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The Effects of Wireless Mobile Phone Technology on Economic Growth in Nigeria

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Abstract: This research studies the effects of wireless mobile phone technology on economic growth in Nigeria. Nigeria is made up of 37 states including the capital territory. The phone ownership and subscription rate per state increased with the availability of wireless mobile phone technology. After deregulation of telecom industry, wireless technology has become widely available, e.g., cellular phone ownership rate per state rose to approximately 80 percent of the population in 2015. This study shows that the availability of wireless mobile phone technology helps to reduce the cost of learning and implementing world technology frontier and thus that it promotes smoother transfer of technology from technologically-advanced countries to Nigeria and brings significant growth in the economy Using the industry-level (NAICS) and the state-level (37) data in two respective econometric models, the study finds that the availability of wireless technology increased transfer of technology measured by the volume of imports and spurred growth in Nigeria. Moreover, it finds that the benefit of the wireless technology is greater for lower income groups and thus the technology helped to reduce distributional inequality of economic benefit.

Keywords: *Transfer of technology, economic growth, mobile phone technology.*

1. Introduction

The Nigerian telecom industry is a non-manufacturing industry that passes different stages of growth and development in its lifecycle. It started as a natural monopoly but later opened up to competition. As more and more new technology and deregulation spurred competition in the industry, this has led to the development of market segments. The market in the telecom industry is often segmented into three categories namely long distance, local and wireless services. In their survey, Green and Teece (1998) used this approach to study the telecom market segmentations of the United Kingdom, Australia, United States and New Zealand. Their study synthesized the regulatory framework and the development of competition in the four countries. They also studied the impact and speed at which competition had evolved in different segments of the markets. In contrast, Nigeria's Communications Commission in 2010 carried out what they called "a Determination of Dominance". They considered two methods of phone communication in Nigeria, namely the mobile telephone and the International Internet Connectivity (IIC) methods. They organized the two methods and produced four major market segments—voice, data, upstream and downstream. NCC further divided these four market segments into various sub-segments as shown in Table 1.

Table 1: Telecom Market Segments

Serial Number of Market Categorization	Market Segment	Sub-Segment
1	Voice	-Mobile Telephone (includes messaging) -Fixed Line Telephone
2	Data	-transmitting data by Fixed lines, Data Transmission: by retail Services and by Leased Lines -Mobile telephone Data (Using Dongles /Data Cards/Tablets, and using internet through mobile phone connections e.g. 3G/GPRS/Edge

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3	Upstream Segments	-Spectrum -Tower sites - Equipment for the Network - broadband/Internet Access in wholesale capacity - Leased Lines and Transmission in wholesale Capacity
4	Downstream Segments	-The Device operating system which include handset. M-commerce include applications and content)

Source: NCC website; 2013

Furthermore, the purpose of the dominance determination survey was to assist the Commission in determining whether certain telecommunications service providers were in a position of market dominance in selected telecommunications market segments in Nigeria within the meaning of the Nigerian Communications Act of 2003. It found that none was in dominance, not even NITEL. In line with its policy of openness, transparency, fairness and participatory regulation, the commission informed stakeholders in September 2012 of its intent to conduct a study on the level of competition in the relevant markets of Nigeria's Telecommunications Industry. It held meetings with a cross section of industry operators. The meetings were one-on-one interactive sessions. The commission later organized an enlarged stakeholders' forum where it sensitized players in the industry. This forum provided them the chance to make constructive contributions on the trends in Nigeria's telecommunications market. Data was collated from the operators during this period (NCC, 2013).

Prior Studies: Hunya (2000) agrees that there is a privatization and deregulation related FDI upswing in the 1990s in the Central and Eastern European Countries (CEECs) that target sectors based on resource endowment. This is accompanied by the introduction of a new world technology frontier in the recipient economy. This technology when transferred to the local suppliers in the domestic economy brings to par the level of domestic technology with the world technology frontier and leads to welfare gains (Garrick and Gertler, 2004). It should also be added here that the ability of absorption of the recipient nation may also influence the mechanism of transfer. The rate of the technology transfer also counts, as argued by Aggarwal (2013). This rate of transfer increases with the fall in cost of transfer, which is also enhanced by R&D and education. Aghion and Howitt, (2009) argue that countries that invest in the adoption of new technology, grow and make headway while others who do not, otherwise stagnate. The research hereby contributes to the literature by showing that availability of mobile phone technology, education and research help to reduce the cost of technology transfer in Nigeria and thereby enhanced growth. According to the ministry of trade and industry classification (2013), large firm was defined as companies with at least 500 employees.

While some studies have stressed the significance of personal contacts and networks in technology transfer, it is imperative to stress that the major mechanism for technology transfer has been the international exchange of goods and services as in international trade which closes up the gap between world technology frontier and the technology of the recipient nation (Aggarwal, 2013). It is a well-known fact that the new products are usually developed by firms in recipient countries through extensive investment in rigorous research and development (R&D). For a larger return on this extensive investment in R&D, Jamison, Douglas and Jansen (2001) suggest that there should be a program to increase the elasticity of output to justify the huge investment. The model predicts that if the cost of technology transfer is too high, no technology transfer occurs and we have no growth. On the other hand, if the cost of technology transfer is sufficiently small, technology transfer is enhanced and positive growth is achieved. So the question is what are the factors that can reduce the cost of technology transfer, i.e., the cost of learning the world technology frontier? This research will attempt to explain the cost of technology transfer by the availability of mobile technology and the level of education (or human capital stock).

Mobile Technology: Greater access to mobile technology makes communication and transfer of information cheaper and easier, hence, economic growth. Vanags and Gravelis (2014) found a positive effect of 4G investment on growth using Swedish and Estonian data.

Education (Human Capital): The higher the level of a worker's education is, the lower the cost of learning the new technology. Nelson and Phelps (1966) argued that human capital has a positive role in facilitating the adoption of new technologies.

2. Method

Transfer of technology is the process of transferring scientific knowledge, skills, and methods of manufacturing for practical purposes in industry. Most scholarly literatures agree that telecommunications technologies greatly assist in knowledge acquisition (Norton, 1992; Leff, 1984 and Jensen, 2007). The advent of satellite technology drastically reduces the cost of acquiring telecommunications equipment and products. This is seen in the role wireless mobile telephone technology plays in communications and information dissemination in the world. A contemporary example is that mobile phone technologies also enable the internet, which is a less expensive source of knowledge (Jerbashian and Kochanova, 2012). By implications, there may be a positive relationship between mobile phone technologies and technology transfer. Hence, the availability of technology boosts output and creates growth. With the above analysis at-hand in this study, the current research study will attempt to investigate the effect of mobile phone technology on transfer of technology and economic growth. First, using the industry-level data, we studied the effect of mobile phone technology on technology transfer measured by the volume of imports for seventeen industries for the time period of 1999 to 2017. Then, we also study using the state-level data, the impact of mobile phone technology on economic growth for 36 states and the Federal Capital Territory in Nigeria for the time period of 1999 to 2017.

For the first test on the effect of mobile technology on technology transfer, we used the following model:

$$transfer_{it}=\alpha_i+\beta_0 mph_{it}+\beta_1 X_{it}+\beta_2 dpn_{it}+\beta_3 edu_{it}+\varepsilon_{it} \quad (1)$$

Where $transfer_{it}$ is the volume of technology transfer to industry i at time t measured by the volume of imports by industry i at time t, mph_{it} is the mobile phone subscription rate at time t, X_{it} are control variables for all industries *i* at time t, dpn_{it} is the dependence on mobile phone technology for industry i at time t, α_{it} are the sector unobserved effects, edu_{it} is the number of the population with high school education and above that is employed divided by the total population at time t and ε_{it} is the error term. For the second test on the effect of mobile technology on per-capita GDP growth rate, the following models were specified:

$$growth_{jt}=\beta_0+\beta_1 gdp_{99jt}+\beta_2 X_t+\beta_3 mph_{jt}+\beta_4 mph_{jt}*gdp_{99j}+\beta_5 edu{>}hs_{jt}+\beta_6 lgfrm_{jt}+\beta_7 Z_{jt}+\varepsilon_{jt} \quad (2)$$

Where $growth_{jt}$ is the growth rate of per capita GDP at time t-1 of state j, X_t are the control variables at time t such as tariff and inflation. Z_{jt} is the state j's population growth rate at time t and the state j's investment as share of GDP at time t. The variable mph_{jt} is the mobile phone ownership rate as a percentage of the population at time t for state j, gdp_{99j} is the initial per capita GDP at 1999 for state j, $edu{>}hs_{jt}$ is education level above high school at time t for states j, $lgfrm_{jt}$ is the number of firms with equal or greater than 500 employees at time t in states j and ε_{jt} is the error term. In the model, the interest and emphasis is on the coefficients of the interaction parameters β_3, and also β_4 .

Measures and Data: For the first model in equation 1, the study used data for seventeen industry sectors classified using North American Industry Classification System (NAICS) and International standard industrial classification (ISIC). For the second model (2) data for thirty-six states and FCT in Nigeria are collected and studied. For both models, the period of focus is from 1999 to 2017. The major limitation of this study is that the dependence rates on mobile phone technology of industry sectors are calculated based on the US data due to the non-availability of such data for Nigeria. The intuition behind the use of US data for other countries is based on the assumption that economic sectors behave alike globally. For example, Jebershan and Kochanova (2012) applied the US mobile phone technology dependence rates to the European industry sectors. This current study applied the US rates to Nigeria industry sectors; however, the study admitted that there is a possibility that the US industry structure may differ slightly from that of Nigeria.

Transfer of Technology: In many studies, transfer of technology is measured by the volume of import or the FDI. They are carriers of new technology from the world frontiers of technology (see for example, Saggi, 2002; Keller, 2004). Since FDI data is not available at the industry level, in this study, transfer of technology to each industry sector is measured by the volume of import by each industry sector. The data is obtained from the Nigerian Federal Ministry of Industry, Trade and Investment and the Nigerian Federal Office of Statistics.

Mobile Phone Subscription Rate: For the first test model equation 1, the Nigerian mobile phone subscription rate is the number of mobile telephone subscribers per 100 persons obtained from the 2013 World Bank data. For the second test for equation 2, the state-by-state mobile phone use was calculated as a percentage of each state's total population that own mobile telephone for Nigeria's 36 states and Federal Capital Territory. The data sets used were obtained from the 2016 Nigerian General Household Survey and the Federal Office of Statistics; Table 2 offers the basic statistics on the percentage mobile phone subscription rate by state in Nigeria in 2016

Table 2: Percentage of Mobile Phone Subscription Rate by State in Nigeria, 2016

No	State	Population	%mph	No	State	Population	%mph
1	Kano	9,383,682	81	27	Abia	2,833,999	76
2	Lagos	9,013,534	89.56	28	Ekiti	2,384,212	89
3	Kaduna	6,066,562	88	29	Kwara	2,371,089	70
4	Katsina	5,792,578	80	30	Gombe	2,353,879	88
5	Oyo	5,591,589	88	31	Yobe	2,321,591	88
6	Rivers	5,185,400	89	32	Taraba	2,300,736	84
7	Bauchi	4,676,465	88	33	Ebonyi	2,173,501	69
8	Jigawa	4,348,649	89	34	Nasarawa	1,863,275	68
9	Benue	4,219,244	86	35	Bayelsa	1,703,358	80
10	Anambra	4,182,032	89	36	Abuja (FCT)	1,405,201	81
11	Borno	4,151,193	80	37	Cross River	2,888,966	84
12	Delta	4,098,391	83				
13	Niger	3,950,249	85				
14	Imo	3,934,899	88				
15	Akwa Ibom	3,920,208	82				
16	Ogun	3,728,098	87				
17	Sokoto	3,696,999	85				
18	Ondo	3,441,024	89				
19	Osun	3,423,535	82				
20	Kogi	3,278,487	89				
21	Zamfara	3,259,846	82				
22	Enugu	3,257,298	84				
23	Kebbi	3,238,628	72				
24	Edo	3,218,332	83				
25	Plateau	3,178,712	83				
26	Adamawa	3,168,101	87				

Telecom Technology Dependence Rate: A measure of an industry's dependence on telecommunication, hereafter called telecom dependence rate, was computed as the share of expenditures on telecommunications out of the total expenditure on intermediate inputs (Jerbashian and Kochanova, 2012). The variable reflects each industry's current state of telecom technology adoption**.** Using the North America Industry Classification System (NAICS), we first classified all industries in Nigeria into seventeen industry sectors. Due to non-availability of this kind of complex data in Nigeria, the U.S. data set was employed to estimate the telecom dependence of Nigerian industries. The use of the US data for Nigerian economic sectors is based on the assumption that sectors behave alike worldwide. The data set used are from individual state's agencies in charge of data (from 37 of them) and Nigeria's Office of Statistics, Abuja. Jerbashian and Kochanova (2012) also use the U.S. data based on this assumption to estimate the dependence rates for industries in OECD (Organization for Economic Co-operation and Development) countries.

Economic Growth: In most countries, a naïve measure of economic growth rate would be the per capita GDP growth rate. The 37 states of Nigeria's per capital's GDP growth rates are collected and this variable can represent the rate at which output per person grows in each state, which when aggregated, indicate the total economy's growth trend. The data set used are from individual state's agencies in charge of data (from 37 of them) and Nigeria's Office of Statistics, Abuja.

Education: For the first test of model equation 1, education is measured as a stock variable which is the number of the population with a minimum of high school education, and above that is employed divided by the total population of the country at time t using data obtained from Nigeria's Office of Statistics (2016), Abuja, Nigeria. For the second test using equation 2, education is measured at the state level using the number of people with a minimum of high school education divided by the total population of the state at time t. The data for high school educational level were obtained from UNESCO PARIS 6 – 7 September 2012 Action Plan Nigeria and Federal Ministry of Education, Nigeria which offers the basic statistics. Most firms that employ more than 500 in Nigeria are financial institutions and multinational companies. They are mainly in joint ownership with foreigners. These large firms are concentrated in Lagos, Ogun (South West, Nigeria), Abuja (FCT), Rivers, Akwa Ibom, and Bayelsa (Southern region - the oil region). The state-by-state list of firms with more than 500 employees was obtained from the Federal Office of Statistics, Abuja Nigeria, 2016.

3. Results

The descriptive statistics and definitions of variables are presented in Table 3. Table 4 and Table 5 are the correlation matrices for the variables in the volume of import regression and variables in the state economic growth regression. The correlation matrixes do not show unusual or strange noise. In Tables 6 and Table 7, the main econometric results are presented from the baseline specifications (1) and (2) and are estimated using least squares method. For transfer of technology (1), this study identified four models a, b, c and d. In model 'a', we dropped these variables: tariff, expenditure on education, terms of trade and control for inflation. In model 'b', we dropped inflation, expenditure on education, terms of trade and control for tariff. In model 'c', we control for expenditure on education and drop others. Finally, we dropped other variables and control for terms of trade. For economic growth, we used two models 'a' and 'b'. In 'a', we also dropped tariff and control for inflation and drop inflation in 'b' and control for tariff.

Industry-Level: It is the total import of goods and services in each sector or industry in Nigeria (1999-2017). Sectors' Telecoms dependency ratio the share of real expenditure on telecoms out of total expenditures on intermediate inputs in US industries averaged over the period 1999-2017. Source: Author's calculations using 1997-2013 - 15 industries (XLSX), 71 industries (XLXS), 2007-389 industries (XLSX) from Bureau of Economic Analysis. Web site http://www.bea.gov/industry/io_annual.htm

State – level Variables

GDP Growth Rate: The annual percentage growth rate of GDP at market prices based on constant local currency. Nigeria is constituted by 36 Federal States and a Federal Capital Territory (Abuja) with yearly GDP figures (1999-2017). Source: States' office of statistics (2017), Nigerian Bureau of Statistics, Abuja (2013) and Nigerian vision 20:2020 Document (2012).

GDP Per Cap It: It is the gross domestic product of each state divided by the population of the respective states (1999-2017). Source: states' Office of Statistics (2017), and Nigeria's Bureau of Statistics (2017). GDP_{99}, it is the initial GDP per capita of the beginning year of study (1999) of each state that is assumed to be the value of per capita GDP for the 15 years (1999-2017).

Investment as a Share of GDP: This is the share of investment in total production. It is derived by computing gross capital formation as percentage of GDP for the 36 states and Abuja (1999-2017). Source: states' Office of Statistics (2013) and States' Ministry of Economic Planning (2017).

Mobile Phone Subscription: The mobile phone subscription as a percentage of the states' population (1999-2017). Source: Nigeria Bureau of Statistics, General Household Survey (2017).

State Population Growth Rate: It refers to the rate of increase in each of the 36 states' population during the period 1999-2017 and expressed as percentage of the states' population (1999-2017). It shows births and deaths (1999-2017). Source: National Population Commission, Abuja, Nigeria (2017).

Education: This refers to the number of people with high school education and above in each state of the federation divided by the total population of the state. Source: Federal Office of Statistics (2017).

Education: This refers to the number of the employed people with high school education and above in the country divided by the total population of Nigeria at time t. Source: Federal Office of Statistics, Abuja, Nigeria (2017) and Ministry of Education (2017).

Inflation Rate: This is measured as annual percentage increase in the general price level for goods and services in Nigeria (1999-2013). Source: Central Bank of Nigeria Bulletin (2017) and Global Finance site (2017).

Investment as a Share of GDP: This is the share of investment in total production. It is derived by computing gross capital formation as percentage of GDP for Nigeria (1999-2017). Source: Ministry of Economic Planning (2017).

Population Growth Rate: It refers to the increase in Nigeria's population during the period 1999-2017 and expressed as percentage of the population at the start of the period 1999-2017. It shows births and deaths (1999-2017). Source: National Population Commission, Abuja, Nigeria (2017).

Tariff Rate: Nigeria had used over the years two restrictive policy instruments to protect domestically produced goods from competitive imports. They are tariffs and quota. Tariffs are rates used to raise the price of imported goods to make them look more expensive to consumers. Source: World Bank staff estimates using integrated trade solution system (1999-2017) and Nigerian Department of Customs and Exercise (1999-2017).

Terms of Trade: This refers to the ratio of an index of Nigeria's export prices to the index of its import prices (1999-2017). The changes in terms of trade were derived using base year 2000 =100 at Net Barter terms of trade World Bank data set (2013) and Federal Ministry of Industry, Trade and Investment, Abuja, Nigeria (2017). In regression model equation 1, the dependent variable is volume of import which is the main measure of technology transfer over the period 1999 to 2017 and it is in logarithm form. The variable mph is the factor that can reduce the cost of technology transfer. The estimates of the coefficients of dependence on mobile phone technology and mobile phone subscription rates in models a, b, c, and d are positive they are for models a, b, c, and d: [2.816 (1.012), 2.826 ((1.011), 2.627 (1.010), 2.821 (1.012) and .005(0.006), 0.004(0.006), 0.001(0.006), 0.004(0.006)] respectively. The mobile phone subscription is significant at 10% and the coefficient of the industry dependence rate is significant at 1%. This implies that availability of mobile phone technology reduces cost of transfer of technology and dependence on it increases volume of import that carries the technology. Population growth rate is positive in all the models: (0.004(0.568), 0.038(0.640), 0.075(0.562) and 0.056(0.648) which implies that as population increases, rate of import increases.

Table 3: Summary Statistics

Variable Industry level	Obs.	Mean	SD	Min	Max
Volume of import	255	6.811	1.752	2.661	12.538
Mobile phone dependence	255	.0893	.1715	0	.7341
Country level					
Inflation	255	11.587	3.954	5.4	18.9
Tariff	255	15.419	6.221	10	24.32
Education	255	.2750	.1023	1323	4914
Population growth rate	255	2.373	.2569	1.94	2.75
Terms of trade	255	139.973	41.909	59.6	35693
Investment as share of GDP	255	24.906	3.166	20.19	31.921

Mobile subscription rate	255	28	27	0	77
State level (36 states and FCT)					
State citizens with above high School education	555	.316	.202	.332	.586
State GDP growth rate	555	4.336	2.678	.65	13
State GDP per capita	555	1379.716	2007.057	108.43	16433
State GDP_{99}	555	1201	1461.2	140.9	6345.2
State Investment as share of GDP	555	23.793	13.243	8	58
State population growth rate	555	3.238	1.072	2.14	9.3
State percentage mobile phone Subscription rate by State	555	21.635	16.615	1	89.56
Large firms	555	29.870	111.81	0	1000

Investment as a share of GDP is negative and significant at 10% level in the four models. The coefficients are (-0.012(0.034), -0.111(0.032), -0.009(0.034), -0.009(0.032). The interpretation is that import decreases domestic investment. The inflation variable is negative and significant at 10% level in model 'a' which implies that its decrease encourages more importation.

Table 4: Correlation Matrix of the Variables in Transfer of Technology Regression

	LOGVIMP	MPH	DPN	POPGRAT	INVSGDP	INFLTION	TARIFF	EDU	TRMSFTDE
LOGVIMP	1								
MPH	0.0359	1							
DPN	0.2143	-0.0193							
POPGRAT	-0.0144	-0.6065	0.0293	1					
INVSGDP	-0.0257	-0.0854	-0.0044	-0.1336	1				
INFLTION	-0.012	-0.3543	0.0176	0.1458	0.0954	1			
TARIFF	-0.0289	-0.8054	0.0383	0.704	0.1101	0.3389	1		
EDU	0.156	0.5633	0.3276	-0.0352	-0.118	-0.128	-0.5171	1	
TRMSFTDE	0.031	0.7196	-0.0378	-0.2223	-0.2223	-0.9205	-0.9205	0.3934	1

The coefficient is (-0.000(0.030) to the three places of decimal. The tariff variable has negative coefficient -0.005(0.033) in model 'b' and it is significant at 10% level. In model 'c', employee education level from master's degree is positive 0.000(0.000) to the three places of decimal and it is significant at 1% level. This means that education enhances foreign trade. In model 'd' terms of trade is positive with coefficient 0.001(0.004) and significant at 10% level. This implies that stronger exchange rate of naira improves importation. Using various checks - fixed and random effects, the values did not change and the test is good from Tables 6a, 6b, and 6c.

Table 5: Correlation Matrix of the Variables in State Economic Growth Regression

	STEGRATE	MPH	INVSGDP	STPGRTE	LRGFRMS	GDP_{99j}	GDP99j*Mph	Eduhs	INFLTION	TARIFF
STEGRATE	1									
MPH	0.684	1								
INVSGDP	0.823	0.482	1							
STPGRTE	0.113	0.2057	-0.0515	1						
LRGFRMS	0.4992	0.4822	0.3981	-0.0001	1					
GDP_{99j}	0.4663	0.2958	0.4632	0.5917	0.1522	1				
GDP_{99j}*Mph	0.5725	0.601	0.4942	0.6511	0.3787	0.849	1			

Eduhs	-0.1608	-0.497	-0.0047	-0.0446	-0.0999	-0.000	-0.1793	1		
INFLTION	-0.0466	-0.157	-0.0261	-0.0256	0.0024	-.0000	-0.0579	0.788	1	
TARIFF	-0.162	-0.232	-0.0435	-0.0925	0.0205	0.0000	-0.1494	0.287	0.3389	1

The baseline specification is split into model 'a' and 'b' as stated earlier in Table 7a and Table 7b. The dependent variable - state $growth_{jt}$ is the growth rate of per capita GDP at time t-1 of state j, which is the main measure of growth. In this model, the variable mph_{jt} is the percentage of the state population that own mobile phones. It tries to capture how mobile phone technology impacts on economic growth. The interaction term of mph and GDP_{99j} per capita is used to find whether the marginal impact of the mobile phone technology on economic growth depends on its initial GDP level for the 36 states and Federal Capital Territory of Nigeria for the period of study. In model 'a' regression, we dropped the variable tariff and control for inflation and in model 'b' regression; we dropped the variable inflation and control for tariff. The estimates of the coefficients of mobile phone subscription rates in models 'a' and 'b' are positive and significant at 1% level. They are [.067 (.007), .066(.007). This means that the mobile phone technology enhances economic growth. The coefficients of GDP_{99j} are 0.0004(0.000) and 0.0003(0.000) for models 'a' and 'b' respectively. They are positive and significant at 1% level. It shows that there is an increase in economic growth rate. However, the coefficients of the interaction between mph_{jt} with GDP_{99j} per capita are negative and significant at 1% level. They are -0.000013(0.000), -0.0000128(0.000) representing models (a) and (b) respectively.

The coefficients' values have negative signs meaning that the interaction is negatively related to growth rate. The independent variable, investments as a share of GDP coefficients are positive and significant at 1% level for model 'a' and 'b'. This means that rise in investment leads to rise in economic growth. This depicts growth as a long-term phenomenon. State population growth rate has positive coefficients in model 'a' and 'b' and they are significant at 1% level. The results for both models 'a' and 'b' are 0.324(0.090) and 0.322(0.089), respectively. The implication is that an increase in state population increases economic growth rate. The sizes of large firms also show positive relationship with economic growth for both models. They are significant at 1% level and the values are: 0.003(0.000) and 0.003(0.000), respectively. This shows that as the number of large firms' increases, then economic growth rate increases. The variable level of education above high school is positive and significant at the 1% level. The positive coefficient of education variable confirms what Nelson and Phelps (1966) said in the literature about the positive impact of human capital on economic growth. The values are 0.007(0.013) and 0.037(0.017) for models 'a' and 'b' respectively. This depicts that education helps in absorption of the new mobile technology in the economy and this increases the economic growth rate. The tariff variable in model 'b' is negative and significant at the 1% level. The coefficient is -0.031(0.013).

This implies that decrease in tariff encourages economic growth. The inflation variable in model 'a' is positive but not significant. In order to find how the new mobile phone technology impacts on each individual state's economic growth, by taking the partial derivative of (2) with respect to mobile phone subscription rate as follows:

$$\frac{\partial y^*_{jt}}{\partial mph_t} = \beta_3 + \beta_4 GDP_{99j}. \qquad (3)$$

The study found that β_3 is positive showing that mobile phone subscription rate is positively related to economic, growth while β_4 is negative implying that the interaction of mobile phone subscription rate. The initial GDP_{99j} are negatively related to economic growth. Note that the negative sign of β_4 does not depict an inverse relationship between the mobile phone subscription and economic growth since the actual value of (2) depends also on the positive magnitude of the coefficient of β_3. On net, the impact is found to be positive for all states. Moreover, because of the negative sign of β_4, it is observed that states with less GDP_{99j} per capita value have greater marginal impact of mobile phone technology than those with higher GDP_{99j} per capita (see Table 6a-). In order to rule out a bias effect for the results, some specification checks (fixed effects and random effects) are carried out and the values did not change, which confirmed that the tests are efficient. The correlation matrix as earlier stated does not indicate unpleasant noise.

Fixed Effects: The intuition behind fixed effects within regression is to remove the pernicious effect of omitted variable bias. Usually, one needs to be worried about unobservable factors that are correlated with the variables that one included in the regression. The fixed effect models are good checks for omitted variable

bias. Here, obtaining multiple observations about each industry and looking at the effect of different variables within the industry is treated. In order to check whether the OLS results have omitted variable bias, industry and state levels fixed effects tests are conducted on the two baseline specifications (1) and (2). In model equation 1, the estimates of the coefficients of mph_t and dpn_{it} variables do no change much and are significant. The intercept coefficient is positive and significant at the 1%, level while other controlled variables do not change much also. In the growth model, the interaction of mobile subscription rate and GDP_{99j} per capita is positive. Its intercept coefficient is positive, as well, and significant at the 1% level. This confirms that the results are qualitatively the same without omitted variable bias and do not change much in values as in Table 7b and Table 7b. The fixed effects results based on Hausman specification test is efficient than random effect.

Table 6a: Econometric Results of Baseline Specification Ordinary Least Squares Results of Technology Transfer as Panel Estimation with Additional Explanatory Variable

Variables	Model a	Model b	Model c	Model d
Mobile Subscription Rate$_t$	0.005*	0.004*	0.001*	0.004*
	(0.006)	(0.006)	(0.006)	(0.006)
Dependence on Mobile Tech$_{it}$	2.816***	2.820***	2.627***	2.821***
	(1.012)	(1.011)	(1.010)	(1.012)
Population Growth Rate$_t$	0.004*	0.038*	0.075*	0.056*
	(0.568)	(0.640)	(0.562)	(0.648)
Investment as share of GDP$_{it}$	-0.012*	0.111*	-0.009*	-0.009*
	(0.034)	(0.032)	(0.034)	(0.037)
-Cons	6.802***	6.764***	6.36***	6.486***
	(1.897)	(1.849)	(0.249)	(2.452)
Inflation$_t$	- 0.000*	-	-	-
	(0.030)			
Tariff$_t$	-	-0.005*	-	-
		(0.033)		
Education $_t$	-	-	0.001 ***	-
			(0.000)	
Terms of trade $_t$	-	-	-	0.001*
				(0.004)
Number of Industries	17	17	17	17
Number of Observations	255	255	255	255
R-Squared:	0.1518	0.0519	0.0642	0.0519

Dependent Variable: Log of Volume of Import and the levels of significance are 1%, 5% and 10%. The standard errors are robust and reported in parenthesis. The sample period is 1999-2016 (17 years).

Table 6b: Industry Fixed Effects Results of Technology Transfer as a Panel Estimation with Additional Explanatory Variable

Variables	Model a	Model b	Model c	Model d
Mobile Subscription Rate$_t$	0.004***	0.004***	0.003**	0.004*
	(0.001)	(0.002)	0.002)	(0.002)
Dependence on Mobile Tech$_{it}$	0.495*	0.571*	0.719**	0.681*
	(1.484)	(1.545)	1. 480)	(1.533)
Population Growth Rate$_t$	0.038*	0.042*	0.056**	0.062*
	(0.141)	(0.158)	(0.141)	(0.159)
Investment as share of GDP$_{it}$	-0.012	-0.012*	-0.011*	0.011*
	(0.009)	(0.009)	(0.009)	(0.010)
-Cons	6.894***	6.904***	6.767***	6.752***
	(0.477)	(0.474)	(0.484)	(0.647)
Inflation$_t$	0.001	-	-	-

	(0.008)			
$Tariff_t$	-	-0.001* (0.009)	-	-
Education $_t$	-	-	0.001 ** (0.000)	-
Terms of trade $_t$	-	-	-	0.000* (0.001)
International Call $Rate_t$	-	-	-	-
Number of Industries	17	17	17	17
Number of Observations	255	255	255	255
R-Squared: (a) within 0.0720, between: 0.0088, Overall 0.0049(b)0.0719,0.1159,0.0088(c)0.0763,0.0628,0.0330 (d)0.0724,0.0702 and 0.0157.				
Hausman Tests chi2 (1)	0.24	0.12	0.29	0.11
Prob> chi2	(0.6234)	(0.7268)	(0.8633)	(0.7439)

Dependent Variable: Log of Volume of Import and the levels of significance are 1%, 5% and 10%. The standard errors are robust and reported in parenthesis. The sample period is 1999 -2017 (18years).

Table 6c: Industry Random Effects Results of Technology Transfer as Pane Estimation with Additional Explanatory Variable

Variables	**Model a**	**Model b**	**Model c**	**Model d**
Mobile Subscription $Rate_t$	0.004*** (0.001)	0.004* (0.006)	0.003** (0.002)	0.004* (0.002)
Dependence on Mobile $Tech_{it}$	1.152* (1.254)	2.820* (1.011)	1.269* (1. 259)	1.311* (1.282)
Population Growth $Rate_t$	0.025* (0.141)	0.038* (0.640)	0.048* (0.141)	0.060* (0.160)
Investment as share of GDP_{it}	-0.012 (0.008)	-0.011* (0.035)	-0.011* (0.009)	-0.010* (0.010)
-Cons	6.870*** (0.619)	6.764*** (1.849)	6.728*** (0.630)	6.674*** (0.752)
$Inflation_t$	0.001 (0.008)	-	-	-
$Tariff_t$	-	-0.005* (0.033)	-	-
Education $_t$	-	-	0.011 * (0.000)	-
Terms of trade $_t$	-	-	-	0.001* (0.001)
Number of Industries	17	17	17	17
Number of Observations	255	255	255	255
R-Squared: (a) within 0.0712, between 0.0545 0verall 0.0411 (b) 0.0712, 0.539 and 0.0438 (C) 0.0758,0.0670 and 0.0571(d) 0.0717, 0.0535 and 0.0454				

Dependent Variable: Log of Volume of Import and the levels of significance are 1%, 5% and 10%. The standard errors are robust and reported in parenthesis. The sample period is 1999-2017 (18years).

Random Effect: Random effect is efficient in controlling for a constant unobserved heterogeneity over time, especially when it is correlated with independent variables. The assumption is that the individual specific effects are uncorrelated with the independent variables. In this study, random effect of variables is conducted for industries and states (provinces). In regression model equation 1, the coefficients of the mobile phone subscription rate and the telecom dependence rate are positive and significant. In the regression equation 2, the mobile phone subscription rate is positive and significant at the 1%, level. The interaction coefficient and other independent variables do not change much and are significant. The random effect assumption as stated above holds. Therefore, the test results are good and efficient in Table 7c and Table 7c.

Table 7a: Econometric Results of Baseline Specification Ordinary Least Squares Results of Nigerian 37 States Economic Growth as Panel Estimation with Additional Explanatory Variable

Variables	Model a	P |t|	Model b	P |t|
Mobile Subscription Rate$_{jt}$	0.066***	0.000	0.066***	0.000
	(0.007)		(0.007)	
State Investment as share of GDP$_{jt}$	0.127***	0.000	0.127***	0.000
	(0.007)		(0.007)	
States Pop Growth Rate$_{jt}$	0.324***	0.000	0.322***	0.000
	(0.090)		(0.089)	
No of Large Firms$_{jt}$	0.003***	0.000	0.003***	0.000
	(0.000)	(0.000)		
GDP$_{99j}$	.0004***	0.000	0.0003***	0.028
	(0.000)		(0.000)	
GDP$_{99j}$* Mobile Subs.Rate$_{jt}$	-0.000013***	0.000	- 0.0000128***	0.000
	(0.000)		(0.000)	
Education$_{jt}$	.005**	0.505	0.024***	0.023
	(0.013)	(0.017)		
-Cons	-1.675***	0.031	-2.691***	0.002
	(0.775)		(0.847)	
Tariff$_t$	-		-0.031	0.018
			(0.013)	
Inflation$_t$	0.003	0.839	-	
	(0.014)			
State	37	37	37	37
Number of Observations	555	555	555	555
R-squared	0.8055		0.8075	

Dependent Variable: Economic Growth and the levels of significance are 1%, 5% and 10%. The standard errors are robust and reported in parenthesis. The sample period is 1999-2017 (18years).

Table 7b: State Fixed Effects Results of Nigerian 37 States Economic Growth as a Panel Estimation with Additional Explanatory Variable

Variables	Model a	P |t|	Model b	P |t|
Mobile Subscription Rate$_{jt}$	0.007**	0.159	- 0.001	0.749
	(0.005)		(0.004)	
State Investment as share of GDPj$_t$	-0.156***	0.000	- 0.139***	0.000
	(0.044)		(0.039)	
States Pop Growth Rate$_{jt}$	-0.208***	0.303	0.074	0.685
	(0.202)		(0.181)	
No of Large Firms$_{jt}$	0.001***	0.002	0.002***	0.000
	(0.000)		(0.000)	
GDP$_{99j}$	-0.002	0.000	0.002	0.000
(0.000)	(0.000)			
GDP$_{99j}$* Mobile Subs.Rate$_{jt}$	0.00000260**	0.043	0.00000300**	0.009
(0.000)	(0.000)			
Educations$_{jt}$	-0.056	0.000	-0.023	0.000
	(0.007)		(0.007)	
-Cons	7.878***	0.000	7.284***	0.000
	(0.799)		(0.719)	
Tariff$_t$	-		-0.046***	0.000
			(0.004)	
Inflation$_t$	0.001	0.817	-	
	(0.005)			
State	37	37	37	37

Number of Observations	555	555	555	555
R-squared (a) within 0.6562, between 0.0000, overall 0.0000; (b) within0.7235, between 0000, overall 0.0024				
Hausman Test:	Chi2 (6) =43.30		Chi2(6) = 56.07	
	Prob>chi2 = (0.0000)		Prob> chi2 = (0.0000)	

Dependent Variable: Economic Growth and the levels of significance are 1%, 5% and 10%. The standard errors are robust and reported in parenthesis. The sample period is 1999 -2017 (18years).

Table 7c: State Random Effects Results of Nigerian 37 States Economic Growth as Panel Estimation with Additional Explanatory Variable

Variables	Model a	P |t|	Model b	P |t|
Mobile Subscription Rate$_{jt}$	0.013***	0.006	0.005	0.302
	(0.005)		(0.004)	
State Investment as share of GDP$_{jt}$	0.097***	0.000	0.094***	0.000
	(0.016)		(0.015)	
States Pop Growth Rate$_{jt}$	-0.403***	0.002	- 0.461***	0.000
	(0.132)		(0.124)	
No of Large Firmsj_t	0.002***	0.000	0.002***	0.000
	(0.000)		(0.000)	
GDP$_{99j}$	0.001***	0.000	0.001	0.000
(0.000)		(0.000)		
GDP$_{99j}$* Mobile Subs.Rate$_{jt}$	0.000000224	0.861	0.000000910	0.432
(0.000)		(0.000)		
Education$_{jt}$	-0.052	0.000	-0.012	0.000
	(0.001)		(0.007)	
-Cons	5.227***	0.000	4.730***	0.000
	(0.685)		(0.634)	
Tariff$_t$	-		-0.046***	0.000
			(0.004)	
Inflation$_t$	-0.000	0.943	-	
	(0.005)			
State	37	37	37	37
Number of Observations	555	555	555	555
R-squared (a) within 0.6327, between 0.7038, overall 0.6998; (b) within 0.7040, between 6747, overall 0.6767				

Dependent Variable: Economic Growth and the levels of significance are 1%, 5% and 10%. The standard errors are robust and reported in parenthesis. The sample period is 1999-2017 (18years).

4. Conclusion

The findings of this study proffer empirically insightful answers to the research questions. Firstly, research question: "Did availability of telecom technology help to increase transfer of world frontier technology by reducing the cost of technology transfer?" This study shows that as the availability of mobile phone technology increases, the volume of import increases and more technology is transferred. Thus, the findings by Freund and Weinhold (2002, 2004) and Arrow (1969) are reconfirmed by the study's empirical result. Secondly, research question: "Did availability of telecom technology help to spur growth in Nigeria?" Yes, the availability of mobile phone technology enhances economic growth in Nigeria. Some of the control variables do not exhibit significant change in values and are significant at the 10% level. The result finding suggest a positive relationship between economic growth and mobile phone subscription rate implying that mobile phone availability effects economic growth positively. The Nigerian economic growth rate has been on the rise since implementation of its deregulation policy in telecom industry in 1999.

Which brought increased use of mobile phone technology, the economy under Goodluck Jonathan administration was rated as the biggest economy in Africa by the World Bank, 2014. The administrations after his own is duty bound to sustain the growth. The finding also reiterates what Alf and Gravelis (2014) find between mobile phone technology and growth in Sweden and Estonia. Thirdly, the research question "Did education increase economic growth?" Education in the transfer of technology model is measured by the total number of employees with high school education in the country divided by the total population of the country at all time. The result also find that the coefficient of this variable is positive, signifying a positive correlation between volume of import and expenditure on education. This implies that education enhances international trade which carries technology from the world frontiers of technology to the recipient industry. In the growth model, education is measured by the number of people with above high school degrees as a ratio of the total population of the state. The coefficient is positive and significant indicating that human capital accumulation leads to a positive economic growth.

Finally, the research question: "Did the availability of mobile phone technology help to reduce distributional inequality of economic benefits?" The finding suggests that the availability of mobile phone technology increases state economic growth by different marginal weights. However, these marginal weights statistical significance across the states in both 90% and 95% confidence intervals could not be ascertained because the covariance has to be estimated using bootstrap. It is therefore left for future research. The study observes that the marginal impact of mobile phone technology is higher in states with lower GDP_{99j} per capita than states with higher GDP_{99j} per capita, thereby bridging the gap between the rich states and poor states as in Tables 7a-7c, Figures 1a-1b and Figure 2. Therefore, technology helps to reduce distributional inequality of economic benefits. In fact, this does not necessarily imply reduction in inequality among rich and poor classes of these societies in the respective rich and poor states. Take for example, Nigeria's rich oil states Bayelsa, Rivers, Akwa Ibom, Delta and commercial capital – Lagos still record huge percentages of poor classes of citizens. To find the impact on mobile phone technology on class inequality, a research is needed that will study individuals' income data. However, unfortunately such data is not available at this time.

Figure 1a: Mobile Phone Technology Impact on Per Capita GDP Growth

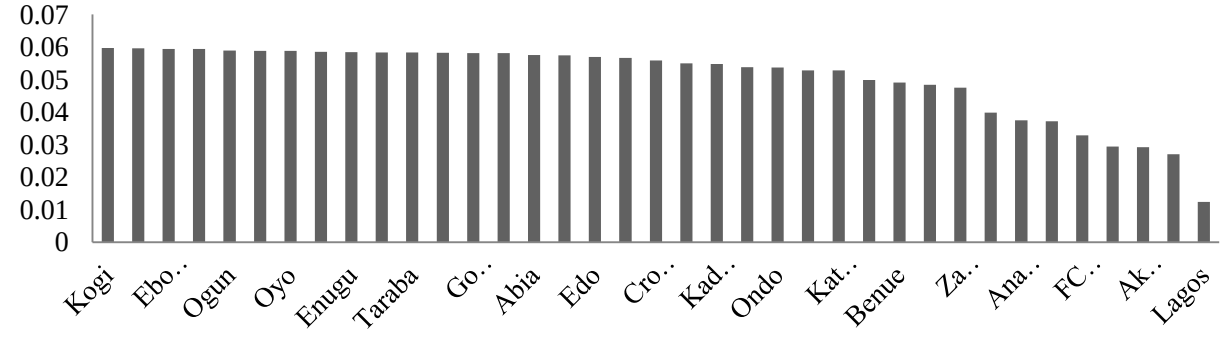


Figure 1b: Mobile Phone Technology Impact on Per Capita GDP growth

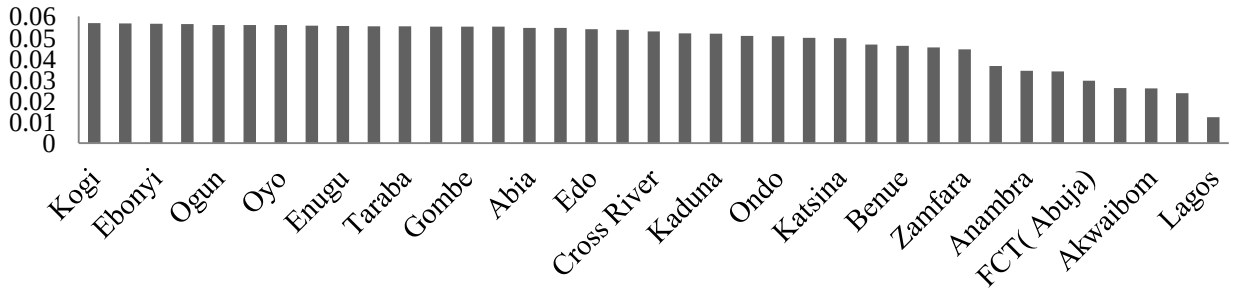
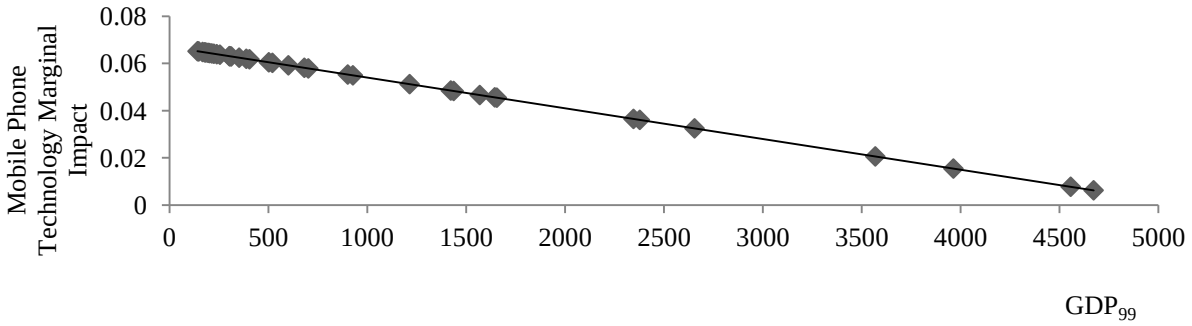


Figure 2: Mobile Phone Technology Marginal Impact on GDP



5. Recommendations

The following recommendations are proffered for these current studies:

- Telecom in Nigeria should continue as a deregulated sector in order to enhance competiveness and fully generate economic growth both in the short and long run.
- Telecom industry in Nigeria should continue to attract new and improved technologies that will help to increase transfer of world frontier technology by further reducing the cost of technology transfer.
- The Nigeria government should encourage sustained investment in the telecom area that will spur growth and development in all sectors of the Nigerian economy.
- Finally, the availability of mobile phone technology will help to reduce distributional inequality of economic benefits in Nigeria. Therefore, this study proffers that the government of Nigeria should engage in policy that will promote technology transfer and the incubation in all sectors of the economy.

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