Innovations

Indigenous technology: A comparative study of Nigeria and some selected countries

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Abstract
Without doubt, indigenous knowledge and technology are under threats in Nigeria; particularly when the use of external sources of knowledge, through foreign direct investment is increasingly influenced by technological convergence, declining costs in acquiring external R&D inputs and other shortening of product cycle. Yet, cognizant of the fact that every culture has her technology for achieving desired goals, having knowledge of other technologies, usually lead to better choices and therefore better results. The challenge before us is therefore it to discern the innovative and integrative mechanism. But, there are pre-conditions for effective technology transfer. What are these pre-conditions or fundamental elements? This paper therefore examined the trend in both inter-country and country specific variations in the fundamental elements required for any meaningful technological efforts/innovative process in Nigeria and some selected countries in the globe and derive some tentative policy lessons, particularly for Nigeria. The trend analysis shared that per capita GDP and human capital development correlate highly with the level of indigenous technological efforts, proxied by current level of spending on R&D in the countries sampled. Whereas per capita GDP and human capital development are on the increase in the countries sampled, Nigeria lags behind. Indigenous technology can function side by side with transferred western technology; given that more scientific system usually make important contributions to help facilitate local adaptations to changing conditions

Keywords: *Trend Analysis; Indigenous Knowledge; Indigenous Technology; Inter Country Variations; Country Specific*

Introduction

Before the advent of British Colonial rule in Nigeria, some level of technological and industrial development was attained by a number of Nigerian communities. Examples include; *Nok* culture area of Bauchi, Jos, Zaria and Kano, indigenous textile technology in Ilorin, Oyo, Okene, Iseyin, Kano, Nupe, Kabba, Abeokuta, Ijebu-Ode, Owo and some parts of Igbo Land; Pottery in Igbo-Ukwu, Ife, Benin, Abuja, Iwo-Eleru etc; leather and skin works in Sokoto, Bida, Kano and Maiduguri; Brewing industry (distillation of coconut water to local wine and palm wine); 'Ogogoro', 'Pito', 'Sapele water' and 'Brukutu' in Warri, Sapele, Markurdi, Oturkpo, Gboko, Jos etc; Canoe building in Riverine Areas of Nigeria and Decorated calabash-carving in Oyo, Osogbo, Ilorin, Ogbomosho, Sokoto, Borno, Umudioko of Awka, Benin etc, (Fabola 2008, Osuntokun 2000 cited in Aworawo 2011; Abubakar 1984, Ogunremi 1989 cited in Olaoye 1991).

Rather than encourage the commencement of growth of industries and change the inherited ownership structure and management of industries, the first National Development Plan (NDP), embraced the Import Substitution Industries (ISI). The ISI, among others, was characterized by a high degree of technological dependence on foreign know-how; thus undermining Nigeria's factor endowments. Amidst, low techno-managerial capacity, the 2nd NDP (1970-74), endeavoured to upgrade local production of intermediate and capital goods and ensure some linkage between the industrial structure to agriculture, transport, mining and quarrying sectors. Also stressed in the 2nd NDP, was some shift in policy from private to public with the Nigerian government providing leadership.

The third NDP (1975-80), coincided with huge oil revenue which facilitated further entrenchment of the establishment of heavy industries (iron and steel, cement etc). These industries were heavily dependent on imported machinery and raw materials. The dwindling foreign exchange earnings, associated with the then prevailing global economic recession did not only welcome the 1981-85, 4th NDP, but witnessed the inability to import the required raw materials and parts in the industrial sector. The Structural Adjustment Programme (SAP), was therefore put in place in 1986, to among others, stimulate non-oil exports, promote efficiency of Nigeria's industrial sector, privatize and commercialize state-owned enterprises, use of local raw materials and intermediate inputs, while adopting and upgrading domestic technology (Egbon, 1996, Chete et. al, 1995).

A National Science and Technology (S and T) policy was launched in 1986 and this was followed by the establishment of the *Raw Materials Research And Development Council* in 1987; in order to hasten the self-reliant attribute of the S&T policy. In addition to the establishment of the Standard Organization of Nigeria (SON) in the same period, the S&T policy stressed on the transfer of foreign technology to local firms through the licensing and registration of patents, trademarks, technical assistance arrangements, research and development, training and operations. The trade and financial liberalization policy was also enacted, so as to promote industrial efficiency, through competition among domestic firms and between domestic import-competing firms and foreign firms. In order to address the Medium and Long-Term Financial Constraints, the National Economic Reconstruction Fund (NERFUND) was established in 1989 (Chete et. al, 2014, Egbon, 2017[a]).

Between 1997-2007, the economic reform agenda aimed at strengthening the role of S&T as a cross-cutting issue needed to be promoted within the context of the National Economic Empowerment and Development Strategy (NEED), The four year strategic plans of the Manufacturers Association of Nigeria (MAN), 7-Point-Agenda and the Nigerian Industrial Revolution Plan (NIRP) derived from the vision 20:2020 framework, constituted other plans geared towards bringing about changes within the industry. Particularly, the NIRP emphasized the Export-Promoting Industrialization (EPI) and the intensification of Foreign Direct Investment (FDI).

The challenge before us is therefore how to discern that innovative and integrative mechanism. Reasons adduced for Nigeria's low level of technological and industrial development, in spite of pre-colonial technological attainment include, but not limited to the;

- Off and on commitment on the part of government and relevant agencies, reflected in low budgetary allocation to the subsector and policies to regulate it..
- Attitude of Nigerian industrialists, that are often satisfied with assembling or packaging products for quick returns (Aworawo 2011).
- Internal factors which include, inconsistency in the formulation and implementation of industrial policy, poor infrastructural base, a near absence of visionary leadership, and high level of corruption.
- External factors manifesting through the nature of colonial master, relegation of indigenous knowledge, wrong philosophy of western education and conflicting interest in transfers of technology. (Isioto-Nte, Philip-Kpae, Dickson, 2017). Technological change propels productivity growth and the differentials in productivity constitute a key source of Cross-Country income variations. (Pietrobelli & Soete, 2010). It follows that technological innovation is a major element of industrialization and catch up in developing countries, including Nigeria.

The relevant questions include;

- Are traditional knowledge systems (internal technology) incompatible with scientific knowledge systems (external technology)?
- What innovative mechanisms exist that could integrate both the traditional and scientific systems for mutual benefit, since such understanding could minimize the inadvertent damage to the ecosystem or culture?
- What drives technological change and catching up, particularly in developing countries?
- In the face of globalization and a liberal trade regime, what is the relationship between indigenous innovation and the acquisition of foreign technology? How would the resulting change from such interaction respond to the peculiar attributes of a country?
- In the context of global value chain, do external or internal technology spillovers have influence on innovation efficiency in countries?

Answers to some of the questions a foretasted will help to address the focus of this paper: given that formal Research and Development (R&D) systems are efficient in generating new knowledge quickly and given that the indigenous technical knowledge is the bedrock of indigenous technology, the issue should be; finding the determinants of the optimal mix between indigenous participation and scientific participation in R&D processes rather than a choice of either one or the other (Howes & Chambers 1977, Lalonde 1993, Fu, Pietrobelli & Soete, 2010). This paper is aimed at conducting a comparative analysis that examines, mainly, the trend in both inter-country and country-specific variations in indigenous technological efforts/innovation process.

Conceptual Framework

Technology is been observed as the knowledge and machinery required in running an enterprise, including the hardware (equipment) and software (skill). This implies, among others that technology could be referred to as 'a device, tool or piece of equipment'; 'the application of local methods in the production of goods and services' and 'the use of raw materials, tools, skills and techniques, available locally' (Okpoko & Ezeadiche, 1999, Manabete & Umar, 2014, Olaoye, 1991). When the design and fabrication of technology is essentially rooted in the tradition, culture of a people and adopted for the use in the environment of such people, the technology is termed indigenous. Indigenous technology is characterized with low capital intensity, often environment and ecology-friendly (hence sustainable), very location-and-site-specific (thus with limited adaptability), diffuse over small homogenous zones over time and generally generate small increments in output (Jha, 2008).

Due to some developments over which the indigenous people have no participation, some traditional lifestyles are threatened with extinction. The threats confronting indigenous knowledge and technology include; problems associated with imported technologies; understanding the foreign language of the technologies, insufficient knowledge of repair fundamentals, inability to appreciate and articulate the design principle and the unavailability of spare parts (Manebete & Umar, 2014). Given the constraints and challenges for maintaining and transferring indigenous ecological knowledge and the need to enhance indigenous technologies (ITs), Foloyan (1998) opined that;

> *'Every culture has her technology for achieving desired goals. However, knowledge of other existing technologies/methods and materials often lead to better choices and therefore better results' (cited in Manabete and Umar, 2014).*

The States and Models of Development

It is no longer news that the core values of Washington consensus have collapsed; since openness of a nation's economy and having minimal role for government as policies are no longer panacea to ensuring economic growth. Consequently, understanding the nature and quality of interventions of States is critical, particularly in Africa, where effective industrial policy-making calls for political leadership at the apex, as well as coordination across ministries and departments (Rodrik, 2008, Obinyeluaku, 2017)

It is also very fundamental to understand the character of the dominant forces in States, when confronted with issues of weak private sector participation, inadequate support for IPO capacity and institutional failures in training, monitoring and evaluation systems (Kohli, 2009). Kohli (2009) delineated three types of States; the Neopatrimonial States, the cohesive capitalist States and the fragmented multi-class States. Whereas public resources are treated by public officers as their personal patrimony in Neopatrimonial States, sustained economic growth is equated with national security based on centralized and purposeful authority structures in the cohesive capitalist State. Overwhelmed with issues of legitimacy, the fragmented multi-class States are usually characterized with politicized policy formulation and implementation.

Ironically, in the context of State Directed Development (SDD), the cohesive capitalist States characterized by a marriage of repression and profit are most conducive for rapid industrial growth. The Neopatrimonial is the worst setting. Implied from the foregoing, is the conterminous nature of 'models of State intervention' and 'models of accumulation'. The State can play either a 'support' role or a 'controlling' role in the accumulation process. The resultant decline of the pre-colonial indigenous manufacturing industry without a replacement by modern manufacturing industry was therefore consistent with 'ensuring maximum economic advantages for expatriate bourgeoisies in the management of the economy' (Ekuerhare, 1991).

There is however, mixed signals as regards the impact of colonialism on state formation. Whereas, South Korea originated during Japanese Colonial rule; Nigeria is associated with British colonialism. South Korea, hitherto associated with corrupt and ineffective agrarian bureaucracy became transformed, using extensive state power. In order to sustain high growth, conditions were created to help in the accumulation of capital, efficient capital investment and hastened upgrading of technology; including human capital. But in Nigeria, British colonialism seemed to have reinforced a pattern of patrimonial and personalistic rule that has so far failed to develop an effective civil service and the required minimal political capacities. The elites are yet to overcome the initial deficiencies of state construction (Kohli, 2009).

Empirical Issues

Hypotheses

Particularly in Africa, the inability to build technological capacity and the unenviable level of domestic absorptive capabilities constitute major impediments of industrial development (Obinyeluaku, 2017, Fu, Pietobelle and Soete, 2010). The Multinational Enterprises (MNEs) are able to diffuse technologies to developing countries through; direct transfer to affiliate joint ventures, spillover effects and conducting R&D within a developing country (Obinyeluaku, 2017). Whereas Brazil, India and China have opened up to international trade and investment, albeit different degrees, most African countries are relatively not sufficiently opened to external trade. Again, while the aforementioned emerging economies are increasingly putting emphasis on indigenous knowledge creation and innovation, most developing countries have developed low patronage for indigenous technology due mainly to their favorable disposition for foreign technologies (Lalonde, 1993; Fu, Pietrobelli and Soete, 2010, Akinwale, 2016).

In order to transform China into an innovative society; promoting indigenous innovation, certain conditions were expected to hold;

- By 2020, 2.5% of GDP should be allocated to R&D expenditure, to ensure 10% growth rate of GDP.
- Reduction in reliance on foreign technologies from 60% to less than 30% and focus on promoting national innovation capabilities.

- The Business Sector, becoming the main driver for creating indigenous innovation through favourable tax policies and fiscal incentives, to enable increased investment in R&D and enhance the innovation capabilities in the business sector.
- Innovation to contribute 60% to GDP growth in the future (Bicher & SchmidKonz, 2012).

In addition to encouraging foreign enterprises to locate R&D activities in China, in order to reap from the implied technology and knowledge spillovers, an S&T plan was also put in place. The aim of the S&T was to improve China's innovation capabilities in order to develop indigenous efforts in R&D in the context of home-grown standards and avoid the hard lessons of the global financial crisis on manufacturing exports. The stress is therefore on indigenous innovation as the main driver. Whereas, in South Korea and Taiwan, innovations have been largely domestic with less than 2% of its patents from multinationals, a combination of 'domestic firms and foreign multinationals' dominate India and Taiwan. Also, worthy to note is that Research Institutes play important role in innovation in most countries. Examples include the electronics and telecommunications Research Institute (Taiwan), Korea Institute of Science and Technology (South Korea) and Isiaghua University (China) (Mahmood & Singh, 2003). Governance reforms were also implemented in order to support indigenous innovation policies, through organizational changes of the government body and the enhancement of rule of law (Bicher and SchmidKanz, 2012).

Qin and Du (2017), tried to ascertain the extent external or internal technology spillovers influence innovations efficiency in China. They decomposed innovation process into 'knowledge creation' and 'technology commercialization' stages while employing a network data envelopment analysis approach to measure innovation efficiency at each stage. The spatial analysis of the distribution of 'knowledge creation efficiency' and 'technology commercialization efficiency' revealed the heterogeneity of innovation efficiency at the provincial level. A panel data regression of the effect of FDI and University-Institute-Industry Corporation (UIC) on innovation efficiency at each stage showed that;

- FDI had a higher coefficient and stronger, significance level at the knowledge creation stage.
- Only UIC linkages portrayed a stronger association with innovation efficiency at the 'technology commercialization' stage.

Earlier, Xie (2013) had examined the effect of multiple knowledge sources on 'internalization and indigenous technological efforts of emerging economy firms'. In effect, the author attempted to ascertain the influence of indigenous and foreign innovation efforts on technological change and catching up in emerging economies. The study revealed among others that;

- Exporting stimulates Emerging Economies (EE) firms need for advanced technology which may be met with either indigenous technological effort or foreign knowledge inflows. Given that EE firms have better access to foreign knowledge and more effective in absorbing knowledge they are more likely to replace indigenous technological efforts with knowledge influence.
- Besides the mixed results on the relationship between export and indigenous technological efforts, the impact of foreign ownership and FDI intensities on indigenous technological efforts are also largely inconclusive.
- There is need, to investigate the different foreign linkages interplay influence on the indigenous firms, in the future.

Japan's catch-up product cycle model (CPC) involved importation of machines, borrowing of technology, learning of the working principles of the imported machines, starting of domestic production to substitute import and finally exporting of its product abroad as it became competitive internationally. The conditions for Reverse engineering include; imitation driven R&D/imitation design sector, intermediate goods-sector and final goods sector. The a forestated three conditions could further be aggregated into Human Capital and Domestic sector (Azeta et. al, 2016

Method of Research

This section is mainly of two parts; the trend analysis and the descriptive component The trend analysis and the descriptive components are made up of trend analysis, tables and summary statistics/correlation matrices in both inter-country and country-specific variations in indigenous technological efforts/innovation process.

Nature and Sources of Data

Data used for country comparative study spanned 17 years (2000-2016), informed by the availability of data. Data were sourced from WDI, and UNESCO. Variables used are;

- Average per Capita GDP
- Average Research and Development
- Average Literacy rate, adult total (% of people ages 15 and above)
- Average gross enrolment ratio, pre-primary, secondary and Tertiary, both sexes
- Patents by Origin

Seven (7) countries were adopted for the study. They include; Germany, India, Japan, Malaysia, Nigeria, South Africa and South Korea.

Trend Analysis

Within the relevant period, 1990-2016, fig 1 show that whereas the average per capita GDP for Japan was about 45,000 US dollars, followed by Germany with about 40,000 US dollars and South Korea with 18,000 dollars, Nigeria constituted the rear with an average less than 2,000 US dollars. Yet, there is a high and positive correlation between technology transfer and per capita GDP. Per capita GDP is regarded, particularly in the short term as a proxy for market demand for innovative products; which tend to raise the demand for new technology.

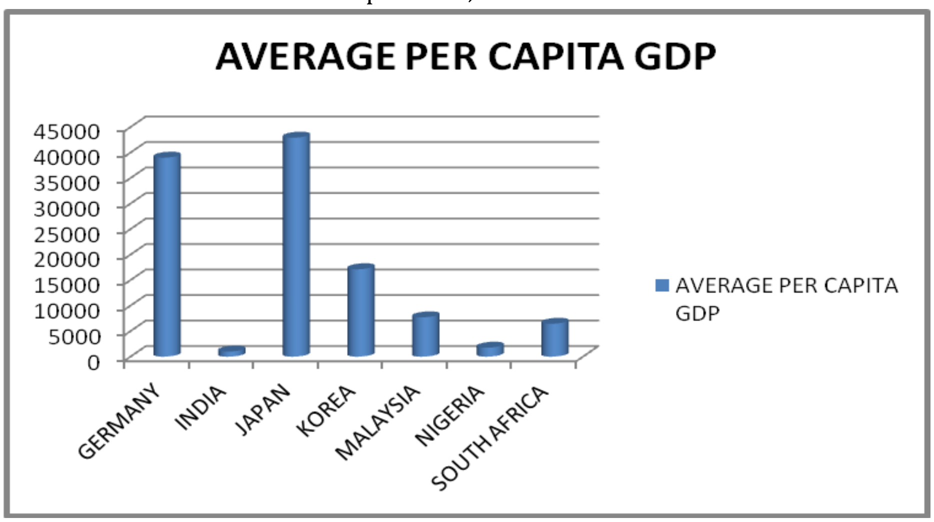

Figure 1: Average per Capita GDP for 2000-2016
Source: Author

Fig 2 embodies investment in R&D which has both positive effect on knowledge accumulation and employees' productivity. It is an important indicator often equated to economic development, since it strengthens innovation. Data available show that the average R&D expenditure (as % of GDP) in the relevant period for Malaysia and Nigeria were 0.805% and 0.219% respectively; very thinly distributed budget. In Japan and Germany, 3.107 and 2.527 were recorded respectively

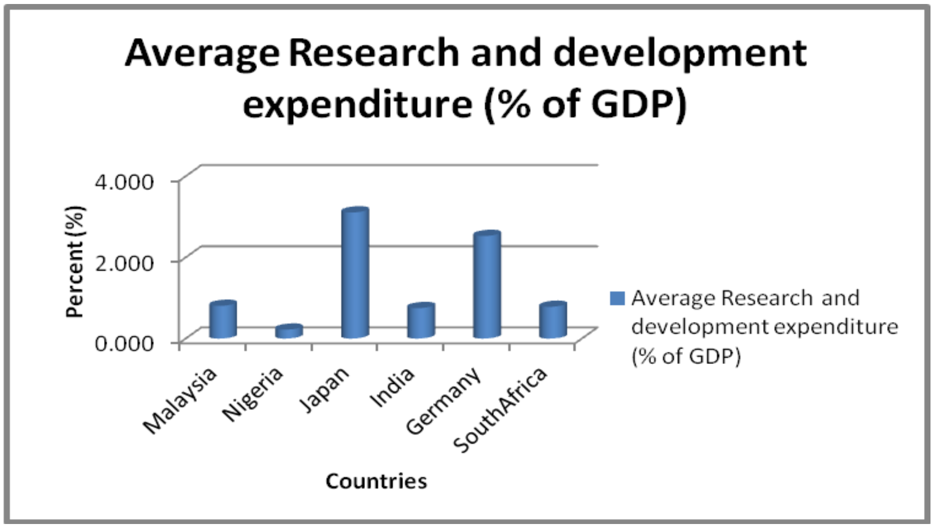

Figure 2: Average R&D Expenditure (% of GDP) for 2000-2016
Source: Author

Fig 3a shows the 'average literacy rate, adult total as % of people ages 15 and above'. Besides having a positive impact on growth and on reduction of inequalities, the availability of a highly skilled labour force contributes towards productivity and improvement on the profitability of investment. Within 1990-2016 period, the average literacy rate, adult total for South Korea was 99.978 %, those for Malaysia and Nigeria were 86.764 and 53.766% respectively. In the pre-primary (both sexes), exhibited in fig 3 (b), whereas South Korea recorded an average gross enrolment ratio of 67.025%, Malaysia and Nigeria recorded 61.881% and 38.818 % respectively. At the secondary education level, as embodied in fig 3 (c), the average gross enrolment ratio (both sexes), in Korea was 97.542%, Malaysia and Nigeria recorded in the same period, 70.538% and 35.555% respectively.

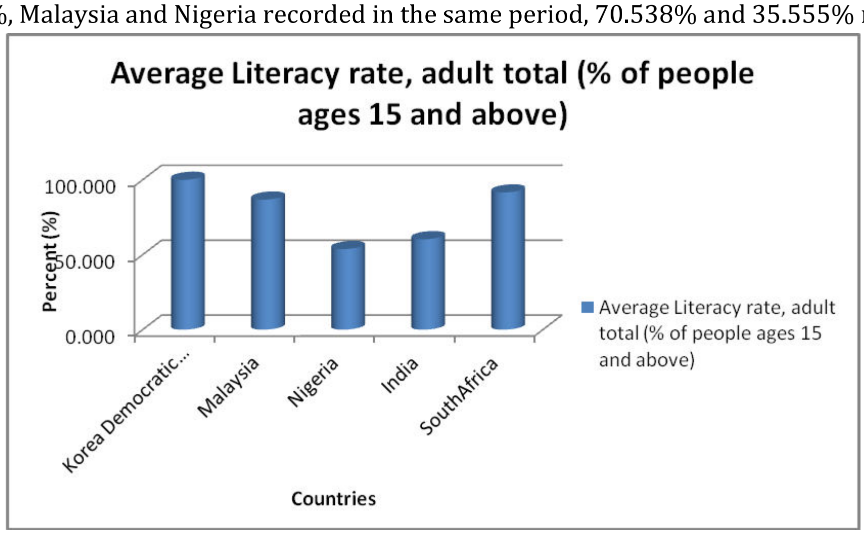

Figure 3a: Average Adult Literacy Rate, Adult total (% of people age 15 and above for 2000-2016
Source: Author

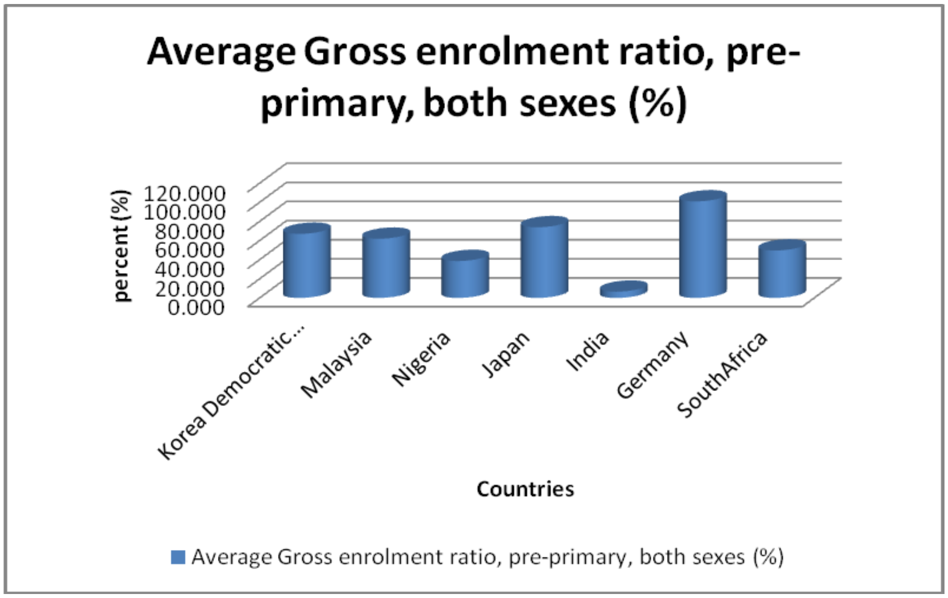

Figure 3b: Average Gross Enrolment Ratio, Pre-primary, Both Sexes (%) for 2000-2016
Source: Author

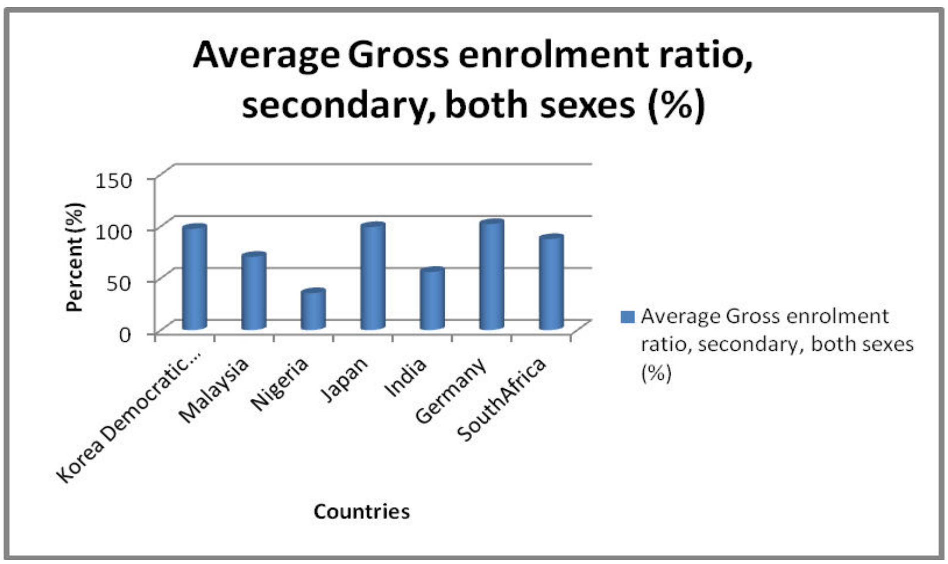

Figure 3c: Average Gross Enrolment Ratio, Secondary, Both Sexes (%) for 2000-2016
Source: Author

Often, an indicator of the level of human capital available is the tertiary level enrolment of the population. In fig 3(d), between 1990-2016, while the average gross enrolment rate (tertiary of both sexes %) for Korea was 29.776% Malaysia and Nigeria recorded 17.738% and 9.329% respectively as against 50.369% and 48.044% for Japan and Germany. As regards total patent applications, whereas Germany and Japan recorded average total patent applications of 56,418.63 and 375,770.7 respectively, Korea recorded 124,637.7 applications and Nigeria, 676.5 applications (WIPO Intellectual Property Statistics, 2016).

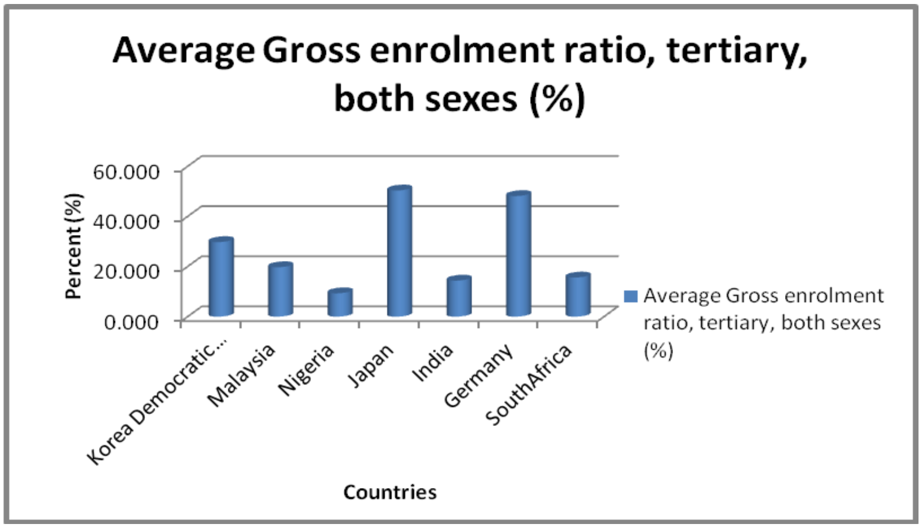

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Figure 3d: Average Gross Enrolment Ratio, Tertiary, Both Sexes (%) for 2000-2016
Source: Author

While the average patent granted by local origin recorded 3,812 and 346.346 for Korea and Malaysia respectively, Nigeria recorded 1,416. Compared to 35,374.93 and 306,811 for Germany and Japan respectively; a lot more needs to be done particularly in Nigeria (WIPO Intellectual Property Statistics, 2016). Again, a critical look at data on patent by foreign origin, showed that whereas Japan and Germany recorded 56,332.65 and 17,027.04 patents in the relevant period, Korea and Nigeria recorded 2,264 and 1,454 respectively (WIPO Intellectual Property Statistics, 2016).

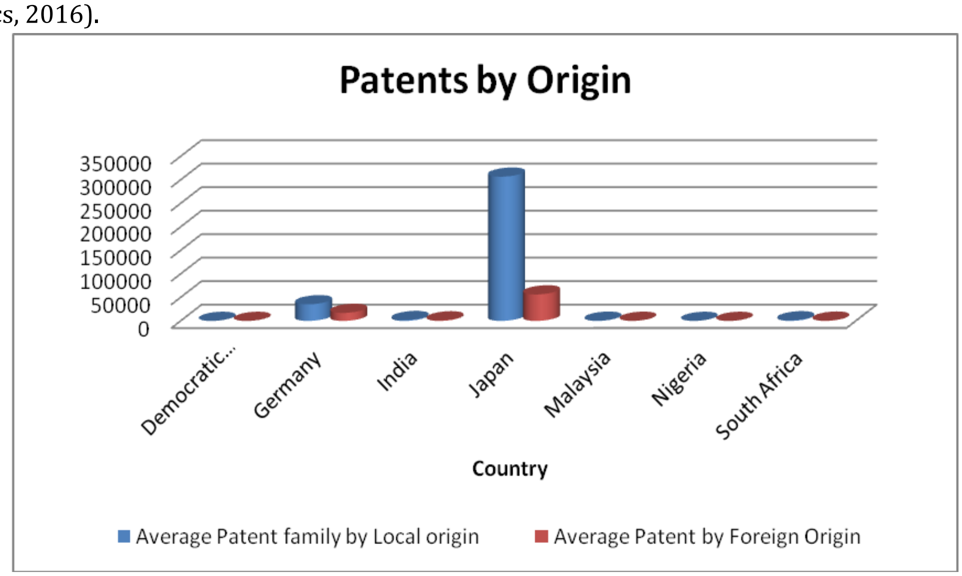

Figure 4: Average Patents by Origin (1990-2016)
Source: Author

The trend of the result above is reflective of the heterogeneity of the a foretasted factors and indigenous technological efforts. The panel descriptive statistics, generally suggest that the factors (such as FDI intensity, foreign ownership, local tech scale, R&D intensity and export intensity), significantly influence indigenous technological efforts.

Summary of major findings, policy implications and lessons for Nigeria
Findings and Policy implications
Major findings derived from the trend analysis, summary statistics and correlation matrices and panel regression results include;

- The trend analysis showed that per capita GNP and human capita development correlate highly with the level of indigenous technological efforts, proxied by current level of spending on R&D in the countries sampled. Whereas, per capita GNP and human capital development are on the increase in the countries sampled, Nigeria lags behind.
- GDP per capita, government support, infrastructure and R&D investment variables associate significantly with innovation efficiency, albeit, at different degrees in Germany, Japan, India, Korea, Malaysia and South Africa. Implied from findings (1) and (2), among others, is that Nigeria needs to upscale her absorptive capacity, through increased investment in R&D and human capital development, in order to attain an increasing level of indigenous technological effort and innovation efficiency.

Policy Lessons for Nigeria
Lessons to be derived from the findings and policy implications above include;

- Indigenous technology can operate side by side with transferred western technology even at the risk of being squeezed out in the long run; given that much more scientific system often make important contributions to help facilitate local adaptations to changing conditions.
- The issue is not the choice of either indigenous participation or scientific participation in R&D process, but what constitutes the optimal mix; which is dependent on technology and innovation capability: which forms the basis of absorptive capacity.

Conclusion
Before Nigeria's political independence, there existed some pre-colonial indigenous technologies that were associated with some form of industrialization. At independence, Nigeria failed to leverage on the existing state of technology. Given the often conterminous relationship between 'models of state intervention' and 'models of accumulation', understanding the relative effectiveness of state intervention tantamount to identifying differences in how states are organized on one hand and the relationship of the state to the private sector on the other hand (Kohli, 2009, Ekuerhare 1991).
In the cohesive capitalist state (say Japan, South. Korea, Malaysia, Brazil etc), conditions are created to facilitate capital accumulation, investment of capital efficiently and upgrading of technology; including human capital. However, in the Neopatrimonial setting (say Nigeria), state officials often misappropriate and divert economic resources away from productive investments. In effect, some dose of *purposive dictatorship* seems conducive for rapid industrialization; since it allows for a 'marriage of repression and profit', amidst robust private sector (Kohli, 2009).

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