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Analysis of Post Covid-19 Lockdown Offline-Customer Service Delivery in Access Bank Akwanga Branch: A Queuing Theory Approach

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Abstract

Queues are formed when different people require similar services in the same place and at the same time interval, especially when current demand exceeds the current capacity to serve. In this paper, we present a post COVID-19 lockdown analysis of the offline-customer delivery unit of Access Bank Akwanga Branch using Queuing theory. We develop a suitable model for the system and used the quantitative method for the analysis, with the primary data obtained from observation. Results from the analysis show a reduction in customers' waiting time, thereby encouraging COVID-19 preventive measure of social distancing; increasing the number of servers in the customer care unit causes a decrease in the average waiting time of customers in queue as well as in the system, implying an automatic adherence to COVID-19 safety measures. This means that Queuing theory improves customers waiting time as well as encourages social distancing.

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1 Introduction

Delays and waiting in line for services are common problems in everyday life. Wikipedia has it that Queuing theory is the mathematical study of waiting in line, or queues. It is a fair way of addressing a large flow of customers in the presence of limited resources. Any system in which arrivals of customers place demand upon a finite capacity resource may be referred to as a queuing system, [1]. Queuing models are used as powerful tools for designing and evaluating the performances of queuing systems. Over the years, queuing theory has been applied in so many fields of human endeavor including telecommunications, industrial engineering, school and library systems, project management, different means of transportation, logistics, finance/banks, health and emergency services. Most of these studies in the literature have shown the negative effects of queues on customers, [2-8].

Most service points attend to one customer at a time. In doing so, others tend to wait on a queue for those who may have arrived at the service center first. In most cases, the number of queues depend on the number of servers available. Where there are multiple servers, customers tend to consider queue length of each server before making choices for maximum satisfaction, [9]. The quest for a smile at the end of every transaction is a basis for customers' choice of server, especially where the queue lengths differ. According to [10,11], queuing models are useful in providing basic framework for efficient design and analysis of several practical situations which include various technical system as affirmed by [12-14] when they saw queuing models as essential tools for designing and monitoring of several communication systems.

Queuing theory application in banks is age-long, especially in the analysis of reducing the average waiting time in queue and in the system in withdrawal, customer care and deposit units to gain full customer satisfaction. In recent years, most banks have adopted the use of modern technology such as Internet banking, Mobile Applications, Automated Teller Machine (ATM) and other means of off-bank banking to help reduce the queuing problems. This idea has not yielded much results especially with the rising rates of Internet frauds and the fact that these modern technologies often require special skills, as such, most people still prefer to visit the banks for most transactions. There are different banks in Akwanga LGA of Nasarawa State, Nigeria with different operational units performing various kinds of transactions but this study focuses on the customer care unit of Access bank, Akwanga, where all primary data are anonymously gotten.

COVID-19 pandemic is a worldwide deadly disease that originated in December 2019 in Wuhan, China [15]. It started in a market before spreading wide across cities and other countries. In 2020, just about a few months later, there were already 2,804,796 confirmed cases of COVID-19 in the world with 193, 710 deaths, [16]. Also, a total of 585,086,861 confirmed cases worldwide with a total of 6,422,914 deaths as at August 11, 2022, [17]. When infected, individuals show symptoms in stages, ranging from cough, fever, loss of smell or taste, chills, shortness of breath, sore throat, muscle pain, Diarrhea and vomiting for the primary efficacy endpoint to fatigue, headache, nasal congestion or running nose and Nausea at the secondary efficacy endpoint, [18]. Realizing that COVID-19 is transmittable through close contacts with infected persons or environment and the importance attached to social distance and/or use of facemasks, the government enforced and implemented lockdown (in form of restrictions) in markets, worship centers, banks, airports, train stations, viewing centers and other social gatherings to help reduce quick and unguarded spread of the disease while managing the already infected. These unusual by-laws lasted for weeks and even months in some over-crowded cities in Nigeria and other parts of the world, causing delayed transactions and accumulated number of complaints in banks. While lifting the ban on COVID-19 lockdown, the government, through its agencies advised the general public to avoid crowded areas and observe social distance among other safety measures; the less number of time customers spend in a queue, the more they obey social distancing law of COVID-19. Just after the lockdown, people in and around Akwanga Local Government Area of Nasarawa State, Nigeria came out in good number to meet up with failed transactions, resulting in long queues in most service units within the bank, queues that have now become a norm despite the number of months after COVID-19 ban lift, hence the need for this study.

The ensuing parts of this paper (in sections) is organized as follows; section (2) presents related works in Queuing theory applied in the banking sector while section (3) gives the specific method applied in the paper.

Results and findings from the study are summoned in section (4) with tables and chart giving good representations while conclusion and recommendations are presented in the last section (5).

1.1 Objectives of the Study

The main aim of this study is to analyze post COVID-19 lockdown offline-customer service delivery in Access bank Akwanga using Queuing theory to determine and improve customers' satisfaction.
Specifically, the study sought to:

i. Observe the queue system of the offline-customer service delivery unit in Access bank Akwanga Branch in order to determine where applicable.
ii. Develop an appropriate model for the observed problem.
iii. Determine statistical results from analysis as well as the performance measures for the model for an improved service delivery in Access Bank Akwanga.
iv. Compare results from analysis with an assumed increase in the number of servers.
v. Make conclusions on the derived comparison.

2 Literature Review

The discipline of applying appropriate analytical method used in making business decision about resources needed to provide a service, also known as Operations Research existed since 1940s, [19]. Queuing theory is an aspect of Operational Research where waiting lines are studied mathematically, [20]. This can be traced to Agner Krarup Erlang, a Danish Mathematician and an Engineer who first applied it to a telephone facility. Erlang modeled a system to describe the Copenhagen Telephone Exchange Company to address the problem of people placed on hold for too long while making calls, [21]. He wanted to determine how many circuits were needed to provide a satisfactory Telephone service and also the number of operators needed to process a given volume of call. Erlang identified that the number of telephone conversation and telephone holding time fit into Poisson distribution and are exponentially distributed. He later developed models that accounted for callers that dropped their call due to frustration from waiting for an operator known as the M/D/l queuing model of 1917 and those that were patient enough to wait for their call to be connected known as the M/D/k queuing model of 1920. After the work of A.K Erlang, queuing theory has been practiced in so many settings including industrial or retail management.

Queuing theory has various features and applications as illustrated by [22], when he looked at the basic features of the queuing theory and its application to reduce waiting time. His work spelled out the perimeters of queuing system to include queue length, mean queue length, idle period, busy period and waiting period. He conclusively emphasized the diverse applications of queuing system to include application in banks, hospitals, railway stations, traffic system, and library management among others. Most Automated Teller Machine (ATM) points are always overcrowded as demonstrated by [23] in their consideration of the ATM service optimization of First Bank PLC in Zamfara state. They established the fact that a customer spends on an average two (2) or three (3) minutes in a three (3) or two (2) servers respectively as against the 12 minutes spent in a single server system and provided evidence to suggest that to fully optimize the system, a single server system should not be considered. Ajao [24] in his effort to improve customer satisfaction in the banking sector discovered that asides from demand exceeding supply, insufficient physical and manpower facilities and technological deficiencies are the major causes of long queue in banks.

Realizing the need to consider the use of modern technology in solving this persistent queue problem, [24] developed a web application which, upon touching the screen, assigns each customer an electronically stored queue number on arrival. Their system considers three servers (savings, current and fixed deposit) and is well designed to increase efficiency and reliability of stored information, produce accurate data and information for report generation and attain to customers with queue number only. The researchers conclusively reported that the system displays the performance measure after daily successful operations in the bank, noting that three server model is best to reduce total expected costs. Customers find it difficult to regain time lost in long queues among other valuable resources as well put by [25], who developed a model for optimal service level in GT Bank, Jos, considering waiting time spend by customers, service time spend by a customer and the average cost a customer loses while in queue and the service cost of each server in order to fully optimize the system. They analyzed their primary data using TORA optimization software together with the queuing formula and found that five (5) servers should be used rather than the three (3) servers currently used by the bank in order to fully utilize the system. Long queues in bank is a common problem in most Nigeria banks, [26], hence the need to narrow their study to the peculiar banking situation in Nigeria using the withdrawal section of the banking hall of Zenith Bank PLC in Abakaliki. They considered the cost incurred from waiting and discovered that any increment on the number of servers will help reduce customer waiting time on queue and also reduce cost incurred on waiting. They also noted that bad network or poor power supply could also be causes of delayed transactions in bank, aside which capable servers should be employed to do good jobs.

In improving bank services, [27] converted the M/M/Z/α/:FCFS model to an M/M/1/α:FCFS model to make a comparison on their efficiency. Their study increased customer satisfaction through reduction of queuing time. Khaskheli et al. [28] applied a multi-server queuing model to analyze the queuing system of OPD during COVID-19 pandemic and carried out calculations using MS Excel for data entry and average arrival and service rates, Rockwell Arena software for input analysis of the data and TORA optimization software for performance measures, to reduce waiting cost by greater extent. After an in-depth analysis, they discovered that an additional receptionist and a doctor will be needed to utilize the queue system and patient's flow. In an attempt to further reduce queuing waiting time in banks, [29] analyzed banks efficient service delivery and stated that there is need to increase service points, give periodic orientation to customers on e-banking and introduce ATM and recruit more staff to prompt customers' service delivery.

This work will consider the queue length in the presence of COVID-19 threat of social distancing and increased population of offline-customers in customer service delivery unit due to failed online-customer service delivery.

3 Methodology

The type of design used in this particular research is a case study design that examines a particular bank out of the numbers of banks in Akwanga Local Government Area. The research method used is the quantitative research method; we collected primary data from the case study through a close observation of the queuing system at the customer care unit of the bank in different shifts. The instruments used in collecting these data include but not limited to pen, a stop watch, recording sheet. All customers arrived at the arrival point with one complaint or the other. Access bank Akwanga branch opens for normal banking activities from 8:00am to 4:00pm, Monday to Friday every week, except for some cases where they close by 3:00pm. Data was collected for five (5) consecutive working days beginning from Monday for a period of four (4) hours, that is, 8:00am – 12:00 pm. The average formula is used to show some level of accuracy in the number of days used in analysis.

3.1 Model Formulation and Specification

In this section, we specify the particular model to represent the system we are working on. This model is a description of the way and manner our queuing system behaves, based on the situation we are dealing with.

The appropriate queuing model for this study was established using the method in [30] as M/M/c/∞/∞/FIFO.

For this particular model, certain assumptions were generally made to guide the whole process. Such assumptions include;

i. Arrival process follow a Poisson process.
ii. No arrival left the queue without being served.
iii. Every customer arrives at the queue independently at the same arrival rate.
iv. The servers used were all identical.
v. Service times were exponentially distributed.
vi. The system capacity has no limit.
vii. Customers were served on a First-in-First-Out (FIFO) basis, irrespective of status or rank.

3.1.1 The M/M/c queuing model

The M/M/c queuing model is the general form of the M/M/c/∞/∞/FIFO, especially when there are no limits to the queue capacity and the size of the population and the queue discipline allows customers to be served according to when they arrive at the queue. It assumes a single queue with unlimited waiting room that feeds into c identical servers. For the model formulated above, we work with the following parameters;

(i) Arrival Rate: Rate at which customers arrived at the customer care unit of the bank per specified time. It is denoted by λ and given as $\lambda = \frac{\text{Number of customers that arrived(Nca)}}{time\ of\ observation(To)}$.

(ii) Number of Servers: This gives the number of attendants serving customers in this unit. We are using a multi-server system since we have two (2) servers in place. The number of server is denoted by c.

(iii) Service Rate: Number of customers served per unit time. It is denoted by μ and given as $\mu = \frac{\text{Number of customers served (Ncs)}}{time\ of\ observation(To)}$.

(iv) Traffic Intensity: The queue intensity is the ratio of the total number of customers who join the system and the total number of customers who are served by the two channels in a given period of time. It is denoted by ρ and given by the expression below as $\rho = \frac{\lambda}{c\mu}$.

Other parameters to be used include;

i. The probability that the system is idle is denoted by P_o and is given by

$$P_o = [\sum_{n=0}^{c-1} \frac{(c\rho)^n}{n!} + \frac{1}{c!} (\frac{(c\rho)^c}{1-\rho})]^{-1}. \quad (1)$$

ii. The average number of customers in queue is denoted by L_q and is given by the expression below

$$L_q = [\frac{1}{(c-1)!} \left(\frac{\lambda}{\mu}\right)^c (\frac{(\mu\lambda)}{(c\mu-\lambda)^2})] P_o. \quad (2)$$

iii. The average number of customers in the system is denoted by L_s and is given by

$$L_s = L_q + \frac{\lambda}{\mu}. \quad (3)$$

iv. The average waiting time for a customer in queue at the customer care unit is denoted by W_q and is given by

$$W_q = \frac{Lq}{\lambda}. \quad (4)$$

v. The average waiting time for a customer in the system is denoted by W_s and is given by

$$W_s = W_q + \frac{1}{\mu}. \quad (5)$$

We shall determine the performance measures for the proposed model using the above parameters, taking note of the total number of days. Below is a schematic representation of our multi-server model presented in Fig. 3.1.

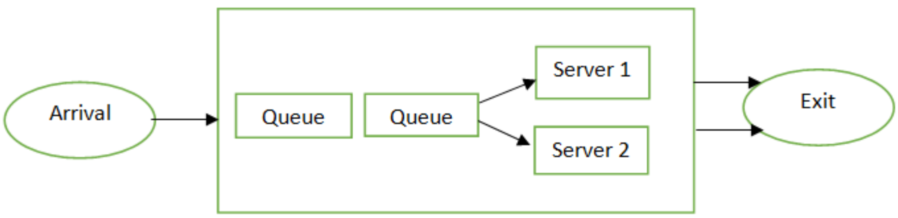

Fig. 3.1. Customer Multi-Server Facility

4 Results and Discussion

4.1 Results

This section presents the cumulative findings for the entire five (5) days of this research. The primary data is presented in Table 4.1 which also displays the results of analysis for each of the days prior to comprehensive compilation and following similar approach as [31], we have the below results.

4.1.1 Data Presentation

Table 4.1. Primary data from customer care unit

Inputs	Day 1	Day 2	Day 3	Day 4	Day 5
Arrival	129	92	102	76	110
Served	91	74	81	59	83
Time (Hours)	4	4	4	4	4
c	2	2	2	2	2
λ	32.3	23	25.5	19	27.5
μ	22.8	18.5	20.3	14.8	20.8
ρ	0.7083	0.6216	0.6281	0.6419	0.6130
P_o	0.1708	0.2334	0.2284	0.2181	0.2399
L_q	1.4271	0.7831	0.8183	0.8996	1.2065
L_s	1.4167	2.0263	2.0745	2.1834	2.5287
W_q (Hours)	0.0442	0.0340	0.0321	0.0473	0.0439
W_s (Hours)	0.0881	0.0881	0.0814	0.1149	0.0920

Source: Computation by Authors

We can present the above results in a more reasonable form using averages to make a decision for the total number of days used. These results are well presented in Table 4.2.

Table 4.2. Cumulative results in five (5) days

Inputs	Results for five (5)
Total Arrived in 5 days	509
Total Served in 5 days	388
Total Time for 5 days	20
c	2
λ	25.46
μ	19.44
ρ	0.6426
P_o	0.2181
L_q	1.0269
L_s	2.0459
W_q (hours)	0.0403
W_s (hours)	0.0929

Source: Computation by Authors

The type of queuing model used in this study is the M/M/c queuing model, where c represents the number of servers. In this study, we are presented with only 2 servers that give the average waiting time of customer in queue, Wq as 0.0403hours (145.08sec) and the average waiting time of customers in the system Ws as 0.0929hours (334.44sec). Assuming we increase the number of servers to say, 3 or 4 or 5, we will end up with different average waiting time for customers in queue and in the system as shown in Table 4.3.

Table 4.3. Reactions on increased number of servers

Inputs	c=2	c=3	c=4	c=5
ρ	0.6426	0.4366	0.3274	0.2619
P_o	0.2181	0.2609	0.2686	0.2697
L_q	1.0269	0.1343	0.0238	0.0042
L_s	2.0459	1.4467	1.3335	1.3139
W_q (hours)	0.0403	0.0053	0.0009	0.0002
W_s (hours)	0.0929	0.0567	0.0523	0.0516

Source: Computation by Authors

The results in Table 4.3 can further be shown on a chart for easy understanding.

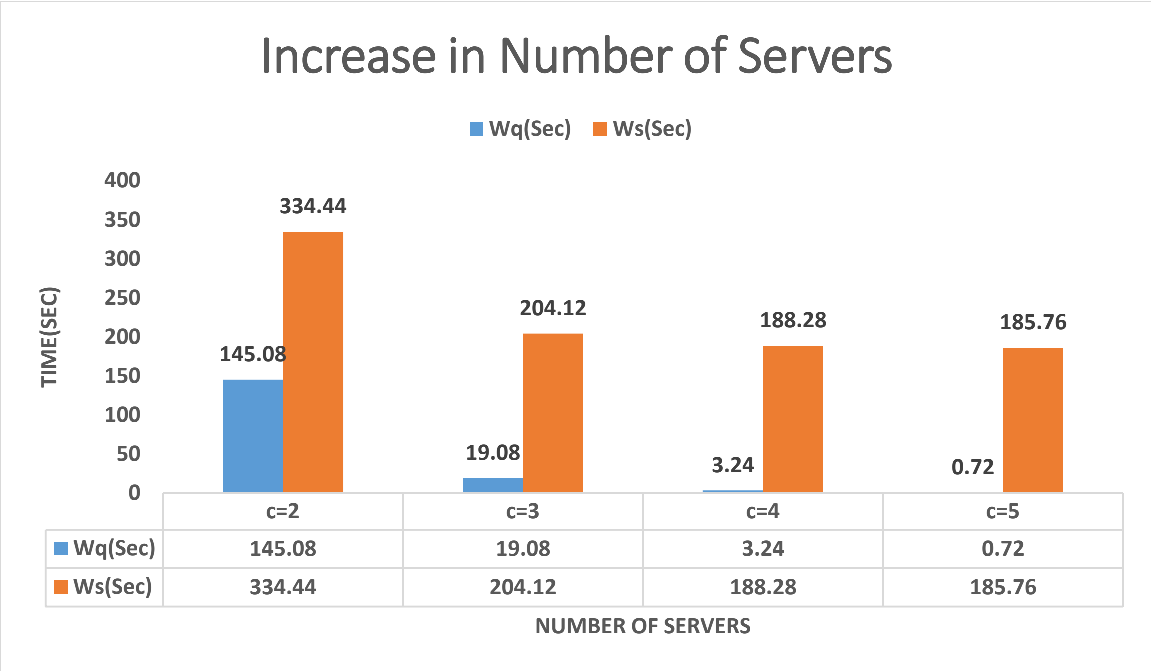

Fig. 4.1. Chart showing increase in the number of servers
Source: Computation by Authors

4.2 Discussion

Table 4.1 shows results of analysis of primary data with two (2) servers for the separate five (5) days while table 2 summarized the data in averages, giving more reasonable representation. From the concise analysis in Table 4.2 above, we observe that a customer spends an average of 0.0403 hour (145.08sec) waiting in queue with an average of 0.0929 hour (334.44sec) waiting time in system. It then means that a customer waits for 145.08sec in queue before being served and spends an average of 334.44sec waiting time in the system [32-35].

We observed also that an increase in the number of servers has great influence in the waiting time of customers. Increasing the servers from two (2) to three (3) reduces the waiting time in queue, Wq from 0.0403 hour (145.08sec) to 0.0053 hour (19.08sec) and average waiting time in system, Ws from 0.0929 hour (334.44sec) to 0.0567 hour (204.12sec), which is considerably okay and will help improve social distancing, a safety measure put in place to control COVID-19. Further increase in the number of servers from three (3) to four (4) as shown in Table 4.3 depicts another reduction in the queue waiting time, Wq from 0.0053 hour (19.08sec) to 0.0009 hour (3.24sec) and average waiting time in system, Ws from 0.0567 hour (204.12sec) to 0.0523 hour (188.28sec). It can be observed also that if the number of servers is increased from four (4) to five (5), the queue waiting time, Wq is reduced from 0.0009 hour (3.24sec) to 0.0002 hour (0.72sec) and average waiting time in system, Ws from 0.0523 hour (188.28sec) to 0.0516 hour (185.76sec). Supposing the bank agrees to increase its number of servers from two (2) to five (5) as presented in this study, customers are likely to wait in queue for just 0.72sec to be served in just 185.76 sec. This in turn will mean that customers will automatically be observing the COVID-19 safety measures of avoiding crowded population.

5 Conclusion and Recommendations

This study analyzed the customer care unit of Access Bank Akwanga using queuing theory, where much emphasis was placed on the relevance of queuing theory in improving social distancing, a measure put in place by World Health Organization (WHO) to reduce the spread of COVID-19. Results of the analysis ensured maximum customer satisfaction through improved waiting time and reduced overcrowded population in customer care unit of the bank. More number of servers are needed to reduce the average time of waiting in queue as well as in the system, which will automatically mean observing COVID-19 safety measures of avoiding overcrowded population.

This study is an eye opener to the management of Access Bank Akwanga and other concerned stakeholders to see better and improved ways of ensuring customers' satisfaction and generation of ceaseless revenue while observing social distancing. Addition of more number of servers in the customer care unit implies recruiting more staff to fit into the required number of servers. We recommend that banks should always have among their staff, experts in Operations Research for maximum customer satisfaction and improved revenue generation. Further research in this area will consider the cost implication of waiting in queue for a long time.

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Competing Interests

Authors have declared that no competing interests exist.

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