

EFFECT OF INFORMATION AND COMMUNICATION TECHNOLOGY ON THE EFFICIENCY OF DEPOSIT MONEY BANKS IN NIGERIA

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Purpose. This study examined the effect of information and communications technology (ICT) on the efficiency of deposit money banks in Nigeria during the period 2006–2020. Specifically, the effect of volume of transaction on automated teller machine, mobile banking, internet banking and point of sale terminals on the efficiency of deposit money banks was evaluated.

Results. The result of Granger Causality test revealed that information and communications technology channels of Automated Teller Machine (ATMs), mobile banking, internet banking, and point of sale (POS) terminals have no significant effect on the efficiency of deposit money banks in Nigeria. Volume of transactions on ATMs, mobile banking, and POS terminal have negative insignificant relationship with efficiency of deposit money banks. On the other hand, volume of transactions on internet banking was negatively and non-significantly linked with efficiency of deposit money banks in Nigeria. The non-significant effect of ATMs transactions points to the need for deposit money banks in Nigeria to ensure availability of money in the ATMs machines.

Scientific novelty. This study is pursued within the framework of the Technology Acceptance Model. The theory is relevant as it explains user's acceptance of ICT strategies and usage in an organizational context. This finding will add credence to the Technology Acceptance Model postulation on information and communications technology and efficiency of the banking industry.

Practical value. This research will be of tremendous importance to the banks' staff as well as managers (top management staff) and investor in the banking industry. This is by the way of providing valuable information on the issues and possible factors that can influence deposit money banks efficiency. The knowledge gained from this study will help make efficient use of information and communications technology gadgets. It will aid the efficiency and growth of banks, and possible provide investment in banking assets.

Key words: information and communication technology, bank efficiency, banking innovations.

Introduction. Information and communications technology (ICT) driven services offered by the commercial banks in Nigeria have to a high extent improved customers' satisfaction when compared to the traditional banking system where customers are forced to come to the banking hall to have services delivered. Information has always played a prominent role in human activities. Information and communications technology innovation has become an indispensable tool to improve the human lives and connect the nations of the world. The last decade has seen information and communications technology dramatically transforming the world, enabling banking innovations and productivity increases; connecting people and communities; improving standards of living and creating employment opportunities across the globe (Okonkwo et al., 2015). The robust development in science and technology has immeasurably increased the role of information in every facet of human endeavour. The pace of change brought by new technologies has had significant effect on the way people live, work, and play globally. Today's business environment is very dynamic and experience rapid changes as a result of creativity, innovation, technological changes, increased awareness and demands from customers. Business organizations, especially the banking industry of the 21st century operates in a complex and competitive environment characterized by these changing conditions and highly unpredictable economic climate with information and communications technology at the centre of this global change curve (Azojiri & Nzube, 2020). Banks have always been at the fore front of controlling and making use of technology to improve their performance and services to their customers. Banks nowadays operate in a complicated and competitive environment due to the nature of our highly unpredictable economy.

The use of information and communications technology in banks brought competition, flexibility, efficiency etc. to the banking industry and has also played a very important role in improving service delivery standards in the banking industry for example, the use of Automated Teller Machine. Information and communications technology now allows customers to carry out their various banking transactions beyond banking hours. It allows customers to withdraw money without going inside the bank (Onyeka, 2018). The use of mobile banking allows the customer to do any transaction and check their balances without stress. This has created a cashless economy where there is no need for carrying cash around; transactions are done through the internet. The use of computers and internets made bank works faster and easier. We also have point of sales, smartcards, etc. The use of information and communications technology has helped the banking industry in improving their performance. With information and communications technology, customers and employees have access to information in a way that is controlled and safe. the deployment of information and Communication Technology products in the banking sector has been argued to be a force for diversification of product channel systems such as Automated Teller Machines (ATMs), mobile, point of sale terminals, and internet banking. Information and Communication Technology drive revenue, reduce cost to

both banks and customers as customers can access their accounts with their mobile phones (Ibenta & Anyanwu, 2017; Abubakar & Rasmiani, 2012). The use of sophisticated banking technology, paper transaction model, including the application of information and communications technology to their banking operation became evident to repositioning Nigeria deposit money banks to an unanticipated improvement in the array of banking products and instruments that are stimulating the customer's need and preference (Okonkwo et al., 2015). In Ghana, the deployment of financial innovation products have enhanced the performance of the banking sector and customer's as well, customers are efficiently served and profit motive of banks enhanced (Joshua, 2005).

Bank sector efficiency is vital issues confronting the public and policy makers. This has become essential in transition countries that have been faced with one banking crisis or the other or incessantly faces crisis and those associated with frequent policy change and somersault. The regulatory authorities are often confronted with finding out whether inefficient banks operating in an economy will pose additional risks to the banking system and its safety net. This is so because a key role of a country's bank regulators is to limit systemic risks that is, the risk that the problem of a few banks could spread to many other banks that are otherwise liquid and solvent. When systemic risks are avoided or reduced, the money supply and the payment system are being protected from severe disruption thereby enhancing effectiveness of monetary policy. Stability in the financial sector and minimization of bank run tendencies are also achieved. The lessons from the 2006–2010 global financial crises have reinforced the urgency for regulatory institutions to increase concerns over reduction or elimination of systemic risks in the financial sector. This, among other issues, has called for the need for regulations to be incentive compatible over time and across institutions, while balancing possible negative effects on efficiency of the banking industry.

The motivation for carrying out this research work lies on two contemporary issues observed in literature. At first, despite the potential benefits of information and communications technology, there is a debate about whether and how their adoption improves efficiency of the banking industry. There are several empirical studies on the alleged nexus between information and communications technology and banking industry operation however, the results emanating from these researches are mixed and conflicting. The studies of Azojiri & Nzube (2020), Rahman et al. (2020), Nwakoby et al. (2018), Ankrah (2015), Eruemegbe (2015), Adesola et al. (2013) have found that the deployment of information and communications technology have improved bank performance. On the other hand, the revelation from Okonkwo et al. (2015) is that investments in information and communications technology vide e-banking services and Automated Teller Machines do not really improve banks' performance. Following the same line of argument, Woldu & Belay (2020), Festus et al. (2020), Appiahene et al. (2019), Wasilwa & Omwenga (2016), and Alabar & Agema (2014) information and communications technology has no significant effect on banks performance, whereas Aggreh et al. (2020), Mahboub (2018), and Ibenta & Anyanwu (2017) established that

banks performance are not affected by information and communications technology. Studies like Bukar & Tahir (2019), Okanta (2019), Kyeremeh et al. (2019), Gontur et al. (2017), Ilo et al. (2014), Ibrahim & Muhammad (2013), Agbolade (2011), and Akujuobi & Akujuobi (2009) have unveil the existence of a positive relationship between information and communications technology and banks performance. On the contrary, Muhammad et al. (2013) found an inverse relationship between additional sustained investment in information and communications technology and efficiency. The lack of consensus on the linkage between information and communications technology and banking industry operation calls for a study of this nature using up-to-date data on the variables of interest.

Secondly, all the afore-mentioned empirical works in the Nigerian environment focused only on profitability (return on assets, return on equity, net profit margin) while neglecting efficiency of the banking industry except for Ibenta & Anyanwu (2017) that studied financial innovation and the efficiency of the Nigerian banking industry from 2006 to 2014. This study improves on previous literature as well as the study of Ibenta & Anyanwu (2017) by first increasing the number of observations from nine (9) years to 15 years that is, 2006 to 2020. Finally, it utilized the volume of transactions on the four e-money products in Nigeria: automated teller machine, mobile banking, internet banking, and point of sale terminals as against the use of value of transactions. The section one takes care of the introductory aspect of the study, section two reviewed important literature in the subject area, section three detailed the methodology adopted, section four reveals the results of the analysis and discussed the findings, while section five summarized the study and gave some useful policy implications.

Review of literature. Information and communications technology (ICT) is the automation of processes, controls, and information production using computers, telecommunications, software and other gadgets that ensure smooth and efficient running of activities (Dabwor et al., 2017). ICTs can be described as a complex varied set of goods, applications and services used for producing, distributing, processing, transforming information including telecoms, TV and radio broadcasting, hardware and software, computer services and electronic media (Laudon & Laudon as cited in Okonkwo et al., 2015). When it comes to information and communications technology, Woldu & Belay (2020) contended that it is the application of computers and internet to store, retrieve, transmit and manipulate data, or information, often in the context of a business or other enterprises. Azojiri & Nzube (2020) posited that information and communications technology is having a dramatic influence on almost all spheres of human activity, which the banking sector is the most significant as we can attest. Today's business environment is very dynamic and dramatic changes are high sequel to, technological changes, heating innovations, increased awareness and enormous demand from customers and clients. Efficiency is related to the ability to produce a result with minimum effort or resources. It measures how close a production unit gets to its production possibility frontier, which is composed of sets of points that optimally combine inputs in order to produce one unit of output. Following Harker & Zenios as

cited in Megwa (2016), the drivers of bank efficiency are grouped into three broad categories: strategy, execution of strategy, and environment. The articulation of a strategy is a key driver for success and especially so in dynamic, competitive environments such as that in the financial services industry. The second broad set of performance drivers deals with the execution of a strategy, and the operational decisions that a bank makes in order to achieve its strategic goals. Environmental factors are indirectly controlled by the banks – through lobbying activities, marketing efforts, research and development – and hence, they can also be viewed as major factors in understanding performance.

Theories have been modelled in an attempt to establish a linkage between information and communications technology and efficiency in the banking system. Some of these theories include Technology Acceptance Model, Diffusion of Innovation Theory and Task Technology Fit (TTF) Theory. Nevertheless, this study is pursued within the framework of the Technology Acceptance Model. This theory is relevant to this study since it explains user's acceptance of ICT strategies and usage in an organizational context. Acceptance is the first process in technology use and has a bipolar implication. First of all, acceptance is a precursor to adoption and hence this theory complements the preceding theories. Secondly, acceptance dictates the attitude and perception of the users which eventually affects efficiency of use and hence performance. Strategic adoption as well as operational efficiency and hence productivity of systems are a function of acceptance of the technology. It is thus plausible to conclude that without acceptance, the rest of the theories would be redundant and invalid. Though acceptance is an initial phase, it is also an attitude shaping facet that influences adoption and effectiveness of use. Technology acceptance model (TAM) was originally proposed by Davies in 1986. This model was designed to forecast the user's acceptance of information technology and usage in an organizational setting. Wasilwa & Omwenga (2016) posits that firms are adopting technology to cope with the dynamics of the external environment. This model has been tailored in a manner that can accommodate changes for improved costs reduction and efficiency. Technology Acceptance Model deals with perceptions as opposed to real usage, the model suggest that users are the key factors that influence their decision on how, where and when they will use it.

Empirically, the review of related studies were tabulated to make it more concise for readers' accessibility/analysis and comprehension. However, it is worthy to note that there is dearth of empirical studies on the use of volume of transactions on the four e-money products in Nigeria: automated teller machine, mobile banking, internet banking, and point of sale terminals as against the use of value of transactions on efficiency of the banking industry. The nearest study is that of Ibenta & Anyanwu (2016) which utilized value of transactions in the four e-money products as independent variables and efficiency of deposit money banks as the dependent. In this regard, the bulk of the empirical studies reviewed were hinged to profitability of the banking industry in different environment as seen in Table 1.

Table 1

Summary of Related Empirical Studies Reviewed

S/N	Author (s) and Year	Country/Period	Topic / Scope of study	Variables	Method of analysis	Major findings
1	2	3	4	5	6	7
1	Rahman, Mutsuddi, Roy, Al-Amin & Jannat (2020)	Nigeria	Performance efficiency evaluation of information and communications technology (ICT) application in human resource management during COVID-19 pandemic: a study on banking industry of Bangladesh	People management, regular human resource activities, human resource payroll and rewards, and performance evaluation and promotion	Correlation and regression analyses	The use of ICT assures Human resource management performance efficiency without taking face-to-face interaction during the pandemic.
2	Woldu & Belay (2020)	Ethiopia	Assessment on the roles of ICT in improving the customer satisfaction and employee performance of commercial banks: The case of Dashen and United Bank Branches in Mizan-Aman, Southwestern Ethiopia	Investment in ICT, bank revenue	Pearson correlation	IT indeed has an impact on the performance of commercial banks. It was found that the IT based services provided by the two bank branches were found to be convenient and user-friendly to customers.
3	Azójiri & Nzube (2020)	Nigeria, from 2000–2015	Effect of information communications technology on banks performance in Nigeria	Direct line usage, mobile line usage, internet network usage, banks total assets	Ordinary least square regression	The findings also showed that increased banks based investment in ICT had eventually increased banks assets.
4	Aggreh, Malgwi & Aggreh (2020)	Nigeria, 2010–2017	ICT investment and banks financial performance in Nigeria	Return on assets, return on equity and investment in ICT	Panel regression	The findings of the study reveal that ICT investment does not always result in instantaneous positive effects on financial performance in the immediate period.
5	Ekele & Ukpata (2020)	Nigeria, 2000 and 2017	Implications of electronic banking on commercial banks' performance in Nigeria (2000–2017)	Net income, annual ICT cost, annual operating costs, annual cost on other assets	Panel regression techniques	There is a significant relationship between e-banking services and the performance of commercial banks in Nigeria.
6	Festus, Kazeem & Ayodeji (2020)	Nigeria	Information and communications technology and sustainable performance of selected listed deposits money banks in Lagos State, Nigeria	Mobile banking, online banking, automated teller machine and bankers automated clearing service	Pearson correlation	The result of findings show that ICT dimensions (mobile banking, online banking, automated teller machine and bankers automated clearing service) has significant effect on customer loyalty.
7	Ohiani (2020)	Nigeria, 2013 to 2017	Technology innovation in the Nigerian banking system: prospects and challenges	Innovation adoption, service quality, cybercrime	Pearson correlation	Innovation adoption, service quality, cybercrime have significant relationship with the competitiveness

Continuation of Table 1

1	2	3	4	5	6	7
						of banks, the intention of bank customers, and perception of customers towards online services.
8	Uzomah (2019)	Nigeria, 2008–2018	Information communications technology (ICT) and performance of deposit money bank (DMBs) in Nigeria 2008–2018	Point of sale (POS), mobile banking (MB) and web banking (WB), profit after tax (PAT)	The ordinary least square (OLS)	Point of Sale has a positive and insignificant effect on the Profit after Tax mobile Banking has a positive and insignificant effect on Profit after Tax and also Mobile Banking has a positive and insignificant relationship between Web Banking and profit after Tax.
9	Umeobi & Uchehara (2019)	Nigeria	The effect of technological change on employee performance: a study of Union Bank of Nigeria Plc Oko Branch	Questionnaire	Chi squared statistical tool	ICT has contributed to the social infrastructural development in the organization under study and it has led to improvement of information in the bank.
10	Ankrah (2019)	Ghana	The impact of information systems investment on bank performance in Ghana	Market share, profitability and return on assets	The ordinary least square (OLS)	The findings revealed that, there has been a high rate of investment in the past three years made by the various banks.
11	Bukar & Tahir (2019)	Nigeria, 2007–2016	Effect of information and communications technology (ICT) investment on deposit mobilization of commercial banks in Nigerian	Deposit mobilization, total asset	Panel regression	The study discovered that ICT-investment has significant effect on deposit growth of Nigerian commercial banks.
12	Okanta (2019)	Nigeria, 2004–2017	Effect of information and communications technology on the Nigerian economy: evidence from the banking sector	Automated teller machine, mobile banking payment	Panel regression	The paper revealed that only the mobile banking payment component positively and significantly affected the gross domestic product.
13	Kyeremeh, Prempeh & Forson (2019)	Ghana	Effect of information communications and technology (ICT) on the performance of financial institutions (a case study of Barclays Bank, Sunyani Branch)	Questionnaire	Qualitative research method	The study revealed that ICT has an appreciable positive effect on performance due to improved customer service delivery.
14	Appiahene, Missah & Najim (2019)	Ghana	Evaluation of information technology impact on bank's performance: the Ghanaian experience	Questionnaire	Two-stage DEA model	IT had significant impact on the banks' overall performance even though their respective efficiencies in deposit and investment were not good.
15	Nwakoby, Sidi &	Nigeria, 2006 to 2015	Impact of information and communications technology on the	Return on equity, ATM, mobile banking	Log-linear regression model	The result showed that the adoption of various forms of information and

Continuation of Table 1

1	2	3	4	5	6	7
	Abomeh (2018)		performance of deposit money banks in Nigeria			communications technology has greatly influenced the quality of banking operations, performance and has specifically increased banks return on equity.
15	Nwakoby, Sidi & Abomeh (2018)	Nigeria, 2006 to 2015	Impact of information and communications technology on the performance of deposit money banks in Nigeria	Return on equity, ATM, mobile banking	Log-linear regression model	The result showed that the adoption of various forms of information and communications technology has greatly influenced the quality of banking operations, performance and has specifically increased banks return on equity.
16	Adebola (2018)	Nigeria	Impact of information communications technology on bank performance of selected banks in Ondo State Nigeria	Questionnaire	Pearson correlation	The findings revealed that technology innovation has influenced Nigerian banking industry performance.
17	Mahboub (2018)	Lebanese from 2009–2016	Role of information communications technology (ICT) in Nepalese banking industry	ATM, mobile banking, internet banking, telephone banking (TB), debit and credit cards (BC) and point of sale (POS) terminals	Multivariate OLS model	The results demonstrated that the application ATM, IB, TB and POS terminals does not significantly affect banks performance.
18	Ibenta & Anyanwu (2017)	Nigeria from 2006 to 2014	Financial innovation and efficiency on the banking sub-sector: the case of deposit money banks and selected instruments of electronic banking (2006–2014)	Automated teller machine (ATM) and point of sale (POS), efficiency ratio, web/internet and mobile banking	Granger causality analysis	The finding revealed that the value of transaction on automated teller machine (ATM) and point of sale (POS) are negatively related with efficiency ratio while web/internet and mobile banking are positively related.
19	Dabwor, Ezie & Progress (2017)	Nigeria	Effect of ICT adoption on competitive performance of banks in an emerging economy: the Nigerian experience	Automated teller machine, web based transactions, and mobile payments	Independent sample t-test	Findings from the study revealed that a positive relationship exists between ICT and banks performance in Nigeria.
20	Okhankhuele (2017)	Nigeria	Extent of use of ICT facilities in selected banks, located in Federal University of Technology, Akure, Ondo State, Nigeria	Questionnaire	Pearson correlation	The study disclosed that, there was a high extent of use of ICT facilities in the banking industry.
21	Alhousary, Underwood & Xanthidis (2017)	Omani	ICT developments and utilization in the Omani banking sector	Questionnaire	Pearson correlation	The study found that while the IT infrastructure follows the latest technologies in the field, there is still room to

Continuation of Table 1

1	2	3	4	5	6	7
						optimize the utilization of this infrastructure by improving its administrative as well as technical management of it.
22	Silas, Kubba & Yunana (2017)	Nigeria	Influence of information communications technology in building customer loyalty among deposit money banks in jos metropolis	Structured questionnaire	Pearson correlation	The result revealed that there is a significant relationship between automatic teller machine and customer loyalty.
23	Mbogo (2017)	Kenya	The influence of information technology innovation on the operational performance of commercial banks in Kenya	Questionnaire	Pearson correlation	The findings on research question one revealed the existence of a statistically significant relationship between ICT-based product innovations and operations management.
24	Wasilwa & Omwenga (2016)	Kenya	Effects of ICT strategies on performance of commercial banks in Kenya: a case of equity bank	Automated teller machines, internet banking and mobile banking	Correlation analysis	ICT strategies had statistically significant influence on income, profitability and customer deposits of commercial banks in Kenya and tests for significance also showed that the influence was statistically significant.
25	Mensah (2016)	Ghana 2011 to 2014	The effect of information and communications technology on financial performance of rural banks in Ghana	ICT investments and return on assets, return on capital employed, gross profits	Panel data regression	The findings also revealed significant linkage between efficiency and the dependent variables; return on capital employed and gross profits of the rural banks.
26	Okonkwo, Obinozie & Echekoba (2015)	Nigeria 2001 to 2013	The effect of information communications technology and financial innovation on performance on Nigerian commercial banks (2001–2013)	E-Banking services and ATM	Panel data regression	The findings of the study indicated that an increase in banks' profitability performance increases commercial banks' return on equity. Investments in e-banking services and ATMs do not really improve banks' performance.
27	Ankrah (2015)	Ghana	The impact of information systems investment on bank performance in Ghana	Market share, profitability and return on assets	Pearson correlation	The findings also revealed that both the foreign banks and the local banks asserted to the fact that market share, profitability and return on assets increases as investments are employed in the banking industry.

Continuation of Table 1

1	2	3	4	5	6	7
28	Eruemegbe (2015)	Kenya	Effect of information and communications technology on organization performance in the banking sector	Questionnaire	Pearson correlation	ICT leads to efficient and effective performance of banks.
29	Dinh, Le & Le (2015)	Vietnam 2009–2014	Measuring the impacts of internet banking to bank performance: evidence from Vietnam	Internet banking, profitability	Panel data regression	The results from the regression model showed that internet banking had an impact on bank profitability through an increase of income from service activities.
30	Olushola (2015)	Nigeria	The impact of information and communications technology on company income tax collection in Nigeria	Questionnaire	Pearson correlation	The study found that the level of effectiveness of revenue collection realized increased as a result of use of ICT in company income tax collection.
31	Efunboade (2014)	Nigeria	Impact of ICT on tax administration in Nigeria	Questionnaire	Pearson correlation	This paper revealed the extent of utility of ICT to a tax administration's core operations in Nigeria.
32	Ilo, Ani & Chioke (2014)	Nigeria, 2008 to 2013	Impact of technological innovation on delivery of banking services in Nigeria	Questionnaire	Pearson correlation statistics	The findings showed that positive relationship exists between technology innovation and banks employee's performance also second findings showed that introduction of ICT improves customer satisfaction and retention.
33	Alabar & Agema (2014)	Netherland	Information and communications technology and customer satisfaction in the Nigerian banking industry	Questionnaire	Regression analysis	It was discovered that the present state of ICT had significant influence on customer satisfaction.
34	Saeed & Bampton (2013)	Libya	The impact of information and communications technology on the performance of Libyan banks	Questionnaire	Pearson correlation	The results confirmed the level of using ICT is low in Libyan commercial banks; in addition an analysis revealed that poor state infrastructure.
35	Ahoya (2014)	Kenya	Information communications technology innovations and financial performance of Kenya Commercial Bank Ltd	Questionnaire	Pearson correlation	The results of the study established that technology innovations, process innovations and market innovations had a positive and significant effect on performance of Kenya Commercial Bank Ltd with t-values of 2.302, 2.065 and 2.175 respectively at significance levels of less than 0.05.

Continuation of Table 1

1	2	3	4	5	6	7
36	Makinde (2014)	Nigeria	The correlation between IT investment and corporate performance in the Nigerian banking sector	Banks' net income and annual investment in ICT	OLS, Pearson correlation statistics	There is a strong positive relationship between the banks' net income and the annual investment in ICT by the selected banks. That is, ICT has greatly impacted positively and significantly on bank operations in Nigeria given the period of study.
37	Binuyo & Aregbeshola (2014)	South Africa	The impact of ICT on the performance of South African banking industry	Return on capital employed, return on assets, and ICT investments	Panel data analysis	The findings of the study indicated that the use of ICT increases return on capital employed as well as return on assets of the South African banking industry.
38	Agwu, Okpara, Aigbiremolen & Iyoha (2014)	United Kingdom and Nigeria	The role of ICTs in the strategic and operational management of financial institutions	Questionnaire	Pearson correlation	ICTs have indeed contributed a lot in improving the functioning of all departments of the selected banks such as marketing, operations, human resource, finance, call centres, customer services.
39	Muhammad, Gatawa & Kebbi (2013)	Nigeria	Impact of information and communications technology on the Nigerian banking industry	Return on equity, investment in ICT, and efficiency	Panel data analysis	The use of ICT in the banking industry in Nigeria increases return on equity. It has also been found an inverse relationship between additional sustained investment in ICT and efficiency.
40	Adesola, Moradeyo & Oyeniya (2013)	Nigeria	The impact of information and communications technology on the Nigerian banks operations	Questionnaire	Pearson correlation	The result showed the usage of ICT contributed significantly to the speed of banking operations, and efficient service delivery, workers' performance and bank's profit.
41	Ibrahim & Muhammad (2013)	Nigeria	Impact of information and communications technology (ICT) on banks performance in Nigeria	ICT investments, return on assets, return on equity	Modified ordinary least square (FMOLS) and Generalized Method of Moments (GMM)	Fully Modified ordinary least square (FMOLS) and Generalized Method of Moments (GMM) to reveals a positive impact of ICT on banks performance in the country.
42	Sadeghimanesh & Samadi (2013)	Iran	Effect of information technology on the financial performance of the banks listed on Tehran Stock Exchange	Questionnaire	Pearson correlation	Infrastructures of information technology has the first rank.

Continuation of Table 1

1	2	3	4	5	6	7
43	Saeed & Bampton (2013)	Libya	ICT, performance and efficiency of banking sector in Libya	Questionnaire	Pearson correlation	The results confirmed the level of using ICT is low in Libyan commercial banks; in addition an analysis revealed that poor state infrastructure.
44	Luka & Frank (2012)	Nigeria	The impacts and trends of ICTs on the banking industry of the 21st century	ICT investment, investment in working practices, human capital, and return on assets	Panel OLS	The findings indicated that ICT investment does not lead to productivity growth at firm-level by itself.
45	Mwangi (2012)	Kenya	Impact of ICT investment on banking performance	Questionnaire	Pearson correlation	Investment on ICT systems and infrastructure has been a key element in productivity and growth in the banking industry.
46	Emmanuel & Adebayo (2011)	Nigeria	How far are ICTs diffused in the Nigerian banking sector	Questionnaire	Pearson correlation	Nigerian banking sector has almost entirely embraced the ICT ideology, banks have extensively applied ICT into their operations.
47	Agbolade (2011)	Nigeria	The nature of the relationship that exist between banks profitability and the adoption of information and communications technology	ATMs, POS, Return on assets	Ordinary least square	The data analysis showed that a positive correlation exists between ICT and banks profitability in Nigeria.
48	Arnaboldi & Claeys (2010)	EU banking groups	Determinants of banking groups' strategic choices with respect to the offer of on-line services	Operational cost structure, market share, deposits, and internet banking.	Panel OLS	The results suggested that banks with a heavy cost structure, a large market share in client deposits and high non-interest activities are more likely to introduce internet banking.
49	Akujuobi & Akujuobi (2009)	Nigeria	The impact ICT on the performance of the Nigerian banks	POS, ATM, return on equity, net profit margin	Ordinary least square	The t-ratio (difference between means) and found that the introduction of information technology has positively impacted on the performance of the banks.
50	Maldeni & Jayasena (2009)	Sri Lanka	Relationship between information and communications technology (ICT)	Questionnaire	Pearson correlation	The analysis revealed that ICT usage has a positive linear relationship with financial performance and quality performance of bank branches.

Source: systematically assembled by the authors.

Materials and methods. This study examined the effect of information and communications technology on the efficiency of deposit money banks in Nigeria. In this

study, an *ex-post facto* research design was employed. The time period was from 2006 to 2020. The selection of an *ex-post facto* research design is on the presumption that the author's cannot manipulate the data as they are available in public domain vide established and regulated government agencies. The data were secondary in nature and on annual basis, while the Central Bank of Nigeria (CBN) banking and supervision and Nigeria Deposit Insurance Corporation (NDIC) annual reports served as the collection point of data used in the analysis. The dependent variable is operating efficiency. Efficiency Ratio (ER) as used in this research work is the measure of total overhead expenses against operating income. This definition is in line with the Central Bank of Nigeria (CBN) banking and supervision reports. The independent variables are information and communications technology services channels employed by deposit money banks in Nigeria vide volume of transaction on the four e-money products available in Nigeria: Automated Teller Machine (ATM), Mobile Banking (MBNK), Internet Banking (IBNK), and Point of Sale (POS) terminals. The model was estimated using the Auto-regressive Distributive Lag (ARDL) regression framework. The causality effect of information and communications technology channels on the efficiency of the deposit money banks in Nigeria was determined with the aid of the granger causality test. However, the stationarity properties of the data was done to establish the presence or absent of unit root test by using the Augmented Dickey-Fuller (ADF) and Philip Peron (PP) test for stationarity.

This study adapted and modified the model of Okonkwo, Obinozie & Echekoba (2015). The original model of Okonkwo, Obinozie & Echekoba (2015) is stated as:

$$BP = f(PAT, ATM, ebserv), \quad (1)$$

where BP – bank performance;

PAT – profit after tax;

ATM – number of automated teller machines;

Ebserv – number of e-banking services.

The model has been modified by introducing efficiency ratio to replace bank performance; volume of transaction on automated teller machines, mobile banking, internet banking, and point of sale terminals to substitute profit after tax, number of automated teller machines, and number of e-banking services. Consequently, the modified model this for study is stated as:

$$ER = f(ATM, MBNK, IBNK, POS), \quad (2)$$

where ER – efficiency ratio of deposit money banks in Nigeria;

ATM – volume of transactions on automated teller machines;

MBNK – volume of transactions on mobile banking platform;

IBNK – volume of transactions on internet banking platform;

POS – volume of transactions on point of sale terminals.

$$\text{Log}ER_t = \beta_0 + \beta_1 \text{Log}ATM_t + \beta_2 \text{Log}MBNK_t + \beta_3 \text{Log}IBNK_t + \beta_4 \text{Log}POS_t + \varepsilon_t, \quad (3)$$

where β_0 – a constant term;

$\beta_1, \beta_2, \beta_3$ and β_4 are the coefficients of the regression equation;

ε – the error term;

t – the time trend.

A priori expectation is that the parameters: $B_1 - B_4$ should be greater than zero ($\beta_1, \beta_2, \beta_3, \beta_4 > 0$). Put differently, it expected that the volume of transactions on automated teller machines, mobile banking, internet banking, and point of sale terminals should positively relate with efficiency of deposit money banks in Nigeria.

Results and discussion. *Data Descriptive Features.* The descriptive features of the data were structured to capture the mean, median, maximum, standard deviation, skewness, kurtosis, Jarque-Bera, p-value and number of observations of the data set. From the descriptive features of the data common sample in Table 2, mean were shown to be 77.12867 for ER, 420.6887 for ATM, 60.42600 for MBNK, 23.85933 for IBNK, and 89.75400 for POS. The median for the sample data are 71.43000, 375.5000, 15.80000, 5.600000 and 9.400000 respectively for ROA, ATM, POS, ECOM and Mobile. The maximum and minimum values are 181.7700 and 31.77000 for ER, 968.4300 and 12.10000 for ATM, 377.2000 and 0.410000 for MBNK, 125.2700 and 0.220000 for IBNK, 438.6000 and 0.400000 for POS. The standard deviations are 32.01367, 326.4569, 108.4325, 39.39743, and 145.0039 for ER, ATM, MBNK, IBNK and POS. The variables of standard deviations were found to be positively skewed towards normality as evidenced by the positive values of the skewness statistic. The Jarque-Bera suggests that all the variables are normally distributed owing to the 5 % level of significance of the p-values of the Jarque-Bera statistics.

Table 2

Data Descriptive Features

Indicators	ER	ATM	MBNK	IBNK	POS
Mean	77.12867	420.6887	60.42600	23.85933	89.75400
Median	71.43000	375.5000	15.80000	5.600000	9.400000
Maximum	181.7700	968.4300	377.2000	125.2700	438.6000
Minimum	31.77000	12.10000	0.410000	0.220000	0.400000
Std. Dev.	32.01367	326.4569	108.4325	39.39743	145.0039
Skewness	2.378683	0.350117	2.143212	1.794802	1.435003
Kurtosis	9.074289	1.816970	6.325473	4.733266	3.530869
Jarque-Bera	37.20595	11.18118	18.39513	9.930918	8.324221
Probability	0.000000	0.004000	0.000101	0.006975	0.049801
Sum	1156.930	6310.330	906.3900	357.8900	1346.310
Sum Sq. Dev.	14348.25	1492038.	164606.4	21730.20	294365.8
Observations	15	15	15	15	15

Source: E-views 10.0 version data output.

Data Unit Root Test Result. The assessment of the stationarity of the data were carried with Augmented Dickey-Fuller (ADF) and Phillips Perron (PP). The unit root test was performed at level and first difference. The non-stationarity of the data at level necessitated the first difference estimation. ADF results are presented in Tables 3 and 4, whereas PP tests in Tables 5 and 6. The ADF and PP unit root test results indicated that all the variables were not stationary at level but all became stationary at first difference of estimation via none, intercept, and trend and intercept. In overall, the data were stationary which freed them from any stationarity defect that most time series data possess.

Table 3

Result of ADF Test at Level

Variables	Intercept	Trend & Intercept	None	Inference
ER	-2.767384 (0.08)	-7.075164 (0.00)*	-0.091007 (0.63)	Stationary
ATM	0.335952 (0.97)	-2.191781 (0.45)	2.522577 (0.99)	Not Stationary
MBNK	3.748588 (1.00)	1.422613 (0.99)	4.499588 (0.99)	Not Stationary
IBNK	3.097112 (1.00)	1.118812 (0.99)	2.236971 (0.98)	Not Stationary
POS	-1.794213 (0.36)	-1.167870 (0.86)	-1.627990 (0.09)	Not Stationary

Note. The optimal lag for ADF test is selected based on the Akaike Info Criteria (AIC), p-values are in parentheses where (*) & (**) denote significance at 1 % and 5 % respectively.

Source: E-views 10.0 version data output.

Table 4

Result of ADF Test at First Difference

Variables	Intercept	Trend & Intercept	None	Inference
ER	-3.932947 (0.01)*	-2.464418 (0.33)	-4.242097 (0.01)*	Stationary
ATM	-3.249186 (0.04)**	-2.875604 (0.21)	-1.913083 (0.05)**	Stationary
MBNK	0.256531 (0.96)	-3.285316 (0.12)	-3.907188 (0.02)**	Stationary
IBNK	1.356264 (0.99)	0.603441 (0.99)	-4.359264 (0.00)*	Stationary
POS	-0.369132 (0.88)	-15.29631 (0.00)*	0.007570 (0.66)	Stationary

Note. The optimal lag for ADF test is selected based on the Akaike Info Criteria (AIC), p-values are in parentheses where (*) & (**) denote significance at 1 % and 5 % respectively.

Source: E-views 10.0 version data output.

Table 5

Result of PP Test at Level

Variables	Intercept	Trend & Intercept	None	Inference
ER	-5.538251 (0.00)*	-8.091500 (0.00)*	-0.983758 (0.27)	Stationary
ATM	1.332587 (0.99)	-2.112242 (0.49)	2.728862 (0.96)	Not Stationary
MBNK	-0.959947 (0.73)	-2.189504 (0.45)	-0.469918 (0.49)	Not Stationary
IBNK	3.097112 (1.00)	1.118812 (0.99)	4.171701 (0.99)	Not Stationary
POS	-0.036698 (0.93)	-1.491537 (0.78)	0.595613 (0.83)	Not Stationary

Note. Spectral estimation methods are Bartlett kernel and Newey-West method for Bandwidth, p-values are in parentheses where (*) & (**) denotes significance at 1 % and 5 % respectively.

Source: E-views 10.0 version data output.

Table 6

Result of PP Test at First Difference

Variables	Intercept	Trend & Intercept	None	Inference
ER	-19.60145 (0.00)*	-22.24250 (0.00)*	-20.51383 (0.00)*	Stationary
ATM	-3.893495 (0.01)*	-4.690073 (0.01)*	-1.829241 (0.06)	Stationary
MBNK	-4.506657 (0.00)*	-5.556643 (0.00)*	-4.264161 (0.00)*	Stationary
IBNK	-1.488979 (0.50)	-2.613674 (0.28)	-4.356488 (0.00)*	Stationary
POS	-1.927186 (0.31)	0.930309 (0.99)	-1.976806 (0.04)**	Stationary

Note. Spectral estimation methods are Bartlett kernel and Newey-West method for Bandwidth, p-values are in parentheses where (*) & (**) denotes significance at 1 % and 5 % respectively.

Source: E-views 10.0 version data output.

ARDL Co-integration Relationship. The confirmation of the stationarity of the data made way for the testing of the long run relationship between information and communications technology and efficiency of deposit money banks in Nigeria. The

Autoregressive Distributive Lag (ARDL) was selected because it takes into consideration the different order of integration of variables. The result of the ARDL long run relationship is detailed in Table 7. From the ARDL result it was observed that there is a long run relationship between information and communications technology and efficiency of deposit money banks in Nigeria. This assertion is based on the fact that the value of the f-statistic of 3.759915 is higher than the upper and lower bound test of 3.49 and 2.56 respectively at 5 % significance level.

Table 7

ARDL Bound Test

T-Test	5 % Critical Value Bound		Remark
F-Statistic	Lower Bound	Upper Bound	-
3.759915	2.56	3.49	Null Hypothesis Rejected

Source: E-views 10.0 version data output.

ARDL Short Run Relationship. The nature of relationship between information and communications technology and efficiency of deposit money banks in Nigeria was assessed using the ARDL methodology. From the result in Table 8, there is an insignificant negative relationship between ATMs, MBNK, POS transactions, and efficiency ratio of deposit money banks in Nigeria. On the contrary, internet banking transactions was found to have insignificantly and positively associated with efficiency ratio. A unit rise in ATMs, MBNK, POS transactions lead to 13.55 %, 10.61 %, and 15.66 % depreciation in efficiency ratio of deposit money banks.

Table 8

ARDL Regression

Variable	Coefficient	Std. error	t-statistic	Prob.
ER(-1)	-0.474424	0.311455	-1.523248	0.1662
ATM	-0.009202	0.067875	-0.135578	0.8955
MBNK	-0.032151	0.303046	-0.106094	0.9181
IBNK	0.107443	0.858940	0.125088	0.9035
POS	-0.042566	0.271747	-0.156639	0.8794
C	122.0677	33.01451	3.697396	0.0061
R-squared	0.250472	Mean dependent var		77.53571
Adjusted R-squared	-0.217984	S.D. dependent var		33.18185
S.E. of regression	36.62025	Akaike info criterion		10.33661
Sum squared resid	10728.34	Schwarz criterion		10.61049
Log likelihood	-66.35625	Hannan-Quinn criter.		10.31125
F-statistic	0.534676	Durbin-Watson stat		2.099976
Prob (F-statistic)	0.745837	-		-

Source: E-views 10.0 version data output.

However, the reverse is the case for internet banking transactions as Table 8 suggests that efficiency ratio of deposit money banks would appreciate by 12.51 % following a percentage increase in internet banking transactions. The co-efficient of the constant indicates that when ATMs, MBNK, IBNK, and POS are held constant, efficiency ratio would be valued at 369.74 %. The adjusted R-square reveals that approximately -21.80 % changes in efficiency ratio of deposit money banks was as a result of fluctuations in ATMs, MBNK, IBNK, and POS transactions. This is not

statistically significant with respect to the p-value (0.74) and F-statistic (0.53). The Durbin Watson coefficient of 2.0 shows that there is no element of autocorrelation in the estimated model. Furthermore, the serial correlation LM test in Table 9 proves that there is no issue of autocorrelation in the model.

Diagnostics Test. Serial Correlation LM Test. When the variables in a model are serially correlated, inferences from estimation of such model would be spurious and unreliable in statistical terms. In order to prevent the occurrence of serial correlation in the model specified for this study, the serial correlation LM test was performed. The result which indicated in Table 9 reveals that the variables in the model were not serially correlated with each other as the p-value are insignificant at 5 % level of significance.

Table 9

Serial Correlation LM Test

F-statistic	0.288344	Prob. F (2,6)	0.7593
Obs*R-squared	1.227613	Prob. Chi-Square (2)	0.5413

Source: E-views 10.0 version data output.

Heteroskedasticity Test. The presence of heteroskedasticity is considered not ideal and casts a dent to inference that would be made from such estimation of a model. In an attempt to be sure of the absence of heteroskedasticity, the model was checked accordingly. The results of the test which is highlighted in Table 10 points to the fact that there is no heteroskedasticity in the model judging from the insignificant p-value of the f-statistics coefficient at 5 % level of significance.

Table 10

Heteroskedasticity Test

F-statistic	1.944908	Prob. F (5,8)	0.1922
Obs*R-squared	7.681077	Prob. Chi-Square (5)	0.1747

Source: E-views 10.0 version data output.

Ramsey RESET Test. The Ramsey Reset specification is the general test for how well a model is specified. It determines whether non-linear combination of the fitted values help to explain the dependent variable. With the result in Table 11, the non-linear combination of the fitted values of the independent variable does not explain the changes in the dependent owing to the insignificant p-value (5 % level of significance) for the regression model estimated.

Table 11

Ramsey Reset Specification

Estimates	t-statistic	df	P-value
F-statistic	10.63497	(2, 2)	0.0859

Source: E-views 10.0 version data output.

Granger Causality Test. To determine the effect of information and communications technology on efficiency ratio of deposit money banks in Nigeria, the granger causality analysis was performed. The regression output in Table 12 reveals that transactions on ATMs, mobile banking, internet banking, and point of sale terminals have no significant effect on efficiency ratio of deposit money banks. This is based on the fact that there is no unidirectional or bidirectional causal relationship

between transactions on ATMs, mobile banking, internet banking, and point of sale terminals and efficiency ratio of deposit money banks at a significance level of 5 %.

Table 12

Granger Causality Result

Null Hypothesis	Obs	F-statistic	Prob.	Remarks
ATM does not Granger Cause ER	13	0.84127	0.4660	No causality
ER does not Granger Cause ATM		0.19514	0.8265	No causality
MBNK does not Granger Cause ER	13	0.47197	0.6401	No causality
ER does not Granger Cause MBNK		0.03196	0.9687	No causality
IBNK does not Granger Cause ER	13	0.36311	0.7064	No causality
ER does not Granger Cause IBNK		0.07932	0.9245	No causality
POS does not Granger Cause ER	13	0.40529	0.6797	No causality
ER does not Granger Cause POS		0.00458	0.9954	No causality

Source: E-views 10.0 version data output.

Discussion of findings. Table 7 shows that there is a long run relationship between information and communications technology and deposit money banks efficiency ratio. This is an indication that whenever there is continuous increase in the adoption of information and communications technology by the banking system, the likely effect would be increase in the efficiency of the deposit money banks service delivery. Table 8 suggests an insignificant negative relationship between ATM and POS transactions and efficiency ratio of deposit money banks in Nigeria. This result agrees with previous study of Ibenta & Anyanwu (2017) who found a negative insignificant relationship between ATM and POS transactions and efficiency ratio of deposit money banks in Nigeria. Increase in ATM and POS transactions lowers the efficiency ratio of deposit money banks in Nigeria. Internet banking having a positive insignificant relationship with efficiency ratio also affirms the works of Ibenta & Anyanwu (2017) on the positive link between internet banking and efficiency ratio of deposit money banks in Nigeria. It is worthy to point out here that previous empirical studies focused on profitability of deposit money banks or some selected quoted deposit money banks in Nigeria resulting in the use of panel data analysis thus the need to the restriction of affirmation of result to this study to Ibenta & Anyanwu (2017).

The granger causality test in Table 12 provides evidence of the insignificant effect of transactions on ATMs, mobile banking, internet banking, and point of sale terminals on efficiency ratio of deposit money banks in Nigeria. This is in line with Ibenta & Anyanwu (2017) that financial innovation has no significant effect on the efficiency of deposit money banks in Nigeria. This is revelation that transactions on ATMs, mobile banking, internet banking, and point of sale terminals do not in any way significantly affect efficiency ratio of deposit money banks in Nigeria. The banks will also lack the ability to compete favourably with its competitors since there will be reduced operational efficiency. If banks do not put adequate measures to increase channels of information and communications technology, deposit money banks plan and strategies will be endangered it can even lead to the liquidation of banks. Increase in information and communications technology channels in the country will encourage foreign direct investment and foreign investors, it will also lead to greater efficiency, capital base,

and national image of deposit money banks in Nigeria.

Conclusions. This study examined the effect of information and communications technology on the efficiency ratio of deposit money banks in Nigeria over a period of 15 years. Specifically, the effect of volume of transaction on automated teller machine, mobile banking, internet banking and point of sale terminals on the efficiency of deposit money banks was evaluated. The study covered a time frame of 15 years that is, from 2006 to 2020 based on available data from the Central Bank of Nigeria (CBN) banking supervision reports. The study employed an ex-post facto research design with the aid of the Auto-Regressive Distributed Lag (ARDL) technique to analyse the data. The result of Granger Causality test revealed that information and Communications Technology channels of Automated Teller Machine (ATMs), mobile banking, internet banking, and Point of Sale (POS) terminals have no significant effect on the efficiency of deposit money banks in Nigeria. Volume of transactions on Automated Teller Machine (ATMs), mobile banking, and Point of Sale (POS) terminal have negative insignificant relationship with efficiency of deposit money banks. On the other hand, Volume of transactions on internet banking was negatively non-significantly linked with efficiency of deposit money banks in Nigeria. The non-significant effect of ATMs transactions points to the need for deposit money banks in Nigeria to ensure availability of money in the ATMs machines. The result of this study concludes that information and communications technology has not improved the efficiency of deposit money banks in Nigeria.

The issue of debiting a customer without dispensing cash/automatic reversal of failed transactions should be carefully and vehemently harmonized with information and communications technology to ensure efficiency in service delivery. There is need for banks to have a strong information and communications technology that will take care of mobile banking services as the when due through mobile applications and USSD on mobile phones. The situation where a buyer receives a debit alert at a point of transaction without the seller receiving a corresponding credit alert within a time frame of 10 to 15 minutes in most cases should be completely resolved. Deposit money banks in Nigeria are advised to make internet banking services available to customers, especially on Saturdays and Sundays when customers cannot access the banking halls owing to the fact these days are not working days in Nigeria for the banking system. The scenario where a customer need to go to his/her bank for failed transaction on ATMs/POS should be automatically overhauled to improve efficiency in ATMs/POS transactions in Nigeria.

Limitations of the study. The study of this nature is normally faced with lack of accessibility to data because most of the data are classified and considered to be confidential in nature. Furthermore, lack of co-operation from the bank management and staff on issues relating to information and communications technology investment and other ICT related issues. Often, banks are reluctant to divulge data bothering on these issues for competitive reasons. However, this limitation was overcome by relying on official data from the Central Bank of Nigeria (CBN) banking and supervision

reports and Nigeria Deposit Insurance Corporation (NDIC) annual reports which were capable of furnishing the required information by virtue of the fact that they regulate the activities of deposit money banks in Nigeria.

Research perspectives. The nucleus of this study is on bank financial institutions with emphasis on deposit money banks/commercial banks. At first, further studies should venture into bank driven technology innovations vide Unstructured Supplementary Service Data (USSD), Real Time Gross Settlement (RTGS) system, and Automated Cheques Clearing Transaction (ACCT). This is with a view to finding out how the application of this technology have helped in improving efficiency of the banking system. Secondly, the analysis in this study was performed using annual data for the time frame 2006 to 2020. However, extending beyond this period and possibly using a quarterly data is suggested to confirm that the result of this research work was not influenced by the number of data observations. Finally, further studies should extend to other non-bank financial institutions such as insurance companies, finance house, and brokerage firms among others whom have embraced information and communication technology in their operations.

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