Innovations

Indigenous technology and industrial development: the case of Nigeria and some selected countries

Egbon, Peter Chukwuyem[1], & Obi, Callistar Kidochukwu[2]
[1]Department of Economics, Delta State University, Abraka, Nigeria.
[2]Department of Economics, Delta State University, Abraka, Nigeria.
Corresponding author: Egbon, Peter Chukwuyem

Abstract
Undoubtedly, Nigeria had an early start with indigenous technology and some form of industrialization, particularly in the pre-colonial period but failed to leverage on it at independence. Technology has therefore remained the bane of Nigeria's industrial development. Reverse-engineering has become a by-product of globalization and trade liberalization. With a collection of countries, this paper conducted a comparative study, using panel data methods, to examine, among others, the determinants of the resultant technological efforts in Nigeria. Export intensity was statistically significant in explaining indigenous technological efforts in all sampled countries (including Nigeria). Whereas, R&D investment, GDP per capita, government support and foreign direct investment were found to be statistically significant in influencing the knowledge creation efficiency stage of innovation process, only the R&D investment and infrastructural variables were found to be both statistically significant and rightly signed in explaining the stage of technology commercialization efficiency in the innovation process. In order to attain an increasing level of indigenous technological effort and innovation efficiency, Nigeria needs to diversify her economy and upscale her budgetary allocations/expenditure on R&D and human capital development

***Key Words**: 1.Indigenous Technological Efforts, 2.Indigenous Technology, 3.Industrial Development, 4.Innovation Process*

Introduction

Given the British Colonial policy; a philosophy that kept Nigeria as a source of cheap raw materials for industries in Europe and a market for its finished products, it was perceived that Colonialism stunted and obstructed development in the indigenous skills and techniques of the pre-colonial economy (Ake, 1981). Besides, it was also asserted that there was no need to adopt and strengthen traditional technologies, since the process was backward and primitive, research results are international property that could be accessed by desiring countries, all existing inventions are easily transferable from source and that the Nigerian economy can afford the importation of all her required technological needs. But confronted with the fact that research findings are guarded secrets and the constraint of scarcity of foreign exchange to import technologies, it became clear that the aforementioned assertions were premised on false assumptions (Okon 1991).

Cognizant of the fact that, there are strong relationships between industrial development and economic growth, research and technological advancement and that the responsibility for improving the level of technology and industrialization in Nigeria rests on the government, supposedly relevant policies/programme were put in place by various governments, after Nigeria's political independence. Such policies/programmes were embedded in the first through the fourth National Development Plans, the Structural Adjustment Programme (SAP), the National Economic Empowerment and Development Strategy (NEEDS); the Vision 20:2020, the Nigerian Industrial Revolution Plan (NIRP) and the Economic Recovery and Growth Plan (ERGP) (Egbon 2017[a], Egbon 2017[b])

Over time, therefore, since 1960, Nigeria had switched from ISI (Import Substitution Industrialization), through EPI (Export Promotion Industrialization) to Foreign Direct Investment (FDI) strategies, just as was done in the Asian and Latin American Countries, with substantial industrial growth rates. What then went wrong with Nigeria's industrialization process? (Chete, et al 2014, Egbon, 2017[b]). Crucial to the performance in the external sector were incentives for securing domestic efficiency and fostering economic development through industrialization. In addition, any special incentive for technological development not linked with capital goods would not be viable. Yet, the total effect of Nigeria's past policies has been to impose the highest tariff on consumer goods imports (Obi and Ifelunini, 2019) and relatively low duties on intermediate and capital goods imports. This, provided the consumer goods industries the greatest degree of protection in the domestic market. Consequently, the share of domestic manufacturing value-added dependent on imports did not only increase but the long-run rate of industrial expansion was strongly linked to the capacity of the Nigerian economy to import (Obi, 2015). Also, the greatest obstacle to the success of the indigenization decree was Nigeria's high level of technological dependence (Egbon, 1985; Obi, 2018)

Given that Reverse-Engineering has become a by-product of globalization and trade liberalization, the main objective of this paper is to ascertain the nexus between indigenous technological efforts and industrial development in Nigeria, establishing some quantitative relationships in both inter and country specific relationships that are consistent with some stated hypotheses between;

a. Indigenous technological effort and some macro-variable (Export intensity, foreign ownership, local tech scale;
b. Knowledge creation efficiency and some macro-variables (R&D, Investment, GDP per capita, Government support, infrastructure and foreign direct investment).

Conceptual/Theoretical Issues

Technology is variously conceived as the application of scientific knowledge, skills and resources for the improvement of both the physical and rational aspects of life. Four types of technologies exist; the technologies of production, sign systems, power and self. Emphasis in this paper would be on technologies of production and self. Whereas the technologies of production imply production transformation and manipulations of things, self technologies constitute the 'other dimensions of human performance that enable socio-economic and political institutions to function and remain functional over time (Egbon and Obi, 2022). Particularly in Africa, the dimensions referred to above that could threaten progress manifest as growing conflicts, tensions and corruption (Peters, 2003, Adjibolosoo, 2003 cited in Manabete and Umar, 2014). Indigenous technology is therefore not only practical and utilitarian but usually embodies the people's cultural and ecological diversities (Manabete and Umar, 2014).

Indigenous technical knowledge constitutes the bedrock of indigenous technological development. Indigenous Technical Knowledge (ITK), differs from science. Besides, being in the main of direct practical value, ITK is anchored mainly on intuition and evidence directly available to the senses. But the scientific mode of thought involves 'breaking down of data and reassembling it in different ways' (Manabete & Umar, 2014; Howes & Chambers, 1979).

In the context of criteria of evaluation of science and ITK, whereas ITK and science are comparable as regards systems of classification, science is superior to ITK in terms of systems of explanation and prediction, as well as in the area of speed of accumulation. Generally, ITK lacks means for systematic and rapid Research and Development (R&D). Most often, putting ITK and scientific stocks side by side or together, ITK is squeezed out, culminating in loss of confidence on the part of possessors of ITK. This squeezing-out phenomenon undermines the foundations for indigenous participation in the process of generating new technological knowledge (Howes & Chambers, 1979).

Foreign Direct investment (FDI) is not only a major vehicle for the transfer of advanced foreign technology to developing countries but also a principal driver of R&D, training of employees and provide incentives to transfer of technology across boundaries between parent companies and subsidiaries. The resort to the use of external sources of knowledge is increasingly influenced by technological convergence, declining costs to acquire external R&D inputs and the shortening of product cycle times (Fu, Pietrobelli & Soefe, 2010).

Yet, there are pre-conditions for effective technology transfer. These include; legal regulatory policies, trade policies (in terms of openness), sufficient linkages between foreign and local firms, technological gaps between foreign and local firms and sufficient absorptive capacity. Technology and innovation capability constitute the basis of absorptive capacity; which is made up of four different capabilities;

i. Acquisition (the search for new knowledge).
ii. Assimilation (understanding new knowledge)
iii. Transformation (seeing how new knowledge can be used in the context of the firm's issues and existing knowledge) and
iv. Application (implementation of actions enabled by the new knowledge).

Empirical Review

Xia & Jiatao (2014), Kumaraswamy et. al (2012), observed among others that the Emerging Economies (EE) firms with higher export intensity are better positioned to acquire advanced technology from abroad and therefore less motivating to make indigenous technological efforts. But firms with small export intensity tend to increase their indigenous technological effort with export intensity so as to "cultivate, adapt and assimilate' advanced technology required for international competition.

Saidharan & Kathiria (2011), Kumor & Aggarwal (2005) posited that the relationship between export and indigenous technological efforts is moderated by foreign ownership. Indigenous technological efforts ordinarily stimulated by exports are often provided by foreign parents of the EE firms.

Saidharan & Kathiria (2011) emphasized that the competitive pressure associated with FDI intensity increased the local demand for advanced technology. This may in turn lead to stimulation of local firm's indigenous technological efforts for in-house technological development and for better adaptation of the knowledge-spillover. The FDI induced knowledge-spillover may substitute indigenous technological efforts by helping the firm meet the demand for technological competencies.

Feinberg & Majumdar (2001) underlined the observation that, local technology supply had no significant direct effect on indigenous technological efforts. They also suggested that high quality local technology supply encourage EE firms to make indigenous technological efforts when compelled to struggle to meet the technology and quality requirements of export.

Though local technology sources may not be able to provide the exporters with required foreign technology needed to compete in the international market, they are positioned to provide quality and often less costly domestic technologies that can be upgraded through indigenous technological efforts.

Qin & Du (2017), observed among others that, the pattern of heavy R&D investment in China is in the Long-run, not sustainable. The contribution of innovation outputs to economic growth through improvement in innovation efficiency should rather be emphasized than incur massive R&D expenditure.

The innovation process can be divided into 'knowledge creation and 'technology commercialization' stages. There are also 'internal technology spillover" and external technology spillover". Whereas, the internal technology spillover occurs through local R&D activities, brought about by University-Institute-Industry Corporation (ULC), FDI promotes the flow of knowledge from foreign countries to domestic enterprises. FDI's presence also influences technology commercialization through diversity of industries with foreign firms (Li et al, 2013) Valiter, 2011 Qui & Du, (2017).

Schartinger et. al (2002) and Qui & Du (2017), opined that both external and internal technology spillovers improve innovation performance in developing countries. The core technology of foreign countries hardly flows into the host country through FDI, since the Multinational Corporations (MNCs) are likely to shift production to host country firms rather than transfer technology, in order to maintain their technology superiority.

Methods.

This section is mainly descriptive and inferential. The secondary data on R&D intensity, Export Intensity and Foreign Direct Intensity were obtained from the *World Bank Development Indicators* (WDI, 2000-2016). Foreign Ownership and Local Technology Supply/Scale were generated from *UNESCO Institute of Statistics*. Data used for the cross/pooled country and specific country panel regressions pooled spanned 17 years (2000-2016) and based on avaliability. Countries adopted for this study are seven (7); including; Germany, India, Japan, South Korea, Malaysia, Nigeria and South Africa. Countries were selected to ensure global context; connoting representations from advanced industrialized economies, Emerging Economies (EE) and Africa economies. Data availability constitutes the general constraining factor. Table 1 defines each measurement unit alongside its source.

Table 1: Definition, Measurement Units and Sources of Data

Variable	Definition	Units	Sources
R&D Intens-ity	Expenditure by a firm on its R&D divided by the firm's sale. A proxy for indigenous technological effort.	Percentage of total expenditure	UNESCO
Export Intensity	A ratio of aggregated export sales to total firm sales	Purchasing Power Parity	World Development Indicator
FDI Intensity	The average of inward and outward FDI flows divided by GDP	Percentage of GDP	World Development Indicator
Foreign Ownership	Proxied by the lag of FDI intensity (FDI_{t-1})	Percentage of GDP	World Development Indicator
Local Tech Scale	Proxied by number of patents	Total count by filing	UNESCO
Knowledge creative efficiency	Proxied by the number of publications and patents by filing office	Local currency units relative to US dollars	UNESCO
Technology commercialization efficiency	Proxied by R&D expenditure on experimental development and new product development	Constant 2010 and $US	UNESCO
Infrastructure	Proxied by individuals using the internet	Percentage of population	World Development Indicator

Source: Compiled by the Author

3.2 Model Specification/Estimation Techniques

Model 1

$$RI_t = \alpha_0 + \alpha_1 EI_{t-1} + \alpha_2 (EI)^2{}_{t-1} + \varepsilon_t$$

Where

RI_t = R&D Intensity at current period.

EI_{t-1} = One period lagged Export Intensity

$(EI)^2{}_{t-1}$ = One period lagged Export Intensity, Squared

ε_t = Error term.

Model 2

$$RI_t = \alpha_2 + \alpha_3 FO + \varepsilon_t$$

Where

RI_t = R&D Intensity at current period.

FO = Foreign ownership

Model 3

$$RI_t = \alpha_3 + \alpha_4 EI_{t-1} * FO + \varepsilon_t$$

Where

RI_t = R&D Intensity at current period.

$EI_{t-1}.FO$ = Export Intensity $_{t-1}$ * Foreign Ownership

Model 4

$$RI_t = \alpha_4 + \alpha_5 EI_{t-1}.LTS + \alpha_6 FO + \alpha_7 LTS_{t-1} + \alpha_8 FDI_{t-1} + \alpha_9 RT_{t-1} + \alpha_{10} RDI_{t-1}$$

Where

RI_t = R&D Intensity at current period.

$EI_{t-1} * LTS$ = Export Intensity lagged one period * Local Tech Scale lagged

FDI_{t-1} = Foreign Direct Investment, one period lag

FO = Foreign Ownership

LTS_{t-1} = Local Tech Scale lagged

Model 5

$$Kc = \alpha_5 + \beta_1 RDI + \beta_2 GPC + \beta_3 GS + \beta_4 I_f + \beta_7 FDI + \varepsilon_t$$

Where

Kc = knowledge Creation Efficiency

RDI = R&D Investment

GPC = GDP per capita

GS = Government Support

I_f = Infrastructure

FDI = Foreign Direct Investment.

Model 6

$$TCE = \alpha_6 + \delta_1 RDI + \delta_2 GPC + \delta_3 I_f + \delta_4 FDI + \varepsilon_t$$

Where

TCE = Technology Commercialization Efficiency

FDI , GPc , I_f and FDI as defined in model 5.

Models (1) to (4) were specified to cover all countries constituting the sample (Germany, India, Japan, Korea, Malaysia, Nigeria and South Africa). Model (5) and (6) excluded Nigeria due to data insufficiency. Whereas models (1) to (4) were formulated for both Cross-Country and Country-Specific panel regression, models (5) and (6) were specified for Cross-Country panel regression only, due to irregular behaviour. The Husman tests were conducted to enable the selection of models with best effect among the pooled, fixed and random formulations. Whereas models (1) to (4) covered the indigenous technological efforts and its determinants, models (5) and (6) covered technological spillovers effects on innovation efficiency

Results

Summary Statistics/Correlation Matrix

Table 2 shows the descriptive statistics and correlation matrix stressing factors that are likely to significantly influence or facilitate indigenous technological efforts for pooled sample (made up of Germany, India Japan, South Korea, Malaysia, Nigeria and South Africa). The means of R&D intensity and Export intensity are 2.430 and -2.566 respectively and standard deviations of 1.184 and 0.484. Also the means of FDI intensity and foreign ownership are 0.204 and 23.130 respectively and standard deviations of 1.101 and 1.853 respectively.

Table 2: Summary Statistics and Correlation Matrix

	Variable	Mean	S.D	1	2	3	4	5	6	7	8	9	10
1	**R&D Intensity$_{(t)}$**	2.430	1.184	1.000									
2	**Export Intensity$_{(t)}$**	-2.566	0.484	-0.077	1.000								
3	**FDI Intensity$_{(t)}$**	0.204	1.101	0.151*	0.194*	1.000							
4	**Foreign ownership$_{(t)}$**	23.130	1.853	-0.020	-0.227*	-0.308*	1.000						
5	**Local Tech Scale$_{(t)}$**	3.774	0.314	0.529*	-0.120*	-0.287*	0.410*	1.000					
6	**R&D Intensity$_{(t-1)}$**	2.428	1.199	0.992*	-0.078	0.165*	-0.016	0.529*	1.000				
7	**Export Intensity$_{(t-1)}$**	-2.567	0.491	-0.095*	0.945*	0.228*	-0.236*	-0.136*	-0.089	1.000			
8	**FDI Intensity$_{(t-1)}$**	0.198	1.126	0.118*	0.117*	0.470*	-0.262*	-0.181*	0.120*	0.132*	1.000		
9	**Foreign Ownership$_{(t-1)}$**	23.089	1.842	-0.020	-0.242*	-0.304*	0.588*	0.397*	-0.023	-0.254*	-0.138*	1.000	
10	**Local Tech Scale$_{(t-1)}$**	3.788	0.314	0.543*	-0.129*	-0.289*	0.442*	0.981*	0.542*	-0.146*	-0.174*	0.429*	1.000

Source: Author's Computation for period (2001-2016) pooled for the 7 countries (Germany, India, Japan, Korea, Malaysia, Nigeria and South Africa) adopted for the study.

S.D represents (Standard Deviation) *Significant at 5%

Regarding table 3 (which connotes country specific summary statistics and correlation matrix), all the variables in focus, except for local tech scale, seem to have high and significant relationships between and among themselves.

Table 3: Results of Country Specific Summary Statistics and correlation matrix

	Variable	Mean (Germany)	Mean (India)	Mean (Japan)	Mean (Korea)	Mean (Malaysia)	Mean (Nigeria)	Mean (South Africa)
1	**R&D Intensity$_{(t)}$**	2.770 [0.087]	1.953 [0.126]*	2.993 [0.189]*	3.369 [0.086]	3.881 [0.134]*	0.351 [0.958]*	1.707 [0.104]*
2	**Export Intensity$_{(t)}$**	-3.186 [0.081]	-3.028 [0.195]*	-2.443 [0.127]*	-2.242 [0.114]*	-2.492 [0.103]*	-1.901 [0.495]*	-2.745 [0.368]*
3	**FDI Intensity$_{(t)}$**	0.577 [0.497]*	0.577 [0.497]*	-1.509 [0.629]*	-0.096 [0.388]*	0.913 [1.121]*	0.761 [0.625]*	0.180 [0.909]*
4	**Foreign ownership$_{(t)}$**	25.231 [0.810]*	22.997 [1.102]*	25.269 [1.023]*	23.229 [1.378]*	22.045 [1.367]*	20.855 [1.387]*	22.711 [1.073]*
5	**Local Tech Scale$_{(t)}$**	4.052 [0.102]*	3.665 [0.052]	3.996 [0.029]	4.142 [0.049]	3.836 [0.082]	-	3.212 [0.025]
6	**R&D Intensity$_{(t-1)}$**	2.779 [0.097]	1.942 [0.132]*	3.019 [0.206]*	3.387 [0.095]	3.901 [0.139]*	0.262 [0.969]*	1.724 [0.119]*
7	**Export Intensity$_{(t-1)}$**	-3.171 [0.095]	-3.017 [0.212]*	-2.435 [0.139]*	-2.265 [0.107]*	-2.472 [0.124]*	-1.832 [0.479]*	-2.781 [0.361]*
8	**FDI Intensity$_{(t-1)}$**	0.706 [0.719]*	0.706 [0.719]*	-1.722 [1.063]*	-0.042 0.438]*	0.905 [1.117]*	0.812 [0.600]*	0.176 [0.911]*
9	**Foreign Ownership$_{(t-1)}$**	25.163 [0.812]*	22.975 [1.154]*	25.177 [0.864]*	23.123 [1.302]*	22.023 [1.370]*	20.779 [1.397]*	22.576 [1.102]*
10	**Local Tech Scale$_{(t-1)}$**	4.072 [0.042]	3.671 [0.061]	3.992 [0.035]	4.135 [0.056]	3.854 [0.094]	-	3.210 [0.028]

Source: Author's Computation for period (2001-2016) pooled for the 7 countries (Germany, India, Japan, Korea, Malaysia, Nigeria and South Africa) adopted for the study.
[ ] represents standard deviation *Significant at 5%

Table 4 portrays the summary statistics and correlation matrix underlying the fact that innovation efficiency is significantly associated with internal or external technology spillover in sampled countries of Germany, India, Korea, Malaysia and South Africa. The means of Creative Efficiency and Commercialization Efficiency are 9.046 and 16.976 respectively and their standard deviations are relatively low.

Similarly, the countries have means of 16.972 for GDP per capita and 0.410 for government support with standard deviations of 1.353 and 0.687 respectively, reflecting the heterogeneity of innovation activities and internal or external technology spillovers. The calculated Variance Inflator Factor (VIF) for each variables were high far above the rule of thumb cut-off of 10; suggesting multicollinearity as a major issue for these analyses (Ryan, 1997).

Table 4: Results of Panel Descriptive Statistics and Correlation Matrix

	Variable	Mean	S.D	1	2	3	4	5	6	7
1	**Creative Efficiency**	9.046	1.484	1.000						
2	**Commercialization Efficiency**	16.976	1.348*	0.782*	1.000					
3	**GDP Per Capita**	16.972	1.353*	0.619*	0.474*	1.000				
4	**Government Support**	0.410	0.687*	0.685*	0.801*	0.821*	1.000			
5	**Infrastructure**	3.456	1.228*	0.437*	0.330*	0.828*	0.650*	1.000		
6	**R & D Investment**	16.972	1.353*	0.780*	0.999*	0.474*	0.801*	0.328*	1.000	
7	**FDI**	0.107	1.139*	-0.563*	-0.397*	-0.280*	-0.388*	-0.116*	-0.395*	1.000

Source: Author's Computation for period (2001-2016) pooled for the 6 countries (Germany, India, Japan, Korea, Malaysia and South Africa) adopted for the study; with the exclusion of Nigeria due to insufficient data

S.D represents (Standard Deviation) *Significant at 5%

Table 5, documents the panel regression results with R&D intensity$_{(t)}$, as the dependent variable. The results show among others that;

i. Lagged Export intensity was statistically significant (albeit negative) in model 1; implying that R&D is not likely to increase with export intensity.
ii. Lagged Export intensity squared was not statistically significant (albeit negative) in model 2.

Table 5: Panel Regression Results with R&D Intensity$_{(t)}$ as the dependent variable

Hypotheses	**Variable**	**OLS (None)**
Model 1	**Export Intensity$_{(t-1)}$**	-3.920 (-3.091)**
	(Export Intensity)$^2_{(t-1)}$	-0.778 (-3.552)**
Model 2	**Export Intensity$_{(t-1)}$*Foreign Ownership$_{(t-1)}$**	-0.007 (-0.108)
Model 3	**Export Intensity$_{(t-1)}$*FDI Intensity$_{(t-1)}$**	0.084 (0.630)

Model 4	**Export Intensity$_{(t-1)}$*Local Tech Scale$_{(t-1)}$**	0.004 (0.020)
	Foreign Ownership$_{(t-1)}$	-0.041 (2.423)**
	Local Tech Scale$_{(t-1)}$	0.645 (1.123)
	FDI Intensity$_{(t-1)}$	0.272 (7.795)**
	R &D Intensity$_{(t-1)}$	0.708 (13.211)**
	C	-5.921 (-1.607
	R-Squared **Adjusted R-Squared** **Durbin Watson stat.**	0.90 0.89 2.16

Source: Author's Computation for period (2001-2016) pooled for the 7 countries (Germany, India, Japan, Korea, Malaysia, Nigeria and South Africa) adopted for the study
N.B: ** Significant at 5% level; * Significant at 10% level; ( ) t- statistics in parenthesis**

iii. The combined effect of export intensity and FDI intensity is positive but not statistically significant in model 3. This implies that indigenous technological effort may not be weakened by FDI intensity in the sampled countries.

iv. Except for the negatively signed foreign ownership factor, all others (combined effort of export intensity/local tech scale, FDI intensity and the control variable, R&D intensity$_{(t-1)}$) were rightly signed and statistically significant (excluding export intensity$_{(t-1)}$, local tech scale$_{(t-1)}$], in model 4.

The results must be understood with some caution, given the high presence of multicollinearity.

Table 6 captures the country specific results with R&D intensity $_{(t)}$ as the dependent variable.

Table 6: Country Specific Regression Estimates for (R&D Intensity $_{(t)}$ as the dependent variable)

Hypotheses	Variable	Germany (GER)	India (IND)	Japan (JPN)	Korea (KOR)	Malaysia (MYS)	Nigeria (NGR)	South Africa (ZAF)
Model 1	**Export Intensity$_{(t-1)}$**	1.017 (7.231)**	-2.836 (0.851)**	2.409 (4.213)**	-2.739 (4.693)**	-4.994 (6.829)**	-10.270 (-0.736)	1.628 (0.734)
	(Export Intensity)$^2_{(t-1)}$	0.221 (5.073)	-0.940 (-0.889)	1.042 (5.760)**	-0.449 (1.833)***	-1.937 (-0.670)	-0.095 (-0.014)	0.756 (1.143)
Model 2	**Export Intensity$_{(t-1)}$*Foreign Ownership$_{(t-1)}$**	0.037 (0.067)	-0.031 (-0.275)	0.037 (0.120)	0.077 (2.858)**	-0.486 (-0.777)	0.405 (2.398)**	-0.231 (-0.414)
Model 3	**Export Intensity$_{(t-1)}$*FDI Intensity$_{(t-1)}$**	0.309 (5.558)**	0.865 (4.466)**	0.092 (2.858)**	0.116 (0.166)	0.235 (3.602)**	-0.405 (-0.107)	0.042 (2.820)**
Model 4	**Export Intensity$_{(t-1)}$*Local Tech Scale$_{(t-1)}$**	-0.158 (-4.905)**	-0.898 (-1.346)	0.433 (2.986)**	-0.276 (-0.151)	1.498 (0.815)	-	2.410 (0.538)
	Foreign Ownership$_{(t-1)}$	0.111 (6.357)	-0.124 (-0.343)	0.103 (0.131)	0.157 (2.530)**	-1.227 (-0.778)	0.615 (2.062)**	-0.697 (-0.416)
	Local Tech Scale$_{(t-1)}$		-1.872 (-1.086)	0.951 (2.844)**	-1.011 (-2.416)	4.315 (0.932)	-	6.971 (0.522)
	FDI Intensity$_{(t-1)}$	0.954 (5.397)**	2.416 (4.403)**	0.240 (2.999)**	0.257 (1.629)***	0.589 (3.583)**	-0.305 (-0.044)	0.074 (1.716)***
	R &D Intensity$_{(t-1)}$	0.681 (0.539)	-0.192 (-1.092)	0.934 (5.623)**	0.435 (1.203)	0.385 (0.866)	0.407 (1.061)	0.392 (1.628)**
	C	3.29 (0.08)	41.55 (1.11)	-16.05 (-0.37)	23.78 (0.38)	41.55 (1.11)	37.85 (1.73)	15.54 (0.34)
	R-Squared	0.56	0.91	0.92	0.72	0.75	0.52	0.58
	Adjusted R-Squared	0.12	0.80	0.86	0.41	0.47	0.32	0.10
	Durbin Watson stat.	1.71	2.73	0.93	2.02	2.57	2.17	2.11

Source: Author's Computation for period (2001-2016) pooled for the 7 countries (Germany, India, Japan, Korea, Malaysia, Nigeria and South Africa) adopted for the study.

N.B: ** Significant at 5% level; *** Significant at 10% level; ( ) t- statistics in parenthesis

In model 1, export intensity$_{(t-1)}$ was statistically significant in explaining indigenous technological efforts in all the sampled countries (Germany, India, Japan, Korea, Malaysia, except Nigeria and South Africa). Whereas export intensity$_{(t-1)}$ was correctly signed in its coefficients as associated with Germany, Japan and South Africa, it was wrongly signed in India, Korea, Malaysia and Nigeria; thereby weakening the overall influence of export intensity$_{(t-1)}$ on indigenous technological effort in the sampled countries. It is also very likely that most of the R&D needs of the existing companies/firms are met by the parent R&D centres in (their) home countries. In model 2, export intensity*foreign ownership$_{(t-1)}$ joint effect on indigenous technological efforts was significant only in Korea and Nigeria, in spite of having the right sign in Germany, Japan and Nigeria. The positive right sign suggests that the indigenous technological efforts in the concerned countries were improved on by the joint influence of export intensity$_{(t-1)}$*foreign ownership$_{(t-1)}$. As regards, model 3, the variable (export intensity$_{(t-1)}$*FDI intensity$_{(t-1)}$ is jointly significant in explaining the level of indigenous technological efforts in Germany, India, Japan, Malaysia and South Africa. Besides Nigeria, the variable in focus behaved as hypothesized; positively signed and ensuring improvement in the indigenous technological efforts in the countries aforestated. In model 4, one period lagged FDI, turned out not only significant but rightly signed (positive) with respect to indigenous technological efforts in all sampled countries, except in Nigeria. Most of Nigeria's FDI's are in the extractive industry; highly capital-intensive and largely foreign sourced. Tables 7 and 8 embodied models 5 and 6 respectively. Whereas, table 6 contains the panel regression results with 'knowledge creation efficiency' as the dependent variable, 'technology commercialization efficiency' constitutes the dependent variable in table 7. In model 5, the Hausman test at 5% significant level, preferred the random effect to the fixed effect. Four of the explanatory variables (R&D investment, GDP per capita, Government support and FDI) were statistically significant in influencing the knowledge creation efficiency stage. But, only two of the variables (R&D investment and Government) are rightly and positively signed. In model 6, the Hausman test at 5% significant level, preferred random effect to fixed effect. Although, the variables (R&D Investment, Government support, infrastructure and FDI) were statistically significant in explaining the stage of technology commercialization efficiency in the sampled countries, only two of the variables (R&D investment and infrastructure), were rightly signed (positive).

Table 7: Panel Regression Results with Knowledge Creation Efficiency as the dependent variable

	Variable	OLS (None)	Fixed Effect	Random Effect
Model 5	**R & D Investment**	1.066 (11.064)**	1.674 (1.219)	1.066 (17.853)**
	GDP Per Capita	0.908 (6.797)**	-2.805 (-1.818)***	0.908 (10.968)**
	Government Support	-1.796 (-6.181)**	-0.699 (-0.465)	-1.796 (-9.974)**
	Infrastructure	-0.016 (-0.173)	0.506 (3.318)**	-0.016 (0.280)
	FDI	-0.373 (-5.885)**	0.047 (0.893)	-0.373 (-9.496)**
	C	-16.686 (-7.448)	5.333 (0.490)	-16.686 (-12.018)
	R-Squared	0.82	0.93	0.82
	Adjusted R-Squared	0.81	0.92	0.81
	Durbin Watson stat.	1.576	1.762	1.576
	Hausman Test			

	Chi-Sq. **Prob.**	15.412 (0.36)

Source: Author's Computation for period (2001-2016) pooled for the 6 countries (Germany, India, Japan, Korea, Malaysia and South Africa) adopted for the study; with the exclusion of Nigeria due to insufficient data

N.B: ** Significant at 5% level; * Significant at 10% level; ( ) t- statistics in parenthesis**

Hausman (Prob. Value) P>0.05, Random effect is appropriate

The panel regression analyses show that the variables were expressed either in logarithm form or in ratios, in order to make the estimation less sensitive to outliers and thus ease interpretation of the estimated coefficients. Observe that the Hausman tests were conducted for the six models, in order to test for systematic difference between the Random Effects (RE) and the Fixed Effects (FE) models. As regards the panel regression results with 'knowledge creation efficiency' as the dependent variable, the Hausman test with a p-value greater than 0.05 shows that there is significant unobserved heterogeneity, such that Random Effect (RE) specification is preferred. Within this context, R&D investment, GDP per capita, Government support and foreign direct investment (FDI) are statistically significant, albeit wrongly signed (except for R&D and GDP) on knowledge creation efficiency. The R-Squared value 0f 0.82, indicates the satisfactory power of the model.

A critical look at models 5 would reveal the centrality of R&D investment and FDI with respect to the improvement in innovation efficiency; since 'knowledge creation efficiency' and, 'technology commercialization efficiency' are its components. The R&D investment builds on human capacity and provides opportunities for innovation subjects to acquire tacit knowledge. In truth, FDIs do not transfer their core technology to their host country. They, as in China, prefer to shift production that would in turn ensure internal/external technology spillovers in the innovation value China (Qin and Du 2017).

The model with 'Technology Communication Efficiency' as the dependent variable, confirms the existence of unobserved heterogeneity, such that the Random Effect (RE) specification is preferred. Consequently, R&D investment, Government support, Infrastructure and FDI are found statistically significant in explaining technology communication efficiency. The R-squared value 0f 0.89 is indicative of the satisfactory power of the model. Government support is also important in indigenous technology build-up. Besides the promotion of innovation activities by the enhancement of the innovative environment and providing funding, government could be useful in bringing about reforms in governance. The governance reforms in China through 'organizational changes of the government body' and the 'enhancement of the rule of law' supported indigenous innovation policies (Bichler & Schmikdor, 2012, Qin & Du, 2017).

Table 8: Panel Regression Results with Technology Commercialization efficiency as the dependent variable

	Variable	**OLS (None)**	**Fixed Effect**	**Random Effect**
Model 6	**R & D Investment**	0.999 (42.503)**	1.070 (27.294)**	0.999 (58.239)**
	GDP Per Capita	7.58E-05 (0.023)	-0.169 (-3.851)**	7.58E-05 (0.032)
	Government Support	-0.015 (-2.171)**	-0.057 (-1.329)	-0.015 (-2.977)**
	Infrastructure	0.006 (2.710)**	0.025 (5.788)	0.006 (3.717)**
	FDI	-0.002 (-1.925)***	1.42E-05 (0.009)	-0.002 (-2.641)**
	C	-0.008 (-0.160)	0.333 (1.072)	-0.008 (-0.219)

	R-Squared	0.89	0.87	0.89
	Adjusted R-Squared	0.79	0.85	0.79
	Durbin Watson stat.	0.293	0.662	0.293
	Hausman Test			
	Chi-Sq.	8.688		
	Prob.	(0.76)		

Source: Author's Computation for period (2001-2016) pooled for the 6 countries (Germany, India, Japan, Korea, Malaysia and South Africa) adopted for the study; with the exclusion of Nigeria due to insufficient data

N.B: ** Significant at 5% level; * Significant at 10% level; ( ) t- statistics in parenthesis**

Hausman (Prob. Value) P>0.05, Random effect is appropriate

Findings and Policy implications

Major findings derived summary statistics and correlation matrices and panel regression results include;

1. The summary statistics and correlation matrices show that;
    i. Though export intensity*FDI intensity$_{(t-1)}$, foreign ownership$_{(t)}$ and local tech scale$_{(t)}$ correlate with indigenous technological efforts, the relationships are heterogeneous among the sampled countries.
2. The inferential (quantitative) component revealed, among others that;
    i. In model 1, export intensity was statistically significant in explaining indigenous technological efforts in all the sampled countries. Implied therefore is the need to avoid export concentration but improve on export diversification.
    ii. In model 2, export intensity*foreign ownership$_{(t-1)}$ joint effort on indigenous technological efforts was significant only in Korea and Nigeria in spite of having the right sign in Germany, Japan and Nigeria. This implies that the positive effect of export on indigenous technological efforts is often weakened by the foreign ownership in firms.
    iii. Besides Nigeria, the variable (export intensity*FDI intensity$_{(t-1)}$), is jointly significant in explaining the levels of indigenous technological efforts in Germany, India, Japan, Malaysia and South Africa in model 3. This implies that the expected positive effect of export on Nigeria's technological efforts is weakened, given the high FDI intensity in Nigeria's extractive industry, particularly the petroleum subsector.
    iv. In model 4, the one-period lagged FDI was not only significant but rightly signed (positive) with respect to indigenous technological efforts in all sampled countries, except in Nigeria. The knowledge spillover from the FDI dampens the indigenous technological efforts stimulated by Nigeria's export.
    v. In model 5, the Hausman test preferred the random effect to the fixed effect. Although, four of the explanatory variables (R&D investment, GDP per capita, Government support and FDI), used were statistically significant in explaining the knowledge creation efficiency stage of the innovation process, only two of the variables (R&D investment and Government support), were rightly and positively signed.
    vi. In model 6, while R&D investment, government support, infrastructural and FDI variables were statistically significant in explaining the stage of technology commercialization efficiency in the innovation process, only the R&D investment and infrastructural variables were rightly signed

(positive). Implied is the fact that, whereas, both internal-external technology spillovers do improve innovation performance, particularly in the developing countries.

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

i. Reverse-engineering has become an inescapable by-product of globalization and liberalization of trade and it is dependent on the four distinct capabilities of acquisition, assimilation, transformation and applications. Conditions for Reverse Engineering include; imitation driven R&D/imitation design sector, intermediate goods sector and final goods sector. The aforementioned conditions can be grouped into, human capital and domestic industrial sector.

ii. Nigeria's R&D allocation of $US 0.582 billion in 2007, an approximately 0.00004% of the world's expenditure on R&D in 2007. The Nigerian government would need to reorder her priorities.

iii. Given that export intensity has positive effect on technological efforts, Nigeria needs a more functional diversification of the economy rather than the current and largely export concentration economy.

Conclusion

Given globalization and a liberalization regime; indigenous technology as originally conceived may be confronting extinction and its place taking over by *Reverse-Engineering*. This is a form of self-reliant technology that is not only capital-saving but 'could be easily operated, controlled, repaired and maintained locally'. In order to attain this level of technology amenable to sustainable industrial development, Nigeria must raise her funding in R&D/innovations activities, human-capital development and the provision of infrastructure (Darrow & Pam 1981 Cited in Olaoye, 1991)

In addition, strengthening the rule of law and the protection of the International Property Rights (IPR), require reforms in governance structure; so as to, among others, attract quality FDIs. There is the need to diversify and make competitive its exports, cognizant of the fact that the nature of exports and the extent to which a country participate in world markets influence patenting abroad. Growth in parenting, among others, implies increase in innovative capabilities (Mahmood & Singh, 2003).

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