

Conclave of Scientists on Science, Technology and Innovation Policy:

**Foresight, Growth, Roadmaps,
Sectoral Impact Assessment and Alliances**

Proceedings

Edited by

Dr. Mohsin U Khan



ZAHEER SCIENCE FOUNDATION

**4, Udyan Marg, New Delhi - 110001
INDIA**

**CONCLAVE OF SCIENTISTS
ON
SCIENCE, TECHNOLOGY AND INNOVATION
POLICY: FORESIGHT, GROWTH, ROADMAPS,
SECTORAL IMPACT ASSESSMENT AND
ALLIANCES**

November 27-29, 2014

Venue :

Indian National Science Academy (INSA) Auditorium
Bahadurshah Zafar Marg, New Delhi-110002, India

PROCEEDINGS

Organized by:

Zaheer Science Foundation
UNESCO, New Delhi Office &
Centre for International Co-operation in Science (CICS) Chennai

Supported by:

Department of Science and Technology (DST)
Indian Council of Medical Research (ICMR)
Haryana Governor, Government of Haryana
Ministry of Earth Sciences (MoES)
Department of Biotechnology (DBT)

Contents

Chairman's Message	v
Preface	vi
Introduction, Theme and Objectives of the Conclave	vii
Research Papers	xiii
1. Science, Technology and Innovation (STI) Policy and its Implementation	xv
Evolutionary Perspective on STI Policy : Presidential Leadership on STI Policy in Korea <i>Sung-Goo Han</i>	1-12
The Imperative of Economic Growth in Science and Innovation Policy: Observations from the OECD, European Union and Asian Countries <i>Marja Häyrynen-Alesto</i>	13-35
450mm Semiconductor Wafer Foundries: Implications for the Emerging Economies <i>Thomas Pastore, Aqueil Ahmad</i>	37-60
Promoting Women Career In Science, Technology And Biotechnology <i>Arun S. Ninawe</i>	61-67
STI Prioritization in Nepal: Process And Findings <i>Dinesh R Bhuj</i>	69-82
The European Commission Stimulus to Improve Sub-National Regional Research And Innovation Strategies <i>Annaflavia Bianchi</i>	83-98
Constructing Local Knowledge With Low-Cost DIY Methods <i>Yu Fujimoto</i>	99-106
A New Social Contract with Science: A Reality? <i>Jaime Jiménez and Juan C. Escalante</i>	107-117
Government Interventions in Promoting Innovation Driven Economies in Asia Focusing on India <i>Mohsin U Khan</i>	119-166

2. STI Policy and its Sectoral Impact Assessment on Health, Environment and Climate Change	167-235
Technology Foresight in Developing Countries <i>David Feige, Nicholas S. Vonortas</i>	169-182
Moving From Illness To Wellness: Towards Integrative Health Policy <i>Bhushan Patwardhan*, Gururaj Mutalik, Girish Tillu</i>	183-200
Reaching the Unreached Assistance to Small Nations on Capacity Building in STI Policy Role of Science Diplomacy <i>G. Thyagarajan</i>	201-206
Strong Therapeutic Potential of Indigenous Herbal Drugs in The Management of Different Types of Cancer: A Prospective Area of Future Research <i>Himanshi Kapoor and Veena Agrawal</i>	207-225
Global Perspectives on Science and Technology, Ecology, Employment and Economic Development <i>Prof. Arif A. Waqif</i>	227-235
3. Institutional Models of STI Policy	237-282
Two Institutional Models Of R&D And Innovation Policy: "State As Investor" And "State As Regulator" <i>Svetlana Kirdina</i>	239-253
The Main Principles Of Innovation Processes Decomposition <i>Yulia Balycheva</i>	255-268
Modes of Global Technology Knowledge Tapping <i>O. Golichenko</i>	269-282
4. STI Policy in the promotion of Science Education Private Investment in R&D and Commercialization	283-352
Linkages Between Transnational Corporate R&D Units With Indian Firms And Institutions <i>Swapan Kumar Patra & VV Krishna</i>	285-296
Leveraging Web And Mobile Technologies to Enhance Access to and Application of Online Learner Competencies: A Project of The International Board of Standards for Training, Performance, and Instruction (IBSTPI®) <i>Dr. Khusro Kidwai, Dr. Michael Beaudoin</i>	297-305
Translational Research Initiatives of ICMR for Product Development: Engagement of The Private Sector <i>Sadhana Srivastava</i>	307-311

University in the Research and Innovation Ecosystem - Case Study of India <i>Sujit Bhattacharya and Swagat Yadav</i>	313-331
R&D Expenditure in Indian Steel Industry: A Model <i>Bagchi, Nirmalya</i>	333-343
Industrial R&D and Innovation Still Poor <i>S. Viswanathan</i>	345-347
Neoliberal Science and the Crisis of The Traditional System of Training the Scientific Fellows <i>Anatoly Ablazhey</i>	349-352
5. Regional Cooperation in STI Policy	353-422
Towards Evidence Based Impact Assessment of Science, Technology and Innovation Policies on a Basis of Systematically Collected Innovation Data <i>Torsti Loikkanen, Nina Rilla</i>	355-371
A Study On The Proposed Policy On Science And Technology For Thailand <i>Avudh Ploysongsang, Ph.D., Narong Boonyasaquan and Pong Chevanun</i>	373-388
Building National Capability through S&T and Innovation Policies - Opportunities and Challenges in Select Developing Countries <i>Tabassum Jamal, Kasturi Mandal, Ayanniyi Ayanshola</i>	389-412
Education And Scientific Training In Afghanistan <i>S. R. Samady</i>	413-421
Technical Programme	423-437
List of Delegates	439-453

Building National Capability through S&T and Innovation Policies - Opportunities and Challenges in Select Developing Countries

Tabassum Jamal¹, Kasturi Mandal¹ & Ayanniyi Ayanshola²

¹. CSIR-NISTADS, Dr. K.S.Krishnan Marg, PUSA, New Delhi.

². Faculty of Engineering & Technology, University of Ilorin, P.M.B. 1515, Ilorin Kwara State, Nigeria. (Currently at CSIR-NISTADS as CSIR-TWAS Fellow)

Abstract

The stunning advances in various fields of science and technology have had a profound impact on our lives in almost every sphere of activity, such as health, agriculture, communication, transportation, and defense. The world is today sharply divided by a technology boundary that separates the technologically advanced countries from the technologically backward ones. In this context, countries like India, China, Russia are struggling to achieve sustainable economic growth, self-reliance in technology development and gaining an important global position. Here, S&T policy of a country plays a significant role in order to set and thereafter achieve the target. More importantly studying the evolution of the S&T policy and other related policies also helps to build an understanding of how the S&T structure of a country is built. It also reflects several other aspects, such as infrastructural development, sectoral development etc. resulting into capability and capacity building through S&T and Innovation Policies in newly industrialized countries particularly. In the present paper, we therefore attempt to understand the evolution of S&T policy in select countries like Russia, China, Korea and Nigeria vis-a vis India and trace the developments that had taken place as a consequent of adopting such policies. The modest S&T advancements/development observed in case of Nigeria may be looked into setting up some examples on cooperation among developing countries on science, technology and innovation policy making.

Keywords: Policy, S&T, Innovation, developing countries

Introduction

Knowledge and innovation are the key drivers in the global socio-economic development of all the economies regardless of the specific socio-economic development phases of countries.

In the developing world many countries, especially large emerging economies have managed to upgrade their economies and social welfare by investing in education, science and innovation capabilities and institutions. On the other hand, numerous developing economies still have not recognized well the significance of Science, Technology and Innovation (STI) and related policies for development and more so in case of less developed countries due to lack of resources and expertise to set up science and innovation capabilities and institutions. In these cases development assistance policies and funding as allocated to STI can bring a change and more so by initiating cooperation among developing countries to develop science, technology, innovation and other related policies based on mutual experiences and demand driven approach.

Keeping this as backdrop the present paper therefore attempts to understand the evolution of S&T policy in select countries like Russia, China, Korea and Nigeria vis-a-vis India and trace the developments that had taken place as a consequent of adopting such policies. The aim of the paper is to highlight the role of policies in shaping the S&T system of the respective countries. Over the years, in general, what has been observed is that the science and technology policies pursued in India, China and Russia particularly since 1990s, have been very successful in reorganization and in reforming the science and technology infrastructure capabilities which is being utilized effectively for applications in different sectors of the economy in the changed scenario of globalization and competition, where there has been a distinct shift in S&T policies supporting the market culture to play a dominant role.

This cultural change has moved from the dominant politico-bureaucratic and academic orientation (during 1970s and 1980s) towards dominant market orientation of science where market forces and Non-Government Organizations (NGOs) (factors external to science) have become dominant in policy decisions at the national level (Krishna, 2001).... and so is reflective in India's new Science, Technology and Innovation policy (2013) aiming for a *strong and visible Science, Research and Innovation System for High Technology led path for India*. Being announced 2010-20 as the "Decade of Innovations" further aims to bring fresh perspectives to bear on innovation in the changing context of the cultural change mentioned above. In Korea, since 1962 the process of Science and Technology policies being formulated on a national scale started and thereafter various legislations were drafted in a systematic manner to support the development and the establishment of S&T system. In case of Nigeria, the first National Science and Technology Policy was announced in 1986. The policy aimed at ensuring a better quality of life for the people using S&T knowledge. In 1997, the policy was reviewed in order to place more emphasis on coordination and management of S&T system, sectoral developments, collaboration and funding. The policy went through another review in year 2003 to take care of some of identified lapses in the implementation of the 1997 policy. Recently in 2012, a revised STI Policy was launched by

the Federal Ministry of Science and Technology (FMST) to take care of the changing global policy of S&T and the emerging realities of knowledge-driven economy. Nigeria as a nation has progressed in policy making and formulation but has not effectively made use of its S&T policy in promoting national development. The structure of STI system in Nigeria has been identified to be weak and unable to link up with the productive sector, thereby limiting its impact on economic development (Ajoku and Onwualu, 2012). In case of Russia, 23 years ago the USSR dissolved leaving the legacy of the world's superpower to its legal successor, the Russian Federation. The country had to go through the terrible years of structural reforms and economic turmoil to finally gain the status of a market economy in 2002. Today, Russia has seemingly regained its former role of the world's leading political and economic player justly holding membership in the G8 and G20. However, more and more voices are heard that the country cannot retain its current status if it does not perform urgent structural reforms and diversify its economy. In November 2008, the government adopted the Concept for long-term socioeconomic development of the Russian Federation (Concept-2020), which explicitly set the goal of modernizing the country and achieving the technological edge. In the 1950s, the Soviet Union was the main source of policy learning in China. While China was isolated politically and economically from the West, the Soviet Union provided China with assistance, with the result that China followed the Soviet model. The structure of S&T and innovation in China therefore relied, like the Soviet Union, on central state control, specialization and the concentration of similar tasks in one organization to avoid competition and redundancy. Prior to the reforms, therefore, Chinese science and innovation systems were based on a centrally planned rather than market-driven and a mission-oriented rather than diffusion-oriented model. Structural reform of the S&T system started after the 1978 Science Conference. In March 1985, the Central Committee of the Chinese Communist Party (CCPCC) issued the Decision on Reforming the Science and Technology System. This established the guiding principle for S&T policy, namely, that economic development must rely on science and technology, and S&T must be oriented to economic development (the "orientation-reliance" principle), and launched the reform of the system of appropriations, of institutional structures, and of the personnel system. China's S&T system thus began to depart from the Soviet model; contract research and technology markets were introduced. The 1985 Decision marked the official start of S&T reform.

Following can be seen a brief outline on various S&T policy pronouncements in select countries and assess the impact on sectoral development showcasing the changes reflective through need-based approach to boost economic development.

A) National S&T Structure and Policy framework in India

Science and Technology Policy Statements are the policy tools for the Government of India for stating science & technology policy objectives and approaches. Since Independence, four S & T policy statements have been issued, viz. (i) Scientific Policy Resolution (1958),

(ii). Technology Policy Statement (1983), (iii) Science and Technology Policy (2003) and (iv) Science Technology & Innovation Policy (2013). Every policy statement has emphasized on a specific view point. This led to the creation of huge infrastructure for science and technology which encompasses organizations under central governments, state governments as well as public and private sectors working in the areas as diverse as agriculture and healthcare on the one hand and nuclear energy and space research on the other hand. How far these policy statements brought into translation/ implementation is very much dependent on a well structured S&T system. India has huge infrastructure for science and technology which encompasses organizations under central governments, state governments as well as public and private sectors working in different areas.

The research and development statistics 2011-12 from the Department of Science and Technology reported the presence of 4,533 R&D institutions in the country in 2011. Global investments in science technology and innovation are estimated at \$ 1.2 trillion. India's R&D investment is less than 2.5 percent of this and is currently under 1 % of the GDP. Though the Gross expenditure on R&D (GERD) in the country has been consistently increasing over the years and has doubled from Rs.24, 117.24 crores in 2004-05 to Rs. 53,041.30 crores in 2009-10 and further increasing in 2011 and 2012, still the increase in GERD to 2% of GDP is yet to be achieved which has been a national goal for quite some time.

The R&D expenditure by major scientific agencies as given in Table 1, shows the growth pattern over a period of time, viz. from 1970-71 to 2009-10. The data provides an overall picture of the changing pattern of allocation and utilization of plan resources made available to the Central Scientific and Socio economic Departments from central plan. This data on progress of plan expenditure on science and technology allocated to Central Scientific and Socio-economic Departments indicates that while the rate of growth of plan expenditure of Central Scientific Department has gone high over a period of time (1970-71 to 2009-10), a predominant proportion of additional resources have however, gone to strategic sectors namely Defence Research & Development Organization, Department of Atomic Energy and Department of Space. Amongst the major scientific agencies, DRDO accounted for the maximum share of 31.6% followed by DOS (15.5%), DAE (14.4%), ICAR (10.8%), CSIR (10.0%) and DST (8.3%) etc.

Department of Science and Technology (DST), Govt of India is primarily entrusted with the responsibility of formulation of S&T policies and their implementation, identification of thrust areas of research in different sectors of S&T; information technology, technology forecasting, international collaboration, promotion of science and society programs and coordination of S&T activities in the country.

However, there are other S&T departments working under central government which include Department of Atomic Energy (DAE), Department of Space (DoS), Department of

Table 1: Expenditure on R& D by Major Scientific Agencies

(Rs. in crores)

Agency\ Year	1970- 71	1980- 81	1990- 91	1995- 96	2000- 01	2005- 06	2006- 07	2007- 08	2008- 09	2009- 10
Council of Scientific & Industrial Research	21.56	69.00	249.19	411.70	864.12	1427.04	1457.46	1863.70	2355.20	2666.44
Defence Research & Development Org.	17.55	79.70	681.00	1395.40	3359.32	5283.35	5362.82	6104.55	7699.07	8475.38
Department of Atomic Energy	28.72	73.48	275.54	486.64	1005.52	1752.50	2060.09	2138.57	2982.50	3858.21
Department of Biotechnology	-	-	41.37	73.83	120.58	325.85	432.32	491.59	635.23	727.38
Ministry of Communication & Information Tech. (DIT)	-	5.41	33.03	36.38	51.07	167.85	199.18	236.22	243.04	327.96
Ministry of New and Renewable Energy	-	4.00	16.02	6.98	12.27	9.62	16.12	23.53	16.83	26.51
Ministry of Earth Sciences	-	-	27.80	45.64	84.23	235.48	256.55	292.98	271.76	448.24
Department of Science & Technology	0.84	40.64	119.82	223.67	311.46	1237.05	1359.46	1676.01	1991.16	2222.90
Department of Space	0.00	56.02	386.22	917.88	1905.40	2667.60	2988.67	3278.00	3493.57	4162.96
Indian Council of Agricultural Research	18.37	97.45	276.25	432.37	1161.74	1717.27	2014.16	1992.38	2583.80	2881.30
Indian Council of Medical Research	2.18	9.00	44.54	50.61	149.12	331.00	394.00	266.65	564.18	583.50
Ministry of Environment & Forests	-	3.74	162.09	244.60	272.86	235.31	275.71	311.21	376.13	415.57
Total	89.21	438.43	2312.88	4325.69	9297.68	15389.94	16816.54	18675.40	23212.46	26796.35

Source: Research and Development Statistics 2011-12, DST, September 2013

Biotechnology (DBT), Department of Ocean Development (DOD). Among the S&T organizations associated with other central government ministries, Defence Research and Development Organization (DRDO) under the Ministry of Defence, Indian Council of Agricultural Research and Indian Council of Medical Research (ICMR) under the ministry of Health and Family Welfare etc. have large R&D infrastructure. The Indian S&T structure includes all organizations and institutions playing a role in the system (public, private and semi-public) and their interaction.

Policy making and evaluation practice

(i) Scientific Policy Resolution (1958)

The main aim of Scientific Policy Resolution (1958) was to have scientific approach and method and the use of scientific knowledge so that reasonable material and cultural amenities and services can be provided for every citizen of the country as it was out of recognition of this possibility that the idea of a welfare state has grown. Hence, the Government of India accordingly decided the aims of their scientific policy as, i.e. (i) to foster, promote, and sustain, by all appropriate means, the cultivation of science, and scientific research in all its aspects - pure, applied, and educational; (ii) to ensure an adequate supply, within the country, of research scientists of the highest quality, and to recognize their work as an important component of the strength of the nation; (iii) to encourage, and initiate, with all possible speed, programmes for the training of scientific and technical personnel, on a scale adequate to fulfil the country's needs in science and education, agriculture and industry, and defence; (iv) to ensure that the creative talent of men and women is encouraged and finds full scope in scientific activity; (v) to encourage individual initiative for the acquisition and dissemination of knowledge, and for the discovery of new knowledge, in an atmosphere of academic freedom; (vi) and, in general, to secure for the people of the country all the benefits that can accrue from the acquisition and application of scientific knowledge.

(ii) Technology Policy Statement (1983)

After twenty five years of Scientific Policy Resolution 1958 a new white paper called Technology Policy Statement (TPS) was announced by then Prime Minister in January 1983. It emphasized the need to plan collaboration agreements in ways that would ensure effective transfer of basic knowledge, know-why important inputs to the importing firms for subsequent absorption, adaptation and up-gradation of the initially acquired knowledge.

The TPS placed emphasis on reducing technological dependence in key areas by reducing technology acquisition from abroad and by giving due recognition and support to the indigenous initiatives which eventually led the path for import substitution policy. It contemplates that lists of technologies that have been adequately developed locally be prepared and updated periodically and normally no imports of these will be permitted. A National Register on Foreign Collaboration (NRFC) was to provide analytical inputs of various stages of technological acquisition.

The initiative taken as follow up of TPS included a Technology Absorption and Adaptation Scheme (TAAS) that aims to provide catalytic support for accelerated absorption and adaptation of imported technology by the industrial units. It was made mandatory to highlight efforts taken towards absorption of technology imports in a separate chapter of the annual reports of all importing firms. The above cited S&T policy deliberations implicitly enabled the economic policy of India in 1991. Policy changes announced by the government abolished industrial licensing except for short list of industries related to security and strategic concerns, hazardous chemicals. The restrictions imposed by Monopolistic and Restrictive Trade Practices (MRTP) Act on large firms expansion, merger, amalgamation and take over etc was abolished. Now Multinational Corporations (MNCs) were free to use their brand names. Now MNCs could increase the permissible extent for foreign equity from 40-51 per cent.

The above policy has been evaluated and reviewed number of times since then by a committee appointed by the Ministry of Finance and which has further liberalized the Indian economy, for example in Drugs and Pharmaceutical sector 100% foreign investment automatically permitted, abolition of industrial licensing for all bulk drugs intermediates and formulations.

(iii) Science and Technology Policy (2003)

The economic liberation of India in 1991 significantly brought competition in industrial production which set the tone for the Government of India to announce the new, Science and Technology Policy 2003, which lays a lot of emphasis on international collaboration in science and technology. It states as one of the objectives to promote international science and technology cooperation towards achieving the goals of national development and security and make it key element of international relations. The policy has thought of a strategy and a kind of plan of action for meeting the objectives of the policy and it states Scientific Research and Technology Development can benefit greatly by international cooperation and collaboration. International collaboration programs especially those contributing directly to scientific development and security objectives were encouraged between institutions and national laboratories in India and other counterparts in all parts of the world including participation in mega science projects as equal partners. Special emphasis was also placed on collaboration with other developing countries.

(iv) Science Technology & Innovation Policy (2013)

With the pronouncement of 2010-20 as the 'Decade of Innovation', the government of India stressed the need to enunciate a policy to synergize science, technology and innovation, the Prime Minister in January 2013 announced a new policy entitled, 'Science, Technology and Innovation Policy 2013'. Main features of the STI policy include a) expressed levels of aspiration, b) balancing between excellence and relevance, c) creating an enabling policy

ambiance for attracting larger investments of private sector into Research and Development, d) promoting a science-led innovation ecosystem and e) establishing linkages between discovery processes of science and developmental priorities of the country in agriculture, manufacturing, services and infrastructure sector. To make this policy effective there is a need to create the necessary framework for enabling the integration in identified priority areas by exploiting endogenous resources, strengths and capacities. The investment in science and investment in science-led technology and innovation in select areas of socio-economic importance aspires to bridge the gaps between the STI system and the socio-economic sectors.

Needless to say that the state S&T Councils need to develop effective linkages with S&T institutions, State Government line departments and central S&T agencies/departments to ensure better effectiveness in their schemes and programmes and to be aligned with the new STI policy objectives and outcomes. Since there cannot be a uniform S&T policy across the states as each state has different characteristics, potentials, resources and priorities, therefore each state has to plan its priority areas for development and accordingly a comprehensive S&T policy. Thus it is the state S&T Councils who play the lead role to bring into the development mechanism by stating mission oriented goals/targets of the state and to achieve them with the help of S&T interventions. State priority has also been emphasized by the Hon'ble Prime Minister Shri N.Modi indicating his office to consider issues, especially those raised by the States on priority and with sensitivity. The statement said ".....this is important because India's progress lies in the progress of states and this would strengthen our federal structure."(Times of India 29th May, 2014)

B) S&T Structure and Policy framework in Korea:

Science and Technology emerged as one of the overriding tools in the beginning of economic development in South Korea, leading to the national institutionalization of science and technology which enabled South Korea to secure local supply of science and technology required for economic development. It is worth noting that at the same time, the country has become independent in science and technology at a more fundamental level. It includes a paradigm shift among the South Korean people to appreciate science and technology both culturally and socially which has resulted Korea to be transformed itself from a poor agrarian society to a modern industrial nation within one generation. What makes Korea's experience so unique is that its rapid economic development was relatively broad-based, which can offer invaluable insights and lessonPs and knowledge that can be shared with the rest of the international community.

The main idea of science and technology policies in Korea could be synthesized as an "internalization" strategy. Three major components to support the internalization strategy at the early stage of science and technology promotion.

- National leadership: presidential:
 - Promotion of science and technology
 - Government oriented setting of S&T priorities

- Institutional building:
 - Governmental innovation system
 - Legal framework and administrative system

- Human resource development:
 - Vocational training and science learning campaign
 - S&T focused new education system

The first factor was national leadership guiding science and technology toward national developmental issues. Since then, science and technology in Korea have largely equated to national mission-oriented activities. Institutional building was the second driver of the internalization. In a condition that the private sector was immature, the Korean government took the lead in building a legal framework to introduce the public-funded innovation system including research institutes and supporting organizations. As human resources in Korea were regarded as the only competent driver for the economic development, the government introduced various policy tools of technical training and science and technology education.

National Administration and Research Systems for Science and Technology

Since the early 1960s, the Korean government considered science and technology as the country's inherent capacity and decided to build a foundation for cultivating this field. The foundation was built with the establishment of a national science and technology system during its early stage where the Ministry of S&T and the Korea Institute of Science and Technology (KIST) were set up in the late 1960s. In terms of administration and research, Korea's national science and technology system has undergone phenomenal growth over a short period of time. Science and technology began to be recognized as a critical asset for the country's development under the First Five-year Technology Plan (1962-1966). Accordingly, an environment to develop science and technology was created through a long-term national plan. Rather than immediately setting up the National Institute of Science and Technology, however, the Korean government decided to take a more gradual approach. Instead, the government decided to install a bureau in charge of science and technology within the EPB (Economic Planning Board) during the first Five-year Technology Plan. Accordingly, the Bureau of Technology was established under the EPB in June 1962. This heralded the birth of Korea's first administrative department in the fields of science and technology.

Development of Science and Technology Manpower

The Ministry of S&T fostered science and technology manpower to strengthen the foundation of science and technology and realign the science and technology promotion system. It focused on implementing policies to strengthen basic research and increase international technological collaboration. Until the 1960s, the main source of high quality workers in science and technology were mostly those who had studied abroad. But there was an urgent, growing demand for domestically fostering high quality manpower with skills that could be utilized on the field according to the progress in industrial development.

Government Research Institutes (GRIs)

In February 1966, the two governments signed an agreement on a joint project between Korea and the U.S. to establish and operate a research institute. As a result, Korea Institute of Science and Technology (KIST) was officially inaugurated on February 10, 1966. It was completed in January 1969. It was the first research institute in Korea with modern research equipment and facilities that met the level of advanced countries, and prominent researchers attracted from advanced countries were in the line-up. KIST's basic ideology was the guarantee of research freedom, assurance of financial stability, and creation of a reasonable and liberal atmosphere. It received government funding in the form of contribution rather than subsidy. This limited the government's intervention in R&D, enabling autonomy in research. It became an important precedent in the enactment of acts to promote the establishment of Agency for Defense Development (ADD), and the Korea Atomic Energy Research Institute (KAERI). In order to enhance the efficiency of GRIs, it implemented various policies such as (1) development of mid-long term R&D plans, (2) computerization of research tasks, (3) integrated operation of overlapping administrative support, (4) flexible operation of organization based on research tasks, and (5) improvement of reimbursement for researchers and creation of a research environment.

Development of the Country with Science and Technology

Korean economy has managed to maintain steady growth since the 1970s except for two events of the Asian financial crisis in 1997 and the global financial crisis in 2008. GNI per capita first exceeded 1,000 dollars in 1977 and 10,000 dollars in 1995. GNI per capita passed the threshold of 20,000 dollars in 2010. As evidenced by these milestones, Korea is showing constant growth since it began its economic development. As shown in the table 2 the total R&D has continued to increase since 1970. The proportion of R&D investments in GDP has also increased. It is worth noting that investments in science and technology have steadily increased before and after the Asian financial crisis in 1997 and the global financial crisis in 2008. In the case of 1998, there was a partial contraction in R&D investments due to the national financial crisis, but in 2008, science and technology investments remained strong. This illustrates that despite economic difficulties, Korea did not slacken investments in this field.

Table 2. : Trends in R&D Expenditure in Korea*(Unit: KRW 100 million)*

Year	1970	1980	1990	1995	1998	2000	2005	2008	2011
Total R&D Investments	105	2117	32105	94406	113366	138485	241554	344981	498904
% of GDP	0.38	0.54	1.68	2.30	2.26	2.30	2.79	3.36	4.03

Source: NTIS (National Science and Technology Information Service), National Science and Technology Commission

While examining changes in manpower in 1969, the total number of R&D personnel in Korea was about 12,000. At the time, R&D personnel per population of 10,000 were 1.4 persons. There are no accurate statistics on PhD-level personnel in the 1960s, but they are estimated to be no more than 1,000 persons. Total R&D manpower in 2011 reached 530,000, with R&D personnel per population of 10,000 at 54 persons in 2010.

Table 3: Changes in R&D Manpower in Korea*(Unit: Persons)*

Year	1969	1976	1980	1986	1996	2006	2011
Total R&D Manpower	12,145	27,051	30,473	87,430	202,347	365,794	531,131
PhD-level	-	2,700	3,400	9,000	36,106	60,013	84,674
Per 10,000 persons	1.4	3.3	4.8	12.5	21.8	41.4	54.0 (2010)

Source: *Compilation of Twenty Years' History of Science and Technology Administration*, NTIS (National Science and Technology Information Service), National Science and Technology Commission

Changing People's Perception

Korean case of science and technology promotion provides evidence that a society's deeply rooted cultural customs can change with a country's efforts. In the Korean society, there was an old-fashioned tradition that regarded technology as lowly labor. But its national leader inspired people the confidence towards economic development, and implemented policies that offered preferential treatment to those with technical skills. This was what completely transformed the way people perceived science and technology. The Learning Science Movement the Korean government initiated during the early stages of its economic development was even applied to the prisoners at the time. This campaign, compounded by huge investments in science and technology on a national level, swiftly transformed the Korean society. Such

initiatives encourage many students to move on to science and engineering universities and nurture the hope of working in a science and technology-based industry.

C) S&T Structure and Policy framework in Russia :

The Russian S&T system has gone through a series of reforms in the last twenty years. It can be divided into three main stages. The primary goal of the first period (1991-1996) was to ensure the survival of the Russian science in crisis and initiate a number of structural reforms that would make the country's S&T system more efficient. The government provided selective support to the high priority projects and laid the foundation for the individual-oriented science structure in a hope to create a competitive and transparent environment that would allow the country to join successfully the world scientific community. The second round of reforms (1997-2001) was tainted with frequent change of leadership due to the political and financial turmoil. However, during this period the government succeeded in providing tax privileges to the research institutes and allowed them to lease their property for more profit. It also started to build the elements of the nascent innovation system: the Innovation Technology Centers and a Russian Venture Innovation Fund were established, and modest support was provided for small innovative enterprises and venture investing. The latest stage of reforms (2002-present) aimed at preserving the S&T potential of the country and providing an adequate regulation for the results of innovation activity. This period witnessed adoption of a set of long-term development documents and a range of legislation including the new Patent Law, part of the Civil Code on intellectual property, and others.

One of the biggest achievements of the Russian STI policy has been the institutional reform of the country's S&T system and the introduction of new approaches in the government funding. At the commercialization stage of innovative activity, the government has also created a set of organizations that support small- and medium-size enterprises as well as university spin-offs. Technology parks, Innovation Technology Centers, Special Economic Zones, Technology Transfer Offices, and the Russian Venture Corporation were established to provide a favorable environment for the risky innovation ventures that can grow into big corporations in future.

Starting with mid-2000s, the Russian leadership has been testing one more approach to build an efficient national innovation system and boost the country's performance in science and technology. The government has been trying to develop a set of technology-specific growth strategies, and, among others, it launched a large-scale program of nanotechnology development hoping that it can push forward all other economic sectors. As a general-purpose technology, nano-scale research and innovation is considered to be the key element of the next generation of the global S&T development, which can allow countries to forge ahead and catch up. This new technology-based policy is believed to have significant impact on the Russian economy in future based on the transformative capacity of nano-science and nanotechnology that stretches across multiple fields and sectors including physics, chemistry,

biochemistry, electronics, metrology, etc. It can also be assumed that, given its diverse and particularly wide nature, nanotechnology can have exceptional rigidity and adaptability to any sectoral and national change that makes it a perfect ground for experiment. The government defines the primary goal of its nanotechnology project in building the R&D infrastructure for Russia's enterprises, universities, research institutes and government agencies. Therefore, the nano program is seen as a sort of locomotive for the entire innovation sector of the Russian economy, which is set to test and modify the major elements of the innovation system so that it embraces the best practices of the West as well as adapts to the historical and cultural context of the Russian science and technology.

The level of gross domestic expenditure on R&D (GERD) as a percentage of GDP has climbed slowly after the initial shock of the early 1990s. In 2008, GERD accounted for 1.03% of GDP, down from more than 2% during the late Soviet period. It has also fallen more recently from a peak of 1.28% in 2003. This recent decline can be explained by robust growth in GDP, which has tended to outstrip growth in GERD, rather than by decreased spending on R&D. Indeed, among OECD countries, only Korea had a larger percentage point increase in its share of total OECD R&D expenditure over the ten-year period to 2008. Nevertheless, the Russian GERD/GDP ratio is well below levels seen across the OECD, where the average stands at 2.33%. This reflects both Russia's emerging economy status (more developed economies tend to be more R&D-intensive so as to remain at technological frontiers) and its industrial structure, which is dominated by extraction industries with traditionally low R&D intensities.

D) S&T Structure and Policy framework in China:

Since 1978 the Deng Xiaoping theory of S&T has been the theoretical and ideological foundation of China's S&T policy. The Deng Xiaoping theory of S&T can be summarized as one central and two basic themes. The central theme is that science and technology are a primary productive force. The basic themes are: *i*) intellectuals, including S&T workers, belong to working class and talent must be respected; and *ii*) "The reform of the system for managing science and technology, like the reform of the economic structure, is designed to liberate the productive forces. The new economic structure should promote technological progress, and the new science and technology management system should promote economic development." (Deng, 1985; Liu, 2004)

Since the end of the Cultural Revolution, the Central Committee of the Chinese Communist Party (CCPCC) and the State Council have issued four decisions on S&T policies ie, Decision on the Reform of the Science and Technology System, 1 1985 (hereafter, 1985 Decision), Decision on Accelerating Scientific and Technological Progress, 2 1995 (1995 Decision), Decision on Strengthening Technological Innovation and Developing High Technology and Realising Its Industrialisation, 1999 (1999 Decision), Decision on

Implementing the Medium- and Long-term Strategic Plan for the Development of Science and Technology and Improving the Indigenous Innovation Capability, 2006 (2006 Decision).

Evolution of China's S&T policy broadly categorized into four stages:

- *From the 1975 Outline Report to the 1978 Science Conference.* During this period, Deng Xiaoping launched a "rectification" of the economic, S&T and education systems damaged by the Cultural Revolution. After the death of Mao and the arrest of the Gang of Four, Deng's ideas were reflected in the Science Conference of 1978.
- *Systemic reform, 1979-94.* This period saw a spontaneous trial stage (1979-84), followed by official reforms (1985-94). The CCPCC issued the decisions on the reform of economic system in 1984, on the reform of the S&T system in 1985, and on the reform of education system also in 1985.
- *Deepening reform, 1995-2005.* Following Deng's proposal of faster reform, the Fourteenth Congress of the CCPCC proposed establishing a socialist market economy. The top leadership launched the 1995 Decision on accelerating the progress of S&T, the National Strategy on Science and Education, the 1999 Decision on strengthening technical innovation and high-technology industrialization, and the National strategy on sustainable development.
- *Towards an innovation-driven nation, 2006-20.* The leadership proposed the Concept of Scientific Development and the Harmonious Society; it launched the strategy for revitalizing the nation by talents, the Strategic Plan for the Development of Science and Technology over this period and the corresponding Decision.

Implementing and impact

The government led by the then Premier Zhu Rongji, promised that revitalizing the nation through science and education would be the most important task of his government. It established the State Leading Group for Science, Technology and Education to co-ordinate the national S&T and innovation policy.

Rapid growth of R&D investment

The strategy of "revitalizing the nation through science, technology and education" was generally understood by the science and education communities as "revitalizing science and education by the nation". They argued that in order to revitalize the nation with science and education, the nation must first revitalize science and education. As the strategy was implemented, investment in R&D increased quickly, as reflected in the growth of the ratio of R&D to gross domestic product (GDP) from 0.57% in 1995, to 0.90% in 2000, to 1.33% in 2005.

Prioritization and concentration of resources on major programmes

One characteristic of science policy after 1995 is prioritization and concentration of resources on major programmes (Cao, 2002):

- The Knowledge Innovation Programme of the CAS.
- The Education Revitalization Action Plan towards the 21st Century.
- The State Key Basic Research and Development Programme (the 973 Programme).
- The National Science Fund for Distinguished Young Scholars.
- The State High-technology R&D Programme (the 863 Programme).
- The World Class University Programme (the 985 Programme).

Towards the innovation-driven nation, 2006-20

In January 2006, a national conference on S&T was held. The Medium- and Long-term Strategic Plan for the Development of Science and Technology (2006-20) was issued by the State Council, and the Decision on implementing the Medium- and Long-term Strategic Plan for the Development of Science and Technology and Improving Indigenous Innovation Capability was issued by the CCPCC and the State Council. These two documents signify that China is adopting an innovation-driven development model. China's growth increasingly faces barriers to sustainable development: *i*) social developments, such as public health, have lagged behind economic development as shown by the outbreak of SARS in 2003; *ii*) economic growth has increased the imbalance between urban and rural areas, between lagging regions in the west and northeast of China and the more prosperous coastal regions, and between different social groups with income inequalities; *iii*) growth has generated serious negative environmental externalities; *iv*) growth does not create the necessary new job opportunities; *v*) the manufacturing sector has been locked into low value-added products; and *vi*) catch-up relies heavily on the advanced technology developed by the industrialized countries, but leading-edge high technology is too costly and unavailable. Finally, China faces trade restrictions and disputes triggered by its trade surplus with its major trading partners. Thus, China had to find a shift in the development ideas and strategy. Against this background, the new leadership formulated the "concept of scientific development", which includes people-oriented, comprehensive, co-ordinated and sustainable development, and the Harmonious Society and Innovation-driven Nation.

C) S&T Structure and Policy framework in Nigeria :

The first National Science and Technology (S&T) Policy in the country was produced in 1986 and it was designed to create harmony in the pursuit of knowledge about the environment through research and development (R&D). The policy aimed at ensuring a better quality of life for the people using S&T knowledge. In 1997, the policy was reviewed

in order to place more emphasis on coordination and management of S&T system, sectoral developments, collaboration and funding. The policy went through another review in year 2003 to take care of some of identified lapses in the implementation of the 1997 policy. The need to address the institutional frameworks that should foster interaction among the various elements of the National System of Innovation (NSI) was properly addressed in year 2003 review (Federal Republic of Nigeria (FRN), 2011). However, in year 2012, a revised STI Policy was launched by the Federal Ministry of Science and Technology (FMST) to take care of the changing global policy of S&T and the emerging realities of knowledge-driven economy (Ajoku and Onwualu, 2012).

It is pertinent to note that prior to 1986, the development of S&T was already in progress through the establishment of research institutes in the country. The first sets of research institutes in Nigeria as reported by Abdullahi (2004) were established during the colonial rule to boost agricultural output and thus provide adequate raw materials for industries in Europe. This resulted in the establishment of the first agricultural research station in Ibadan and was called Moore Plantation in 1898. Similarly, research stations were established in the then Northern Region at Samaru, Zaria and Umudike, Umuahia in Eastern Nigeria. The Department of Agriculture (or Moore Plantation) was later renamed Federal Department of Agricultural Research in 1954 (Ajoku and Onwualu, 2012).

Another four sub-regional research stations were further established by the colonial administration with headquarters in the early 20th century. The headquarters of these centres were located in Nigeria which include:

- West African Cocoa Research Institute, Ibadan,
- West African Institute for Oil Palm Research, Benin
- West African Institute for Trypanosomiasis Research, Kaduna.
- West African Council for Medical Research, Yaba, Lagos.

Furthermore, the West African Research Office located in the then Gold Coast (now Ghana) had research centers in Nigeria. The research centres include the following: the West African Road Research Institute, the West African Timber Research Unit and the West African Rice Research Station. Following independence of Ghana in 1957, most of the research institutions and centres became full-fledged national institutes in Nigeria. In 1964, the Agricultural Research Institute Act was enacted by the parliament in Nigeria (Mashi, et al, 2014). The institute was established to coordinate research activities in Nigeria as it relates to agriculture. Following the international conference on the Organization of Research and Training in Africa in 1964, Nigeria established a National Council for Scientific and Industrial Research (NCSIR) by Decree No. 83 of 1966. The Council was expected to act as an advisory body to government and as such, lack executive powers (Mashi, et al, 2014). Its mandate

was quite narrow and therefore had structural weakness that prevented it from functioning efficiently. The real consciousness of the development of science and technology in Nigeria did not come into force until after the Civil war in 1970. Table 4 summarizes the evolution change in STI from that 1966 to 2012 when the present STI policy was drafted by FMST in collaboration with UNESCO.

Table 4: Institutional Changes in the Evolution of STI in Nigeria (1966-2012)

Year	Institution(s) Established/Re-established
1966	Nigerian Council for Science and Industrial Research (NCSIR)
1970	Nigerian Council for Science and Technology (NCST) replaced NCSIR
1977	National Science and Technology Development Agency (NSTDA) replaced NCST
1980	Federal Ministry of Science and Technology (FMST) established to replace NSTDA
1984	FMST scrapped and merged with Ministry of Education
1985	FMST Re-established (1 st Draft of National Policy on S&T produced in 1986)
1992	FMST scraped (All Research Institutes under FMST distributed to Ministry of Agriculture, Health, Industry and Technology); National Agency for Science and Engineering Infrastructure (NASENI) established.
1993	FMST Re-established
1994	All Research Institutes including NASENI transferred back to FMST
1996	Research Institutes under Agriculture, Health, Industry, etc transferred back to the line Ministries.
2000	FMST restructured,
2003	New S&T Policy drafted
2006-2012	5 New Research Institutes (NABDA, NASRDA, NITDA, NBTI, and NAEC) were established. The new S&T policy was launched, focusing on Biotechnology, Space Science and Technology, Information and Communication Technology (ICT), Intellectual Property Rights. Honorary Presidential Advisory Council (HPAC) on S&T established. An inter -ministerial R & D coordinating structure called National Research and Development Coordinating Council (NRDCC) approved. Vision 20:2020 Technical Working committee on STI (2009). Launch of 2012 STI Policy (2012)

[Source: Ajoku and Onwualu, 2012]

The 2012 ST&I Policy was designed in tandem with the objectives and pillars of the NV20:2020 so as to resolve practically the long standing disconnect between economic planning, and science and technology. This latest STI policy is therefore believed to be one of the key drivers for the actualization of vision 20:2020. The Vision 20:2020 programme of the government was designed to pitch Nigeria among the top 20 economies by the year 2020. This is succinctly captured in the programme's vision statement which is "to build a science, technology and innovation system that will derive a competitive knowledge economy towards 20:2020" (Owolabi, et al, 2014)

The Nigeria Government has extensively used the results in the African Innovation Outlook report to review the country's STI Policy in 2012. Nigeria noted among other things that its R&D intensity (GERD/GDP) of 0.2 per cent was too low to drive sustainable development and a far cry from African target of 1.0 per cent. Based on this information the new STI Policy of Nigeria is trying to improve its budgetary allocation to STI, establishing a special fund for R&D called the National Research and Innovation Fund (NRIF) and a Venture Capital has also been launched. Nigeria has also taken steps to increase its human capital development by addressing the admission ratios in favour of Science, Engineering and Technology (SET) and by establishing nine new universities (AOSTI, 2013). However, having such good policy in place does not guarantee automatic translation into performance as observed by NPCA (2014).

Budgetary allocation and political will

A coherent national policy that provides for research into the development of science and technology in Nigeria had been at best, ad-hoc, fragmented, and almost non-existent. Past and present governments, both military and civilian, are responsible for this trend. Yet, technology is central to the development process of any country (Owolabi, et al, 2013). The lack of political will to achieve national objectives and policy has been identified by Omar (2013) as one of the major problems preventing the development of effective research in science and technology in Nigeria. This problem translates into chronic underfunding for research activities. Research and Development (R&D) is not adequately funded as outlined in the National Policy. The overall funding mechanism of S&T in the country is weak as budgetary allocation is proportionally low and erratic over the years (Mashi, et al, 2014; Opara, 2014). The percentage budgetary allocation from a height of 1.04% in 2007, declined each year to a lowest point of 0.56% in 2010. Marginal increase in allocation was witnessed in 2011 with the allocation in 2012 standing at about 60% of 2007. This is not a good signal for a business minded system that desire to transform its S&T system. The system of governance in the nation is characterized by frequent changes in the political leadership. Each government comes out with its own blueprint or plans for development, shelving the programmes of its predecessors, leading to lack of continuity in policy implementation, which, in turn, seriously affects research in science and technology. Changes in government means

changes in the structure, leadership as well as the location of the parastatals established to handle science and technology policies. Consequently, various frameworks were created for science and technology activities with lack of a clear focus. No effective science and technology policy guideline evolved to give these policies a sense of direction, which in the long run would help achieve set goals and national objectives. Unlike in the case of developed nations like Japan and Korea, research activities in science and technology did not bring about the desired economic liberation to Nigeria as a nation.

Though, the current management and financing system for STIs in Nigeria has some desirable features which should be retained or extended. Nevertheless, it does not meet many important criteria and needs to be amended in such a way that the new mechanisms as provided by the new national STI policy do not obstruct their effective functioning. Specifically, as it relates to management and financing, the scientific and technological activities of government STI institutions, should go beyond mere “support for R&D”, but also encompass activities such as natural resource surveys, the development and management of technical libraries and data bases, and the introduction and administration of technical standards and regulations as in most governments, as much is spent on such “related scientific activities” as on R&D (Olawale, et al, 2012).

Research and Industrial Linkage

In Nigeria today, the link between research institution and industry is at a generally low level, and policies are hardly derived from the results of research conducted in our universities. There is a growing need for collaborative research that addresses the complex questions that matter most to our country. Industrial research is based on the norm of ‘proprietary science’ whose central aim is to gain commercial value from the knowledge produced. It builds on an ethos of intellectual property protection and a reward system based on the appropriation of knowledge for economic gains. The productive collaboration of scientist from the university and industry has not been well fostered. This collaboration requires a social infrastructure that allows the co-existence of interconnections of the two communities, and an organizational framework that can reconcile the demands of the two systems. Another major factor that constrains research collaboration across sectors is research funding. There is the reluctance on the part of some businesses to participate in the funding of research. Some key industry players still find it difficult to set aside some financial resources for research purposes. Perhaps, this can be attributed to the recent global recession. The issue of dwindling resources, especially on the part of the industry, hit a lot of organizations very hard that a lot of businesses could not muster enough resources to participate in research efforts in the academia (Ibidapo-Obe, 2014).

Ajoku and Onwualu (2012) have identified insufficient funding to transform ideas or innovation/invention to start-ups or early stages businesses as one of the shortfalls of the linkage. It was further highlighted that the lack of commercialization skills among public

research institutions and universities as well as business services support, especially in the areas of market research, conversion of ideas to concepts, technology planning, intellectual property and licensing and spin-off company formation are linkage shortfalls not peculiar to Nigeria alone but also to other developing countries.

Research and Development Status in Nigeria

Research and Development (R&D), most especially in S&T has become the most enduring and effective means of improving sustainable economic growth, development and re-enforcing competitiveness in industries in a rapidly changing world. The key players in R&D in Nigeria are the Higher Educational Institutes (HEIs), Research Institutes (RIs), the private research establishments, government agencies with R&D mandates, etc. as reported by Siyanbola, et al (2011) includes:

1. 104 universities with varying capacities for pure and applied R & D
2. 71 Polytechnics with modest efforts in applied research
3. 22 Colleges of Agriculture and specialised technological institutions, and
4. 27 Monotechnics
5. 66 RIs with R & D programmes targeted at the different sectors of the economy with a few recording some measure of success in product and process innovation (Bamiro et al., 2008) ;and
6. Very limited private sector R & D outfits (for example, Nigerian Breweries Plc Research Centre, Lagos).

The study conducted by (Siyanbola, et al, (2010) has shown that there is a low level of collaboration between university researchers and industry. The study also shows that, inadequate infrastructure, lack of R&D facilities and poor funding for research are major barriers to research activities in Nigeria. Possible solutions to the problems include improvement of power supply in the country, establishment of central laboratories in some universities and actualisation of the proposed R&D Fund. The University system has however based on personal observation to be more business minded in research activities compared other IHEs such as Monotechnics and Polytechnics.

The RIs also have a mandate to make research findings, technology and knowledge adaptable and applicable to local Nigerian situations. Majority of the research institutes are into scientific and technological research. The RIs can be broken down into 4 categories based on major areas of research which include: Science and Technology (30), Agriculture (25), Education (4), Socio-Economic and Cultural (3) and Medical (4). Most of these RIs has been identified to duplicate efforts as there are similar research institutes with same mandate and focus. The number above could be more if we add the Colleges of Medicine in

the various universities. These centres of excellence also have mandates to, and do conduct, many and ongoing researches in health and medicine. All these RIs are under the auspices of the parent federal ministries (Excellence and Education Network).

Implications

The S&T policy from several years back has been characterized with lack of policy implementation and continuity. This resulted from the change of government system, most especially before 1999. However, some improvement has been in place after 1999 when the country change to democratic system of government. Good governance is inevitable for a desired growth of a country. Eschew bureaucracy and to be business minded in pursuing formulated policy is very germane to the sustainable national economy and this has to be embraced by Nigerian government. Research activities in Nigerian Universities/Allied Institutions are poorly funded. This can be seen from the budgetary allocation as the percentage allocated to the FMST is very low. Aside being low, the rate of funding were seen to be declined over the years until it started to improve in year 2012. There is need to encourage and stimulate S&T institutions as well as research groups to search for opportunities for collaborative research and partnerships from different sources including the private sector, non-governmental organizations so as to reduce the dependence on government for funding. Weak linkage between research centres/universities and Productive Sector is another problem identified in the Nigeria S&T system. There is need to increase the linkages between applied and academic research with the productive sector, and to increase their share in the national effort for scientific and technological development. This requires a significant increase in private investments in R&D.

Other issues militating against good output from STI policy includes the infrastructural facilities and national security. The current infrastructure base in Nigeria is grossly inadequate in terms of capacity and quality and is not capable of catering to anticipated industrial development. Despite government investments, Nigeria still has huge infrastructure deficits, particularly with regards to power generation. The current power generation capacity is less than 2000 Megawatt, which is about 20 per cent of the estimated national demand. A key challenge for government and the private sector is to build a modern, efficient, and effective infrastructure network within the next five to ten years.

The internal security of Nigeria has become a very big challenge in recent times. Internal conflicts, including religious, ethnic and economic, have had debilitating effects on the economy, most notably by scaring investors from certain parts of the country. Even though insecurity lives and properties had become noticeable following the civil war and the subsequent military regimes which directly intensified urban violence, the recent upsurge of violence and insurgency in the country heightens the need to comprehensively address the persistent causes of social tension as a risk factor to Nigeria as an investment destination.

Conclusions

There are thorough differences in economic and institutional systems of countries in different development stages and any general STI system and policies does not fit to all countries. Different developing countries are in different phases in the development of innovations, innovation system and STI policies as described above in each country's S&T policy framework.

Due to specific conditions of each developing economies also innovation system framework adapted differently in these countries. To undertake an in – depth understanding on evidence based STI policies is what needed to be researched for developing best practices and enhancing the welfare of citizens in the developing countries with due emphasis on the role of grass- root, community and other types of innovations in local , regional and national environments and also the dynamics of industrialization patterns based on innovations. These case studies may be helpful in providing insights to adapt the best practices in building capacities and capabilities in STI policy making and to be practiced in implementation in many other less developed countries.

Above cited experiences from the countries, i.e. India, China, Korea, Russia and Nigeria are indicative of undertaking reforms through policy measure either explicitly or implicitly in order to compete in the international environment dominated by the policies of globalization and liberalization. To revitalize the system, China, Korea and India have been more liberal as compared to the Russia and Nigeria. China and India both provide a number of new research facilities based on the principle of 'open, mobile, collaborating and serving the whole country' institutions. In China while the funding for basic research is incurred mainly by the government, funding for technical development institutions is mainly sought from the industry and other financial institutions and banking. This has also resulted in better linkages of the basic and applied research institutions with the industry, much required in National System of Innovation. This is comparatively less so in Russia and India. A peculiar feature of Chinese and Korean S&T policy has been the creation of a number of hi-tech spin-off companies. A number of scientists went out of their laboratories to start ventures at these spin-off companies. With S&T as back-up and the market as the orientation, an integrated entity of a research, development, production and marketing was formed. This policy of reform in China has been very successful and is still wanting in Russia and India. On the whole, the above study clearly shows that while some countries have responded well to the challenges of globalization and liberalization, some are still grappling with the problems of bureaucracy and rigidity, which thus needs deep rooted reforms on the lines of other countries. It is important to acknowledge the scientific, technological and innovative positions of each country and at the same time consider their respective progress in the past 20 years. The way in which these countries managed to transform in the past 20 years, responding to arising challenges, reflects their aspirations to being global scientific and technological superpowers.

This side-by-side analysis of the respective countries' structural transformation sheds light on the comparative success of the state innovative policies.

In conclusion, this paper opens up certain questions that other researchers may look into in greater depth or detail to explore the possibilities/modalities to sensitize the need on cooperation among developing countries on science, technology and innovation policy making for capability and capacity building in the economic development of the developing world.

References

1. Abdullahi, A. (2004), An impact assessment of science and technology policy on national development of Nigeria, Ph.D. Dissertation, St. Clements University, Niue, South Pacific
2. Ajoku, K.B. and Onwualu, A.P. (2012), Unlocking Nigeria's potentials through Science, Technology and Innovation, Published by Raw Materials Research and Development Council (RMRDC), Nigeria.
3. AOSTI (African Observatory of Science, Technology and Innovation) (2013), Science, Technology and Innovation Policy-making in Africa: An Assessment of Capacity Needs and Priorities, AOSTI Working Papers No. 2.
4. Chete, L.N., Adeoti, J.O., Adeyinka, F.M. and Ogundele, O. (2014), Industrial development and growth in Nigeria - lessons and challenges, World Institute for Development Economics Research, United Nations University WIDER Working Paper 2014/019, 40 pp, wider.unu.edu
5. Excellence and Education Network: accessed on 12/12/2014 at: http://exced.ucoz.com/index/research_institutes_in_nigeria/0-69
6. FRN (Federal Republic of Nigeria) (2011), Science, Technology and Innovation (STI)
7. Ibidapo-Obe, O. (2014), Enhancing research collaboration between the academia, government and industry, A Keynote Address delivered at the Computer Science/Information Technology Research and Development Workshop held at Ife, Nigeria on 4th March, 2013.
8. Krishna, 2001, Changing Policy in Science and Technology in India, Science and Technology Policy, Vol II
9. Mashi, S.A., Inkani, A.I. and Yaro, A. (2014), An appraisal of the role of science and technology in promoting national development efforts in Nigeria, The International Journal of Engineering Science (IJES), 3(2): 56-57
10. NPCA (NEPAD Planning and Coordinating Agency) (2014), African Innovation Outlook II 2014, Pretoria
11. Olawale, O.R., Ibikunle, O.O., Francis, F.O. and Caleb, A.M. (2012), Performance budgeting, its planning, implementation and monitoring process: the case study of Nigeria's science, technology and innovation (STI) budget, International Journal of Finance and Accounting, 1(5): 69-81.
12. Omar, M. (2013), Formulating coherent science and technology policies in Nigeria: is there any political will?, Public Policy and Administration Research, 3(7): 46-52.
13. Opara, J. (2014), Nigeria's federal science budget expected to fall sharply in 2014, Research Africa, Roundup News Letter, March, 2014
14. Owolabi, S.W., Owolabi, O.O., Adeleke, Y.S. and Abubakar, K. (2013), Strategic approach to R and D commercialization in Nigeria, International Journal of Innovation, Management and Technology, 3(4): 382-386.
15. Oyewale, A. A. (2005). Addressing the research-industry linkage impasse in Nigeria: The critical issues and implementation strategies, Paper presented at Globelics-South Africa, 2005 accessed on 15/12/2014 at: www.globelics2005africa.org.za/papers/p0032/Globelics2005_Adesina%20Ayobami%20Oyewale.pdf

16. Science & Technology Policy Institute (2013) "The Internalization of Science and Technology in the earlier stage of Economic Development in South Korea"
17. Siyanbola, W. O., Oyewale* A. A. and Isola. O. O. (2010), Industry-knowledge institutions collaborations in Nigeria: critical issues and policy directions, International Conference on University, Industry and Government Linkages, held at Madrid, Spain between 20th and 22nd October 2010
18. Siyanbola, W.O., Isola, O.O., Egbetokun, A.A. and Adelowo, C.M. (2011), R&D and the challenge of wealth creation in Nigeria, *Asian Research Policy*, 2: 20-35
19. Torsti Loikkanen & Hannes Toivanen (2012), proceedings of "World conclave of Scientists on Regional Cooperation in Science and Technology: opportunities and Challenges in the context of Globalisation." November 2010.
20. WIPO (World Intellectual Property Organization) (2014), Statistical country profile, Nigeria [downloaded on 02/09/2014 at: http://www.wipo.int/ipstats/en/statistics/country_profile/countries/ng.html]