addresses issues that both encourage local capacity to innovate and strengthen the entrepreneurial capability of Kenyans. To exploit the available local resources in building a strong STI base, the document proposes the establishment of agencies whose mandate is to ensure the attainment of the goals set out in the STI policy and strategy document. Such agencies include a Kenya National Technology Acquisition Office to spearhead the country's technology search and acquisition effort in support of all sectors of the economy; a national innovation agency to serve as the basis of an effective national innovation system that responds to the distinctive characteristics of Kenya; and the Kenya National Research Foundation which will operate both a national innovation fund and a venture capital fund.

The STI policy and strategy document also identified important new areas in technological advances. The core areas in Kenya's STI policy document on new and emerging technologies include nanotechnology, which allows the manipulation of properties of materials at the molecular or atomic level, giving rise to products with enhanced properties, faster production processes, lower production costs, much smaller manufacturing equipment, a cleaner environment and new manufacturing systems; laser technology, which has a wide application in areas of manufacturing, consumer electronics, telecommunications, data

Box IIIB.1
Kenya's STI policy vision, mission and objectives

STI policy vision: 'A nation that harnesses science, technology and innovation to foster global competitiveness for wealth creation, national prosperity and a high quality of life for its people'.

STI policy mission: 'To mainstream application of science, technology and innovation in all sectors and processes of the economy to ensure that Kenyans benefit from acquisition and utilization of available capacities and capabilities to achieve the objectives of Vision 2030'.

STI policy objectives:

1. Governance framework for STI to support the coordinated and partnership-based application of STI, to ensure the establishment of a national innovation system and to facilitate the integration of STI into all sectors.
2. Facilitate the renewal, upgrading and creation of a supportive infrastructure for science, technology and innovation.
3. Progressively increase the rate of generation of high quality skilled human resources at all levels by providing an environment for building a critical mass of human resource capacity, harnessing and effectively participating in the application of science, technology and innovation for value addition activities, solving problems and enhancing human welfare.
4. Encourage and support collaborative, multi-disciplinary scientific research in universities and other academic, scientific and engineering institutions, and promote regional and international cooperation and collaboration in science, technology and innovation specifically targeted towards achieving the goals of national development and security.
5. Support the application of traditional knowledge in the formal and informal sectors of the economy to enhance livelihoods and promote the use of the full potential of science, technology and innovation to protect, preserve, evaluate, update, add value to and utilize the extensive indigenous resources and traditional knowledge available in the various Kenyan communities.
6. Ensure that the existing intellectual property rights regime is strengthened, to maximize incentives for the generation, protection and use of intellectual property by all types of inventors, and foster the achievement of Kenya's national development objectives.
7. Facilitate the development, transfer and diffusion of technology to accomplish national strategic development goals by strengthening mechanisms that support technology development, evaluation, absorption and upgrading from concept to use.
8. Support and play an active role in research into and the application of STI for forecasting, early warning and the prevention and mitigation of emergencies and natural hazards, particularly, floods, landslides, drought, security threats, acts of terrorism, epidemics and emerging infections.
9. Public communications and advocacy for STI including its ethical, moral, legal, social and economic dimensions by facilitating development mechanisms or communicating STI results/findings to increase knowledge and understanding for adoption and use.
10. Support the effective and efficient leveraging of reliable and adequate public and private sectors, as well as domestic and international funding in support of Kenya's national STI policy objectives and strategies, including a review of administrative and financial procedures to encourage the efficient operation of STI Institutions in Kenya.
11. Integrate STI at all levels of education and training by promoting the learning by discovery method, experiential learning, a participatory approach and through interactive environments, and also by promoting attitudes receptive to STI among all educational stakeholders and establishing sustainable centres of excellence to enhance the quality of the products of training at all levels.
12. Develop a comprehensive performance management framework linking programme outcomes to long term impacts of this STI policy and strengthening science-based monitoring and reviewing mechanisms.

Source: Kenya Ministry of Science and Technology (2009).

communication, surveying and construction, medicine and the military; and biotechnology, which is potent in ensuring the development of biomaterials, including polymers, metals, ceramics and composites, which are produced synthetically or biologically for use in the efficient treatment and management of diseases with growth potential in biogenerics and molecular diagnostics for diseases, as well as in vaccines for tropical diseases.

To benefit from knowledge spillover from developed and emerging economies, systematic actions are being undertaken to attract Kenyans in the diaspora to return and invest in their home country. Prominent among these steps is the putting in place of policies, legislation and other measures – such as the creation of an enabling environment – that will facilitate the active participation of citizens working in the diaspora in exploiting STI for the country's growth. There are, however, still many constraints to using the potential of the diaspora to address the country's growth and developmental challenges. The diaspora presently contributes about 0.46 per cent of GDP (KSh 70 billion annually) in Kenya (Government of Kenya, 2011). This could be improved upon if there were statutory provisions and an institutional framework, as well as administrative structures and mechanisms, attracting both the human and financial resources of the diaspora. Strengthening Kenya's STI profile would therefore require an evaluation of the scientific and technological potential of these returning citizens. This should generate a database to inform Government's decision on integrating the diaspora into its STI development strategies and policies. The overall objective would be the harnessing and mainstreaming of the diaspora's resources in national development.

2.3 Sectoral STI policies and industrialization strategy

2.3.1 Sectoral STI policies

To achieve transformation into a knowledge-based economy, the Government of Kenya has identified priority sectors in which investments in STI can strategically create technology platforms for enhanced productivity and competitiveness. The strategic technology platforms would be sufficiently broad in scope to support the development of products, processes and services in a wide range of sectors. At the same time they will be narrow enough to define a set of competencies that will be developed in order to achieve sustained global competitiveness.

In the agricultural sector the country's Vision 2030 document proposes priority areas to include increasing the value of agricultural products through agribusiness-related processes, agro processing and agricultural research with special reference to biotechnology and drought management, while also addressing biotic and abiotic stresses that lead to losses due to pests and diseases. The application of STI in the production of fertilizers, seeds, animal breeds and irrigation technologies will reduce the cost of farming and improve land use productivity. Investments in STI are also expected to create more value in the domestic market by removing inefficiencies in the supply chain and by enhancing the quality and quantity of storage facilities and mechanisms for market access and pricing.

STI investment priorities in the Kenyan health system are aimed at using STI to achieve world class service and standards improvement, research into multisectoral health issues including infectious diseases, HIV/AIDS, tuberculosis, malaria and emerging infections, traditional knowledge and resources, and the commercial production of traditional plants for medicinal use. It will also involve

streamlining intersectoral and public-private sector partnerships in state-of-the-art medical technologies.

The trade and industry sector has prioritized linkages between research findings and industry, the diversification and upgrading of the productive capacity of local industries, the increased adoption of new and appropriate technologies, promoting the use of intellectual property rights and standards and the growth of SMEs, increasing the use of reverse engineering and of cleaner production techniques.

Infrastructure is a prerequisite for the effective use of science, technology and innovation. Lessons from global experience suggest that infrastructural development provides an important lever through which a nation can enhance its level of technological development. This is through its contribution to the effective use of STI. It will also enhance any potentially positive impact on the technological learning process.

Kenya's priorities for infrastructural development include reforming legal, institutional and regulatory frameworks with a view to enhancing proper infrastructure design and integrity in contract procurement, while also enhancing safety, proper and timely maintenance and allowing for private sector and community participation. It also involves the integration of information technology networks to improve performance and create seamless, efficient and cost-effective telecommunications services for business and social interaction.

The Vision 2030 growth targets are expected to make significant demands for relatively cheap, affordable, reliable and clean energy. In this regard the sectoral priorities are in research and development for the following: efficient energy use and conservation practices; research and analysis of waste management and its use for energy production; exploration to establish the availability and use of alternative energy sources; and capacity-building and human resources development in all areas of engineering and technical fields in the sector.

2.3.2 Industrial policy and industrialization strategy

Kenya's industrial policy guideline is embedded in the national industrial framework promulgated by the Kenya Ministry of Industrialization. This policy framework is a medium-term plan expected to underpin the national industrialization process over a period of five years (2011-2015) in the first instance. It has been aptly conceptualized as a 'revitalization" document in order to underscore the fact that it builds on the solid foundation of various other efforts the Government has made in the past to craft policy interventions aimed at accelerating the country's pace of industrial growth and development (Ministry of Industrialization, 2011).

Industrial policies in Kenya can be said to have evolved through three distinct policy orientations, including the import substitution policy that was embraced soon after independence in 1963, followed thereafter by an export-led policy orientation, and ultimately, by industrial development policies inspired by the structural adjustment programmes (SAPs) that dominated much of the 1990s. On the other hand, in the decade 2000-2010, the policies tended to be influenced by and based on the Government's definition of its policy priorities as spelt out in the two major policy documents of the time: the Economic Recovery Strategy for Wealth and Employment Creation (2003-2007) and the Kenya Vision 2030 policy blueprint, which is also the first major attempt by the Government of Kenya to define a long-term development policy for the country. The Kenya Vision 2030 identified the industrial sector as a potential growth area for the following five reasons:

(a) It enjoys strong forward and backward linkages with other important economic sectors such as agriculture and the services sector;

(b) It offers high prospects for job creation, especially in labour-intensive industries;

(c) It acts as a catalyst for technology transfer and the attraction of foreign direct investment;

(d) It offers high prospects for deepening Kenya's drive to integrate further into the regional and global economy; and

(e) It provides significant foreign exchange earnings for Kenya's economy.

To revitalize the industrial sector, the guiding principles in the industrialization framework include the following: productivity and competitiveness; market development; high value addition and diversification; regional dispersion; technology and innovation; fair trade practices; job creation; environmental sustainability; compliance with the new constitution; and education and human resources development.

3. STI actors' competences and capacity to innovate

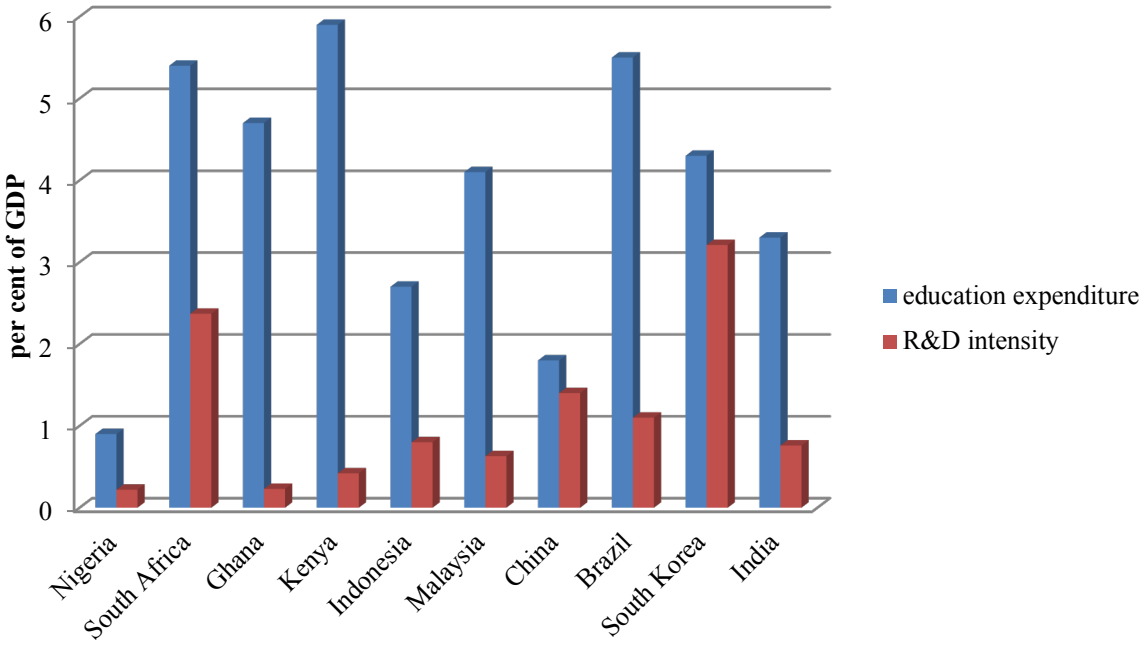
3.1 Science base and structure of investments in scientific activities

Research and Development in Kenya has a long history dating back to the colonial period. Research efforts were then targeted towards the domestic economy, with no long-term plans to promote the science base that is required for an economy envisaged as becoming competitive within a global context.

While most indicators that would enable a comprehensive assessment of the country's STI actors' competences and capacity to innovate are not yet available, it is noteworthy that the limited existing data show Kenya to be strongly committed to expenditure in education. Figure IIIB.VII reveals that Kenya spends more of its GDP on education expenditure than other comparable countries. This could be interpreted to mean that there has been a renewed commitment by the Government of Kenya to the vision of transforming the economy into a knowledge-based one. It is, however, difficult to assess the full impact of this increase in educational expenditure on the scientific base of the country. For instance, most of the investment has not translated into a considerable increase in locally manufactured medium and high-tech products. It would accordingly be necessary for the Government to set up a workable plan ensuring the appropriate monitoring and evaluation of its huge investment in education.

The low level of locally manufactured medium and high-tech products could also be a result of the very low state of R&D intensity in the country. Kenya's R&D intensity is one of the weakest among the developing and emerging

Figure IIIB.VII
Educational expenditure and R&D intensity of selected countries in 2012



Source: WDI (2013).

economies shown in figure IIIB.VII. Although Kenya's R&D intensity is higher than that of Ghana and Nigeria, it ranks lowest in comparison with some of the BRICS countries. There is accordingly a need for deliberate policy actions targeted at increasing R&D intensity at a rate that would, within a medium-term period of about five years, match the level attained in other developing and emerging economies.

Technical and vocational education has also been used in Kenya to enhance the science base and facilitate the economy's transformation into a knowledge-based one. This is being done through the promotion of technical, industrial, vocational and entrepreneurship training (TIVET) by the Directorate of Technical Education. As shown in table IIIB.7, Kenya has over one thousand TIVET institutions, most of which have been established by private individuals/organizations. The Directorate is responsible for policy, curriculum development, and the registration and supervision of TIVET institutions. The extent to which the TIVET institutions are achieving their mandates could only be assessed through a comprehensive country STI survey. Available evidence does, however, reveal that most of the institutions with a mandate to boost Kenya's STI base are short-staffed. For instance, the assessment of human resources adequacy in the Ministry of Science and Technology as at 2007 showed that there was shortage of both technical and support staff in the ministry. Table IIIB.8 shows the shortfall in the required technical and support staff of the ministry.

Table IIIB.7
Type and number of TIVET institutions in Kenya

TIVET institution type	Number
Technical teachers' college	1
National polytechnics*	2
Technical training institutes	25
Institutes of technology	14
Youth polytechnics	817
Private TIVET institutions	Over 1 000

* Two of the initial four national polytechnics (Kenya Polytechnic and Mombasa Polytechnic) were converted into universities in 2008.
Source: Kenya, Ministry of Science and Technology (2007) and Kenya, Ministry of Education (2012).

Table IIIB.8
Staff of the Ministry of Science and Technology

	Technical staff	Support staff	Total
Number of staff in service	78	156	234
Number of staff required	133	235	368
Shortfall in number of staff	55	79	134

Source: Ministry of Science and Technology (2007).

The number of universities involved in science and technology education in the country is also relatively when compared to the total number of universities. In 2013 the total number of universities of science and technology in Kenya was six out of the total of 66 universities in the country. These are the Jomo Kenyatta University of Agriculture and Technology, the Masinde Muliro University of Science and Technology, the Dedan Kimathi University of Technology, the Kiriri Women's University of Science and Technology, the Meru University College of Science and Technology, and the Jaramogi Oginga Odinga University of Science and Technology (Wycliffe and Ayuya, 2013). Enhancing STI activities in Kenya would require establishing, with adequate funding, more universities of science and technology. The building of a vibrant science base that can lead to a thriving innovation driven and knowledge-based economy is crucial for Kenya's future.

3.2 Business R&D and innovation activities

According to the Global Competitiveness Report 2012-2013, Kenya's innovative capacity was ranked at the impressive level of 50 out of 144 countries. This innovative potential is supported by an educational system that is rated relatively highly in terms of both quality and employment-related training. The data on educational expenditure shown in figure IIIB. VII indicates that Kenya ranks relatively highly as a country that has made a major investment in education in recent years. The economy is also supported by a financial market which is among the most developed in Africa.

It is, however, instructive to note that business R&D predominantly takes place in Kenya's informal sector. The *jua kali* enterprises are a prominent feature of the Kenyan informal sector economy. In spite of the fact that *jua kali* enterprises have not received significant governmental support over the years, they are viewed as centres of innovative activities that have helped address the challenge of poverty and unemployment. In addition to the *jua kali*, a few clusters of micro and small-sized enterprises that have remarkable innovation activities also exist within the informal sector economy. Box IIIB.2 provides the case of the Kisumu Innovation Centre Kenya (KICK), as an example of an informal sector innovation hub with some level of business R&D.

The Kenya Industrial Research and Development Institute (KIRDI), a government establishment with a mandate to develop industrial technology, continues to play a supportive role in developing innovative activities in the informal sector. The United Nations Industrial Development Organization (UNIDO) is also increasingly collaborating with the sector on a series of projects. One major project arising from this collaboration is called "Lighting up Kenya". It was spearheaded by UNIDO in partnership with KIRDI to establish rural community power centres that run on off-the-grid generators and encourage activities making productive use of that energy. One productive activity is the charging of new light-emitting diode (LED) lamps to replace traditional kerosene lamps, which are expensive to maintain

Box IIIB.2

Kisumu Innovation Centre Kenya (KICK)

KICK started as a non-governmental organization in 1994, but has now been transformed into a for-profit centre where informal sector entrepreneurs improve their production processes and skills. The centre has contributed significantly to the design of both process and product innovations in Kisumu's Kibuye Market. This market is one of the largest in East Africa. The centre has, over the years, survived the harsh business environment that usually characterizes most African economies. For instance, it rebounded in 2005 to become a stronger and more coordinated innovation park in Kenya after its collapse in 2003, due to mismanagement and corruption. KICK is now thriving and is presently connected to global fair-trade organizations such as Oxfam. The success of the centre is due to its initial strong human capital base in terms of well-trained and qualified staff, who develop new designs for products and train artisans to fabricate them. Primary products from the centre include baskets woven using water hyacinths, beautiful hand-crafted cards made from recycled copper wire and food tin cans, furniture woven from papyrus and water hyacinths, and other noxious lake weeds and wrought iron fabricated designs for home décor. The centre is also dedicated to providing training opportunities for young people, and to assisting them in making career-changing decisions.

The centre also developed a novel form of intellectual property to incentivize entrepreneurs in developing innovative products. This ensures that artisans receive 5 per cent of the sales price of their designs and innovative products, regardless of who makes them. The major challenge facing artisans' activities in KICK is that technological capacity remains very low in the centre and among the artisans, many of whom are not only unskilled, but also completely untrained (particularly those who choose to work in the centre with no machines). Financial literacy and knowledge of accounting are also poor in the centre, as artisans do not understand certain fundamental business concepts and practices such as: investing in capital to grow their businesses; lowering wholesale prices due to economies of scale; and providing a grace period for payment, rather than requiring cash on delivery.

Source: Daniels (2010).

and harmful to the environment. The LED lamps are currently imported from India, but UNIDO plans to gradually move their assembly and production to Kenya. If successfully adopted, given the resilience and capacity to adapt of many *jua kali* enterprises, some of the *jua kali* kerosene lamp-makers will be forced to adapt to a new trade. It is important to note that, even though these collaborations have yielded some positive results, most clusters still operate in a harsh economic environment that could hinder business R&D and innovation activities. Governmental intervention in creating an enabling environment for the growth of clusters is essential for harnessing the innovation potential of informal sector enterprises and existing industrial clusters.

4. STI actors' interactions

4.1 Factors promoting interaction and new opportunities

The factors promoting STI actors' interactions are assumed to be mainly related to the technological infrastructure. For developing countries, critical indicators of the existence or use of technological infrastructure include:

- Electric power consumption (kWh per capita)
- Telephone main lines in operation (per 100 inhabitants)
- Fixed broadband Internet subscribers (per 100 people)
- Mobile cellular subscriptions (per 100 people)

Table IIIB.9 presents the trends in these indicators from 2000 to 2016 for selected African and emerging economies. In spite of Kenya's recent growth experience, its infrastructure support for STI actors' interaction is relatively weak, performing slightly above Nigeria on average, and lagging behind other comparable countries. Kenya's performance is far behind that of South Africa and emerging economies such as Brazil, China, India, Indonesia and Malaysia. Nevertheless, table IIIB.9 shows that mobile line subscription increased significantly in Kenya, from 0.41 per 100 people in 2000 to 80.44 per 100 people in 2016, almost 200 times increase. The boom in telecommunications in sub-Saharan Africa and governmental poverty reduction programmes using ICTs (e.g. the adoption of M-Pesa in the banking industry and M-Farm in the agricultural sector) have been major contributors to this upsurge in teledensity.

For most sub-Saharan African countries, lack of access to broadband Internet is a major barrier to the effective network activities that are required for the flow of data and information among social and economic actors in a national system of innovation. Without broadband access, data uploading and downloading are time-wasting and sometimes so frustrating, constraining the possibilities of research and research collaboration across the country and between the country's researchers and researchers across the world. Concerning Kenya, the state of the broadband infrastructure is relatively poor compared to the emerging economies as shown in table IIIB.9. According to the World Bank fixed broadband subscription per 100 population in Kenya in 2016 was 0.33, placing Kenya 163rd among all countries[93]. More investment in broadband infrastructure would further deepen Internet penetration, raising actors' capacity to interact, consequently improving Kenya's STI readiness.

If Kenya wishes to promote interaction among STI actors, improved investment in the electricity infrastructure to raise power consumption levels has to become a major component of STI investments. Ongoing government efforts to improve power generation could result in significant improvements. Kenya's power development plan includes investments in electric power infrastructure using both renewable and non-renewable sources of energy, tapping into the country's huge reserves of renewable energy sources. Traditional biomass accounts for the bulk of total energy consumption.

93 See http://www.factfish.com/statistic- country/kenya/fixed+broadband+internet+subscribers,+per+100+people

Opportunities for investments in solar energy, wind, biomass, hydropower, and geothermal energy also abound. Strengthening ongoing efforts and encouraging new investments aimed at exploring Kenya's renewable energy potential should be a major focus of governmental policy.

Figure IIIB.VIII below shows that, while Kenya's electricity power consumption per capita is better than Nigeria's, it falls below that of other emerging economies. The growth performance of the economy in recent years has resulted in a large increase in demand for electricity, with the number of electricity consumers more than doubling from 2004/05 to 2013, although connection rates are still rather low.[94] In June 2013, 28.9 per cent of the Kenyan population was connected to electricity, while the proportion of those in rural areas was only 4 per cent.[95]

The outputs of interactions among STI actors would be either innovation or mechanisms that generate innovation. These could be discernible in the trend observed in the following key indicators:

- Number of new products and services introduced
- Number of firms introducing new production processes
- Level of FDI inflows

94 Ministry of Energy and Petroleum of Kenya, National Energy Policy Report, November 2013.

95 ibid.

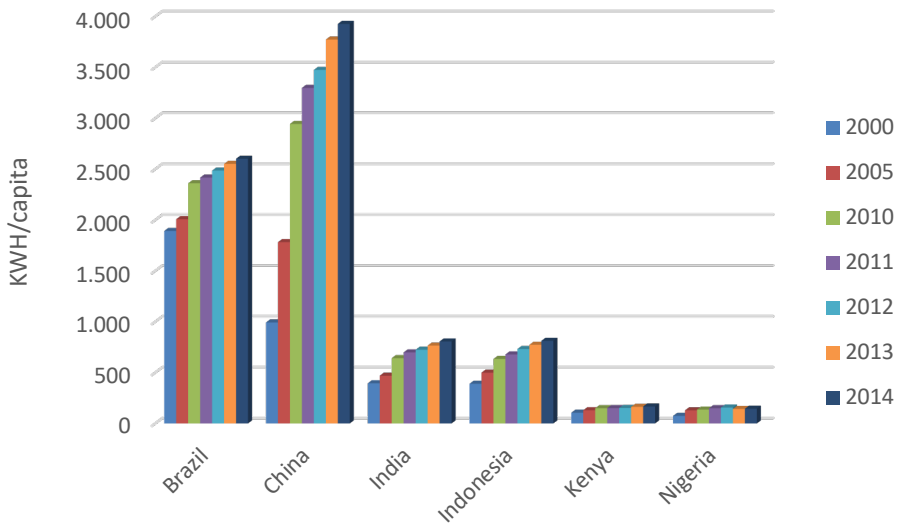
Table IIIB.9

Trends in infrastructure-related indicators of STI actors' interaction

Country	Electric power consumption (kWh per capita)					Fixed telephone subscriptions (per 100 people)					Mobile cellular subscriptions (per 100 people)					Fixed broadband subscriptions (per 100 people)				
	2000	2005	2010	2012	2013	2000	2005	2010	2012	2013	2000	2005	2010	2012	2013	2000	2005	2010	2012	2013
Brazil	1,886.6	1,990.6	2,339.4	2,463.3	2,529.3	17.7	21.4	21.6	22.3	22.5	13.3	46.3	100.9	125.0	135.3	0.1	1.7	7.2	9.6	10.7
China	993.4	1,783.9	2,943.6	3,475.0	3,762.1	11.3	26.6	21.6	20.2	19.3	6.7	29.8	63.2	80.8	88.7	0.0	2.8	9.3	12.7	13.6
India	394.8	469.4	643.9	724.5	765.0	3.1	4.5	2.9	2.5	2.3	0.3	8.0	62.4	69.9	70.8	..	0.1	0.9	1.2	1.2
Indonesia	390.4	500.7	636.6	718.7	787.7	3.2	6.0	17.0	15.4	12.3	1.8	20.9	87.8	114.2	125.4	0.0	0.0	0.9	1.2	1.3
Korea, Rep.	5,907.0	7,803.8	9,744.4	10,345.6	10,427.9	56.3	50.8	58.9	61.4	61.6	58.3	81.5	104.8	109.4	111.0	8.4	25.9	35.5	37.2	38.0
Kenya	107.4	132.8	154.1	156.8	167.7	0.9	0.8	0.9	0.6	0.5	0.4	12.9	61.0	71.2	71.8	..	0.0	0.0	0.1	0.2
South Africa	4,680.7	4,696.8	4,582.4	4,405.7	4,325.5	11.1	10.2	9.4	9.3	7.3	18.6	70.4	97.9	130.6	145.6	..	0.3	1.4	2.1	3.1
Ghana	334.0	247.6	282.8	348.3	382.3	1.1	1.5	1.1	1.1	1.0	0.7	13.4	71.9	101.0	108.2	..	0.0	0.2	0.3	0.3
Malaysia	2,720.5	2,862.0	4,158.6	4,345.5	4,512.0	19.8	16.9	16.3	15.7	15.3	21.9	75.6	119.7	141.3	144.7	..	1.9	7.4	10.0	9.9
Nigeria	74.1	128.6	135.6	155.9	141.9	0.5	0.9	0.7	0.2	0.2	0.0	13.3	54.7	66.8	73.3	..	0.0	0.1	0.0	0.0

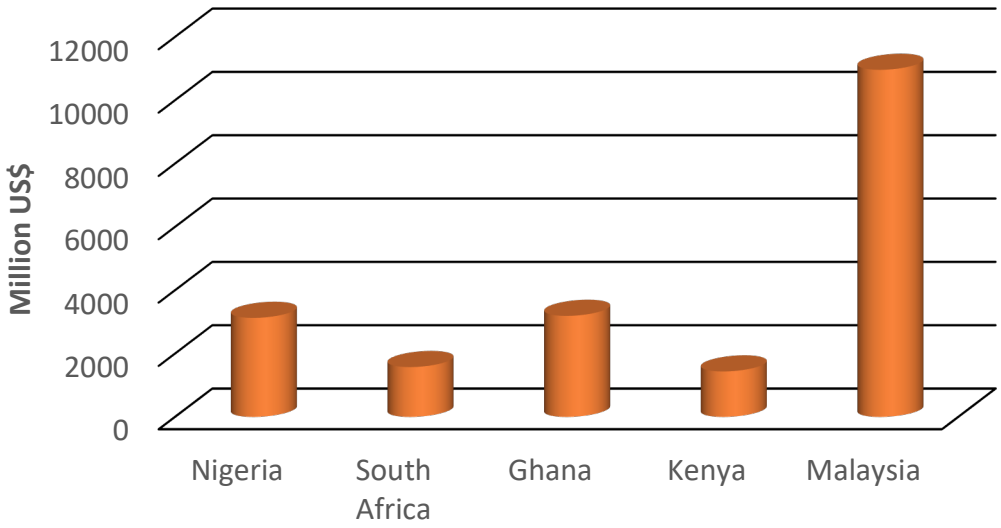
Source: WDI (2017).

Figure IIIB.VIII
Electric power consumption for selected countries (KWh per capita)



Source: WDI (2017).

Figure IIIB. IX
FDI inflows of selected countries in 2015



Source: WDI (2017).

The first two indicators can be tracked in an innovation survey. Data on FDI inflows into Kenya as previously discussed indicate that Kenya has been one of the lowest receivers of FDI in Africa in recent years. This trend continued in 2015 as can be seen in Figure IIIB.IX. Kenya's continuing underperformance relative to other countries, including its peers, could have a negative impact on her ability to benefit from knowledge spillovers from developed and emerging economies with a negative knock-on effect on her STI profile and readiness.

4.2 Barriers to interaction

The national system of innovation recognizes the flows of knowledge and information among people, enterprises and institutions as important to the innovation process. Innovation and technology development is the result of a multifaceted set of relationships among actors in the system, which often include enterprises, universities, research institutes, policymakers and civil society organizations. The network of key STI actors may be viewed as a system guided by a framework of knowledge demand and supply with a defined output of innovation. In this context innovation may be technological or non-technological, given a broad definition of innovation as including technological, organizational, social and marketing innovations. Barriers to interactions are major challenges to the evolution of NSI in many African countries, as a consequence of which industrialization and economic competitiveness are not achieved.

As is the case in most developing economies, interactions among STI actors in Kenya are often based on similar and, often, parochial interests among the actors. National interests mostly do not inform STI interactions. Also, the harmonization of governmental programmes with the need of other actors in the STI ecosystem is poor. Key barriers to interaction among STI actors in Kenya accordingly include:[96]

- Poor demand for local R&D outputs, resulting in low incentives for active interaction among STI actors
- Inefficient education and research into the systems needed to ensure effective synergy among the different actors
- Inadequate supply of and low investment in highly qualified and skilled human resources
- Poor technological learning capacity in local industries
- Lack of innovation that may enhance the competitiveness of the country's economy
- Inefficient intermediate organizations[97] needed to create an overall system of learning and problem solving
- Weak linkages between intermediate organizations and the business system
- Weak institutional and infrastructural base
- Lack of comprehensive fiscal and taxation measures aiming to incentivize innovation among entrepreneurs
- Lack of a coordinated national science and technology agenda
- Non-alignment of academic curricula and graduate scientific and technological skills with industry needs
- Lack of access to data required to measure innovation
- Inadequate funding support for innovation

4.3 Clusters and knowledge flows

In 2009 the Kenyan National Economic and Social Council recommended the adoption of a cluster development strategy in Kenya (NESC, 2013). This initiative was implemented to enhance regional and national competitiveness. The following sectors were

96 Ministry of Science and Technology and Ministry of Higher Education, Science and Technology.

97 Intermediate organizations are defined by the Kenyan Ministry of Science and Technology as developers and transmitters of knowledge between the business system on the one hand and the education and research system on the other.

recommended for the introduction of a cluster development strategy: transport and logistics at the port of Mombasa, horticulture, sugar, tea, tourism, marine and inland fisheries, livestock, energy, ICT, maize, cotton and dairy (Nordkvelde, 2014).

Cluster development is more prominent in the agriculture and service sectors of Kenya. Clustering is identified as a major channel to attract customers and carry out productive activities more efficiently. It confers the advantage of knowledge sharing and linkages among the different actors in the sectors. The *jua kali* – or informal – clusters in Kenya include:

- Gikomba, regarded as the largest concentration of artisans in Kenya
- Racecourse, an agglomeration of several entrepreneurs including carpentry works, electronics, metal works and hair salons
- Kamukunji, the first cluster reported by the Kenyan Government. It comprises about 5000 artisans in more than 2000 enterprises over 10 hectares
- Kawangware, a smaller cluster of different artisans involved in electronic devices repair and sales and repair of mobile phones

According to Daniels (2010), enterprise clusters typically specialize in either consumer or capital goods. Depending on the nature of the work and the market, an entrepreneur may decide to specialize in one good only or may produce an array of products. For instance, in Gikomba, an urban cluster, one can find stretches of sheds filled with burly men hammering hundreds of metal plates into bowls. Yet in rural areas like Siaya, most *jua kali* enterprises do not specialize at all. Instead they take only customized orders.

The range of products offered in clusters such as Gikomba is astonishing. Among the clanging of hammers and the buzzing of welding rods one can find farming tools, kitchenware, a variety of cooking stoves and complex machines such as zero-grazers. Most of these products are made from scrap materials, and while they lack a certain polish, they are affordable and fairly durable – exactly what customers value. However, over time it has become apparent that progress is slow in the *jua kali* world. Most artisans do not invest in innovation, and those who do can rarely find adequate financial support or protect their ideas as intellectual property. Anecdotal evidence suggests that the Kenya Industrial Property Institute has not been receptive to inventions from the informal sector.

Knowledge sharing in *jua kali* clusters arises mainly from apprentices' show of loyalty to their masters after graduation. Former masters frequently send their new apprentices to learn new experiences and methods applied in production by former apprentices. To express their loyalty to their former masters, the apprentices oblige by sharing materials, labour and knowledge with the new apprentices.

A major drawback of the *jua kali* clusters is that the apprenticeship system tends to produce workers who are skilled in only one product or trade. Once they conclude their apprenticeships, workers frequently set up enterprises competing directly with those of their masters. Since copying is rampant, the *jua kali* artisans feel that it is not worth investing time and money in developing new designs. Historically, innovation has occurred more freely in *jua kali* technology and machinery than in its products, although these advances lead only to an incremental increase in quality or productivity, whereas the ripple effect of a new product design can be more far-reaching.

5. Human resources for innovation

5.1 Education and training system

The educational and training system is an important subsystem of the national system of innovation. Apart from defence R&D activities, the private sector plays critical roles in R&D activities for the generation of innovation in industrial countries. However, in a developing economy the public sector plays the dominant role, especially through the network of higher educational institutions and public sector research institutes. Large firms which are better placed (by their apparent resource advantage) to carry out R&D in the private sector are in many cases subsidiaries of multinational enterprises which concentrate R&D activities in either their home countries or other industrial countries. For a developing country the higher education system is therefore an important element of NSI that determines the nature, quality and extent of R&D capabilities that exist to generate innovation.

A major restructuring of the education system in Kenya started in 1984, when the system known as 7-4-2-3, indicating the years spent in successive levels, was abolished to adopt the current 8-4-4 system. The change was done to facilitate hands-on practical experiences in the education system and to build curricula addressing Kenyan specificities. However, there is no evidence that this restructuring has yielded the intended transformation of the educational sector. It has continuously developed the cognitive skills of the intellectually gifted, with no substantial impact on developing the practical skills of great majority of less gifted students.

Kenya's education and training policy, as formulated by the country's Ministry of Education in 2012, focused on making education in Kenya inclusive, relevant and competitive, regionally and internationally. The Government's aim is to create an education and training system that equips learners with the desired values, attitudes, knowledge, skills and competencies, particularly in technology, innovation and entrepreneurship. This is aimed at enabling all citizens to develop to their full capacity and to live and work in dignity, while also enhancing the quality of their lives and facilitating informed personal, social and political decisions for Kenyan citizens (Ministry of Education, 2012).

The country has improved significantly in terms of student enrolments since independence. The Ministry of Education's Management Information System (EMIS) reported that the number of public and private primary schools increased from 6,058 in 1963 to 27,489 in 2010, while the number of secondary schools increased from 151 to 7,308 over the same period. Enrolment in primary education has grown from 892,000 pupils in 1963 to about 9.4 million pupils in 2010, while enrolment in secondary education has grown from around 30,000 students in 1963 to 1.7 million students in 2010. The increase has been accelerated by the introduction of Free Primary Education and Free Day Secondary Education programmes in 2003 and 2008 respectively. At the TIVET level enrolments stood at 82,843 in 2010. Enrolment in the university subsector stood at 180,978 in 2010.

Table IIIB.10

Selected indicators of human resources for innovation in 2015 or latest

Countries	No. of researchers in R&D in 2014 (Per million pop.)	Education expenditure in 2014 (% of GDP)	Secondary school enrolment in 2014 (% of gross)	Tertiary education enrolment in 2014 (% of gross)	No. of patent applications in 2014
Nigeria	38.6*	na	43.8***	10.4^	919^^
South Africa	404.7****	6.1	93.8	19.7^^	7,552
Ghana	38.7***	6.0^^	67.1	15.6	NA
Kenya	230.7***	5.5***	67.6****	4.0**	207
Indonesia	89.5**	3.3	82.5	31.1	8,023
Malaysia	2,051.70	6.1^^	79	29.7	7,620
India	156.6***	3.8****	68.9^^	23.9^^	42,854
China	698.1***	5.9****	101.9^^	46.4^^	30,342
Brazil	1,113.10	na	94.3	39.4	928,177
Republic of Korea	6,899.00	4.6****	97.7^^	98.3^^	210,292

Note: ^2005 data; *2007 data; **2009 data; ***2010 data; ****2012 data; ^^2013 data;

Source: WDI (2017).

The first publicly-owned university in Kenya, the University of Nairobi, was established in 1970. The number of public universities has increased to 22. The first private university was established in 1991, and by 2013 Kenya had 26 privately owned universities (chartered private universities and constituent colleges of private universities). Kenya has six public universities offering teacher training degrees and postgraduate courses. There are 21 public teachers' training colleges offering certificate training for primary teaching and three public teachers' training colleges offering diploma training. There are 13 private universities offering teachers' education degrees, and 19 offering diplomas. A major problem with teacher training in private colleges is the poor quality of entry grade students, which negatively affects the output of trained teachers (Kisirkoi and Kadenyi, 2012).

In spite of Kenya's progressive investment in higher education and training, the state of indicators of human resources in innovation presented in table IIIB.10 suggests that the outcomes of Kenya's education investments are below the threshold that can make Kenya's STI profiles comparable with those of the competitive and emerging economies of Asia and Latin America. While Kenya is estimated to have only 4 per cent of gross school enrolment in tertiary educational institutions, Indonesia has 22 per cent, Malaysia has 40 per cent, India 16 per cent, and Brazil has 26 per cent. The country's tertiary education enrolment also lags behind that of other African countries. For secondary school enrolment, Kenya's enrolment of 60 per cent of gross school enrolment compares well with the emerging economies and is above that of Ghana and Nigeria.

Table IIIB.10, compares Kenya against some countries on some selected indicators of human resources for innovation. Kenya had only 321 researchers in R&D per million people in 2010, Malaysia had 2261, India had 216 and Brazil had 698. The number of patent applications from Kenya is also low._Improving Kenya's STI readiness would therefore require a

great increase in educational expenditure and school enrolments at all levels, along with adequate improvement in the quality of education and training delivered at universities and other institutions with a mandate for education and training.

5.2 Employment, skills and lifelong learning

Kenya's educational system is under continuous process of restructuring and reform to produce with the requirements and demands of the 21st century work place in view. The system is emphasizing lifelong learning and the acquisition of new skills to quickly perform more non-routine tasks, and solve complex problems. Lifelong learning is been promoted in all sectors, including the agricultural sector.

According to the Commonwealth of Learning, the Lifelong Learning for Farmers (L3F) initiative was launched in Western Kenya with three non-governmental organizations, a university, an international organisation and a leading Kenyan bank participating as partners. A workshop was organized for L3F participants in collaboration with the Commonwealth Foundation in Nairobi. The modalities for integrating climate change issues into farm level operations in L3F were identified. Participants represented the Ikonzo Musanda Self Help Group, the Ugunja Community Resources Centre (UCRC) and the Kenya AIDS Prevention Project Group. The Kenya Agricultural Research Institute (KARI) and the Ugunja Community Resource Centre (UCRC) have also arrived at an understanding for establishing the sweet potato farmers' innovation platform under L3F. The UCRC has started a community banking concept called "table banking" that is accessible to 800 women members. The Kenya AIDS Prevention Project Group has entered into a one-year partnership agreement with the Mumias Outgrowers Savings and Credit Bank. The L3F participants, mostly women, received from the bank a first tranche of credit in an amount of KSh 1.25 million for poultry and other agricultural enterprises. In collaboration with the University of British Columbia, the Commonwealth of Learning has developed a learning management system called LIVES (Learning through Interactive Voice Educational Systems). Its goal is to provide communities with a learning tool based on voicemails using mobile phones.

All Kenyan public universities and two of the private universities have introduced distance learning programmes in order to meet the increased need for lifelong learning. Distance learning is gaining popularity because of its ability to reach out to working professionals who cannot take time off from work to enrol in regular classes. This has helped several institutions to reduce operating costs, promote gender equity and take education to the people by finding ways to increase their access to secondary and tertiary education (PHEA, 2007). Raising the skill level and capacity for innovation of the workforce in the public and private sectors is critical for STI readiness, and the ability to achieve this by programmes of lifelong learning and skills upgrading should be regularly assessed to justify investments or to determine alternative investments that would better contribute to improving Country STI profiles. Because there is, however, currently no evidence that any of the existing lifelong learning programmes in Kenya are being evaluated, it is difficult to ascertain their contributions to the status of Kenya's STI readiness.

5.3 Inclusive innovation and innovation culture

The Kenyan Government formulated an STI policy framework in 2012 with the main objective of creating endogenous STI capacities appropriate to national needs, priorities and

resources. It also wanted to create a science, technology and innovation culture whereby solutions to the socio-cultural and economic problems of the individual, the community and the nation are recognized and sought within the domain of STI. The policy is based on the guiding principles of relevance, realism, cost-effectiveness, being multidisciplinary, and synergy, partnerships, environmental protection and conservation, empowerment and participation, equity and non-discrimination, ethical leadership and good governance (Ministry of Higher Education, Science and Technology, 2012). These principles all contribute powerfully to engendering inclusiveness in innovation and to building an innovation culture.

On the basis of published sources, the Global Innovation Index Report also provides important clues about the extent of a national inclusive innovation and innovation culture. Kenya ranked 99 out of 142 countries on the 2013 Global Innovation Index, which measured countries' innovation capabilities and how they drove economic growth and prosperity (GII, 2013). The report shows that Kenya scored 30.3 per cent. While its ranking is higher than that of some larger economies in Africa, for instance Nigeria (ranked 120), the scores do not in any way suggest an appreciable innovation culture among Kenyans. The scores in terms of the different criteria were generally poor. For instance, under institutions (political stability, government effectiveness, press freedom, amongst other things), it was placed 109th; under human capital and research it was graded 122nd; while it was rated 117th under infrastructure. Furthermore, Kenya was placed 69th under business sophistication; 90th under knowledge and technology output; and 98th under creative output.

The report further recommends that underperforming countries including Kenya can boost their innovation capabilities by developing hubs in which large companies whose business goals are aligned with the objectives of the innovation hub can play a key catalytic role. Enterprise champions, including State-owned enterprises, family-owned conglomerates and multinational corporations, can be the critical drivers of innovation hub activities. These enterprise champions can facilitate the building of the capabilities and talent pools of hubs by stimulating innovation and by helping to bridge the gap between research and commercial success.

Inclusive innovation and an innovation culture that relates to human resources for innovation can be illustrated by case studies emanating from the innovation survey or the country STI readiness study. The case study presented in box IIIB.3 is a good example of inclusive innovation engendered by the liberalization of the telecommunications industry in Kenya.

Box IIIB.3

Liberalization of mobile telecommunications for an inclusive growth and innovation culture

In 1998, Kenya enacted a Communications Act which liberalized mobile telecommunications market entry and operations in Kenya. Within two years two mobile operators were functioning effectively, and the mobile telephone sector began to grow rapidly in the early 2000s. Mobile telephone operators began to sell mobile phones from international firms through their stores and partners, typically located in urban areas. Initially such supplies were expensive, and the formal stores soon found themselves in competition with less formal suppliers of mobile phones, particularly long-standing indigenous goods importers importing through grey market routes. This early stage was one of the technology transfer of undifferentiated products. However, while the two mobile operators focused on more affluent urban users, importers increasingly sought wider markets, for example, building supply relationships with micro-entrepreneurs in smaller towns who would sell phones into these areas.

The increasing saturation of markets in the global North during the 2000s made international mobile phone suppliers start to turn their attention to the global South. In East Africa growing demand and stronger regional integration via the East African Community made Kenya an attractive location for international mobile phone firms by 2005. This attractiveness was increasingly focused on the localization and adaptation of mobile phones. In terms of innovation, phone models began to emerge that were more tailored to the needs and the context of poor consumers. This was initially driven by international donor agencies in collaboration with the Government of Kenya. It was subsequently also seen as part of the corporate social responsibility of mobile telephone companies, for example, supporting shared phone models in poor communities and the development of universal service provisions. As the markets for phones expanded, other adaptations were mainstreamed, such as extended battery life and local language interfaces. In terms of the emerging innovation system, the large mobile suppliers were increasingly aware of the competition from less formal importers. It was assumed that Kenya was showing nascent signs of developing an ICT industry with a core of well-educated indigenous entrepreneurs focusing on customized applications for mobile phones and new digital content making mobile phones accessible to poor or marginalized populations.

Source: From Foster and Heeks (2012) and Zachary (2008).

6. STI governance

As earlier indicated, the Government of Kenya recognizes science and technology as vital to the social and economic development of the country. Before independence the colonial government developed a research infrastructure to serve the colonial economy. After independence in 1963, R&D activities continued under the East African Community until its breakup in 1977. Within the same period, there was increasing awareness of the role of S&T in economic development, which identified the need to establish a mechanism to coordinate and promote S&T activities. The Science and Technology Act Cap. 250 of Laws of Kenya was accordingly enacted in 1977. The Act aimed at providing guidance for the development of S&T and ensuring its integration with national social and economic development programmes and projects. Since its enactment, there have been other policy initiatives to integrate science and technology into a national development strategy. One major initiative in this respect was the establishment in 1987 of the Ministry of Research, Science and Technology, to oversee the evolution of a sound national science and

technology base. The ministry had a mandate to enable the country to upgrade its scientific and technological skills, and to mobilize the necessary resources for science and technology, while boosting national efforts to generate, select, adopt and apply science and technology for social and economic development.

The Economic Recovery Strategy for Wealth and Employment Creation 2003-2007 emphasizes the use of science, technology and innovation and technical education as key strategies for enabling productive systems to achieve expected results. The current national activities in scientific research and technological development are spread across governmental and semi-governmental agencies, as well as private and non-governmental organizations and universities. Many of these organizations pursue STI and technical education activities independently and set their own priorities, which are not uniformly harmonized with national development priorities. This has often led to the duplication of efforts and the ineffective use of resources and the weak coordination of STI and technical education activities. STI development efforts have accordingly been uncoordinated, with limited impact on economic activities.

Kenya's STI policy and strategy document outlines the following strategies for good governance of the STI system:

(a) Provide for the continuous review of policies impacting on the mainstreaming of STI in all sectors of the economy;

(b) Establish an enabling legal and regulatory framework to support the growth, application and use of STI;

(c) Promote institutional re-engineering aimed at providing a governance framework supporting the coordinated and partnership-based application of STI to address Kenya's development challenges;

(d) Facilitate the involvement of scientists and technologists in national governance and public policymaking;

(e) Review the staffing and leadership of STI institutions with a view to promoting progressive gender parity in national STI initiatives;

(f) Provide guidelines for compliance with ethical issues regarding research activities.

The policy institutions and the governance structure for STI in Kenya still lack definition, and the national system of innovation appears to be in its infancy. Although the STI policy is robust and based on an innovation system approach to STI governance and management, the extent to which stakeholders participate in the development of the STI policy is, however, uncertain. There is consequently no evidence of strong policy ownership by stakeholders. Moreover, the political leadership's commitment to STI policy implementation has not improved significantly. The results of the innovation survey conducted in 2012 confirmed that Kenyan STI policy institutions and governance structures currently lack the capacity to engender a vibrant and effective NSI that underscores STI readiness. Moreover, the report on the innovation survey revealed that the Ministry of Science and Technology has not been able to significantly strengthen the evolution of NSI. It was observed that its internal linkages are weak, and that knowledge-based institutions are not actively involved as a key information source of innovation in the country.

7. STI investment profiles and prospects

Most developed countries have well-structured and regularly reviewed STI profiles, which have shaped their remarkable economic transformational experiences. Since the mid-1990s most OECD economies have concentrated investments more on knowledge accumulation than on machinery and equipment. The trend in other developed and emerging developing economies also recorded significant improvement in the different indices of STI profiles. African countries and Africa's development partners cannot ignore the vital importance of monitoring progress in country STI profiles if new technologies are to drive and guide Africa's growth along a transformative path marked by sustained growth, global competitiveness, poverty reduction, inclusiveness and environmental sustainability. This pilot study on Kenya's STI readiness provides some insights into the state of STI profiles, their contributions to economic growth and competitiveness, and pathways to ensuring that investments in STI result in real wealth creation, poverty reduction, and the greening of the Kenyan production and consumption patterns.

From the analysis in this report a strategy for improving Kenya's STI profiles should consist of at least the following ten elements:

(a) Adequate monitoring of relatively high educational expenditure, to ensure value for money in educational investments. The analysis shows that investment in education has not translated into a strong scientific base for the economy and the national system of innovation. It would be necessary for the STI governance structure to involve the regular monitoring and evaluation of the performance of education investments, to channel resources into areas that best suit the human capital requirements of the economy;

(b) In spite of Kenya's progressive investment in higher education and training, the state of indicators of human resources in innovation suggests that the outcomes of Kenya's educational investments are below the threshold that can make Kenya's STI profiles comparable with those of the competitive and emerging economies of Asia and Latin America. Improving Kenya's STI readiness would thus require a great increase in educational expenditure and school enrolments at all levels, along with adequate improvement in the quality of the education and training delivered at universities and other institutions with a mandate for education and training;

(c) Deliberate policy actions should aim to increase R&D intensity at a rate that would, within a medium-term period of about five years, match the level achieved in other developing and emerging economies;

(d) Enhancing STI activities in the country would require investing in science and technology fields, with adequate funding for research in universities and research institutes. This is crucial for attaining the goal of becoming a knowledge-driven economy;

(e) Governmental intervention in creating an enabling environment for the growth of clusters is essential for Kenya's industrial growth and competitiveness. International best practices in cluster development through benchmarking against well-developed clusters in other developing or emerging economies should be implemented. The results of this benchmarking should inform the approach to be adopted for the development of innovative clusters. With proper benchmarking some of the informal sector's ***jua kali*** clusters can receive considerable assistance that will help to transform them into hubs of competitive manufacturing activities with high quality products that are suitable for export;

(f) Over time it has become apparent that progress is slow in the development of ***jua kali*** enterprises. Most artisans do not invest in innovation, and those who do can rarely find adequate financial support or have their ideas protected as intellectual property. Anecdotal evidence suggests that the Kenya Industrial Property Institute has not been receptive to inventions from the informal sector. Workable programmes that ensure easy access to capital by ***jua kali*** artisans are becoming a national priority. The protection of intellectual property is also essential to motivate innovators in medium- and high-tech products that have their manufacturing roots in the economy of the informal sector;

(g) With the exception of the mobile line subscription, infrastructural support for interaction involving STI actors is weak in Kenya, whose performance is only slightly better than that of Nigeria, when it is compared with other comparable countries. For Kenya to promote interaction involving STI actors, improved investment in power infrastructure to raise power consumption levels should become a major component of STI investments. Also crucial is investment in broadband infrastructure, as well as further improvements in the mobile cellular infrastructure;

(h) The low FDI inflows into the country would impact negatively on knowledge spillover from developed and emerging economies. Kenya therefore requires decisive actions creating an enabling environment in which foreign investors can operate, in order to create opportunities for knowledge spillovers that can help raise the level of its STI profile;

(i) The harmonization of government programmes with the needs of other actors in the STI ecosystem would be needful to create both effective STI policy institutions and a strong STI governance structure. Moreover, it would be necessary to involve all stakeholders in the country's STI ecosystem in STI policy formulation and implementation, to achieve the desired result of building a strong STI base;

(j) The Kenyan National Innovation Survey conducted in 2012 reveals that the Ministry of Science and Technology has not been able to operationalize a strengthening of the country's innovation system. The survey observes that linkages within the national system of innovation are weak, and that knowledge-based institutions are not actively involved in the country as a key source of information about innovation. There is a need to create awareness amongst innovation actors to work systematically through networks committed to knowledge-sharing and the promotion of an innovation-driven economy.

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