ENGINEERING AND TECHNOLOGY FOR SUSTAINABLE ECONOMIC DEVELOPMENT IN A RECESSED ECONOMY

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Abstract
Commitment to sustainable monetary, fiscal policies and human capital development are identified as key driving factors of an economy. Information available as at May 20017 show that business confidence, consumer confidence, industrial and manufacturing production are currently at negative growth rate of -1.5, -17, -8.7%, -2.9%, meaning, Nigeria was in recession. This paper examines the challenges confronting Nigeria's economy and the role, Engineering and Technology can play to sustain the economy in the face of the recession. A study of Global Comparativeness Index (GCI) revealed Nigeria's economy is ranked 127th/138th globally, and 22nd in sub-Sahara Africa, with poor performances in the four Engineering and Technological driven pillars which includes; infrastructure, Higher education, Technology readiness and innovation, resulting in the current economic challenge. It was discovered that electricity supply and fixed communication networks are the worse hit indicators with GCI of 137th/138th. The paper therefore concluded that since there is an alternative for fixed communication using mobile phones; the sustainability of our economy is largely dependent on improvement of electricity supply. To address the inadequacy of electricity supply, the paper recommends that Nigeria should consider improving its power generation capacity, putting in place efficient energy management systems and harness the abundant alternative energy sources, so as to reduce brain drain, provide adequate research and development environment as well as sustain critical infrastructure. The paper also recommends, that based on the important role Engineering and Technology provides, appreciably investments should be made in Engineering and Technology related sectors, so as to boost and sustain the economy.
Keywords: Energy, Driving factors, Human development, Engineering and Technology,

Introduction

What appears to be the hard truth: the so-called economic crisis in our dear country (Nigeria) is no longer hearsay. The problems of poor sanitation, disease, non-payment of salaries, poor return on investments, inflation and hunger may be unacceptable but cannot be denied. Concern for these problems is far beyond discussions on the media, socio-economic, political, academic and religious institutions. To address these problems, there is the need to increase public awareness, concern and application of technical measures. Obviously, the call for Engineering and Technical approaches for a sustainable economy cannot be overemphasized. Oyelude (2002) and Fayinka (2004) identified some specific hindrances aiding this crisis to include; technical deficiencies, poor utilization of natural resources, inadequate government policies, limited basic physical infrastructures (roads, ports, telecommunication, electricity, energy, water supply, and sanitation), ineffective management system, and non-adherences to policies.

Gylfason (2001) in Akpan and Chuku (2014) studied 65 natural resource–rich countries (including Nigeria) and observed that only four countries (Botswana, Indonesia, Malaysia and Thailand) managed to attain long-term investments exceeding 25% of Gross Domestic Product and per capita income growth exceeding 4 % per annum on average between 1970 and 1998. The study show that, 61 countries failed to attain these levels because they built the base of their economies around their capital natural resource(oil in the case of Nigeria), thereby completely neglecting investment in the development of other economic resources (especially human resources), whose linkage have effects in growth and development. It concludes that, nations that are richly endowed in natural capital resources and mostly dependent on these resources remained poor and undeveloped.

The quest for sustainable development till date remains a dream to Nigerians, as only little achievement has been achieved in this direction. This may not be far from the saying that, no nation can rise or can be sustained beyond her technological level. The agricultural boom, manufacturing industry boom and oil boom, were

opportunities Nigeria would have used to sustain its economy. The lack of sustained economic drive by successive government attracted our current challenges: lack of developing an indigenous agricultural technology, folding up of manufacturing industries as a result of lack of electricity and the global crash in oil price leading to low revenue accruing to the government.

Esho (2008) emphasizes that no advantage is permanent; competitors are always creating new values to attract greater advantages. The environment in Nigeria is competitive and it is evident that no foreign nation would develop our economy for charity; we have to do it ourselves. The strength of a nation is gauged and evaluated on the basis of challenges resolved and commitment to technical education, as well as technological contribution to global economy based on how national needs are matched with technical education curricula and proper planning.

In Akpan and Chuku, (2014) the linkages between natural resource abundance, to human capital development and economic growth in Nigeria was traced, and reported. The study emphasized that; natural resource abundance and human capital accumulation are two vital elements that affect economic development. The report has it that, the abundance of natural resources is producing a negative impact on economic growth and human capital accumulation. Therefore, it recommended that natural resources be better managed through optimal inter-temporal and inter-sectoral mechanisms such as: better inputs (investments) and participation (enrollments) in education to shift comparative advantage away from natural resource (primary) production to manufacturing (intermediate) and services (tertiary) provision, which will accelerate the process of economic growth in a sustainable manner.

Sustainable development can be seen as a development that meets the present needs and goals of the population without compromising the ability of future generations to meet theirs. A properly developed Sustainable development policy seeks to change the nature of economic growth rather than limit it. Such policies are premised on the belief that continual growth in a finite world is possible through the powers of technology, which will suggest new sources or provide alternatives when a particular resource appears to be running out. It can be said that, technology will help suggest how to use and reuse of what is left, in the most efficient manner. Specifically in the face of current economic challenges, this paper addresses the importance of Engineering and Technology to Nigeria's economy. It discusses Nigeria challenges as sovereign nation and the role of Engineering and Technology in the face of current global competitiveness index to provide a sustainable economy.

Review of literature

Contributions of engineering and technology to economy

Technology is the usage and knowledge of tools, techniques, and crafts or systems or methods of organization or a material product such as clothing. Technology significantly affects humans' ability to control and adapt to their natural environments. The human use of technology began with the conversion of natural resources into simple tools. The pre-historical discovery of the ability to control fire increased the available sources of food and the invention of the wheel helped humans in travelling and controlling their environment.

Engineering is defined as the application of scientific and mathematical principles for practical purposes such as the design, the manufacture, the operation of products and processes, while accounting for constraints invoked by economics, the environment and other sociological factors. Many technical advances are brought about through engineering. Engineering activities are significant contributors to economic development, standards of living, well-being of a society, and impact its cultural development on environment. Engineering powered the so-called Industrial Revolution that took off in the United Kingdom in the eighteenth century spreading to Europe, North America and the world, replacing muscle by machine in a synergistic combination between knowledge and capital. The first Industrial Revolution took place from 1750–1850 and focused on the textile industry. The second Industrial Revolution (1850–1900) focused on steam and the railways and the third Industrial Revolution (1875–1925) was based on steel, electricity and heavy engineering. This was followed by the fourth Industrial Revolution (1900–1950) based on oil, the automobile and mass production, and onward. The fifth phase was based on information and telecommunications and the post-war boom from 1950. These waves of innovation and industrial development lead to the sixth revolution (from I980) which was based on new knowledge production and application in such fields as Information Technology (IT), biotechnology and materials. The possible seventh

was based on sustainable 'green' engineering and technology seen to have begun around 2005.

Engineering could be directly linked to sustainability and development; it is directly linked to revolution. That is, engineering uses resources to drive much if not most of the world's economic activity. In virtually all economic sectors, resources used in engineering, whether fuels, minerals or water, are obtained from the environment, and wastes from engineering processes (production, transport, storage, utilization) are typically released to the environment. The services provided by engineering allow for good living standards, and often support social stability as well as cultural and social development. Given the intimate ties between engineering and the key components of sustainable development, it is evident that the attainment of sustainability in engineering is a critical aspect of achieving sustainable development, in individual countries and globally.

Economically successful countries are those that are able to turn technical innovation into economic productivity through, effective science, engineering and technology policies crucial for their development. The success stories of Botswana, Indonesia, Malaysia, Thailand, Japan, Korea, and Taiwan for example, are in large part stories of a long-term strategic policy focused on fostering indigenous innovation capacity, encouraging and using indigenous technology. These technological and engineering developments today, has propelled nations to initiate sustainable innovations in order to avoid crises. France for instance has developed electric cars, declared to be totally in used by 2040 and solar powered boat currently touring the world. China is generating power from solar, Russia and North Korea, are developing powerful war heads. Therefore, long-term strategic policy in Engineering and Technology are central to the developmental prospects of developed and developing countries. As they can provide tools that help alleviate the specific problems that afflict economy and which impede developmental prospects; such as disease, infrastructural (energy, communication, transport, etc.) decay, and the degradation of the environment.

Economic status of the Nigerian nation

The inflation rate of Nigeria's economy between 2012 and 2017shows a maximum rate of about 19.1% see figure 1. Between January 2016 and January 2017, the rate increased from 9.8% to19.10%. It is evident from this analysis that the standard of living of the people was bad within this period. However, it can be observed that the inflation rate came down to an average of 16.25% in May 2017, as against the19.1 % in January of 2017, this shows that Nigeria is gradually moving out of recession.

Figure 1: Nigeria's inflation rate from 2012 to 2017
(Source: Trading economics, 2017)

From figure 2, we observe that between 2012 and 2014, the Gross Domestic Product per Capital (GDPPC) averaged increased from $2415.45to about $2563.10 and remained stable until 2015 ending. However, GDPPC fell to an average of $2457.80 between 2015 and 2016 with growth rate in GDP at -12.92% and

annual growth rate of -0.52%, from these recent GDPPC indication; The GDP per Capita in Nigeria is equivalent to 19 % of the world's average and it's obvious that the economy is not doing well.

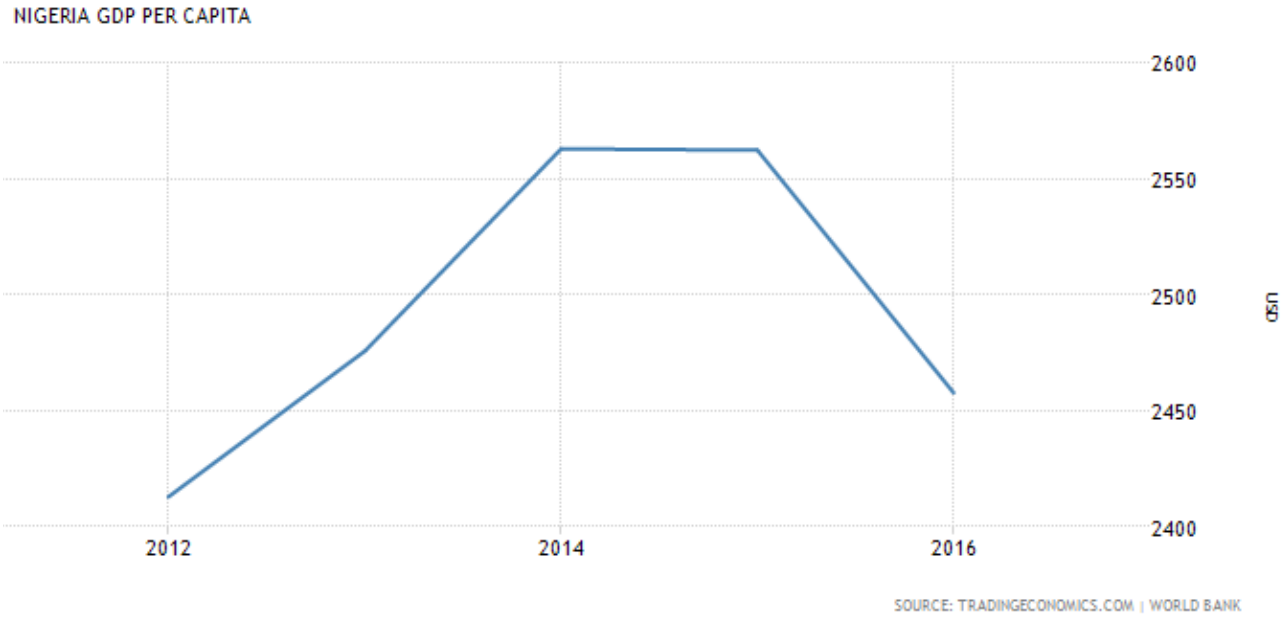

Figure 2: Nigeria's Gross Domestic Product per Capital (GDPPC) from 2012 to 2017
(Source: Trading economics, 2017)

Nigeria compared with other sub-sahara African nations

The inflation rate of 16.25% in the period May 2017 placed Nigeria in the 10th worst position in Africa and 15th worst in the world (Trading Economics, 2017). The growth rate in GDP of -12.92% and annual growth rate of -0.52% in the period and the GDPPC of $2457.80 as at December 2016 placed the Nigeria at 18th position in Africa and 133th in the world, the worst is the business confidence is -1.5, with Consumer confidence -17, industrial production and manufacturing at-8.7% and -2.9% respectively (Trading Economics, 2017). The Global competiveness index 12 pillars shown in figure 3, reveal that Nigeria is ranked best in sub-Sahara Africa when it comes to market size; in other words Nigeria is a consumer nation. Other countries such as Mauritius, South Africa, Rwanda, and Botswana dominated in other pillars. A comparison of Nigeria GCI and the 12 pillars reveal that Nigeria is ranked 127th/ 138th as against 35th, 47th, 52th, and 64th for other countries respectively. Table 2 also shows that Nigeria is the weakest in eight pillars out of the 12 pillars and very poor performances in the 2nd, 5th, 9th, and 12th pillars which could be directly linked to applications of Engineering and Technology for economic growth. These results showed Nigeria need to improve on its applications of technology, in order to boost the economy and sustain the growth.

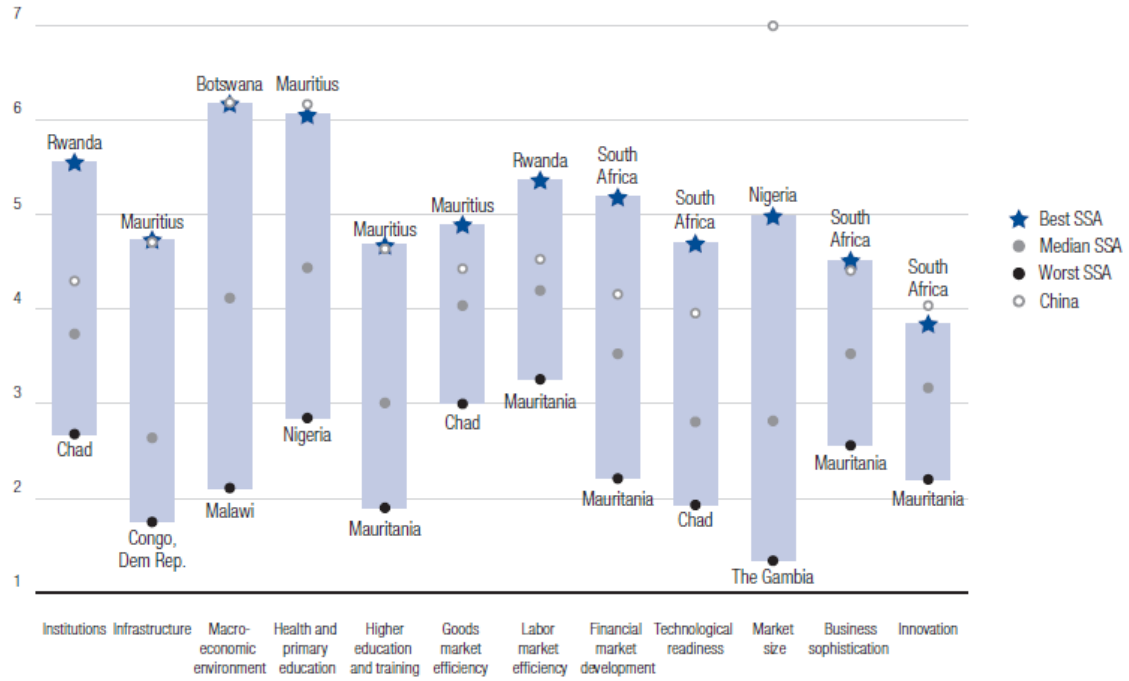

Figure 3: GCI Score range across the 12 pillars in sub- Saharan Africa (SSA), 2016-2017
(Source: Klaus and Xavier, 2017)

Table 1: 2016-2017 GCI Score for Nigeria against leading Countries in sub- Saharan Africa (SSA)

COUNTRY NAMES	MAURITIUS	SOUTH AFRICA	RWANDA	BOTSWANA	NIGERIA
Global Competitiveness Index	35	47	52	64	127
1st Pillar: Institutions	36	40	133	37	118
2nd pillar: Infrastructure	41	64	97	90	132
3rd pillar: Macroeconomic environment	59	79	80	10	108
4th pillar: Health and primary education	48	123	84	113	138
5th pillar: Higher education and training	52	77	114	88	125
6th pillar: Goods market efficiency	26	28	35	73	98
7th pillar: Labor market efficiency	57	97	7	36	37
8th pillar: Financial market development	44	11	32	66	89
9th pillar: Technological readiness	66	49	100	86	105
10th pillar: Market size	118	30	127	105	26
11th pillar: Business sophistication	37	30	64	100	99
12th pillar: Innovation	67	35	47	84	113

(Source: Klaus and Xavier, 2017)

Nigeria's economic and technological challenges

Nigeria is reported to be among the poorest countries in the world, despite that fact that she has been exceptionally favored and blessed with abundant natural, mineral and human resources. The failure of our leaders to raise the standard of our educational system, technological and engineering contributions beyond importations and use of foreign products has increased brain drain, dampened the morale of most Nigerians with respect to the possibility of finding effective solutions to the various challenges confronting us as a nation using indigenous engineering.

Brian drain

Ogbu (2004) says that Africa's brain drain phenomenon has both pull and push factors that have contributed significantly to the poor state of science and technology (S&T) in the region. According to Docquier and Marfouk (2006), 10.7% of the highly skilled population who were trained in Nigeria ended up working abroad in 2006. In the United States and Europe, 83% and 46%, respectively of the Nigerian immigrant population are highly skilled. On average, 64% of the Nigerian emigrant population has tertiary education.

Nigeria is ranked 113th, on the 12th pillar of GCI (innovation) as shown in figure 4, reflecting the poor quality of scientific research (as 126), as well as collaboration with the industries ranked 123. Given the poor political and economic conditions of Nigeria, many top scientists left the shores of Nigeria and refused to return because some developed countries also put in place policies to attract highly specialized Nigerians thereby depleting the meager stock.

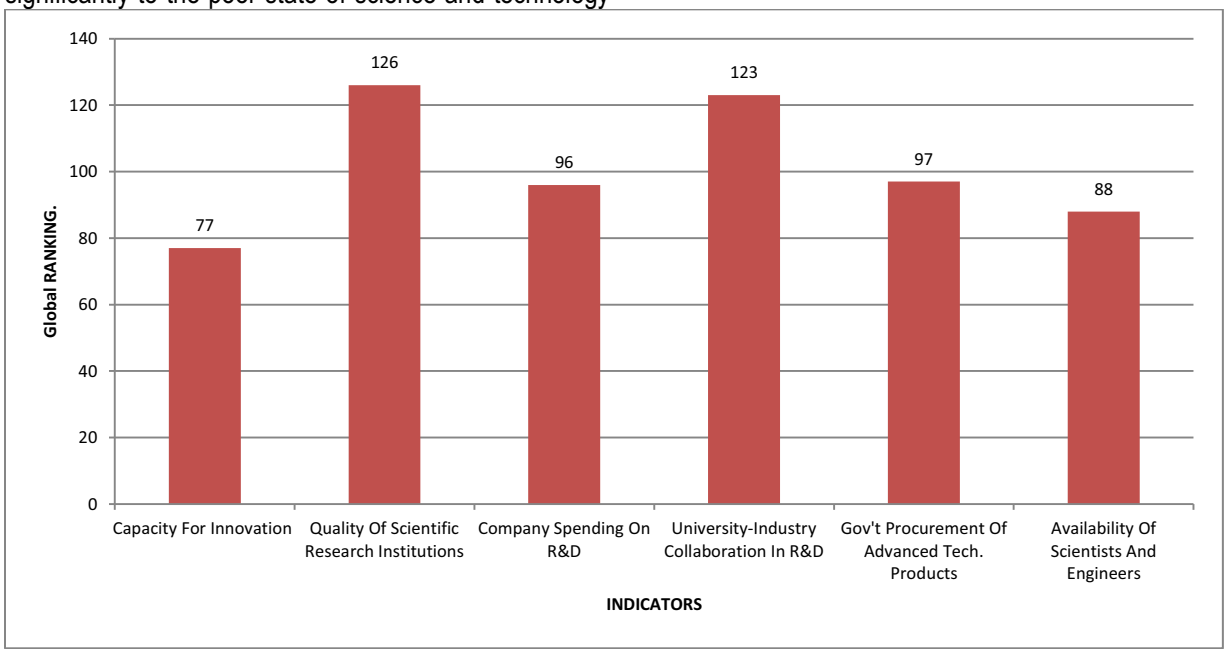

Figure 4: 12th Pillar: Innovation index of Nigeria

Educational policy implementation

The objectives of Nigeria's 1981 National Policy on Education, is to train manpower in Engineering, Applied Science, Technology and Commerce at all professional grades, as well as the provision of technical knowledge, vocational skills necessary for agricultural, industrial, commercial and economic development. Despite efforts by several governments to implement these policies, a review of Nigerian Polytechnic systems reveals that Polytechnic education is underrated, discriminated against, neglected, snubbed and ignored. Victor (2009) opined that while vocational and technical education has continued to thrive in many societies, Nigeria has neglected this aspect of education. Consequently, the society lacks skilled technicians to run the economy.

The GCI 5th pillar: Higher Education and Training index of Nigeria (figure 5), placed Nigeria as the 125thcountry in the world, this may not be un connected to quality of educational system (ranked 118th), quality of math and science education (ranked 124th), as well as internet access in schools where we are ranked 129th.

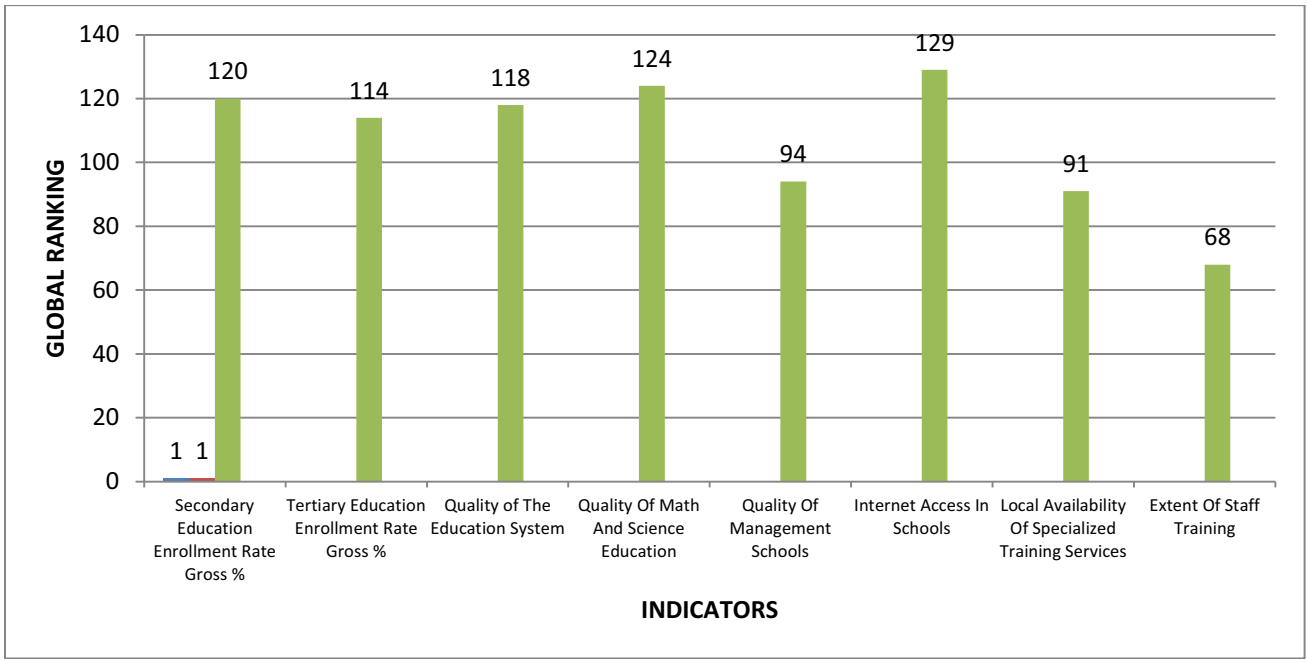

Figure 5: 5th Pillar: Higher education and Ttraining index of Nigeria

Dependence on foreign technology and expatriates

According to Iredale (2003), countries with the most intellectual resources achieve the highest rates of economic growth and the fastest development in S&T. In the drive for human capital, many industrialized countries (United States, the United Kingdom, Canada, Germany, Japan, Singapore, Hong Kong and Australia), give priority to policies aimed at attracting highly skilled immigrants to develop their indigenous technology. This approach in most cases helps in developing indigenous technology as well as building local human capital and not total dependence on those expatriates or imported technology as the case of Nigeria. Though Nigeria is trying in the area of technology transfer, technology absorption and reasonable interest in internet usage, the GCI ranked our technological readiness (figure 6) as 105th, with the indicators; fixed-broadband Internet subscriptions (135th), and Internet bandwidth (127th) which greatly affects research and technological development.

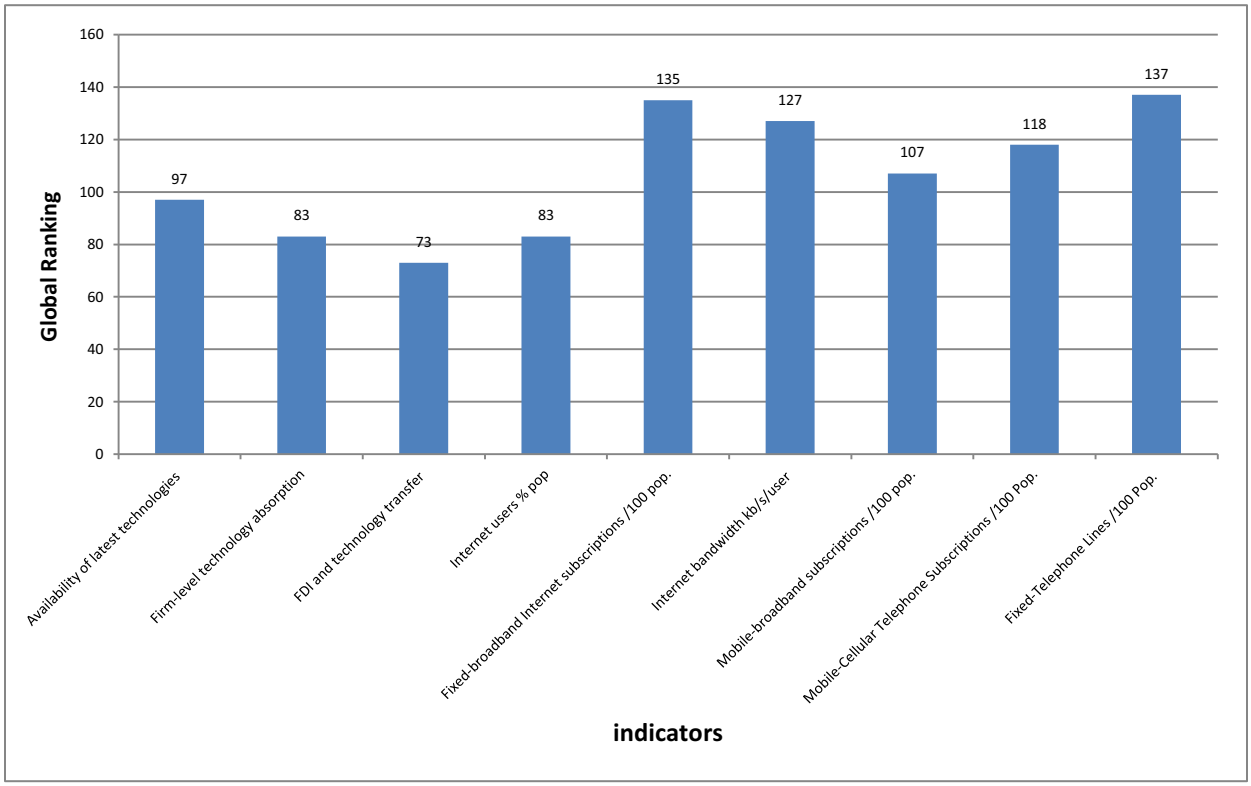

Figure6: 9th Pillar: Technological readiness of Nigeria

Inadequate infrastructure

Infrastructure is one of the key indices for economic and technological development that must be taken seriously otherwise the economy will suffer and go into deep recession, DSC (2007) observes that Nigeria is an example of a mostly rural developing country whose government is unable to provide some basic services, such as potable piped water and electric power to a large proportion of the population in an affordable manner. This inadequacy placed Nigeria at its second worst pillar ranking of 132th (figure 7) after health and primary education which is 138th.Between 1999 and 2007, the Federal Government of Nigeria spent over N1trillion, N204billion naira and$16billion on integrated power supply, road construction and maintenance but Nigeria still wallop in epileptic power supply and unimaginable deplorable roads (Obayelu, 2007; Mba 2010).

Nigeria's energy crisis has produced great negative consequences on the economy; Nigeria receives a large income from oil production and the export of natural gas to neighboring countries in West Africa, yet can't provide for its self. The lack of energy service has a significant impact on the viability of existing industries and the development of new ones. In spite of large installed capacity for electricity generation, average daily production is 1200 MW with typical availability of about 40% of the installed capacity. This has led to Public sector electricity utilization by the industrial sector to remain fairly static hence many companies had resolved to provide their own power for more reliable supply of electricity, thereby increasing costs of products and services (Enebeli, 2010). In other developing countries, many of these services are available from private profit-making companies, using readily accessible technologies. Despite the importance of electricity, the GCI show Nigeria power generation is ranked 137th, this points to the need for urgent investment by individuals, institution, industries and government.

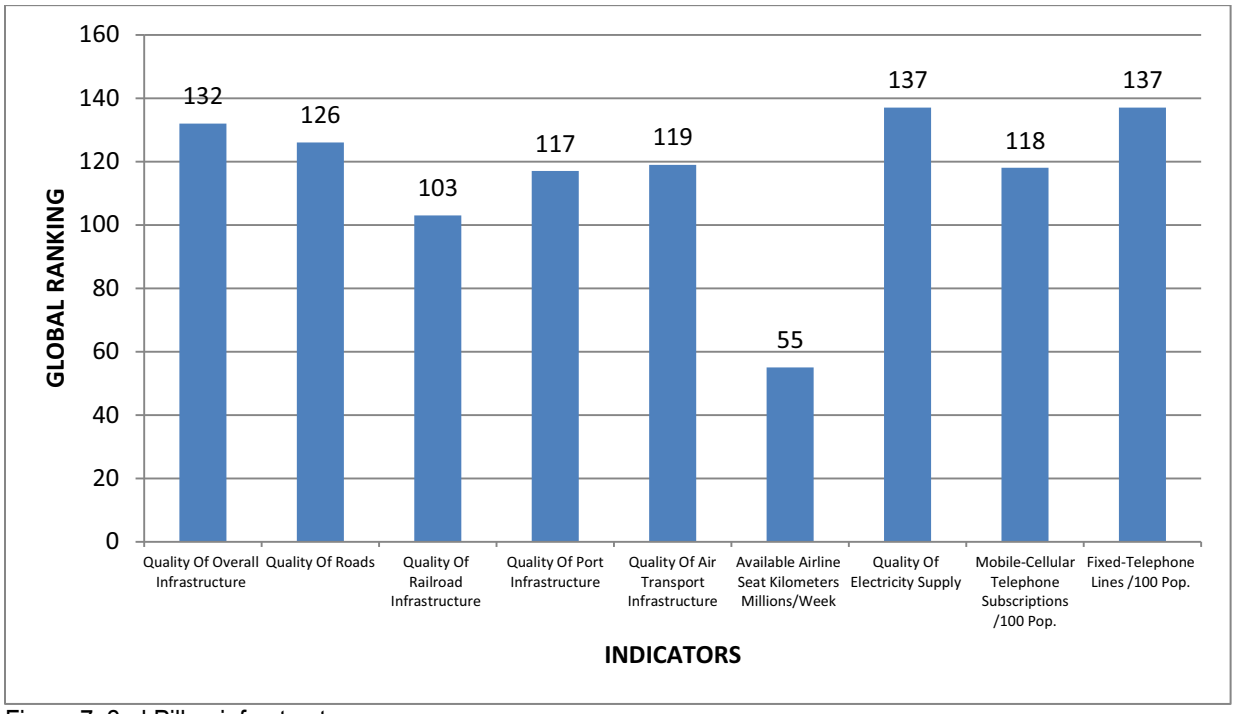

Figure 7: 2nd Pillar: infrastructure

Confronting Nigeria's problems for a sustained economy

From the issues confronting Nigeria discussed, Ekpiwhre (2008) asserts that it is important for us to appreciate the potency of Engineering & Technology to bring about significant changes in our national lives. Investments in Engineering & Technology always pay off, sometimes immediately but always in the long run. Countries like the United Kingdom and France benefited immensely from the industrial revolution of the 19thCentury, and United States emerged from an agrarian economy into an industrial superpower in the 20thcentury, through effective application of Engineering & Technology.

In fact, these countries invested quite heavily in people, Infrastructure and factories, their successes were based on carefully designed plans and strategies. Unfortunately, virtually all the available statistics show that while the rest of the world has advanced technologically, Nigeria has fallen relatively further behind due to recession. The discoveries in science and technology have greatly led to tremendous success in the manipulation of material resources and human environments in favor of humanity. A World Bank report indicated that the first industrial revolution in the United Kingdom took 58 years i.e. 1780 –1838, while the adoption of improved technology took other countries less to attain the same feat. For instance in USA, it took just 46 years i.e. 1839 – 1885, Japan 34 years, South Korea 11 years, China 10 years, etc. This means that if Nigerians are committed to national development, Nigeria may still breakthrough technologically by 80th year of our independence. To address our current challenges, the following steps need to be taken;

Brain drain

Innovation and development policies should be added to our educational curriculum, and industries should be mandated to fund qualitative institutional researches as part of social/ community service. Indigenous scientist, technical experts and engineers should be provided with incentives and the enabling environment that will encourage them to stay and develop our economy.

Nigeria can turn the brain drain "pull push" factors to obtain brain gain "push pull" factor, by ensuring that:

1. Students, as well as other professionals who leave the Country for further education and training should return back;
2. Industries/institutions should invite foreign experts to train staff using available technology rather than sending them abroad;
3. Foreign technology should be transferred to institutions;
4. Information and results of research which are readily available in our institution should be implementation;

5. Business contacts, initiating research and commercial projects should be facilitated;
6. Providing better incentives for skilled and research experts;
7. Technical and engineering professionals should be encouraged to practice only their professions rather than moving into other trades in search of money.

The Science, Tech Expo 2017, held in Abuja show-cased several made in Nigeria products which indicated high innovative capacity of Nigerian , some of these innovations include; solar cooker, magnetic electricity generator , Kaduna Polytechnic mobile juicer tricycle, Tomato processing plants, Bida 1 (wooden car with motorcycle engine), and bamboo house.

Educational policy implementation

Ohize (2017) advocated that there is the need to build indigenous knowledge and skills together with or indigenous method of teaching into modern science and technology curriculum, as there will be a high probability of enthusiasm, improved interest and understanding of students. Our Technical and Engineering Institutions should be well funded and equipped with adequate human, material and physical infrastructure; to address our local challenges using indigenous approach base modern Engineering and Technology. The informal sector of education such as, Entrepreneurial Centre should be setup to train and retrain young graduates to pick up Vocational and Engineering skills or the other especially in the energy sector. Similarly, Nigeria can confront its present educational policies challenges, by encouraging:

1. Technical and Vocational Education and Training (TVET) in Nigeria.
2. National Vocational Qualifications Framework (NVQF)
3. Strengthening of Existing Mono-technics and Polytechnics
4. Vocationalisation of Primary and Secondary Education
5. Craftsmen training through the Ministry of Labour & Productivity
6. Vocationalisation of University Education
7. Flexible and Blended learning
8. Setting up of private Mono-technics and Polytechnics;
9. Provision of infrastructures and internet connectivity for schools.

Dependence on foreign technology and expatriates

Nigeria should not be a dumping ground for developed countries to discard old research work, which may not suit our local needs. The idea of foreign technology and technology transfer should not be the 'cut and paste' approach, Nigerians should be encouraged to use the 'cut and adapt' method similar to what China has done. We must not forget that no foreign country will develop our economy for us, without making gains. Therefore there should be interfacing between foreign and indigenous engineers for sustainability of imported technology and machines. Thus

1. Expatriates should be encouraged to train and transfer knowledge to Nigerians;
2. Advance foreign technology should be acquired mostly for the purpose of technology transfer (cut and adapt) rather than just usage (cut and paste).
3. Setting up of foreign firms locally
4. Encouraging patronage of indigenous technology and locally produced products.

Inadequate infrastructure

Nigeria is blessed with renewables sources, though until now, the country has relied on the use of conventional oil and gas supplies to meet energy demand. In the face of the current economic challenges, the country need to look forward to capitalizing on its economic growth potentials and make the most of its renewable resources to provide a secure basis for Nigeria's future energy needs. The depletion of domestic fossil fuel reserves, combined with projected growth in global energy demand, puts Nigeria's security of energy supply at risk. Exploiting available renewable resources will make a strong contribution to the country's energy needs and allow it to be less reliant on conventional, internationally traded energy resources. The drive to increase the proportion of energy obtained from renewable sources will not only increase the security of energy supplies in Nigeria, it will also provide opportunities for investment in new industries and new technologies.

Petters (2011) is of the opinion that as Nigeria is situated approximately between 4°N and 13°N geographically, it is favorably located to tap unlimited solar energy: the most dependable renewable energy source. It has been estimated that a yearly average of about 2,300 kwh/m^2 of solar energy tails on a horizontal surface in Nigeria. In Makurdi, the intensity of solar radiation is about 28.425MJ/m^2 on a clear sunny day, this can prove sufficient power to address some local needs.

What Nigeria requires is an affordable energy technology and cheap appliances, through;

(i) the deregulation to promote industrial competitiveness;
(ii) energy price reforms to guide energy efficiency;
(iii) initiatives and to encourage international competitiveness; and
(iv) Enforcement of the Energy Conservation Act and the Electricity Act.

From the experience of India, Nigeria stands a lot to gain from energy efficient programmes which would make cost of production to reduce; using compact fluorescent lamps (CFLS), energy-efficient motors, and improved steam boilers.

Conclusions

Economically successful countries are those that are able to turn technical innovation into economic productivity. Effective technological policies are thus crucial for developing countries, Nigeria as a nation must appreciate the potency of Technology to bring about significant changes in our national lives.

Recommendations

Private individuals in Nigeria could be encouraged to do like Dangote and be given the conducive environment. Technical and Vocational centers should be setup, introduction of vocational courses in educational curriculum, to train and retrain students as well as young graduates to pick up one vocation or the other especially in the energy sector.

Funds for indigenous research in Engineering and Technology as well as grants should be attached to breakthroughs. Government should invest in Engineering and Technology related sectors of the economy to absorb research outcomes. The Nigerian government can turn to the very active private sector to provide these basic products and services. Government should redesign and implement effective monetary and fiscal policies in line with current trend in Engineering and Technology. Incentives should be provided to individuals and organizations to invest in the economy, and encourage proper competition to increase the quantity and quality of goods and services.

Fixed telephone line and electricity have been identified as the worse contributors to our economic, mobile phones with an index of 118thcan serve as alternative for communication. However electricity supply which is a major factor affecting the economy with an index factor of 137th, indicate that Nigeria need to manage all sources of alternative power such as Biomass Energy, Wind Energy, Solar Energy, Geothermal Energy and nuclear energy (uranium traces have been found near Gombe in Gombe State and Ugep in Cross River State) can be converted into electricity. This will give room to rapid industrialization and a dynamic service sector to create jobs to reduce the rising youth unemployment and underemployment in the society.

The pull push (brain gain) approach must be applied and the cut and adapt method should be followed as a way of transferring technology. Otherwise we shall continue to invite the super powers to mend our roads, build our houses, provide relieve materials, and dictate our economy.

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