MOBILE BROADBAND AND ECONOMIC GROWTH IN NIGERIA

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Abstract: *The scale of diffusion of mobile wireless broadband technology and its transformational effect across all sectors of the economy cannot be over emphasised. It enables the creation of new business processes/product innovation, thereby boosting job creation, as well as raising economic growth and productivity. This suggests that the mobile broadband is a general-purpose technology capable of producing a protracted critical mass effect at a certain threshold of penetration. It is against this backdrop that this paper examines the impact of mobile broadband on economic growth in Nigeria. Using the Endogenous Growth Model, we employ ARDL Bounds Testing Approach and Toda Yamamoto Granger Causality test on quarterly data from 2001 to 2016, to estimate the growth effect of mobile broadband. The findings show that mobile broadband is impacting economic growth positively in the Nigerian economy. It is therefore imperative for policymakers to design policies that will increase access to broadband infrastructure to both the unserved and underserved. It is also imperative to enact policies and regulations that can stimulate the economic impact of mobile broadband technology by strengthening the capacity of the economy to fully absorb the transformational benefits and make productive use of it as a General-Purpose Technology.*

Keywords: mobile broadband; economic growth, ARDL model, Toda-Yamamoto Granger Causality test, Nigeria.

JEL classification: O31, O33, O47.

1. Introduction

There is a growing recognition of the transformational role mobile internet broadband play in enabling economic development among academics and policy makers around the world (World Bank, 2016; UNDP, 2016). The United Nations and the World Bank have both identified internet broadband as very crucial in empowering people, lifting people out of poverty through job creation, and creating a conducive environment for business and technological innovation as well as enabling developing countries to achieve the targeted Strategic Development Goals. This growing recognition of the economic impact of broadband penetration has spurred massive investment and deployment of broadband infrastructure in both developed and developing countries over the last decade (Minges, 2015).

Mobile wireless broadband deployment in most developing countries have witnessed unprecedented rapid growth in the last decades. This is largely due to a number of factors such as privatization and trade liberalization policies, as well as advances in telecommunication technology. All these have given rise to lower network installation cost and greater service affordability (GSMA, 2014; Minges, 2015). The scale of diffusion of

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mobile wireless broadband technology and the transformational effect it continues to have across all sectors of the economy cannot be over emphasized. It enables the creation of new business processes/product innovation and thereby boosting job creation. It also raises economic growth and productivity. This suggests that the mobile broadband is a general-purpose technology capable of producing a protracted critical mass effect at a certain threshold of penetration (Bresnahan and Trajtenberg, 1995; Roller and Waverman, 2001; Koutroumpis, 2009).
Investments in mobile wireless broadband infrastructure and its corresponding adoption have witnessed exponential growth rate in Nigeria over the last decade following the liberalisation policy reforms of the Nigerian Telecommunication industry in 2001. With the poor state of the fixed wire/wireless internet infrastructure deployment in Nigeria, mobile broadband continues to be a major source of internet access for the majority of the citizens accounting for over 95% of total internet connections in the country and estimated to have contributed over $6 billion to national GDP in 2016. The mobile broadband market grew from less than 400,000 active subscribers in 2001 to approximately 92 million active subscribers in the last quarter of 2016. This account for a penetration rate of 48% of the total population, which is well above the 20% threshold level that is required for countries to achieve the critical mass that will enable economic benefits of broadband investment (Nigerian Communications Commission, 2016).
Even though the social and economic importance of mobile broadband has now been recognized by policymakers and researchers, a thorough survey of the extant literature reveals that there is a paucity of empirical studies on the long-term effect of mobile broadband network penetration on economic growth in Sub-Saharan Africa (Minges, 2015). Most of the existing studies have focused either on developed countries in the European Union and OECD countries (Waverman, Meschi and Fuss, 2005; Qiang and Rossotto, 2009; Koutroumpis, 2009; and Czernich et al., 2009) or developing countries in Latin America and the Caribbean (Garcia Zaballos and Lopez-Rivas, 2012). Out of the few studies that have investigated the long-term effect of mobile wireless broadband on economic growth in Sub-Saharan Africa, a great number of them have been panel studies plagued with issues of oversimplification of heterogeneity across countries giving rise to biased coefficient estimates (Waverman et.al., 2005; Deloitte 2012). In Nigeria, the study by Olusola and Christianah (2013) listed the benefits of broadband penetration to the Nigerian economic development. Thus far, no known country specific time series empirical study has been carried out in Africa, to understand the relationship between mobile broadband network penetration and economic growth. Therefore, this study attempts to fill this research gap.

2. Overview of Mobile Telecommunication in Nigeria: Stylized facts
Nigeria has one of the largest mobile telecommunication industries in Africa, worth over USD 60 billion, and contributes an average of 8% to GDP over the last decade and estimated to contribute 25% of GDP by 2025 (Nigerian Communications Commission, 2016). The industry provides mobile voice and text message communication services on one hand and provides mobile broadband services on the other hand. With rising but relatively low mobile voice and broadband penetration rates of 81.43% and 49.29% respectively, there is growth potential and thus the sector continues to attract considerable investment into the country (GSMA, 2014).
The aggregate investment into the Nigerian telecommunication industry grew from US$50 million in 2001 to US$ 68.2 billion in 2016. For instance, out of the total investment flow into the telecommunication sector in Sub-Saharan Africa between 1998 and 2008, estimated to be US$ 5 billion a year, it was reported that Nigeria and South Africa alone accounted for over 60% of the investment. The remaining 40% was distributed among all the other

countries in the sub region (Foster and Briceño-Garmendia, 2011). Indeed, over 75% of the Foreign Direct Investment capital stock invested in the Nigerian Telecommunication sector has concentrated in mobile network operations, although fixed-line networks have started to experience an upsurge in investments as well. It is also worthy to note that most of the investments have been green-field investments rather than the acquisition of existing networks (National Bureau of Statistics, 2016).
The mobile telecommunication sector in Nigeria is classified into two categories according to technology type; Global System for Mobile Communications Technology (GSM) and Core Division Multiple Access Technology (CDMA). GSM Mobile connections are by far the most dominant form of mobile subscriptions and accounted for 99.09% of the total telecommunication subscribers in the country as at December 2015, up from 98.45% a year before, leaving CDMA with only a marginal share of the total telecom subscriptions. The share of GSM subscriber market continues to grow over the past year in contrast to a corresponding decline in the market share of CDMA from 1.46% subscriptions to 0.79% between March 2015 and March 2016. The dominance of GSM over CDMA is not unique to the Nigerian mobile telecom industry alone but it is rather due to the flexibility it offers subscribers to switch networks as well as roaming accessibility (Nigerian Communication Commission, 2016).

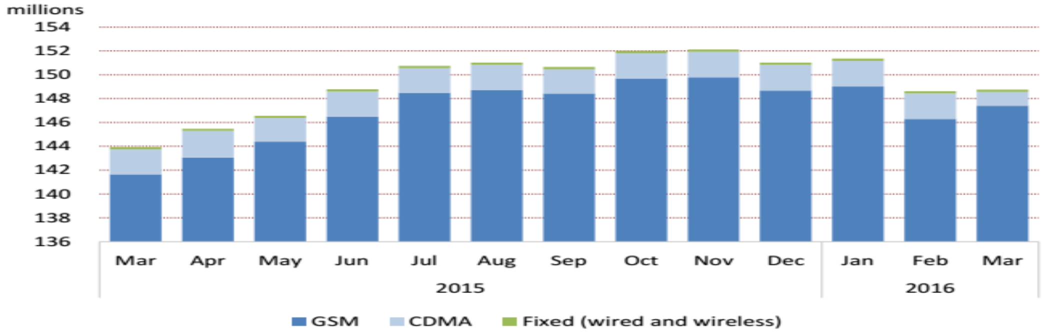

Figure 1: Monthly telecommunication subscription according to technology type, March 2015- March 2016.
Source: National Bureau of Statistics (Nigeria), 2016.

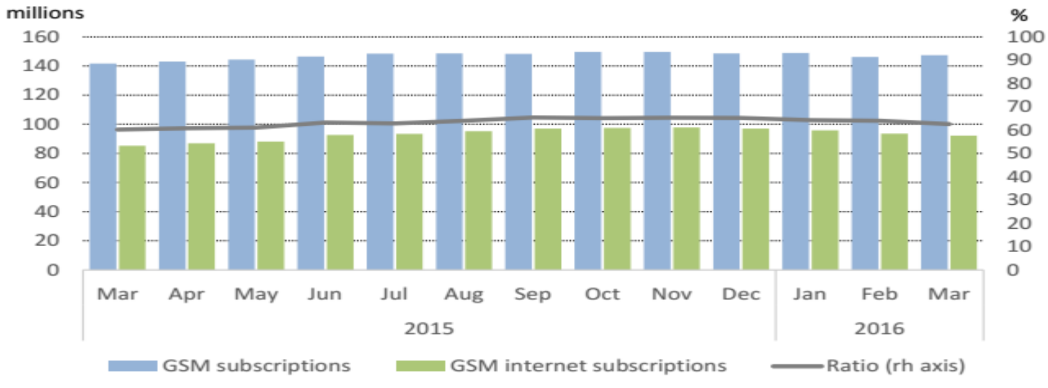

Figure 2: GSM voice and broadband subscriptions, March 2015- March 2016.
Source: National Bureau of Statistics (Nigeria), 2016.

3. Literature Review

3.1. Theoretical Framework: Endogenous Growth Model

The theoretical foundation underpinning the relationship between mobile broadband network penetration and aggregate economic growth is the endogenous growth theory due to its emphasis on both technological effects and network externalities on the economy. The technological effects of mobile telephony are concerned with improving cost efficiency and thereby increasing productivity through product and process innovation, while the network externalities is concerned with the indirect non-compensational marginal benefits that subscribers derived from being on the network at a certain subscription percentage threshold (Katz and Shapiro, 1985; Capello and Nijkamp,1996). The most important innovation in the endogenous growth model over the Solow model was suggested by Paul Romer (1986) who not only emphasised the endogeneity of the productivity function and its implication on economic growth but also the ability of capital to enjoy an increasing return to scale depending on the scale of net investment employed. In other words, growth is a function of investments in physical and human capital resulting from a profit-maximising agent's deliberate decisions. Lucas (1988) and Grossman and Helpman (1991) also contributed in developing and testing the endogenous growth model known as New Growth Theory. The theoretical model adopted in this paper is a simple AK endogenous growth model based on its aggregate production function that incorporate technology, and in this case mobile technology:

$$Y_t = A_t\ (K_t) \qquad 3.1$$

Where Y_t represents the real aggregate output of goods and services in the economy, and $K_{t,}$ represents a broad aggregate measure of capital stock (physical capital, human capital, public infrastructure) in the economy. A_t represents endogenous technical change (A>0). Capital ($K_t = \infty$) assumes an increasing return to scale depending on the level of net investment employed (Barro and Sala-i-Martin, 1992).

$$Y_t = f\,(K_{t,}\ L_{t,}, Mobile\ teledensity_t\ ) \qquad 3.2$$

The aggregate production in equation 3.1 can be expanded into equation 3.2 where aggregate economic growth ($GDP_{t,}$,) is a function of physical capital $K_{t,}$, labour $L_{t,}$ as well as the stock of mobile broadband internet telecommunication infrastructure approximated by $Mobile\ Broadband\ internet\ teledensity_{t,}$ where $GDP_{t,}$, represent GDP at time *t*. Following Gruber and Koutroumpis (2011), the role of stock of mobile broadband internet telecommunication infrastructure is deliberately acknowledged in the model in line with the objective of the study which focuses on the effect of mobile broadband internet telecommunication infrastructure on economic growth.

3.2. Transmission Channels through which Mobile Broadband stimulates Growth

Review of literature reveals the transmission channels through which mobile wireless broadband leads to economic growth; Employment generation; Productivity gains; Consumer surplus; improved market efficiency and financial inclusion (Bhavnani et.al, 2008; Gruber, Hatonen and Koutroumpis, 2014; GSMA, 2015).
International Telecommunications Union (ITU, 2012) categorise the transmission channels of broadband on the economy into four stages. The first stage has to do with the deployment of broadband infrastructure. This creates output and generates employments in many sectors of the economy, with a multiplier effect. The output is created in manufacturing and construction, and employment is generated in engineering, high-tech, and communication

services sectors during the build-up of these networks and well after their completion. The second stage is through the improvement in the general infrastructure level in the country, this improve service delivery, which is the spill-over effect. The development in broadband infrastructure lead to the development in other infrastructure such as electricity. Broadband infrastructure cannot operate where there is no electricity, to develop broadband infrastructure will stimulate the development of electricity infrastructure among others. The third stage effect is actually the usage of the broadband which brings about increase in the production efficiency, and market access, this leads to increase in income, and aggregate demand. The fourth and final stage transmission channels is the consumer surplus, which has to do with the difference in what the household would be willing to pay and what they are actually paying for increase access to information, entertainment, public services etc. The impact of broadband on the economy can be summarised into:

i. Contribution to employment and output of broadband deployment
ii. Improvement in firms' efficiencies and market access
iii. Contribution to economic growth and productivity gains (spill over effect or positive externality)
iv. Creation of consumer surplus, which also add to income gains

4. Research Methodology: Model Specification, Data, and Estimation

4.1. Model specification

This study adopted a simple endogenous technical change model proposed by Barro (1991) to analyze the aggregate impact of mobile phone penetration on economic growth, as follows:

$$Y_t = f\left(K_{t,}\ L_t, Mbb_t, X_{t,} \varepsilon_t\right) \qquad 4.1$$

Where Y is production output represented by a change in economic growth (GDP per capita) i.e.

$$Y_t = \ (\Delta rgdppc_t) \qquad 4.2$$

Incorporating (4.2) into (4.1) gives the model specifications, hence:

$$Y_t = \ (\Delta rgdppc_t) = f\left(K_{t,}\ L_t, Mbb_t, X_{t,} \varepsilon_t\right) \qquad 4.3$$

Expanding equation 4.3 gives:

$$l_n[rgdppc_t] = \propto_1 + \beta_1 l_n[\Delta rgdppc_{t-1}] + \beta_2\ l_n[\Delta Mbb_t] + \ \beta\gamma X_t\ + \varepsilon_t \qquad 4.4$$

Where,

Rgdppc = growth in real GDP per capita (dependent variable)
Mbb = growth in mobile broadband network penetration (variable of interest)
X is a set of growth determinants as control variables (aggregate investment, labour force, human capital).
ε_t denotes the error term in period *t* respectively.

4.1.1. The Autoregressive Distributive Lag Model

This analysis would be employing a robust econometric technique of Autoregressive Distributive Lag (ARDL) model to test both the long- and short-run relationship between the economic growth and the mobile broadband network penetration in Nigeria. The main reason why this method was preferred to others was its unique feature of not requiring that the variables be integrated of the same order pretests for the unit roots (Hamuda et.al., 2013), however, it is weak when the variables are greater than order one i.e. I(2). Also, ARDL estimations is robust in the presence of small sample size, it also allows for variables to have different optimal lags, and endogeneity is less of a problem in the ARDL technique because it is free of residual correlation. Therefore, the following basic model of ARDL model was estimated:

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{n} \beta_i \Delta y_{t-1} + \sum_{i=0}^{n} \delta_i \Delta x_{t-1} + \varphi_1 y_{t-1} + \varphi_2 x_{t-1} + \mu_t \qquad 4.5$$

Where:

B_i and δ_i are the short run coefficients, with Δ as the first-difference operator. The φ_1 and φ_2 are the ARDL long run coefficients and μ_t is the error term. Y_t is the dependent variable which in this case is the real GDP per capita, and X_t's are the independent variables which in this case are the Mobile broadband subscription per 100 (Mbb), Gross fixed capital formation as a share of GDP (GFCF), inflation rate (CPI), and Adult literacy rate as a ratio of the total population (Adultlit). It should also be noted that ARDL model includes the same lagged terms as would be done in an Error Correction Model (ECM), but without restricting the coefficients.

4.1.2. Toda and Yamamoto approach to Granger causality test

We employed a modified Wald test as proposed by Toda and Yamamoto (1995), for the causality test. This test avoids the problems associated with the ordinary Granger causality test by ignoring any possible non-stationary or cointegration between series when testing for causality. The Toda and Yamamoto (1995) approach fits a standard vector autoregressive model in the levels of the variables, as against the case with the first difference fit with Granger causality tests. This minimize the risks associated with the possibility of wrongly identifying the order of integration of the series (Mavrotas and Kelly, 2001). The application of the Toda and Yamamoto (1995) procedure ensures that the usual test statistic for Granger causality has the standard asymptotic distribution where valid inference can be drawn.

The Toda and Yamamoto (1995) version of the Granger non-causality test for Mobile broadband network penetration-GDP per capita model we employed, is represented in the following VAR system:

$$Y_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} Y_{t-i} + \sum_{j=k+1}^{d_{max}} \alpha_{2j} Y_{t-j} + \sum_{i=1}^{k} \emptyset_{1i} Mbb_{t-i} + \sum_{j=k+1}^{d_{max}} \emptyset_{2j} Mbb_{t-j} + \lambda_{1t} \qquad 4.6$$

$$Mbb_t = \beta_0 + \sum_{i=1}^{k} \beta_{1t} Mbb_{t-1} + \sum_{j=k+1}^{d_{max}} \beta_{2j} Mbb_{t-j} + \sum_{i=1}^{k} \delta_{1i} Y_{t-i} + \sum_{j=k+1}^{d_{max}} \delta_{2j} Y_{t-j} + \lambda_{2t} \qquad 4.7$$

From Eq (4.6), Granger causality from Mobile broadband network penetration ($Mbb_{t)}$ to GDP per capita (Y_t) implies $\emptyset_{1i} \neq 0 \ \forall_i$; similarly, in Eq (4.7), Y_t Granger causes Mbb_t, if $\delta_{1i} \neq 0 \ \forall_i$. the model is estimated using Seemingly Unrelated Regression (SUR) (see, Rambaldi and Doran, 1996).

4.2. Data Description

Table 1: Variables employed to measured Mobile broadband network penetration impact on Economic Growth and sources

Variable	Period: 2002Q1-2016Q4	Sources	Data frequency	Rationale	A priori expectation
Economic growth	Real Per capita GDP (constant LC)	Central Bank of Nigeria	Quarterly	Depende nt variable	
Mobile broadband network penetration	Mobile Broadband Subscription per 100	Nigerian Communicati on Commission	Quarterly	Variable of interest	β>0
Physical stock of capital	Gross fixed capital formation as a share of GDP	Nigerian Bureau of Statistics	Quarterly	Control variable	β>0
Consumer price Index	Inflation rate	Nigerian Bureau of Statistics	Quarterly	Control variable	B<0
Human Capital	Adult Literacy as a percentage ratio of total population	UNESCO Statistics	Quarterly	Control variable	β>0

Source: Computed by the authors

5. Estimation Result Analysis

5.1. Unit Root Test

The results of the stationarity test are presented in Table 2 using the Augmented Dickey Fuller and Philip Peron test. It shows that all the variables used in the analysis were not stationary at level, with the exception of GDP per capita and consumer price index. They became stationary at the First difference. Due to the presence of a stationarity problem, we decided to use ARDL since it allows the analysis of variables that became stationary at first difference and does not discriminate against the combination of I(0) and I(1). We are applying ARDL bounds testing approach to test the existence of cointegration among the variables for the establishment of a long run relationship.

Table 2: Stationarity test results

Variables	ADF	Philip-Peron	Decision
Lnrgdppc	0.0481 -2.9287**	0.0024 -4.033	I(0)
D(lnMbb)	0.0000 -7.2908***	0.0000 -7.2738***	I(1)
D(lnadultlit)	0.0285 -3.1414**	0.0162 -3.3626**	I(1)
D(Lngfcf)	0.0000 -5.6837***	0.0000 -5.6837***	I(1)
Lncpi	0.0904 -3.2182*	0.0000 -6.7790***	I(0)

Source: Computed by the authors

5.2. Lag Selection Criteria

In using ARDL, we start with the selection criteria in which final prediction error, Akaike information criteria, and Hannan-Quinn information criteria chose maximum lag of 8.

Table 3: VAR Lag Order Selection Criteria

Endogenous variables: LNRGDPPC LNMBB LNADULTLIT LNGFCF LNCPI						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	10.74632	NA	5.60e-07	-0.205226	-0.024391	-0.135116
1	317.0234	546.9234	2.44e-11	-10.25084	-9.165827*	-9.830180
2	359.3588	68.03900	1.34e-11	-10.86996	-8.880772	-10.09875
3	385.0385	36.68529	1.39e-11	-10.89423	-8.000873	-9.772483
4	409.0104	29.96483	1.61e-11	-10.85751	-7.059979	-9.385217
5	460.2779	54.92955*	7.62e-12	-11.79564	-7.093931	-9.972798
6	494.9821	30.98584	7.38e-12	-12.14222	-6.536333	-9.968827
7	543.7267	34.81759	5.22e-12	-12.99024	-6.480180	-10.46630
8	599.7665	30.02132	3.88e-12*	-14.09880*	-6.684570	-11.22432*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion
Source: Authors' computation.

5.3. ARDL Bound Testing Approach to cointegration

Table 4 present the result of the ARDL bounds test. The F-statistic valued as depicted in the diagram is compared to the upper I(1) and lower I(0) critical bound so as to determine the presence of cointegration among the variables. If the F-statistic is lower than the lower critical bound I(0), we can conclude that no presence of cointegration among the variables exists. In the same vein, if the F-statistic value is greater than the upper critical bound I(1), we conclude that the variables are co-integrated, and if the value falls between the lower I(0) and upper I(1) bound, the conclusion for cointegration is inconclusive and we may have to consider alternative measures to determine the presence of cointegration. Our analysis showed that the F-statistic value is greater than the upper critical bound of both Pesaran and Narayan at 2.5% and 1% levels respectively. Thus, we conclude that a unique long-run relationship exists between the variables.

Table 4: ARDL bounds test approach to cointegration.

Test statistic	**Value**	**K**
F-statistic	4.5996	4
Critical Value Bounds		
Significance	**I0 Bound**	**I1 Bound**
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49***
1%	3.74	5.06

*** denote cointegration at the 1% significance level based on Pesaran critical bounds table.
Source: Authors' computation.

5.4. The Association between Mobile Broadband Internet and Economic Growth

Table 5: ARDL Long Run Cointegration Result.
Dependent Variable: Real GDP Per Capita

Long Run Coefficients				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LNMBB	0.155841	0.051763	3.010681	0.0041
LNADULTLIT	-0.158338	0.480947	-0.329220	0.7434
LNGFCF	-0.132678	0.094438	-1.404928	0.1665
LNCPI	-0.087515	0.063889	-1.369790	0.1771
@QUARTER=2	0.214753	0.098582	2.178425	0.0343
@QUARTER=3	0.385558	0.120793	3.191896	0.0025
@QUARTER=4	0.333734	0.094867	3.517919	0.0010
C	30.967724	1.954849	15.841494	0.0000

R-squared	0.843604	Mean dependent var	30.33792
Adjusted R-squared	0.804505	S.D. dependent var	0.183926
S.E. of regression	0.081323	Akaike info criterion	-1.994228
Sum squared resid	0.317442	Schwarz criterion	-1.544370
Log likelihood	73.82395	Hannan-Quinn criter.	-1.817924
F-statistic	21.57614	Durbin-Watson stat	1.846692
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection. Source: Author's computation

Table 6: ARDL Short Run Cointegration Result.

Short Run Cointegrating Form				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(LNMBB)	0.079484	0.032191	2.469143	0.0172
D(LNADULTLIT)	0.923061	0.717334	1.286795	0.2043
D(LNGFCF)	0.025066	0.216727	0.115657	0.9084
D(LNGFCF(-1))	0.190601	0.305457	0.623988	0.5356
D(LNGFCF(-2))	-0.261937	0.203254	-1.288718	0.2037
D(LNCPI)	-0.044636	0.033775	-1.321550	0.1926
D(@QUARTER = 2)	0.109531	0.034708	3.155756	0.0028
D(@QUARTER = 3)	0.196648	0.032176	6.111667	0.0000
D(@QUARTER = 4)	0.170216	0.030212	5.634122	0.0000
CointEq(-1)	-0.510034	0.109993	-4.636971	0.0000
Cointeq = LNRGDPC - (0.1558*LNMBB -0.1583*LNADULTLIT -0.1327				
*LNGFCF -0.0875*LNCPI + 0.2148*(@QUARTER=2) + 0.3856				
(@QUARTER=3) + 0.3337(@QUARTER=4) + 30.9677)				

Source: Author's computation

5.5. Interpretation of Results

The long- and short-run analysis using the ARDL cointegration model (1,0,1,3,0), selected automatically by applying Akaike Information Criterion (AIC) out of 6561 models are presented in table 5 and 6.

Based on the long- and short-run ARDL analysis, the result shows that mobile broadband internet penetration is positively associated with economic growth in the Nigerian economy. The long-run result indicates that a unit change in mobile broadband internet penetration will lead to a corresponding 0.16 percent change in the GDP with a one percent level of significance. Similarly, the short-run analysis also shows a positive relationship mobile broadband penetration and economic growth suggesting that a 1 percent mobile broadband penetration could boost economic growth by 0.08 percent at 5 percent significance level. The magnitude of the error correction term at 51 percent suggest an average speed of adjustment to the equilibrium in the event of any exogenous shock. The adjusted R-Squared of 0.81 shows that the model can explain 81% variation in the GDP. The results are also consistent with other country-specific empirical evidence from across the world which reported a positive effect of mobile broadband internet on economic growth using both aggregate time series and panel data (Katz and Koutroumpis, 2012a; Katz and Koutroumpis, 2012b; Katz and Koutroumpis, 2014; and Katz and Avila, 2010).

5.6. Test for Serial Correlation

We move on to test for serial correlation amongst the variables so as to avoid running a spurious regression, using Breusch-Godfrey serial correlation LM test. We concluded that our model is a good fit and satisfies the serial correlation test criteria at 0.694 which is high and above the recommended 0.05 value for the null-hypothesis to be rejected.

Table 7: Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.156411	Prob. F(1,47)	0.6943
Obs*R-squared	0.202328	Prob. Chi-Square(1)	0.6528

Source: Authors' computation

5.7. Test of Causality using the Toda-Yamamoto Approach in VAR

In order to capture the direction of causality between the variables, the Granger Causality/Block Exogeneity Wald Tests were carried out, using the Toda Yamamoto approach in VAR. The result presented in table 8 indicates that there is two-way causality between mobile broadband and the GDP. At 10% level of significance, mobile broadband is granger causing GDP. Also, at 5% level of significance, GDP is granger causing mobile broadband.

Table 8: Granger Causality/Block Exogeneity Wald Tests

Dependent variable: LNRGDPC			
Excluded	Chi-sq	Df	Prob.
LNMBB	14.08817	8	0.0795
LNADULTLIT	14.16290	8	0.0776
LNGFCF	44.12819	8	0.0000
LNCPI	15.09859	8	0.0573
All	102.8498	32	0.0000
Dependent variable: LNMBB			
Excluded	Chi-sq	Df	Prob.
LNRGDPC	19.97733	8	0.0104
LNADULTLIT	16.42536	8	0.0367
LNGFCF	45.40619	8	0.0000
LNCPI	9.019224	8	0.3407
All	110.3699	32	0.0000

Source: Author's computation.

6. Conclusion and Policy Implications

This paper focuses on the causational dynamics between mobile broadband network penetration and aggregate economic growth. The study adopts the ARDL estimator in order to control for the endogenous relationship between growth and mobile broadband infrastructure. Empirical evidence on this causational dynamic is quite recent as most extant literature on this relationship tend to focus on a broad categorization of telephony infrastructure networks and not specifically on mobile broadband infrastructure per se. This is certainly the case for empirical studies emanating from Sub-Saharan Africa in general and Nigeria in particular. The result of the current paper suggest that mobile broadband network penetration is positively significant in boosting economic growth. The findings specifically indicate that there is a 0.16% growth effect for every 1% increase in mobile broadband network penetration in the long run and a corresponding 0.08% growth effect in the short run. These findings are within expected range for developing economies and are consistent with the results obtained by Deloitte, GSMA and Cisco (2012) which found that a 10% expansion in mobile penetration in developing markets boost productivity by 4.2%. If this trend is maintained, it implies that we should expect a higher increase in productivity due to mobile broadband network penetration in the near future.

The policy recommendation of this paper can be categorized into policies addressing both the demand- and supply-side constraints to mobile broadband network penetration. The demand-side policy implication entail formulating policies targeted towards addressing the issue of affordability by subsidizing mobile broadband services and devices particularly to rural areas currently unserved and/or underserved. Furthermore, policymakers should consider addressing issues of information asymmetry surrounding mobile broadband adoption not only by raising public awareness but also by building public confidence in the technology as an early adopter. Government can promote number of pro-adoption policy initiatives such as digital financial services, digital tax payment schemes as well as electronic cash transfer system via mobile broadband network platform.

On the supply-side, policymakers should further deepen regulatory reforms aimed at encouraging both local and foreign participation in the deployment of mobile broadband network infrastructure across the country. Policies aimed at promoting investment in support infrastructure such as electricity and transportation as well as promoting interoperability amongst mobile network operators is crucial towards achieving maximum network effects and thereby strengthening the absorptive capacity of the economy to fully benefit from the transformational effects of mobile broadband technology. Furthermore, policymakers should also consider enacting regulatory policies designed towards creating an enabling and competitive business environment for mobile network operators to thrive.

Acknowledgments

This paper is based on the paper presented at the 2017 Biennial Conference of the Economic Society of South Africa held at Rhodes University, Grahamstown, South Africa, 30th August – 1st September, 2017.

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