INVESTMENTS IN INFORMATION AND COMMUNICATION TECHNOLOGY AND BANKS' PERFORMANCE: PANEL DATA EVIDENCE FROM NIGERIA

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Abstract

The study examined the investments by Nigerian banks in ICT development and maintenance and their implications for corporate performance using panel data methodology that modelled for pooled, fixed, random, and redundant effects. It also employed the Granger causality test to determine if causal relations exist between the variables. Globally, ICT investments were found to positively and significantly affect profitability. The evidences from the three panel data models are consistent in showing that while the relationship between ICT development and bank performance is significant, that between ICT maintenance and ROA is not significant. The above results also agree with the findings of uni-directional causality flowing from ICT development to profitability, but not vice versa. It was also found that there is no significant causality flowing from ICT maintenance to profitability. Thus, sustained investments in ICT development, with prudent maintenance expenditure, will go a long way to boosting bank performance.

INTRODUCTION

Banks have remained key players in the causation, as well as pivotal agents, of economic development in a globalize world. Their financial intermediation role of facilitating funds flow and transfers in the economy is quite remarkable, as the bulk of the saving-investment processes in an economy rely heavily on them. As intermediaries in the financial markets, they interface with suppliers (savings-surplus units) and users (savings-deficit units) of funds, as well as other market intermediaries and players, in such manners that characterize efficiency in the global market economy. Such important roles demand heavy dependence on information on, and about, the funds markets. They simply become economic

'organisms' that are highly information sensitive and demanding in a growing knowledge-based global village (Keramati, Azadeh, and Mehran, 2009).

The information needs of banks are all the more amplified in the light of the corporate crave to satisfy the expectations of the banks' publics by charting a desirable path to efficiency and effectiveness in their financial service delivery. Banks provide a plethora of services to its publics, and especially customers, which include depository, lending, safe-keeping, trust, transfers, foreign exchange, domiciliary, and correspondence services. They represent their customers in the various financial markets. The nature and magnitude of these services and operations make the banking sector to be highly amenable to innovative technologies (Polasik and Wisniewski, 2008; Binoyo and Aregbeshola, 2014). It is considered by many an analysts and commentaries that the way banks carry out these operations are being changed on a continuous basis by improvements in technology.

The advent of modern information and communication technology (ICT) has been seen as a salutary and welcome development in the financial service industry, especially in shaping and re-shaping the way banking businesses are being conducted in recent times. Operating in a highly technologically demanding knowledge economy, the bulk of banking businesses are currently been driven by ICT. ICT encompasses the complex whole of systemic computerized technologies that facilitates a variety of activities ranging from communication and the electronic capturing, processing, and transmission of information. These activities are in turn facilitated through such equipment as computers, hand-held devices, wired or wireless intranet, business productivity software, data storage and security devices. (Ashrafi and Murtaza, 2008).

As the nomenclature suggests ICT combined information technology with communication technology, which may account to the rationale why certain researchers attempt to distinguish between their separate impacts on the performance of banks, in their studies, such as in *Hong-Jen and Lin (2007). No matter their conceptual distinctions, it has been argued that the duo technology "merges* merges computing with high speed communication link carrying data, sound and video"; and concerns themselves with "the collection, storage, manipulation and transfer of information using electronic means." (Binoyo and Aregbeshola, 2014; Alabi, 2005). For the purposes of drawing a fine line of demarcation, the communication dimension is usually taken to represent "the physical devices and software that link various computer hardware components and transfer data from one physical location to another" (Binoyo and Aregbeshola, 2014; Laudon, 2001).

The virtues of ICT have been extoled by many protagonists. The long list of attendant benefits are drawn to be ranging from dynamo-change thesis through the key business-driver argument; from the productivity improvement and growth

thesis through networking possibilities argument; from the barrier dismantling argument (as in eliminating or reducing to the barest minimum, time constraint and distance barrier to accessing relevant information) to activities coordination thesis (as in improving coordination of activities within corporate boundaries). (Spanos et al., 2001; Buhalis, 2003; San-Jose, Ituralde, and Maseda, 2009). Others range from operational enhancement thesis to overheads reduction argument (where costs associated with branch maintenance, marketing and personnel are highly reduced). Specifically, it has been posited that online banking cost is significantly lower than that of in-branch banking, while that of ATM is much lower that the teller system. (Hernado and Nieto, 2007; Polasik, 2006; Binoyo and Aregbeshola, 2014).

These benefits may have provided the reasons behind the theoretical and empirical perspective that not only does ICT positively impact bank performance, but the entire macro economy receives significant boost by its advent. For instance, Delgado and Nieto (2004) submitted that the entrance of electronic communication channels has had a profound impact on the banking industry. A number of other researchers, in their studies, have found evidence for significant positive effect of ICT on the operational performance of banks in different countries. These include the works of De Young and Duffy (2007), Hong-Jen and Lin (2007), Keramati, Azadeh, and Mehran (2009), and Arora, Arora, and Mahavidyalaya (2013).

On the other hand, in spite of the much-trumpeted benefits of ICT in the banking industry and the loud ovation given to its introduction and use, as decipherable from the above highlighted researches, its employment has come under very sharp criticism. One of the points muted against ICT relates to the tendency of displacing human beings and by that token making them unemployed. It is argued that one single electronic equipment can efficiently do the work which were originally done by so many persons, and that, at a more reduced time and cost. Thus, some of the very points offered as the *rason d'etre* of ICT have also been offered as its antithesis. Consistent with this line of argument, some authors have found contrary, or mixed-feeling-type of, evidence against ICT investments by banks. Notable among these studies are those of Farouk and Dandago (2015), Muhammad, Gatawa, and Birnin Kebi (2013), Binoyo and Aregbeshola (2014), Agboola and Salawu (2008), Beccalli (2006), and Jegede (2014). These scenarios go to show that the need for more investigation, using appropriate methodology, is rife. It is in this light that the present study finds added justification. The controversy has to be resolved, and that, by more generous and robust evidences from studies in the area.

It becomes the crux of this study to finametrically investigate the causal relations between investments in ICT and the profitability of banks operating in Nigeria. The basic general statement that founds this study is: Profitability is a positive function of investments in ICT (decomposed into development and maintenance expenditures) among quoted banks in Nigeria. More elaborately, we ask the

empirical questions: Do ICT development and maintenance investments actually cause profitability of quoted commercial banks in Nigeria? To what extent and in what direction do ICT investments relate with bank profitability in Nigeria? In order to answer these questions, the study employs the panel data analytical procedure that include examining the pooled regression effects, fixed effects, random effects, company-factor-specific effects and the Granger causality test. It is hoped that the results will contribute to resolving the controversy surrounding the contribution of ICT investments to overall banking performance.

REVIEW OF RELATED EMPIRICAL LITERATURE

Some previous studies have provided empirical background to the current study, and therefore require further review in this section. For instance, Akujuobi and Akujuobi (2009) predicated their study on the wide-spread claim that ICT impacts the banking sector massively such that banks make huge investments in them to improve their operational efficiency. Questioning whether or not associated gains justify these investments, their study examined the effects of introducing new information and communication technologies on the performance of banking firms in Nigeria. The scope of the study's coverage ranges from 1970 through 2008. Use was made of the t-test statistics that determines difference between means. The results indicated that "the introduction of information technology has positively impacted on the performance of the banks" Akujuobi and Akujuobi (2009:1).

It is very interesting that such a conclusion on impact of a phenomenon, ICT, on another phenomenon, bank performance, would be deduced from a non-parametric T-test. Such a tool does not reserve the ability to produce such 'powerful' and far-reaching conclusion, as seen in the study. Thus, the study can be said to suffer serious methodological mis-match between the critical objective and analytical technique, which invariably undermines the usefulness of the study and its concluding remarks. The present study advocates the use of appropriate parametric econometric techniques, if the study's objective is to investigate impact. This anomaly is corrected by this study.

Binoyo and Aregbeshola (2014) analyzed the contribution of information and communication technology (ICT) to the firm performance of four biggest commercial banks in South Africa, namely Absa, FirstRand, Nedbank and Standard Bank. Employing panel regression technique against time-series annual panel data from Bankscope for 1990-2012 period, the results indicated that the use of ICT boosted return on capital employed, as well as return on assets of the banks studied. More particularly, it was underscored that more of the contribution to returns is traceable to ICT cost efficiency activities, instead of ICT investments. The findings made the study's policy implication to favor policies thrusts, for the commercial banks, that redound to optimal utilization of existing ICT equipment as opposed to making further investments in ICT. This recommendation appears to favor ICT maintenance more that of ICT development for the banks.

This argument can only be justified on the grounds that the said banks have reached their peak on the ICT advancement scale, and that there are no further advances and developments in ICT that the banks would need or benefit from, in the course of time. Again, this cannot not an acceptable position in the midst of dynamism pervading the worlds of banking and ICT. Binoyo and Aregbeshola (2014) appeared to have suggested that the banks should turn deaf ears to innovations, advances, and changes in the dynamic world of ICT. Following that policy recommendation, the banks would have to contend with the risks and problems associated with possible obsolescence, anachronism, unfavorable competition, marketing myopia, and market loss. These would become the anti-theses of long-run profitable performance, to say the least.

Muhammad, Gatawa, and Birnin Kebi (2013) investigated the impact of information and communication technology on performance of eleven commercial banks in Nigeria using time-series annual data from 2001 through 2011. Fixed and random effects models were estimated against the data with the findings that ICT use by banks relates positively with return on equity of the banks studied. The study also found evidence of negative relationship between additional sustained investments in ICT and efficiency. On the basis of the latter finding, the study advocated for policies favoring efficient/proper utilization of ICT equipment as opposed to additional investment. It is noteworthy that there seems to be some consistency between the findings and recommendation. One, however, wonders the efficacy of how the variables, efficiency and additional sustained investments, were measured or operationalize in the study. Equally, advocating for more of maintenance expenditure than increased expenditure on development, suggests that banks in Nigeria should become less competitive in the face of globalized financial services market and clientele that are technologically aware and driven, and who would prefer constant innovation in contradistinction with stagnancy.

In a bid to determine the existence or otherwise of productivity paradox, Farouk and Dandago (2015) analyzed the impact of investment in information technology on financial performance of 10 Nigerian banks, from 2006 through 2010. The study adopted panel data regression model with investment in IT (hardware, software and Automated Teller Machine, ATM), total earnings (TR) and total cost (TC) as major arguments. The results revealed the existence of a significant global impact IT investment on the financial performance of Nigeria banks, as measured by return on assets, return on equity, and earnings per share. The study also revealed that the effect on all four explained variables, including net profit margin was positive for TR and negative for TC, and negative for IT investment. By implication, increase in investment in information technology considerably reduces profitability of banks in Nigeria. This finding led the study to invoke the productivity paradox paradigm to explain why huge investment in IT would not improve performance.

There are notable knotty econometric issues raised by Farouk and Dandago's (2015) study. First, using regression to analyze impact or effect is not sufficient given current econometric reasoning. It is thought that the analysis should have gone beyond regression analysis and should have included causality considerations, to say the least. More so, even in the regression analysis done, there is gross omission of the relevant panel data analytical procedure that includes the examination of pooled regression, fixed and random effects. The checking of the possible effects of company specific factors was not also visibly done. Further, it appears that the study regressed data that were not on the same econometric base, such as regressing raw level data (in amounts of money) with data are converted to ratios. Not having the data on the same scale and form, may give rise to unwanted distorts to the observed results. Who knows whether these accounted for the kind of results revealed in the study? Most importantly, the finding of inverse or negative 'impact' or 'effect' of IT investment on profitability is contrary to theory, and even the a priori expectations of the models reveal this contradiction. So, using the paradox phenomenon to explain away obvious theoretical and methodological flaws cannot not be a plausible argument.

The productivity paradox argument of the above study begged for support from an earlier contention by Agboola and Salawu (2008) that banks in Nigeria had not yet fully optimized the use of information technology in processing deposit, withdrawal, account enquiries, new account processing, loans, and overdraft transactions; and as such they were being denied of attendant full benefits of the technology. It must be stated that 'denial of full benefits' does not imply inverse relationship as argued in the said productivity paradox theorem. At best, sub-optimal tendency, as explained in their argument, may simply redound to insignificant, but, of course, not negative relationship. Also, Farouk and Dandago (2015) invoked the position of Beccalli (2006) that the possibility existed that banks operating in Nigeria could be investing in ICT for strategic reasons; simply to discourage or encourage entry, and perhaps, for competitive repositioning. Accordingly, "these countervailing forces balance each other out (or even the former outweigh the latter resulting in lowering market power)" (Beccalli, 2006; Farouk and Dandago, 2015). Once again, a possible balancing out scenario does not immediately suggest negative trends in the relationship between investment and profitability. Thus, the productivity paradox argument cannot be substantiated, on this front, as presented and in the light of drawbacks pointed earlier.

Premising on the possible performance paradox that investments made in information technology to achieve higher profits and returns may not achieve its desired objective at the required time frame, Arora, Arora, and Mahavidyalaya (2013) investigated the experience of 27 Indian public sector banks on the relationship between IT investments and their corporate performance, for the period 2004 through 2009. The study identified four indicators of bank performance to include operating profits, return on assets, profit-to-employee ratio and business-to-employee ratio. These were individually hypothesized to be a

positive function of investment expenditure on information technology by the banks studied. Use was made of the two-stage Generalized Least Square and Generalize Method of Moments techniques applied to the panel data. Results indicated that investment in information technology positively and significantly impacted on operating profits and profit per employee. There was no such evidence of significant effect on return on assets, whereas, the observed effect on business per employee indicator was inconclusive. The study, in the light of these findings, affirmed to the evidence of increased profits and profitability attributable to IT innovations in the banks studied. Evidently, heavy investments in IT by the public sector banks in India have not been a wasteful organizational activity. It is noteworthy that the said performance or productivity paradox was not confirmed in the above study, as was argued in Farouk and Dandago (2015).

Jegede (2014) attempted to analyze the effects of Automated Teller Machine on the performance of Nigerian Banks. The study was designed after the quasi-experimental method with the questionnaire as the critical research instrument. The study surveyed 125 employees of five selected banks in Lagos State. Analytical technique used was the chi-square statistic. The study revealed that "the deployment of ATMs terminals has averagely improved the performance of Nigerian banks", and that "because of the alarming rate of ATM fraud" the banks have only reaped "less than the benefits" desired. It was also claimed that, "ATM service quality is less correlated to security and privacy of users and providers" (Jegede, 2014). These are very interesting 'findings' and inferences, especially when they were made from the 'altars of chi-square statistic. It is strange that the study would pursue analysis of causes and effects using chi-square, and even to discover that, "ATM service quality is less correlated to security and privacy", by means of chi-square computation. This is a case of putting a 'square peg in a round hole', to say it mildly. We have no basis to rely on the conclusion derived from such a methodological mis-match.

The effect of investments in information and telecommunications Technologies (ITT) and the Basel Accord on the performance of commercial banks across 51 different countries was the subject of the study of Hong-Jen and Lin (2007). Using the stochastic frontier approach the study found that ICT investments significantly improved cost efficiencies of commercial banks for countries in Basel Accord, while telecommunications investment reduced cost efficiency of the banks operating in all countries studied, whether in the Basel Accord or not. The Basel Accord proxy was found to enhance the cost efficiency of commercial banks under study. The obvious implication of the above results is that information technology investment, by improving cost efficiency, increases profits and profitability of the banks studied. On the other hand, communication technology, by reducing cost efficiency would reduce profits. Ceteris paribus, the overall profitability of the banks would therefore depend on which of the technologies exert more influence on cost efficiency. A situation of equal influence would produce a balancing out scenario on profits.

In consideration of the moderating effects of environmental dynamism and branch strategy, Keramati, Ali Azadeh, and Mehran (2009) examined the impact of information technology (IT) investment, number of employee, and fixed asset on bank branch performance. The study surveyed 102 branches of Parsian Bank and analyzed generate data using moderated regression modeling approach. The results indicate that "IT investment appears to have a stronger positive impact on bank performance when there are greater environmental changes and more proactive branch strategy" Keramati, Ali Azadeh, and Mehran (2009). The obvious disagreements in the findings of the above reviewed studies indicated the need for further studies in the area to help resolve apparent empirical controversy.

METHODOLOGY

Data

In this paper, panel data is used to examine the relationship between bank investments in ICT development and maintenance and their corporate performance in Nigeria. The data consists of 104 observations on 13 publicly quoted commercial banks in Nigeria observed ranging from 2006 to 2013. The randomly selected banks included are Access Bank, Diamond Bank, Fidelity Bank, First Bank, First City Monument Bank, Guarantee Trust Bank, Skye Bank, Stanbic-IBTC Bank, Sterling Bank, United Bank of Africa, Union Bank, Wema Bank, and Zenith Bank. The data are all obtained from the annual reports and accounts of the selected banks for different years. The data are transformed into logarithms and E-Views 9 software was used for the estimation and analysis.

Estimation Techniques

Three panel data estimation techniques (the pooled OLS, the fixed effects and random effects techniques) are used for the analysis of data. These methods provide the framework for testing our general hypothesis that bank performance is a positive function of ICT development and ICT maintenance; as well as two specific hypotheses that are associated with panel data manipulations as follows:

1. Bank-specific latent (unobserved) factors may have significant explanatory power for bank performance
2. Bank-specific latent (unobserved) factors may be uncorrelated with the explanatory variables

The Pooled Regression Model

The pooled regression model can be specified as:

$$LROA_{it} = \alpha + \beta_1 LICT\_DEV_{it} + \beta_2 LICT\_MAIN_{it} + \epsilon_{it} \quad (1)$$

$$LPAT_{it} = \alpha + h_1 LICT\_DEV_{it} + h_2 LICT\_MAIN_{it} + \epsilon_{it} \quad (2)$$

where: $LROA_{it}$ is the natural logarithm of return on assets and $LPAT_{it}$ is the natural logarithm of profit after tax, which proxy the bank performance, $LICT\_DEV_{it}$ is natural logarithm of the investment in ICT development, $LICT\_MAIN$ is the natural logarithm of investment in ICT maintenance and ϵ_{it} are error terms that are white noises for $1, 2, \dots, N$ cross-sessional units for $1, 2, \dots, T$ dated periods. While α is the intercept, which represents the overall constant, β_1 β_2, h_1 and h_2 are the slope coefficients, which capture the effects of the ICT development and ICT maintenance on the return on assets and profit after tax. The models (1) and (2) assume that latent or unobserved bank-specific factors have no significant explanatory power for return on assets, hence, no subscript is attached to the intercept α

The Fixed Effects Model

The Fixed effects model can be written as:

$$LROA_{it} = (\alpha + k_i) + \partial_1 LICT\_DEV_{it} + \partial_2 LICT\_MAIN_{it} + \epsilon_{it} \quad (3)$$
$$LPAT_{it} = \alpha + ki + \emptyset_1 LICT\_DEV_{it} + \emptyset_2 LICT\_MAIN_{it} + \epsilon_{it} \quad (4)$$

where; k_i is a latent variable representing the bank-specific effects, and $\partial_{is}, \emptyset_{is},$ and ϵ_{it} are as defined in (1) and (2) above. The fixed effects model can be rewritten as:

$$LROA_{it} = \alpha_i + \partial_1 LICT\_DEV_{it} + \partial_2 LICT\_MAIN_{it} + \epsilon_{it} \quad (5)$$
$$LPAT_{it} = \alpha_i + \emptyset_1 LICT\_DEV_{it} + \emptyset_2 LICT\_MAIN_{it} + \epsilon_{it} \quad (6)$$

where; $\alpha_i = \alpha + k_i$ so that $\alpha_1, \alpha_2, \dots, \alpha_N$ are dummy variables representing the differences in banks or the fixed effects. Unlike the pooled OLS assumption, the fixed effects model assumes that $\alpha_1, \alpha_2, \dots, \alpha_N$ have significant explanatory power for $LROA$, LPAT and are correlated with $LICT\_DEV$ and $LICT\_DEV$.

The Random Effects Model

The Random effects model can be specified as:

$$LROA_{it} = \propto + \delta_1 LICT\_DEV_{it} + \delta_2 LICT\_MAIN_{it} + (\gamma_i + \epsilon_{it}) \quad (7)$$
$$LPAT_{it} = \theta + \vartheta_1 LICT\_DEV_{it} + \vartheta_2 LICT\_MAIN_{it} + (\gamma_i + \epsilon_{it}) \quad (8)$$

where; $\gamma_i, \beta_1, \beta_2,$ and ϵ_{it} are as defined in (1) above. The random effects model assumes γ_i are realizations of independent random variables with zero mean and finite variance (EViews, 2015). The model can be rewritten as:

$$LROA_{it} = \propto + \beta_1 LICT\_DEV_{it} + \beta_2 LICT\_MAIN_{it} + v_{it} \quad (9)$$
$$LPAT_{it} = \theta + \vartheta_1 LICT\_DEV_{it} + \vartheta_2 LICT\_MAIN_{it} + v_{it} \quad (10)$$

where; $\propto and\ \theta$ are the overall means, $v_{it} = \gamma_i + \epsilon_{it}$ is the composite error term which absorbs the latent variable γ_i. Unlike the fixed effects model, the random effects model treats γ_i as the deviation from $\propto and\ \theta$ and are uncorrelated with $LICT\_DEV$ and $LICT\_DEV$.

Causality Models

The Granger causality formulation is expressed as follows:

$$LROA_t = \sum_{j=1}^{m} \phi_j \mathrm{ROA}_{t-j} + \sum_{j=1}^{m} a_j \mathrm{LICT\_DEV}_{t-j} + \sum_{j=1}^{m} \beta_j \mathrm{LICT\_MAIN}_{t-j} + E1 \quad (11)$$

$$PAT_t = \sum_{j=1}^{m} \xi_j \mathrm{PAT}_{t-j} + \sum_{j=1}^{m} \lambda_j \mathrm{ICT\_DEV}_{t-j} + \sum_{j=1}^{m} \gamma_j \mathrm{LICT\_MAIN}_{t-j} + E2 \quad (12)$$

Equations 11 and 12 are estimated using the Granger causality procedure. The F-statistics was computed for all the two causality models to determine the magnitude and direction of causation between ICT and bank performance.

DATA ANALYSIS AND DISCUSSION

Data Description

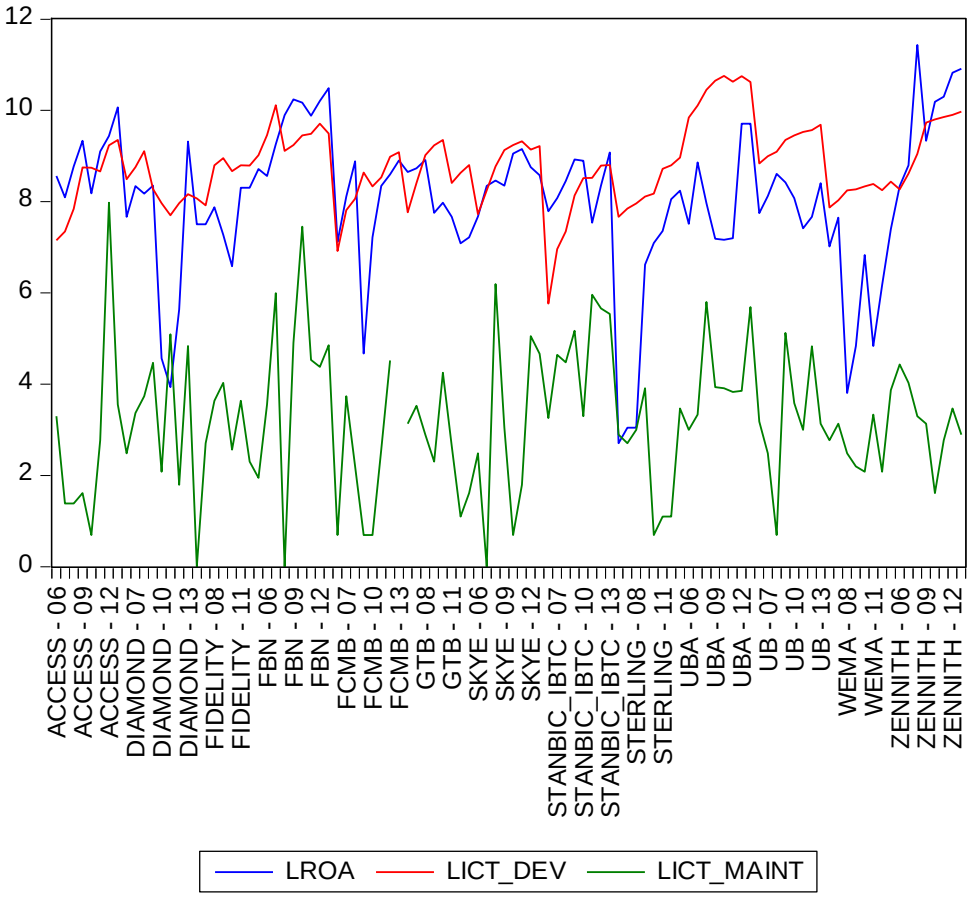
Table 1 reports some summary statistics that describe the distributional properties of our data. As we can see from this table, PAT and ROA have an average value of 14908.16 and 8.18 respectively, while ICT development and ICT maintenance have average values of 9553.019 and 102.621 respectively. The variability of the distributions appears to be very high with 22171.54 for PAT, 9714 for ICT development and 337 for ICT maintenance, and 1.56 for ROA. All the series have a positive skewness coefficient and a kurtosis coefficient that is above 3, indicating that they all have a leptokurtic distribution that is skewed to the right. The Jarque-Bera statistic is associated with a zero probability for all the series, suggesting clear evidence that none of the series is normally distributed. The null hypothesis normal distribution is therefore rejected for all the series. In view of the high standard deviations of the variables, it is no wonder they fluctuate so violently, in demonstration of very high volatility behavior, as shown in Figure 1.

Table 1
Descriptive statistics

Statistic	PAT	ICT_DEV	ICT_MAINT	ROA
Mean	14908.16	9553.019	102.621	8.185436

Median	7727.000	6572.000	24.000	8.307706
Maximum	95803.00	46829.00	2922.000	11.43675
Minimum	-22582.00	319.000	1.000	2.708050
Std. Dev.	22171.54	9714.010	337.095	1.559545
Skewness	1.739	2.346	6.868	-1.215967
Kurtosis	6.241	8.495	53.687	6.027083
Jarque-Bera	97.010	224.169	11836.20	55.28431
Probability	0.000	0.000	0.000	0.000000

Figure 1
ICT Development and Maintenance and Return on Assets of Banks



Diagnostics, Evaluation and Comparison of Models and Effects

Global Statistics of the PAT and ROA Pooled, Fixed, and Random Models.

From Table 2, Panel A, which describes the estimation results of the PAT specifications, the F-statistic is associated with a zero probability for all models, indicating that the two explanatory variables jointly have a significant explanatory power for bank performance. However, the fixed effects model has a better fit than both the pooled regression and random effects models, with the joint influence of ICT development and ICT maintenance explaining approximately 54% of the total variation in bank performance for fixed effects model, and approximately 22% and 16% for pooled regression and random effects model respectively. Thus, given that the difference is quite substantial, our initial conclusion is that the fixed effects estimates perform better than those of pooled regression and random effects.

Table 2
Panel A: PAT Models' Goodness of fit statistics and diagnostics

Pooled OLS Model			**Fixed Effects Model**		**Random Effects Model**	
	Value	**p-value**	**Value**	**p-value**	**Value**	**p-value**
R-squared	0.237	–	0.613	–	0.177	–
Adjusted R-squared	0.219	–	0.540	–	0.157	
F-statistic	13.368	0.000	8.400	0.0000	9.254	0.000

Panel B: ROA Models' Goodness of fit statistics and diagnostics

Pooled OLS Model			**Fixed Effects Model**		**Random Effects Model**	
STAT	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**
R-squared	0.112	–	0.545	–	0.053	–
Adj. R-squared	0.094	–	0.473	–	0.034	
F-statistic	6.338	0.0025	7.539	0.0000	2.832	0.063
DW			2.12		2.37	

From Table 2, Panel B, which describes the estimation results of the ROA specifications, given the results of the adjusted R-squared and the F-statistic, the initial conclusion is that the estimates of the fixed effects model perform better than those of the pooled OLS and random effects models. Approximately 47% of the total variation in ROA is significantly explained by the fixed effects model, while approximately 9% and 3% of the total variation in ROA is significantly explained by the estimated pooled and random effects models respectively.

However, based on the Durbin-Watson statistic, the random and fixed effects models appear to perform better than the pooled OLS. The DW statistic is indicative of absence of autocorrelation problems in the two models being 2.12 and 2.37 respectively for random and fixed effects. The same cannot be inferred of the pooled OLS.

On the aggregate, the PAT models and their effects out-perform the ROA models and their effects, judging by their goodness of fit criterion. This is because, in spite of the fact that the two sets of models recorded all round significant F-statistics, the PAT models explain more of the variation in bank performance than the ROA models. Thus, we are inclined to bias our analysis of relative statistics and attendant conclusions more on the results of the PAT fixed and random effects models than the ROA models. Furthermore, that the fixed effect model appears to have out-perform the random and pooled effects of both the ROA and PAT models is still subject to further inquiry. More particularly, this inference, however, is subject to the Hausman specification test that would enable us to choose between the fixed and random effects model, in terms of performance.

Pooled, Fixed Effects and Random Effects Estimation for ROA Models

Table 3, Panel A, shows the estimation results for the ROA model with the associated pooled effects, fixed effects and random effects. As this table reveals, the results for all the three variants are broadly similar in terms of the signs of the coefficients. The intercept t-statistics values of -2.80 (prob. = 0.006), -1.34 (prob. = 0.182), and – 1.73 (prob. = 0.087) associated with beta coefficients of -34081.8, -20386.6 and -24183.7 respectively for pooled OLS, fixed effects and random effects models indicate that without the ICT development and maintenance, on average, the banking sector may be inclined to have negative performance. Thus, from this evidence, the success of the banking sector, to a very large extent, appears to depend on ICT development and maintenance, and for any meaningful performance to be recorded, banks must, on a regular and sustained basis, invest in ICT development and maintenance. How does the observed trend agree with both theory and practical experiences of the Nigerian banks under study is another question of importance that require concerted empirical answer.

The coefficients of LICT_DEV and LICT_MAIN are both positive for the three models, indicating that both ICT development and ICT maintenance are positively related to return on assets. The higher the investment in ICT development, the higher the return on assets of banks in Nigeria. However, while the relationship between ICT development and return on assets is significant at conventional levels, respectively for pooled, fixed effects and random effects models, the relationship between ICT maintenance and return on assets is not significant all the models.

Table 3
Panel A: Results of the estimated ROA Model showing pooled, fixed effects and random effects models

Pooled OLS Model				Fixed Effects Model			Random Effects Model		
Variable	**Beta Coef**	**t-Stat.**	**Prob**	**Beta Coef.**	**t-Stat.**	**Prob**	**Beta Coef.**	**t-Stat.**	**Prob**
Const.	-3408	-2.80	0.006	-2039	-1.34	0.182	-2418	-1.73	0.087
LICT_DEV	4582	3.22	0.002	3163	1.79	0.076	3574	2.22	0.028
LICT_MAIN	503.5	0.63	0.527	122.1	0.18	0.859	175	0.26	0.796

Panel B: Regression results for the PAT Models showing pooled effects, fixed effects and random effects models

Pooled OLS Model				Fixed Effects Model			Random Effects Model		
Variable	**Beta Coef.**	**t-Stat.**	**Prob.**	**Beta Coef.**	**t-Stat.**	**Prob.**	**Beta Coef.**	**t-Stat.**	**Prob.**
Const.	4.038	3.83	0.000	4.610	3.572	0.000	4.418	3.73	0.000
LICT_DEV	0.564	4.57	0.000	0.508	3.396	0.001	0.521	3.82	0.000
LICT_MAIN	0.075	1.11	0.268	0.051	0.855	0.395	0.056	0.95	0.347

Pooled, Fixed Effects and Random Effects Estimation for PAT Models

Table 3 Panel B reports the results of the PAT model with attendant pooled, fixed, and random effects. As shown, the results are also broadly similar for the different model effects. In this case, the intercept term is positive and highly significant for three models, indicating that if there was no investment in ICT development and maintenance, profit after tax, on the average, would still be positive and significant. This is more akin to what obtained among Nigerian banks before the ICT advent and explosion, since most of the banks were making profits even then. The results here may be interpreted as suggesting that the success of the banking sector in Nigeria does not wholly depend on ICT development and ICT maintenance. These results, therefore, modify the ROA findings above that tend to suggest that without ICT, the banking sector would crumble to the lowest and even suboptimal performance levels. Thus, this is an added revelation that although ICT is important, and perhaps indispensable, there are still other factors that are important

arguments in explaining the changes in levels of profit after tax of banks in Nigeria. From the goodness of fit statistical results, these other factors account for about 46% of the variations in PAT.

Further, and interesting enough, the results indicate that both ICT development and ICT maintenance have positive relationship with bank performance, with both LICT_DEV and LICT_MAIN having positive beta coefficients for all models. These are similar with the ROA model. Again, as indicated in Table 3, Panel B, by the associated p-value of the t-statistic, while the relationship between ICT development and profit after tax was consistently significant at 1% level, the relationship between ICT maintenance and PAT was consistently insignificant. These findings are also quite similarly with those of the ROA model results. It is quite understandable, then, that since ICT development expenditure relates to the outlay that underlies a critical investment activity and hence should contribute more to profitability. On the other hand, ICT maintenance expenditure is basically an overhead that merely supports the investment and would necessarily contribute less to profit, being a charge to it, and which should be pegged at the barest reasonable minimum, if profitability would be enhanced.

The estimated dummies, which account for the differences in bank-specific unobserved or latent factors such as internal control measures, management cultures and philosophies, for the ROA models, are reported in Table 4, Panel A. As this Table shows, the results are broadly similar for different models, with most of the banks showing negative unobserved or latent effects. However, while ACCESS, FBN and ZENNITH banks consistently show positive latent effects for the two models, Standard-IBTC shows conflicting results. For Standard-IBTC bank, the unobserved factors show negative effects for fixed effects model but show positive effects for random effects model. Although, it is assumed that the unobserved bank-specific factors have no significant explanatory powers for bank performance, some studies have however, found that these unobserved effects are significant (Muhammad, Gatawa, and Birnin Kebi (2013); Binoyo and Aregbeshola, 2014). There is, therefore, good reason to test the hypothesis that there is no significant relationship between the estimated unobserved factors and Bank performance.

For the PAT models, Table 4, Panel B, reports the estimated unobserved bank-specific fixed and random effects. As we can see, the estimated bank-specific fixed and random effects are broadly comparable, with most of the banks showing negative unobserved effects or characteristics. Specifically, of the 13 banks, 8 (Fidelity, FCMB, Skye, Stanbic-IBTC, Sterling, UBA, Union and Wema banks) show negative unobserved effects, while the rest (ACCESS, Diamond, First Bank, GTB, and Zenith banks) show positive unobserved effects. Given that the results of the goodness of fit tests in Table 2 seem to favour the fixed effects estimates over those of pooled regression and random effects, we argue that these estimated unobserved effects should be important explanatory variables in the PAT models,

and thus, should be correlated with the other (observed) explanatory variables in that model. If this is the case, then the results would imply that finance managers strategically invest in ICT in order to significantly influence the financial performance of their individual banks.

Table 4
Panel A: Estimated unobserved bank-specific effects for ROA Models

S/no	Bank	Fixed Effects	Random Effects
1	ACCESS	2898.334	2719.494
2	DIAMOND	-3093.289	-2536.357
3	FIDELITY	-4386.251	-3746.114
4	FBN	11311.89	9619.364
5	FCMB	-2489.560	-1869.854
6	GTB	-3811.452	-3273.547
7	SKYE	-2349.447	-2057.979
8	STANBIC IBTC	-33.92131	250.4787
9	STERLING	-4778.645	-3954.559
10	UBA	-7170.078	-6927.078
11	UNION	-6076.925	-5507.371
12	WEMA	-5159.241	-4287.891
13	ZENNITH	24827.40	21571.41

Panel B: Estimated unobserved bank-specific effects for PAT Models

S/no	Bank	Fixed Effects	Random Effects
1	ACCESS	0.020	0.081
2	DIAMOND	0.415	0.421
3	FIDELITY	-0.417	-0.303
4	FBN	0.679	0.644
5	FCMB	-0.100	-0.012
6	GTB	1.182	1.101
7	SKYE	-0.615	-0.481
8	STANBIC IBTC	-0.085	-0.011
9	STERLING	-0.662	-0.505
10	UBA	-0.164	-0.104
11	UNION	-1.555	-1.225
12	WEMA	-0.669	-0.434
13	ZENNITH	0.883	0.829

Effects of Bank-specific Unobserved or Latent Factors for ROA and PAT Models

Likelihood Ratio (LR) Test of Joint Significance for ROA and PAT Models

To determine whether the estimated fixed effects are jointly significant in the PAT models, we perform the Likelihood Ratio (LR) test and its F- test equivalent. The LR test, which asymptotically follows a Chi-Square distribution, involves estimating two models; restricted and unrestricted models. Here, the pooled regression model is the restricted model while the fixed effects model is the unrestricted model. Thus, under the null hypothesis that all the estimated fixed effects are jointly not significantly different from zero, the pooled regression model is valid against the fixed effects model. Table 5, Panel A, presents the Likelihood Ratio Redundant Fixed Effects test for the joint significance of the estimated bank-specific dummies for ROA models. From the Table, the associated probability for both the F-statistic and its Chi-square equivalent is well below any conventional levels of significance, indicating that the test is highly significant. This is clear evidence that the fixed effects model is valid. Thus, we strongly reject the null hypothesis, and align with the assumption that the estimated unobserved factors jointly have significant explanatory power for return on assets.

Table 5
Panel A: Likelihood ratio test for estimated ROA models fixed effects

Effects Test	Statistic	d.f.	p-value
Cross-section F	6.981	12	0.0000
Cross-section Chi-square	68.893	(12,88)	0.0000

Panel B: Likelihood ratio test for estimated PAT models fixed effects

Effects Test	Statistic	d.f.	p-value
Cross-section F	6.013	(12, 74)	0.0000
Cross-section Chi-square	60.579	12	0.0000

For the PAT models, the results are shown in Table 5 Panel B. Here, also the Likelihood Ratio test is implemented as in the case of the ROA models above by using two models; namely, the restricted (pooled OLS) model and the unrestricted (fixed effects model), with the null hypothesis supporting the restricted pooled OLS model. As the results shows, the two test statistics have zero probabilities, indicating that the test is highly significant. Thus, we strongly reject the null hypothesis that the estimated dummies are redundant, implying that the fixed effects model outperforms the pooled regression model. There is therefore, strong evidence that the estimated dummies are important explanatory variables in the in the PAT models.

Lagrange Multiplier Test for the Significance for ROA and PAT Models

Similarly, Table 6, Panel A, reports the Lagrange Multiplier test for the significance of the estimated bank-specific dummies in the ROA random effects model. In essence, the LM test is applied on the restricted pooled OLS model, with the assumption that the bank-specific dummies in the random effects model are not significant explanatory factors, and thus, should be omitted. From the Table, given that all the reported tests statistics have zero associated probabilities, there is clear evidence that there are omitted bank-specific effects in the residuals of the estimated pooled OLS model.

Table 6
Panel A: The LM test results for ROA Model random effects

Statistic	**Cross-section**	**Prob.**
Breusch-Pagan	60.09453	0.0000
Honda	7.752066	0.0000
King-Wu	7.752066	0.0000
Standardized Honda	8.657761	0.0000
Standardized King-Wu	8.657761)	0.0000

Panel B: The LM test results for PAT Model random effects

Statistic	**Cross-section**	**Prob.**
Breusch-Pagan	40.639	0.0000
Honda	6.374	0.0000
King-Wu	6.374	0.0000
Standardized Honda	7.247	0.0000
Standardized King-Wu	7.247	0.0000

Similarly, for the PAT models**,** in order to determine whether the estimated random effects are important variables that are omitted from the pooled regression model, we also performed different versions of the Lagrange Multiplier (LM) test. As noted earlier, the LM test involves estimating only the restricted pooled model under the assumption that the estimated random effects are not significantly different from zero. The results for the PAT models are shown in Table, Panel B. As we can see, the test statistics all have probabilities that are almost zero, indicating that they are all highly significant. This is clear evidence, again, that the estimated random effects are important variables that are omitted from the pooled regression model. Thus, random effects model has outperformed the pooled regression model.

Comparing Fixed and Random Effects for ROA and PAT Models

To compare the random effects estimates with those of fixed effects, we perform the popular Hausman specification test. Here, the Hausman test is performed under the null hypothesis that the estimated unobserved bank-specific factors are uncorrelated with the investment in ICT development and maintenance. The test results for the ROA models are presented in Table 7, Panel A. As this Table shows, the Chi-square statistic has a p-value that is well above conventional levels, leading us not to reject the null hypothesis that estimated unobserved bank-specific factors are uncorrelated with the investments in ICT development and maintenance. This is clear evidence that the random effects model is the most plausible for our data.

Table 7
Panel A: Hausman specification test for correlated ROA Model random effects.

Test summary	Chi-Square Statistic	d.f.	p-value
Cross-section random	0.638	2	0.7268

Panel B: Hausman specification test for correlated PAT Model random effects.

Test summary	Chi-Square Statistic	d.f.	p-value
Cross-section random	0.169	2	0.918

Also, the results of the PAT models are shown in Table 7, Panel B. As this Table shows, the Chi-square statistic has a probability that is substantially above all the conventional levels of significance, leading us not to reject the null hypothesis that estimated unobserved bank-specific factors are uncorrelated with the observed explanatory variables. This also suggests that the PAT random effects model is the most preferred panel data model for the relationship between ICT development, ICT maintenance and bank performance.

Pairwise Granger Causality Test

In a bid to determine whether there is causality between bank performance and ICT development and ICT maintenance, we perform the pairwise PAT Granger causality model test. The results are shown in Table 8. As the Table shows, there is evidence of unidirectional causality running from ICT development to bank performance, and from ICT development to ICT maintenance. This in indicative of the point that ICT development drives profitability in a cause and effect manner and magnitude. It is also a point of easy comprehension that development drives, or gives rise to, maintenance. Without the former, the latter cannot happen. By contrast, there is no evidence of significant causality between ICT maintenance

and bank performance. The F-statistic rejects the null hypotheses that ICT_DEV does not Granger Cause PAT, and that ICT_DEV does not Granger Cause ICT_MAIN each at 5% level of significance. Thus by establishing that significant causality flows from ICT development to profits after tax, the study infers that there is a causal relationship between ICT development and bank performance in Nigeria.

Table 8
Granger Causality test for ICT_DEV, ICT_MAIN and PAT

Null Hypothesis	F-statistic	p-value
ICT_DEV does not Granger Cause PAT	3.63556	0.0179
PAT does not Granger Cause ICT_DEV	0.17601	0.9122
ICT_MAIN does not Granger Cause PAT	1.64272	0.1896
PAT does not Granger Cause ICT_MAIN	0.39734	0.7554
ICT_MAIN does not Granger Cause ICT_DEV	1.08446	0.3631
ICT_DEV does not Granger Cause CT_MAIN	3.04107	0.0361

CONCLUDING REMARKS AND POLICY IMPLICATIONS

The paper examined the effects of ICT development and maintenance on bank performance in Nigeria using the panel data methodology; where the data set consists of 108 observations on 13 quoted banks ranging from 2006 to 2013. The main conclusions are as follows:

From the results of the ROA models, there is consistent evidence from the three panel data pooled, fixed, and random effects models that without the ICT development and maintenance, the banks' return on assets (ROA) will dwindle considerably. Thus, the success of the banking sector, are to a very large extent, dependent on the ICT development; and for any meaningful performance to be recorded, banks must, on a regular and sustained basis, invest in ICT development and maintenance. However, the results of the PAT models appeared to modify or put some important caution and caveat on the above submission from the results of the ROA models. The modification is that even when it is revealed that ICT is absolutely important for the successful operations of the banking sector in Nigeria, overall profitability does not wholly depend on ICT development and ICT maintenance, as there is strong evidence that without ICT development and ICT maintenance, bank performance, on average, would be positive and significant.

Further, there is evidence that investment in both ICT development and ICT maintenance have positive relationship with bank performance. However, while the relationship between ICT and bank performance is significant, the relationship between ICT maintenance and bank performance is not significant. This is also lent credence by the results of the causality test that established a positive and significant cause and effect relationship between ICT development and bank performance, with causality flowing from the former to the latter. ICT development causes bank profits or returns. On the contrary, there is no significant causal relationship between ICT maintenance and bank profits.

For both ROA and PAT models, and in terms of goodness of fit, the fixed effects model has a better fit than both pooled regression and random effects model, with approximately 47% and 54% respectively, of the total variation in bank performance being accounted for by the joint influence of ICT development and ICT maintenance. Further, on the basis of Likelihood Ratio test and the Lagrange Multiplier test for both ROA and PAT models, both fixed effects and random effects estimates outperform those of the pooled regression. However, on the basis of Hausman test, there is evidence that the random effects model performs better than the fixed effect model, and thus, is the most plausible model for our panel data analysis.

There is strong evidence that the unobserved bank-specific random effects are omitted in the pooled OLS residuals, and that the fixed effects are significant explanatory factors for bank performance. However, comparing the fixed effects estimates and those of random effects on the basis of Hausman test the results provide evidence that the estimated unobserved bank-specific factors are uncorrelated with the investment in ICT development and maintenance, and thus can be treated as random deviation from the overall mean, which can be absorbed in the composite error term. Thus, the random effects model is the most plausible for the study's data, and would lend to the conclusion that bank performance is positively and significantly associated with ICT development but positively and insignificantly associated with ICT maintenance.

Based on these results, the study recommends that banks should make it a deliberate policy to sustain their investments in ICT development but with prudent outlay on maintenance so as to enhance their corporate performance. This is important in view of the fact that ICT is highly dynamic and no banks should be left behind in the midst of changing technology, if it has to maximally satisfy its customers and garner in their cherished patronage. The risk of loss associated with paying deaf ears to the demands of technological currency and dynamism will be too unbearable for such a careless and negligent bank. Prudent maintenance that is devoid of wasteful practices should be continued alongside the implicated huge outlay that accompanies constant investment in technological development.

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