Innovation and economic growth: evidence from Nigeria

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Abstract. The paper examines the impact of innovation on economic growth in the Nigerian economy during the period 1970-2011. Applying the Dynamic Ordinary Least Squares model, we find evidence in support of positive impact of innovation, proxied by technology-embodied capital imports, on economic growth. Other variables with significant positive impact are human capital and structure of the economy. On the other hand, factors such as openness to trade, high share of government expenditure as well as institutional quality are found to associate negatively with growth.

Keywords: Dynamic OLS, Economic growth, Innovation, Nigeria.

1 Introduction

Early theorists model economic performance as a function of technological progress, knowledge factor or simply innovation (Veblen, 1915; Solow, 1956). In this way, they set forth the agenda for one of the most enduring explanations for differential levels of national economic performance. Innovation, which creates new products, generates new solutions to economic problems and enhances efficiency of resource allocation. Also, that which engenders new process boosts productivity and increases gains accruing from resource utilization. Achieving greater returns (efficiency) from both resource allocation and utilization activities is important for greater economic progress.

The expected positive association between innovation and economic growth that the above intuition suggests is however, not an empirical regularity. Much of the controversies can be located around the transferability of innovation from its author to beneficiaries. In standard neo-classical style, it is common to assume that these beneficiaries are developing countries which simply adopt and adapt innovation output of the developed countries for their own use. The extent to which they have succeeded in translating this to actual economic progress has been a subject of considerable debate. Whereas some significant works have been undertaken to document the experiences of some of these beneficiary economies, there is still a large number of them that we know virtually little or nothing about. This is where this paper contributes to the growing body of knowledge by presenting evidence of the relationship between innovation and economic growth from the Nigerian perspective.

The remainder of the paper is structured as follows. Section 2 covers the theoretical and empirical literature. In Section 3, materials and method issues are discussed. The empirical results are presented and discussed in Section 4. The paper is concluded in Section 5.

2 Theoretical and Empirical Literature

Despite its early recognition as in Veblen (1915), the role that innovation plays in driving economic competitiveness did not receive formal acknowledgement in growth theorising until Solow (1956). Ever since, a bourgeoning literature describing various ways by which innovation impacts on economic growth has emerged. While there is considerable agreement with Solow and his neoclassical collaborators (e.g. Denison, 1962; Jorgenson and Griliches, 1967, among others), that application of new knowledge is the key to realising long run growth in GDP per capita, disagreement exists on how this can be realized in practice.

The neoclassical optimism that technology is a public good that is freely available for everyone everywhere to use is not shared by many. It has even been dismissed as a simplistic interpretation in some quarters. On the contrary, critics argue that there is no guarantee that publicly available technology will be freely captured. Appropriability in their view requires some efforts and that countries or organizations that do not possess the needed capability requirements will not succeed in translating innovation into productivity gains (Abramovitz, 1986; Cohen and Levintal, 1990; Lundvall, 1992; Nelson, 1993; Edquist, 1997).

Empirical inquiries that ensued subsequently were largely shaped by the tone of this controversy and substantially undertaken in the context of the technology catch-up or convergence debate. In other words, a major preoccupation of this literature is with providing explanations for the lack of convergence observed for growth performances of developing and developed countries in terms of inadequate capability, on the part of the former, to translate innovation into productivity and hence into improved growth.

A somewhat competing explanation however, emerged in models of endogenous growth that are otherwise referred to as ‘new growth theory’ (Romer, 1986; 1990; Aghion and Howitt, 1992, 1998). Unlike its earlier counterpart which assumes technology to be exogenously driven, this argument proffers that it is endogenously generated and that because of certain impediments like existence of Intellectual Property Rights (IPR), its spillover across borders is likely to be highly limited. Thus, large and developed countries, often assumed to be more innovative than small and developing ones, should be expected to capture the substantial share of benefits from their efforts. One way the latter can appropriate some residual share of these benefits is, according to this theory, through interaction with the innovator. Such interaction, it is further argued, can be facilitated by openness to trade with the innovator.

Trade can make innovation through technology transfer possible through a variety of ways. One of these is importation into beneficiary country of machinery and equipment made in the innovator country. Innovation activities are often codified and embodied in capital goods such that export of such goods to other countries can imply export of new knowledge. In fact, the idea of technology transfer occurring through export of capital goods is what Thomas Veblen, who is widely credited with providing the first concise analysis of the technology catch-up process, used to predict the prospects of Germany catching up with the United Kingdom, the technology leader of the time

(Veblen, 1915). What this implies for the analysis of impact of innovation on economic growth in developing countries is that importation of capital goods should be expected to associate positively with growth.

Early work by Coe et al. (1997), to confirm the foregoing prediction empirically finds that developing countries achieved substantial improvement in their productivities during the 1971-1990 period by importing intermediate products and capital-embodying foreign knowledge. A good review of some of these early literatures can be found in Keller (2004). A fairly recent evidence comes from Jacob and Meister (2005) who applied methods similar to Coe et al.'s, and confirmed similar results for the Indonesian economy. The methodological approach of Coe et al. is however, criticized by Keller (1998) for wanting in robust measure of import variable and cannot therefore be relied upon as providing strong conclusion on the importance of imports as a vehicle for diffusion. This paper contributes to this strand of literature by focusing on the Nigerian economy.

3 Methodology

3.1 Data Sources and Description

Annual data for the period 1970 to 2011 was employed in the study. The choice was warranted by the availability of data throughout the study period. The data was obtained from the *Statistical Bulletin* of the Central Bank of Nigeria and World Bank *Human Development Indicators*. Based on the theoretical framework, economic growth is a function of macroeconomic, institutional and structural factors, including physical and human capital, the level of technology (which embodies innovation) and the degree of openness. Consequently, economic growth was measured by and computed as annual percentage change in real GDP per capita, in line with standard practice; macroeconomic factors were proxied by government size computed as the ratio of total government expenditure to GDP; institutional factors were captured by contract intensive money, computed as the difference between broad money supply and currency held outside circulation as a proportion of broad money supply; trade openness was proxied by the ratio of total trade to GDP; structural factors were measured as the ratio of the share of agriculture to GDP; innovation (reflecting technological transfer, diffusion and knowledge spillover) was measured by expenditure on imported machinery and equipment; human capital was captured by government recurrent expenditure on education. All the variables employed were first transformed into logarithms to account for non-linear properties and heteroscedasticity.

3.2 Model Specification

Following the extant literature, a model is specified which relates economic growth to innovation, macroeconomic, institutional and other key determinants. The empirical model is presented as follows:

$$EG_t = \alpha_0 + \alpha_1 HK_t + \alpha_2 INOV_t + \alpha_3 INS_t + \alpha_4 STR_t + \alpha_5 GS_t + \alpha_6 OPN_t + \varepsilon_t \qquad (1)$$

where:

EG = Economic Growth
HK = Human Capital
INOV = Innovation
INS = Institutional quality

STR = Structure of the economy
GS = Government Size
OPN = Degree of openness
ε_t = A white noise disturbance term

3.3 Model Estimation Procedure

First, the variables employed in the study were investigated in order to determine their stochastic properties, and to facilitate the determination of the appropriate econometric framework used for analysis. The Ng-Perron and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests were used in the present study, in preference to the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests. Although the PP unit root test is generally considered to have a greater reliability than the ADF due to its robustness in the midst of serial correlation and hetersokedasticity (Hamilton, 1994); both have been shown to suffer from high size distortion (Zivot and Andrews, 1992). This study therefore uses the Kwiatkowski-Phillips-Schmidt-Shin (1992) and the Ng-Perron (2001) tests in order to avoid the problems associated with the aforementioned tests.

The test for unit root for a variable J is carried out using the following specification:

$$\Delta J_t = \Phi_0 + \Phi_{1t} + \Phi_2 J_{t-1} + \sum_{i=0}^{p} \lambda_i \Delta J_{t-i} + \varepsilon_t \qquad (2)$$

where, Φ_0, Φ_1, Φ_2 and λ_1, ... λ_p are parameters to be estimated, and ε_t is the disturbance term assumed to be Gaussian white noise.

The unit root tests are followed by the test of cointegration using the Johansen (1988, 1991) framework, in preference to Engle and Granger's (1987) two-step approach, in that the former does not, a priori, assume the existence of at most a single cointegrating vector; instead the number of cointegrating relationships is tested. Moreover, as against the Engel-Granger procedure, which is sensitive to the choice of the dependent variable in the cointegrating regression, the Johansen framework assumes that all the variables in the cointegrating equation are endogenous (Masih and Masih, 2000). Thereafter, the examination of the cointegrating growth equation is carried out. It must be emphasized that the existence of cointegration among a set of time series variables implies the existence of an adjustment mechanism. Although the use of the OLS estimator to generate the cointegrating regression is consistent, it is however fraught with the problem of nonnormal distribution, so that the results of statistical inferences are invalid when the usual tests are executed. It is therefore germane to employ appropriate estimators in order to overcome this problem. In the present study, the Dynamic Ordinary Least Square (DOLS) estimator engineered by Stock and Watson (1993) is adopted. This framework or approach is particularly useful because it introduces dynamics in the model specified while allowing for simultaneity bias. Thus the DOLS estimator of the cointegrating regression equation incorporates all variables in levels, in addition to leads and lags of values of the change in the explanatory variables. The estimated DOLS is specified as follows:

$$Y_t = \alpha_0 + \beta_i X_t + \sum_{j=-q}^{q} \Gamma_i \Delta X_{t-j} + \mu_t \qquad (3)$$

where Y_t is economic growth, X_t is a vector of regressors, previously defined, and Δ is the lag operator.

To overcome the problem associated with the non-normal distribution of the standard errors of the cointegrating regression equation, the specified model was estimated by OLS using the Newey and West's (1987) Heteroscedastic and Autocorrelation Consistent (HAC) covariance matrix estimator, whose standard errors are robust and make inferences about the coefficients of the variables entering the regressors in levels to be valid. Using *Eviews7.1* package, the model was estimated by including 1 lead and 2 lags of the change in the regressors, while lag selection was based on the Schwarz Bayesian Criterion (SBC). Following Hendry's (1986) General to Specific (GETS) methodology, the parsimonious dynamic OLS results are presented. Results of lead coefficients are not reported, to conserve space (the results are available on request). The diagnostics include tests for autocorrelation, misspecification, normality, heteroscedasticity and stability of estimated coefficients.

4 Results and Discussions

4.1 Results

The results of the unit root tests (with intercept and a linear trend) are presented in Table 1.

Table 1 Unit Root Test Results

Table 1(a): Ng-Perron Test

Variable	MZa		MZt		MSB		MPT	
	Level	FD	Level	FD	Level	FD	Level	FD
EG	-3.64756	-19.9810**	-1.25767	-3.15928**	0.34480*	0.15811	23.5455*	4.56968
HK	-15.6232***	-18.7891	-2.79484***	-3.06504	0.17889*	0.16313	5.83317*	4.84997
INOV	-10.5267***	-19.0417	-2.28534***	-3.07370	0.21710*	0.16142	8.69896*	4.85752
INS	-3.44967	-8.03377	-1.27492	-2.00339	0.36958*	0.24937	25.7089*	11.3451
STR	-5.57711	-19.5699**	-1.66308	-3.12126**	0.29820*	0.15949	16.3213*	4.69776
GS	-16.8372***	-17.4277	-2.87533***	-2.95053	0.17077*	0.16930	5.56902*	5.23715
OPN	-9.13800	-18.9262**	-1.73970	-3.05290**	0.19038*	0.16130	11.3841*	4.95570

Table 1(b): Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Test

Variable	Level	1st difference
EG	0.187648**	0.201254
HK	0.074810	0.488136*
INOV	0.081333	0.054736
INS	0.112868	0.158961**
STR	0.091104	0.129527***
GS	0.148411**	0.500000
OPN	0.136965***	0.118317

Note: *, ** and *** denote rejection of the null hypothesis at 1%, 5% and 10% level of significance respectively. FD represents first difference. MZa, MZt, MSB and MPT are modified versions of the Phillips (1987), Phillips-Perron (1988) Za and Zt tests, the Bhargava (1986) R_1 statistic and the point optimal statistic of Elliot, Rothenberg and Stock (1996). The lag lengths are selected based on the Schwarz information criterion.

Source: Authors' computations.

The results of the Ng-Perron tests in Table 1(a) suggest that HK, INOV and GS are stationary in levels for all test types. EG, STR, OPN are stationary in first difference for MZa and MZt. All variables are stationary in levels for MSB and MPT. In Table 1(b), the results of the KPSS tests suggest that the null hypothesis of stationarity for EG, GS and OPN is rejected at levels and accepted in the case of HK, INS and STR at first difference, with INOV rejecting the null hypothesis at both level and first difference. The variables are integrated of different order in both tests, which necessitated a test of cointegration with a view to determining an appropriate estimation technique.

The results of the cointegraton tests are presented in Table 2.

Table 2 Johansen Cointegration Test Results

Table 2(a): Johansen Cointegration Test (Maximum Eigenvalue)

Null	alternative	Statistic	95% Critical Value
$r = 0$	$r \geq 1$	62.77929*	46.23142
$r \leq 1$	$r \geq 2$	32.47615	40.07757
$r \leq 2$	$r \geq 3$	21.79625	33.87687
$r \leq 3$	$r \geq 4$	16.04380	27.58434
$r \leq 4$	$r \geq 5$	11.42135	21.13162
$r \leq 5$	$r \geq 6$	3.549710	14.26460
$r \leq 6$	$r \geq 7$	0.016289	3.841466

Table 2(b): Johansen Cointegration Test (Trace)

Null	alternative	Statistic	95% Critical Value
$r = 0$	$r \geq 1$	148.0828*	125.6154
$r \leq 1$	$r \geq 2$	85.30355	95.75366
$r \leq 2$	$r \geq 3$	52.82740	69.81889
$r \leq 3$	$r \geq 4$	31.03115	47.85613
$r \leq 4$	$r \geq 5$	14.98735	29.79707
$r \leq 5$	$r \geq 6$	3.565999	15.49471
$r \leq 6$	$r \geq 7$	0.016289	3.841466

Note: r indicates the number of cointegrating vectors. * indicates rejection of the null hypothesis at 5% level of significance.

Source: Authors' computations.

Results in Tables 2(a) and 2(b) suggest that there is a long-run equilibrium relationship among the variables of interest. Both the maximal eigenvalues and trace test statistics indicate that the hypothesis of no cointegration among the variables is rejected at the 5% significance level. From the results, there is at least one cointegrating vector based on both the maximal eigenvalues and trace test statistics. The existence of long-term equilibrium relationships among non-stationary variables precludes the results of spurious regression when the variables are used in levels for estimation purposes.

The estimated dynamic OLS results are presented in Table 3.

Table 3 The estimated DOLS Results

Dependent Variable: EG

Variable	Coefficient	Std. Error	t-value
CONSTANT	-1.480309	0.111115	-13.32233(0.0000)
INOV	-0.074305	0.003863	-19.23682 (0.0000)
INS	-0.114014	0.047069	-2.422250 (0.0227)
STR	-0.150246	0.054602	-2.751690 (0.0107)
GS	-0.026007	0.020903	-1.244172 (0.2245)
Δ STR $_t$	0.356448	0.053560	6.655168 (0.0000)
Δ INOV $_{t-1}$	0.040707	0.008931	4.557660 (0.0001)
Δ STR $_{t-1}$	0.222864	0.037954	5.871981 (0.0000)
Δ HK $_{t+1}$	0.015172	0.003069	4.943393 (0.0000)
Δ OPN $_{t+1}$	-0.027038	0.013750	-1.966387 (0.0600)
Δ HK $_{t-2}$	0.027438	0.006535	4.198607 (0.0003)
Δ INOV $_{t-2}$	0.027851	0.009310	2.991316 (0.0060)

Diagnostic Statistics

R^2	0.98
Adjusted R^2	0.98
F-statistic	200.3654 (0.000000)
SER	0.026040
DW	1.71
BG: $[\chi^2, 2]$	0.569842 (0.7521)
$[\chi^2, 3]$	0.807936 (0.8476)
$[\chi^2, 4]$	0.868422 (0.9290)
ARCH: $[\chi^2, 1]$	0.068693 (0.7932)
$[\chi^2, 2]$	0.750939 (0.6870)
$[\chi^2, 4]$	2.286134 (0.6833)
JB	2.643028 (0.266731)
RESET (t-stat.)	0.354896 (0.7256)

Note: Probability values are in brackets. DW: Durbin-Watson statistic for autocorrelation; BG: Breusch-Godfrey Serial Correlation LM Test; SER: Standard error of regression; ARCH: Engle's test for conditional heteroskedasticity; JB: Jarque-Bera test for normality of residsuals; RESET: Ramsey's test for specification error.

Source: Authors' computations.

4.2 Interpretations and Discussion

The estimated results in Table 3 show that with the exception of government size (GS), all the explanatory variables are statistically significant. Thus, macroeconomic, institutional and structural factors, in addition to human capital, innovation, and the degree of openness are vital factors that impact economic growth. Discussion of results for the variable of interest, i.e. innovation is first presented, followed by other variables used as controls.

4.2.1 Variable of Interest

Innovation: The lagged coefficients of innovation are statistically significant at the 1% level. Thus, past levels of innovation are beneficial to economic growth. The implication is that for higher economic performance to be experienced, the level of technologies (embodied in capital goods imports), including their adaptation is crucial. The imperatives of technological progress in terms of new knowledge and innovation (referred to as new accumulation factors) are key drivers of long–run economic growth with significant sources of growth coming from new knowledge (Romer, 1990; Grossman and Helpman, 1991) and innovation (Aghion and Howitt, 1992).

The result of the current period coefficient of innovation indicates that it is growth-undermining. This suggests that innovation activities tend to take some time before its impact on growth is felt. This is understandable given that huge expenditure on capital goods, research and development and the like might not immediately translate into desired goods and services. The wisdom here is that the importation of technology-embodied capital goods would require time to improve current production levels, due inevitably to set up and associated costs. For example, technological product innovation involves the implementation/adoption of new or significantly improved production or delivery method, which may involve changes in equipment, human resources, working methods or a combination of these, all of which are not likely to be achieved within a short period. Thus the sign of the current period coefficient of innovation is not out of place.

4.2.2 Control Variables

Human Capital: Human capital was used to measure the degree of labour quality. The coefficients of human capital are all statistically significant and are positively related to growth and are therefore in line with the prediction of theory. The results are consistent with empirical studies linking labour quality to productivity and economic growth (Barro, 2001). It is known that investment in human capital promotes technological innovation and adaptation which reflects in economic growth and thus fosters improved economic performance (Barro and Sala-i-Martin, 1997).

Institutions: Institutional quality and capacity is crucial to growth. The current period coefficient of the institutional variable is highly statistically significant and negatively related to economic growth. This tends to suggest that for the Nigerian economy, the quality of its institutions has not been effective in improving growth. The expectation is that institutions matter for improved economic performance via higher growth so that, the higher the capacity of institutions, the better it is for growth and the performance of the economy (Olson, 1993; North, 1990; Nelson and Sampat, 2001; Rodrik et al., 2002; Acemoglu et al., 2003). The result is not implausible given the nature of the various institutions in Nigeria. The country has not scored very highly in various institutional indicators such as the corruption perception and governance indices which over the years have been consistently worsened. Consequently, weak administrative, political and legal systems have not helped the real sector of the economy in a significant way. The result is consistent with previous study (Iyoboyi and Pedro, 2014).

Structure of the economy: The coefficients of changes in current and lagged values of agricultural component of GDP are positively related to growth, while the current value of agricultural component of total GDP is negative. The implication of the latter is that a higher share of agriculture in total GDP is associated with lower economic growth and performance, while transition (changes) from agriculture to manufacture or service (implied in the former) indicates that higher growth is associated with industrialization. This is in line with findings linking transition of economic activity from agriculture to industrial or manufacturing sectors to higher economic growth (Jaumotte and Spatafora, 2007).

Government Size: The result of the coefficient of government size indicates a non-statistically significant negative relationship. This implies that government expenditure tends to be harmful to growth. Although the results of empirical studies are mixed, what may be inferred from the result is that the Nigerian experience tends to be supportive of the view that a large and growing government size is not beneficial to higher economic growth due to the inefficiencies and distortions arising from government interventions. This is amply supported by a number of empirical studies (Barro, 1991; Folster and Henrekson, 2001; Anaman, 2004).

Openness: The one-period lead openness coefficient is statistically significant, implying that higher degrees of openness tend to be harmful to growth. Although several studies including Dollar and Kraay (2004) maintain that higher degrees of openness can generally affect growth positively through higher propensity for technological diffusion, this depends on the relative proportion of imports and exports that enter into the computation. If total trade is in favour of higher imports of consumption rather than production or capital goods, and higher imports relative to exports, the impact of openness on economic performance may be moot. Based on the indicator used (total trade as a component of GDP) this might have introduced a bias, as Nigeria's trade flows are not in favour of higher non-oil exports. Given the dominance of crude oil sale in Nigeria's export trajectory, the results are hardly surprising. In addition, the degree of openness in itself is less helpful in analyzing growth unless it is coupled with the quality of macroeconomic policies, suitable business regulations, in addition to supporting market-based institutions and dynamic labour markets (Chang et al., 2005).

Diagnostic Statistics: The diagnostic statistics for the estimated model are satisfactory. The overall fit of the estimated model exemplified by the Adjusted R^2 value of 0.98 shows that the independent variables employed jointly accounted for 98 percent of the total variation in growth. There is joint significance of all the variables employed, as indicated by the F-Statistic and its associated probability. Moreover, the estimated model satisfies the diagnostic Durbin-Watson (DW) and Breusch-Godfrey (BG, at various lags) serial correlation tests, the p-values of which reject the null hypothesis of serial correlation in the residuals. The model passes the test of normality, in that the JB statistic of 2.643028 and the probability of obtaining the value, on the basis of the normality assumption of 27%, indicate that the null hypothesis of normally distributed error term cannot be rejected. The null hypothesis of heteroscedasticity is rejected at the 1% level of significance at the specified lag lengths. In addition, the Ramsey residual error specification test indicates that the model is correctly specified.

4.2.3 Stability test

The cumulative sum of recursive (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) tests were used to determine the stability of the coefficients of the estimated model. The CUSUM and CUSUMSQ tests are shown in Figures 1 and 2.

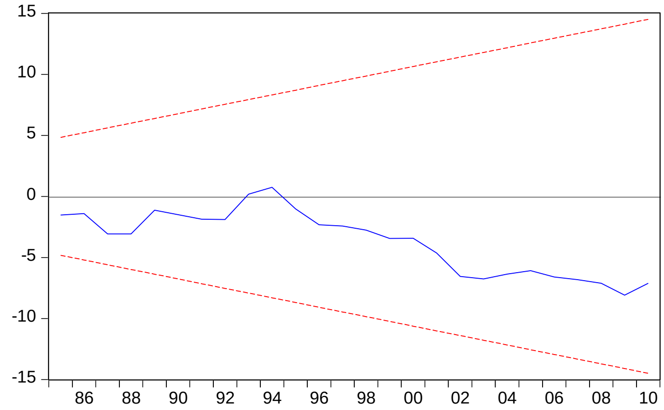

Figure 1. CUSUM Test
5% Significance

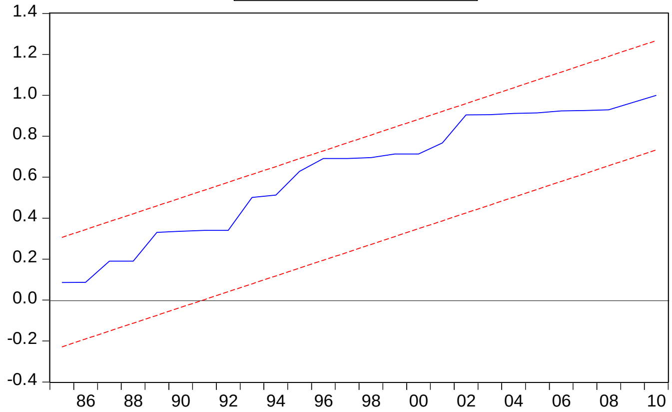

Figure 2. CUSUM of Squares Test
5% Significance

From Figures 1 and 2, both the CUSUM and CUSUMSQ plots do not cross the 5% critical lines, implying that over the entire sample period of investigation, the stability of the estimated coefficients exist, so that the regression coefficients are reliable and suitable for policy making.

5 Concluding Remarks

The results are of the paper which investigates the impact of innovation on Nigeria's economic growth, using annual data for the period 1970 to 2011 and employing the Dynamic OLS methodology are in favour of a long-run equilibrium relationship between the dependent variable (economic growth) and the main explanatory variable of interest (innovation, proxied by technology-embodied capital imports). Other variables used as controls that also impacted positively on growth are human capital and structure of the economy. Contrarily, proxies for other control variables that include openness to trade, high share of government expenditure and the quality institutions were found to have impacted negatively on economic growth.

The association between growth and technology-embodied capital imports is evidence that innovation impacts positively on economic growth. This is consistent with the findings of some previous works in this area. The major policy implication of this finding is that efforts to enhance economic growth must deliberately seek for ways to promote application of knowledge factor in economic activities. As captured in the present study, promoting intensive use of capital equipment represents one sure way of bringing this agenda into fruition.

6 References

Abramovitz, M. (1986). "Catching Up, Forging Ahead, and Falling Behind". *Journal of Economic History* 46, 386-406.

Acemoglu, D., Johnson, S., Robinson, J. and Thaicharoen, Y. (2003). "Institutional causes, macroeconomic symptoms: volatility, crises and growth," *Journal of Monetary Economics* 50, 49-123.

Aghion P. and Howitt P. (1992). "A Model of Growth through Creative Destruction", *Econometrica* 60, 323-351.

Aghion, P. and Howitt, P. (1998). *Endogenous Growth Theory*. Cambridge (MA), MIT Press.

Anaman, K. A. (2004). "Determinants of economic growth in Brunei Darussalam", *Journal of Asian Economics* 15, 777-796.

Barro, R. and Sala-i-Martin, X. (1997). "Technological Diffusion, Convergence, and Growth." *Journal of Economic Growth* 2, 1–26.

Barro, R. J. (1991). "Economic Growth in a Cross Section of Countries", *Quarterly Journal of Economics* 106, 407–443.

Barro, R. J. (2001). "Human Capital and Growth," *American Economic Review* 91, 12–17.

Bhargava, A. (1986). "On the Theory of Testing for Unit Roots in observed Time Series", *Review of Economic Studies* LIII, 369-384.

Bhargava, A. (1986). "On the Theory of Testing for Unit Roots in Observed Time Series". *The Review of Economic Studies* 53, 369–384.

Brown, R.L., Durbin, J. and Evans, J.M. (1975). "Techniques for Testing the Constancy of Regression Relations over Time". *Journal of the Royal Statistical Society* 37, 149-192.

Chang, R., Kaltani, L. and Loayza, N. (2005). Openness Can Be Good for Growth: The Role of Policy Complementarities. National Bureau of Economic Research (NBER), Working Paper No. 11787.

Coe, D. T., Helpman, E. and Hoffmaister, A.W. (1997). "North-South R&D Spillovers". *Economic Journal* 107, 134-149.

Cohen, W M. and Levinthal, D.A. (1990). "Absorptive Capacity: A New Perspective on Learning and Innovation". *Administrative Science Quarterly* 35, 128-152.

Denison, E. (1962). *The Sources of Economic growth in the States and the Alternatives before Us.* New York: Committee for Economic Development.

Dollar, D. and Kraay, A. (2004). "Trade, Growth, and Poverty." *Economic Journal* 114, 22–49.

Edquist, C. (1997). *Systems of Innovation: Technologies, Institutions and Organizations*. London: Pinter.

Elliott, G., Rothenberg, T.J. and Stock, J.H. (1996). "Efficient Tests for an Autoregressive Unit Root," *Econometrica* 64, 813-836.

Engle, R.F. and Granger, C.W.J. (1987). "Co-integration and Error Correction: Representation, Estimation, and Testing". *Econometrica* 55, 251–276.

Folster, S. and Henrekson, M. (2001). "Growth effects of Government Expenditure and Taxation in rich countries". *European Economic Review*, 45, 1501-1520.

Granger, C.W.J. (1969). "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods". *Econometrica* 37, 424–438.

Grossman, G. and Helpman, E. (1991). "*Innovation and Growth in the Global Economy*" Cambridge, Mass., MIT Press.

Hamilton, J.D. (1994). *Time Series Analysis*, Princeton University Press, Princeton, New Jersey.

Hendry, D.F. (1986). "Econometric Modeling with Cointegrated Variables: An Overview". *Oxford Bulletin of Economics and Statistics* August, 201-212.

Iyoboyi, M. and Latifah, M. Pedro (2014), "Institutional Capacity and Macroeconomic Performance: Empirical Evidence from Nigeria". *Research in Applied Economics*, 6(1), 38-60.

Jacob, J. and Meister, C. (2005). "Productivity gains, technology spillovers and trade: Indonesian manufacturing, 1980-96," *Bulletin of Indonesian Economic Studies* 41, 37-56.
Jaumotte F. and Spatafora, N. (2007). Asia Rising: A Sectoral Perspective. IMF Working Paper No. 07/130.
Johansen, S. (1988). "Statistical analysis of co-integrating vectors", *Journal of Economic Dynamics and Control* 12, 231–254.
Johansen, S. (1991). "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models". *Econometrica* 59, 1551-1580.
Jorgenson, D. and Griliches, Z. (1967). "The Explanation of Productivity Change", *Review of Economic Studies* 34, 249-284.
Keller, W. (1998). "Are International R&D Spillovers Trade Related? Analyzing Spillovers among Randomly Matched Trade Partners". *Europ. Econ. Rev.* 42, 1469–1481.
Keller, W. (2004). "International Technology Diffusion". *Journal of Economic Literature* 42, 752-782.
Kwiatkowski, D., Phillips, P. C. B., Schmidt, P. and Shin. Y. (1992). "Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root". *Journal of Econometrics* 54, 159–178.
Lundvall, B. A. (ed.) (1992). *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter Publishers.
Masih, R. and Masih, A.M.M. (2000). "A Reassessment of Long-run Elasticities of Japanese Import Demand". *Journal of Policy Modelling* 22, 625-639.
Nelson, R. (1993). *National Innovation Systems: A Comparative Analysis*. New York: Oxford University Press.
Nelson, R. R. and Sampat, B. N. (2001). 'Making sense of institutions as a factor shaping economic performance', *Journal of Economic Behaviour and Organisation* 44, 31-54.
Newey, W. and West, K. (1994). "Automatic Lag Selection in Covariance Matrix Estimation". *Review of Economic Studies* 61, 631–653.
Ng, S. and Perron, P. (2001). "Lag Length Selection and the Construction of Unit Root Tests with Good Size and Power," *Econometrica* 69, 1519-1554.
North, D.C. (1990). *Institutions, Institutional Change and Economic Performance*, New York: Cambridge University Press.
Olson, M. (1993). "Dictatorship, Democracy and Development". *The American Political Science Review* 87, 567-576.
Phillips, P.C.B. (1987). "Time Series Regression with Unit Roots," *Econometrica* 55, 277-302.
Phillips, P.C.B. and Perron, P. (1988). "Testing for a Unit Root in Time Series Regression". *Biometrika* 75, 335–346.
Rodrik, D A., Subramanian, A. and Trebbi, F. (2002). "Institutions Rule: The Primacy of Institutions over Geography and Integration in Economic Development", *Journal of Economic Growth* 91, 131-165.
Romer, P. M. (1990). "Endogenous Technological Change", *Journal of Political Economy* 98, 71-102.
Romer, P.M. (1986). "Increasing Returns and Long-run Growth". *Journal of Political Economy* 94, 1002-1037.
Solow, R.M. (1956). "A Contribution to the Theory of Economic Growth". *Quarterly Journal of Economics* 70, 65-94.
Stock, J.H. and Watson, M. (1993). "A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems". *Econometrica* 61, 783-820.
Veblen, T. (1915). *Imperial Germany and the Industrial Revolution*. New York: Macmillan.
Zivot, E. and Andrews, D. (1992). "Further Evidence of the Great Crash, the Oil-Price and the Unit-Root Hypothesis", *Journal of Business and Economics Statistics* 10, 251-270.