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Customers' Flow Assessment of Some Banks using Queuing Model Technique

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ABSTRACTS

Queuing theory is the mathematical study of waiting lines of customers in a service system such as fuel stations, supermarket check-out counters, post offices, cafeteria, and banking halls. In queuing theory, a model is constructed so that important queuing characteristics of the service systems can be obtained as a measure of the service performance. The obvious cost implications of customers waiting range from idle time spent when queue builds up, which results in man-hour loss, to loss of goodwill, which may occur when customers are dissatisfied with a system. However, in a bid to increase service rate, extra hands are required which implies cost to management. The onus is on the management to strike a balance between the provision of a satisfactory and reasonable quick service and minimizing the cost of such service. Descriptive research method was employed in carrying out the study at Access Bank Plc., through observation, interview and questionnaire administration. The variables measured include arrival rate (λ) and service rate (μ), analyzed for simultaneous efficiency in customer satisfaction and cost minimization through the use of a multichannel queuing model, which were compared for a number of queue performances such as; the average number of customers in the queue and in the system, average time each customer spends in the queue and in the system and the probability of the system being idle. It was discovered that, using a four (4)-server system was better than a 2-server or 3-server systems in terms of the performance criteria used and the study inter-alia recommended that, the management should adopt a four (4)-server model to reduce total expected costs and increase customer satisfaction.

Introduction

Queuing theory is the mathematical study of waiting lines of customers in a service system such as fuel stations, supermarket check-out counters, post offices, cafeteria, and banking halls. In queuing theory, a model is constructed so that important queuing characteristics of the service systems can be obtained as a measure of the service performance of the systems (Nah & Siau, 2020). Examples of such characteristics are queue lengths (number of customers waiting to be served), the waiting times involved etc. Obtaining a good model for a queuing system requires an understanding of key components of the queuing system from which the system characteristics are derived. The basic features of a queuing system are:

i. **Input:** It describes the way in which the customers arrive and join the system. Generally, customers arrive in a random fashion which is not worth making the prediction. Thus, the arrival pattern can be described in terms of probabilities, and consequently the probability Distribution for inter-arrival times (the time between two successive arrivals) must be defined.

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ii. **Service Mechanism or Service Pattern:** This means the arrangement of service facility to served customer on arrivals and there will be no queue. But on the other hand, if the number of servers is finite then customers are served according to a specific order with service time a constant.

iii. **Queue Discipline:** It is the rule according to which the customers are selected for service when a queue has been formed.

The most common disciplines are:

- First come first served (FCFS)
- First in first out (FIFO)
- Last in first out (LIFO)
- Selection for service in random order (SIRO)

There are various other disciplines according to which a customer is served in preference over the other. They are pre-emptive and non-pre-emptive systems. In pre-emptive system the patient of high priority is serviced before the low priority customer (patients). In non-pre-emptive system, patients of low priority are considered before that of high priority.

iv. Customer Behavior

The customers generally behaved in the following ways namely.

a. Reneging: A customer at a point of arriving to the hospital and sees that the queue is too long, and he has no time to wait or has no sufficient waiting space, then leave.
b. Balking: It occurs when a waiting customer leaves the queue due to impatience.
c. Jockeying: Customers that jockey from one waiting line to another. It is most common in the hospitals, bank, supermarket etc.
d. Priorities: In certain applications, some customers are served before others regardless of their arrival. These customers have priority over others.

Delays are as a result of disparity between demand for a service and the capacity available to meet that demand. Usually, this miss-match is temporary and due to natural variability in the timing of demands and in the duration of time needed to provide service.

Statement of the Problem

Queuing theory over the years has been the only panacea for customer satisfaction in the banks but most banks fail to properly implement this application effectively and efficiently (Ahmed et al., 2022).

Waiting for services is part of our daily life. We wait to eat at restaurants, we “queue up” at the check-out counters in grocery stores and we “line up” for service in post offices, banks and petrol filling stations. The waiting phenomenon is not an experience limited to human beings only; jobs wait to be processed on a machine and cars stop at traffic lights. Unfortunately, we cannot eliminate waiting without incurring inordinate expenses. In fact, all we can hope to achieve is to reduce the adverse impact of waiting to acceptable levels. In a traditional non-queuing environment, customers can be left confused as to what line to stand in, what counter to go to when called and distracted by noisy crowded environment. In situations where facilities are limited and cannot satisfy the demand made upon them, bottlenecks occur which manifest as queue but customers are not interested in waiting in queues. When customers wait in queue, there is the danger that waiting time will become excessive leading to the loss of some customers to competitors (Conference *Proceedings*, 2022).

But allowing them to serve themselves so easily is a key factor in both keeping and attracting customers (Dwivedi et al., 2021). The days of a customer adopting one product or company for life are long gone. With easy access and global competitiveness, customers are often swayed by advertising and a chance at a better deal. Quality levels and features between competing brands and organizations are often comparable. The thing that separates competitors is their level of service. It is not unusual for customers to switch back and forth between products or organizations simply because of pricing, a bad first impression or lack of quality service.

The aim of this study, is to determine the average waiting time of customers in the banking sector by using queuing model data to estimate the average waiting time for customers' satisfaction. The objective of this study is to examine how queuing model as a technique can be used by banks in offering satisfactory service to customers. Developing a queuing model specific to the banking sector that accurately represents the flow of customers in banking operations. analyzing the efficiency and effectiveness of the queuing model in predicting and managing customers' flow in some banks and evaluate the impact of implementing the queuing model on customer satisfaction, waiting times, and overall service performance in the banking sector.

Related Works

Queuing Theory is a branch of operations research that deals with the study of waiting lines, or queues. In the banking sector, queuing models are essential tools for managing customer flow, reducing wait times, and optimizing the allocation of service resources such as tellers, ATMs, digital service points (Saini, B., Singh, D., & Sharma, K. C. 2024) The primary goal is to improve customer satisfaction and operational efficiency by understanding and managing the dynamics of customer arrivals and service processes.This involves managing resources effectively to minimize both service time and customer waiting time.
A queuing system can simply be described as customers arriving for service, waiting for service if it is not immediate and if having waited for service, leaving the system after being served. The term "Customers" is used in a general sense and does not imply necessarily a human customer. For example, a customer could be a ball bearing waiting to be polished, an airplane waiting in line to take off, a computer program waiting to be run, or a telephone call waiting to be answered. Queuing theory is the formal study of waiting line and is an entire discipline in operation management. Tang, J., Jiang, Y., Dai, *et al* (2022), Queuing theory utilizes mathematical models and performance measures to asses and hopefully improve the flow of customers through the waiting line). Eri I., Mihaela M. (2020), Queuing theory is also a set of tools and techniques for analyzing such problems, concerned with providing service to customers so as to have balance of the cost of waiting and cost of servicing customers in a line. Generally, a queuing or waiting-line problem arises whenever the demand for customer service cannot perfectly be matched by a set of well-defined service facilities that is, there is more demand for service than there is facility available for service. There may be many reasons such as shortage of available services, economically infeasible for a business to provide the level of service necessary to prevent waiting or limitation to the amount of service that can be provided.

Generally, these limitations can be removed with the expenditure of capital. To know how service should be made available, one need to know answers to such questions as "How long will a customer wait?" and "How many people will form the line?" Queuing theory attempts to answer these questions through detailed mathematical analysis and in many cases, it succeeds (Gross and Harris, 2021).

Etaga, *et al* (2019*)* A Queuing Model for Customers' Flow in Banking Sector in Rural and Urban Centres. Queuing system or waiting line theory is primarily concerned with processes characterized by random arrivals (i.e., arrival at random time interval); the servicing of the customer is also a random process. there are costs associated with waiting in line, and there are costs of adding more channels (i.e. adding more service facilities), it is possible to minimize the sum of the costs of waiting and the costs of providing service facilities. The computations will lead to such measures as the expected percentage utilization of the service facilities. These measures can then be used in the cost computation to determine the number and capacity of the service facilities that are desirable

Methodology

Research Design

The research design adopted for this study was the survey research design. Survey research design enables the researcher to observe what happens to the sample subjects. The population of study comprise the service rate recorded for the five (5) days of the study from the three (3) servers used by Access Bank which is the bank of the study. Primary method of data gathering was observational techniques. The primary instrument used for the collection of data for this study is the questionnaire. The questionnaire was designed in open and closed ended patterns and administered directly on the respondents.

Sample Technique

Sample is the fraction of any given population. Sampling is the technique or a method of selection of samples. In this research, the research point is selected using convenience sampling technique. In the realization of these objectives, primary data in respect of customer arrival rate and cashier/tellers' service rate was used and was obtain through observations while customer attitude survey was carried out through a total of One Hundred and Fifty-Nine (159) copies of questionnaire was administered on one Hundred and Fifty-Nine (159) stochastically selected customers for this purpose.

Method of Data Analysis

The variables measured and some characteristics of the model are calculated thus: For multiple servers, s,

$$Mean\ Arrival\ Rate\ (\lambda) = \frac{Total\ Arrival\ TIme}{Number\ of\ customers} \quad (1)$$

$$Mean\ Service\ Rate\ (\mu) = \frac{Total\ Service\ TIme}{Number\ of\ customers} \quad (2)$$

$$Mean\ Waitng\ Time = \frac{Total\ Waiting\ TIme}{Number\ of\ customers} \quad (3)$$

Traffic intensity $\rho = \frac{\lambda}{s\mu}$ (4)

Where

$\lambda = the\ mean\ arrival\ rate,\ \mu = the\ mean\ service\ rate,\ s = the\ number\ of\ service\ points$

The probability of having exactly zero number of customers in the system or probability that the system is idle is p_o which is obtained as

$$p_0 = \left[\sum_{n=0}^{s} \frac{1}{n!}(S\rho)^n + \sum_{n=s+1}^{1} \frac{s^s}{s!}\frac{\rho^n}{1-\rho}\right]^{-1}$$

$$= \left[\sum_{n=0}^{s} \frac{1}{n!}(S\rho)^n + \frac{S^s}{S!}\frac{\rho^{s+1}}{1-\rho}\right]^{-1}$$

For s = 3

$$P_0 = \left[1 + 3\rho + \frac{(3\rho)^2}{2} + \frac{1}{6}(3\rho)^3 + \frac{3^3}{3X2}\frac{\rho^4}{1-\rho}\right]^{-1} \quad (5)$$

The probability of having servers in the system is given by

$$p_s = \frac{1}{n!}(s\rho)^n p_0 \quad (6)$$

Where s is number of servers and n is number of customers attended to simultaneously
The probability that all servers are busy is obtained from equations 3 & 4 on the waiting time distribution of such a model

$$P[W(t) \geq y] = P_s(1-\rho)^{-1}\rho^{-\mu s(1-\rho)y;} y \geq 0 \quad 7$$

Where $W(t)$ represents waiting time, therefore all servers are busy when $W(t) \geq 0$ with probability $= \frac{P_s}{1-\rho}$ 8

The expected number of people waiting to be served is given by

$$E(N) = \frac{\rho P_0}{(1-\rho)^2} \quad 9$$

The expected time that customer waits for service

$$E(W)(t)) = \frac{p_s}{\mu s(1-\rho)^2} \quad 10$$

If a customer has to wait, the expected length of his waiting time = $\frac{1}{\mu s(1-\rho)}$ 11

Probability that a customer will queue on arrival = $\left(\frac{(\rho s)^s}{S!(1-\rho)}\right) P_0$ 12

Probability of not queuing on arrival is = 1 – $\frac{(\rho s)^s}{S!(1-\rho)} P_0$ 13

4. Results and discussion

This bank has 3 servers. From the data collected during field survey the following results were obtained. These results are focus on 3 servers.

$$Mean\ Arrival\ Rate\ (\lambda) = \frac{Total\ Arrival\ TIme}{Number\ of\ customers} = \frac{336.28}{159} = 2.1150$$

Similar computation was done for the other days used for field survey and we have;

Table 4.1: Mean Arrival Rate of Customers.

Day 1	Day 2	Day 3	Day 4	Day 5	Average
2.1150	2.2013	2.5477	2.5662	2.6185	2.4097

From the results in Table 1, the mean arrival rate of customers in the Bank for the first day is 2.1 minutes and 2.6 minutes for the last day of the week. On the average, the mean arrival rate within the week is 2.4 minutes.

4.1 Computation of Mean Service Rate

Mathematically, the Mean Service Rate (MSR) can be computed using the expression

$$Mean\ Service\ Rate\ (\mu) \frac{Total\ Service\ Time}{Number\ of\ customers} = \frac{44.05}{53} = 0.8311$$

Table 4.2: Mean Service Rate of Customers in minutes.

	Day 1	Day 2	Day 3	Day 4	Day 5	Average
Server 1	0.8311	2.0962	1.9292	2.9319	2.8185	2.12138
Server 2	2.5151	1.9481	2.3808	3.0057	2.5894	2.48782
Server 3	0.8166	2.1321	2.6313	4.6275	2.7625	2.5940
General Mean	1.3876	2.0588	2.3138	3.5217	2.7235	**Grand Mean 2.4011**

The mean service rate of customers in the first day is 1.4 minutes and on average is 2.4 minutes within the week.

4.2 Computation of Mean waiting time

Mean Waiting Time can be computed using the expression

$$Mean\ Waitng\ Time\ \frac{Total\ Waiting\ TIme}{Number\ of\ customers} = \frac{40.17}{53} = 0.7579$$

Table 4.3: Mean Waiting time of Customers.

	Day 1	Day 2	Day 3	Day 4	Day 5	Average
Server 1	4.5315	10.2698	9.6066	5.6843	11.6489	8.3482
Server 2	4.2651	10.1179	10.1036	4.8534	11.7113	8.2103
Server 3	4.4283	10.0104	12.3683	9.5740	7.8704	8.8502
General Mean	4.4083	10.1327	10.6928	6.7039	10.4102	**Grand Mean 8.4696**

From the result in Table 3, server 3 has the highest waiting time and server 2 has the least waiting time. Using the average waiting time, it can be concluded that server 2 is the most efficient server among all, since time spent on the queue by the customers is at the minimal level.

Computation of Traffic Intensity

Traffic intensity (ρ) can be computed using the expression

Traffic intensity $\rho = \frac{\lambda}{s\mu} = \frac{2.1150}{4.1628} = 0.5081$

Table 4.4: Traffic Intensity

	Day 1	Day 2	Day 3	Day 4	Day 5	Average
λ	2.1150	2.2013	2.5477	2.5662	2.6185	2.4097
S. μ	4.1628	6.1764	6.9414	10.5651	8.1705	7.2033
ρ	0.5081	0.3564	0.3670	0.2429	0.3205	0.3345

Traffic Intensity is a measure of the average occupancy of a server or resource during a specified period of time, normally a busy hour. Therefore, from the computation, the intensity was at the peak on the first day and the least on the fourth day of the week.

Computation of Probability of Idleness of the system (P_0).

The probability of having exactly zero number of customers in the system or probability that the system is idle is P_0 which is obtained as;

For s = 3

$$P_0 = \left[1 + 3\rho + \frac{(3\rho)^2}{2} + \frac{1}{6}(3\rho)^3 + \frac{3^3}{6}\frac{\rho^4}{(1-\rho)}\right]^{-1} =$$

$$\left[1 + 3(0.5081) + \frac{(3\,X0.5081)^2}{2} + \frac{1}{6}(3\,X\,0.5081)^3 + \frac{3^3}{6}\frac{2.7902^4}{(1-0.5081)}\right]^{-1} = 0.2047$$

Table 4.5: Probability of Idleness of System and Traffic Intensity

	Day 1	Day 2	Day 3	Day 4	Day 5	Average
ρ	0.5081	0.3564	0.3670	0.2429	0.3205	0.3345
P_0	0.2047	0.3381	0.3270	0.4809	0.3785	0.3623

The higher the probability of idleness, the greater the possibility of idleness of a system. From Table 5, it can be seen that the system has highest possibility of been idle on the fourth day and has the least possibility of idleness on the first day.

Computation of Probability of having Servers in the System

The bank has three servers. Therefore, there is need for P1, P2 and P3. The probability of having servers in the system is given by

$$p_s = \frac{1}{n!}(s\rho)^n p_0$$

Table 4.6: Probability of having Server in the System

	Day 1	Day 2	Day 3	Day 4	Day 5	Average
ρ	0.5081	0.3564	0.3670	0.2429	0.3205	0.3345
P_0	0.2047	0.3381	0.3270	0.4809	0.3785	0.3623
p_s	0.1209	0.0689	0.0728	0.0310	0.0561	0.0610

The higher the probability of an event, the higher the chance of occurrence. As observed in Table 6, the probability of having servers in the system is at the peak on the third day.

Computation of Probability of servers been busy. P(W(t))

Busy server is necessary in the process as idleness implies redundancy which can be interpreted as wastage. Mathematically, probability of server been busy can be computed using equation. It can also be computed using 1 minus probability of idleness of the system. Table 7 is computed from Table 5.

Table 4.7: Probability of servers been busy.

	Day 1	Day 2	Day 3	Day 4	Day 5	Average
ρ	0.5081	0.3564	0.3670	0.2429	0.3205	0.3345
P_0	0.2047	0.3381	0.3270	0.4809	0.3785	0.3623
$(1 - P_0)$	0.7953	0.6619	0.6730	0.5191	0.6215	0.6377

Table 7 shows that servers are busier on the first day than any other day and on the average, the servers are busy 64% of the working hours.

Computation of Expected Numbers of People Waiting to be Served E(N)

The expected number of people waiting to be served as given in equation 10.

$$\mathrm{E(N)} = \frac{\rho P_0}{(1-\rho)^2} = 0.4298$$

Table 4.8: The Expected Number of People Waiting to Be Served

	Day 1	Day 2	Day 3	Day 4	Day 5	Average
ρ	0.5081	0.3564	0.3670	0.2429	0.3205	0.3345
P_0	0.2047	0.3381	0.3270	0.4809	0.3785	0.3623
ρP_0	0.1040	0.1205	0.1200	0.1168	0.1213	0.1212
$(1-\rho)2$	0.2420	0.4142	0.4007	0.5732	0.4617	0.443
E(N)	0.4298	0.2909	0.2995	0.2038	0.2627	0.2736

From Table 8, on the first day at least 43 per cent of the available customers are expected to wait on queue. 29 per cent, 30 per cent, 20 per cent and 26 per cent for second, third, fourth and fifth day respectively. On the average, for the bank considered, it is expected that 27% of the customers waited on queue to be served.

Computation of Expected Time a Customer Waits for Service E(W(t))

The expected duration of waiting time of customer as given in equation 11

$$\mathrm{E(W)(t))} = \frac{p_s}{\mu s(1-\rho)^2} = \frac{0.1209}{1.0074} = 0.1200$$

Table 4.9: Expected Time a customer waits for Service.

	Day 1	Day 2	Day 3	Day 4	Day 5	Average
p_s	0.1209	0.0689	0.0728	0.0310	0.0561	0.0610

μ	1.3876	2.0588	2.3138	3.5217	2.7235	2.4011
3.μ	4.1628	6.1764	6.9414	10.5651	8.1705	7.2033
$(1-\rho)2$	0.2420	0.4142	0.4007	0.5732	0.4617	0.443
$3.\mu(1-\rho)2$	1.0074	2.5583	2.7814	6.0559	3.7723	3.1911
E(W)(t)) in mins	0.1200	0.0269	0.0262	0.0051	0.0149	0.0191
E(w)(t)) in secs	7.2	1.614	1.572	0.306	0.894	1.146

As observed in Table 9, customers spent more time waiting for service on the first day than any other day as the expected waiting time for the day is 7 second. The least waiting time was observed on the fourth day with waiting time of 0.3 second.

Computation of Conditional Probability of waiting time for service.
If a customer has to wait, the expected length of his waiting time, given in equation 12. Using the collected data, the results of the computation are as shown in Table 10.

If a customer has to wait, the expected length of his waiting time = $\frac{1}{\mu s(1-\rho)} = \frac{1}{(2.0477)} = 0.4884$

Table 4.10: Conditional Probability of waiting time for service

	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Average**
3.μ	4.1628	6.1764	6.9414	10.5651	8.1705	7.2033
$\boldsymbol{\rho}$	0.5081	0.3564	0.3670	0.2429	0.3205	0.3345
	0.4919	0.6436	0.633	0.7571	0.6795	0.6655
$3.\mu\,(1-\rho)$	2.0477	3.9751	4.3939	7.9988	5.5519	4.7938
$E[W(t) \mid W(t) \geq 0]$	0.4884	0.2516	0.2276	0.1250	0.1801	0.2086

The expected duration of customer waiting for service on the first day if at all there is queue is 0.4884min and on the average, the customer waiting time is 0.2086min.

Computation of Probability that a customer will queue on arrival.

This aspect is different from expected waiting time as it shows the possibility of a customer on arrival waiting to be served. The higher the probability of a customer queuing on arrival, the longer the queue in the system. Mathematically, this can be computed using the expression

$$\left(\frac{(\rho s)^s}{S!(1-\rho)}\right) P_0 = \left(\frac{3.5417}{2.9514}\right) 0.2047 = 0.2456$$

Table 4.11: Probability that a customer will queue on arrival.

	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Average**
$\boldsymbol{\rho}$	0.5081	0.3564	0.3670	0.2429	0.3205	0.3345
$(\rho.3)^3$	3.5417	1.2223	1.3346	0.3869	0.8889	1.0105
$(1-$	0.4919	0.6436	0.633	0.7571	0.6795	0.6655
$S!(1-\rho)$	2.9514	3.8616	3.798	4.5426	4.077	3.993
$(\rho.3)^3/S!(1-\rho)$	1.2000	0.3165	0.3514	0.0852	0.2180	0.2531
$[(\rho.3)^3/S!(1-\rho)]\,P_0$ **P(Queuing)**	0.2456	0.1070	0.1149	0.0410	0.0825	0.0917

Table 11, day 1 has the highest probability of customer waiting on arrival before service.

Probability of not queuing on arrival.

This can be computed using the expression; 1 minus probability of queuing on arrival. Then, we have:

Table 4.12: Probability that a customer will not queue on arrival.

	Day 1	Day 2	Day 3	Day 4	Day 5	Average
P(Queuing)	0.2456	0.1070	0.1149	0.0410	0.0825	0.0917
P(Not Queuing)	0.7544	0.893	0.8851	0.959	0.9175	0.9083

The table above shows high level not queuing and arrival which gives the customers confidence and satisfaction.

Test of Goodness of fit using Chi-Square.

This is used to test whether arrival time and service time follow exponential distribution

Table 4.13: Mean Arrival Time and Service Time

	Day 1	Day 2	Day 3	Day 4	Day 5	Average
Arrival Time (λ)	2.1150	2.2013	2.5477	2.5662	2.6185	2.4097
Service Time(μ)	1.3876	2.0588	2.3138	3.5217	2.7235	2.4011

Chi-Square Test of Goodness-of-fit of Arrival Time

To test the hypothesis;

H_0: the data do not follow exponential distribution. vs

H_1: the data follow exponential distribution.

Decision Rule: Accept the null hypothesis if the calculated value of Chi-Square is greater than the table value of the test. Otherwise, reject.

$Estimation\ of\ \lambda = \frac{1}{\mu} = 0.4150$

Using this $P(x) = \lambda e^{-\lambda x} = 0.1725$

$E(x) = \frac{1}{\lambda} = 2.4096$

$X^2 = \Sigma \frac{(Oi-Ei)2}{Ei} = 0.0902$

Table: 4.14 Arrival time Chi Square

Observed [O(x)]	P (x)	Expected [E(x)]	(Obs– Exp.)	(Obs − Exp)2	Chi-Sq. Value
2.1150	0.1725	2.4096	- 0.2946	0.0868	0.0360
2.2013	0.1665	2.4096	- 0.2083	0.0433	0.0180
2.5477	0.1442	2.4096	0.1381	0.0191	0.0079
2.5662	0.1431	2.4096	0.1566	0.0245	0.0102
2.6185	0.1400	2.4096	0.2089	0.0436	0.0181

From the computation, α = 0.05

Chi – Square $X^2_{calculated}$ is 0.09.

Chi-Square tabulated is $X_{tabulated\ 1-0.05,\ 4} = 9.49$

Conclusion: Comparing both calculated and tabulated values of Chi-Square; 0.09 and 9.49, there exists enough evidence to accept the alternative hypothesis and conclude that the data follow Exponential distribution**.** This implies that Arrival Time follows exponential distribution.

Chi-Square Test of Goodness-of-fit of Service Time

To test the hypothesis:

H_0: the data do not follow exponential distribution.

H_1; the data follow exponential distribution.
Decision Rule: Accept the null hypothesis if the calculated value of Chi-Square is greater than the table value of the test. Otherwise, reject

$Estimation\ of\ \lambda = \frac{1}{\mu} = 0.4165$

Using this $P(x) = \lambda e^{-\lambda x} = 0.2337$

$E(x) = \frac{1}{\lambda} = 2.4010$

Table: 4.15 Service Time Chi Square

Observed [O(x)]	**P (x)**	**Expected [E(x)]**	**(Obs– Exp.)**	**(Obs − Exp)2**	**Chi-Sq. Value**
1.3876	0.2337	2.4010	-1.0134	1.0270	0.4277
2.0588	0.1767	2.4010	-0.3422	0.1171	0.0488
2.3138	0.1589	2.4010	-0.0872	0.0076	0.0032
3.5217	0.0961	2.4010	1.1207	1.2560	0.5231
2.7235	0.1340	2.4010	0.3225	0.1040	0.0433

From the computation, $\alpha = 0.05$
Chi – Square $X^2_{calculated}$ is 1.05
Chi-Square tabulated is $X_{tabulated\ 1-0.05,\ 4} = 9.49$

Conclusion: Comparing both calculated and tabulated values of Chi-Square; 1.05 and 9.49, there exists enough evidence to accept the alternative hypothesis and conclude that the data follow Exponential distribution.
Since the data follow exponential distribution, this implies that the service time too follows exponential distribution.
Therefore, I have the evidence to say, application of queuing theory lead to customer satisfaction and organization performance.
The queuing model suitable for the Bank of study is **M/M/C.**

Computation of the cost Implication on the Multi-Channel Systems.
Table 4.16: Cost implication of Multi-Channel System.

	Performance Measure	**2 Channels**	**3 Channels**	**4 Channels**
1	Probability of the Idleness of the system	2.29 = 229%	1.70 = 170%	1.00 = 100%
2	Average Number of Customers in The System (Ls)	1.06	1.22	1.42
3	Expected Time that Customer Waits for Service ($W_{s)}$	0.8	0.51	0.52
4	Average Number of Customers in the Queue (Lq)	0.11	0.08	0.07
5	Average Time a Customer Spends in The Queue (Wq)	0.24	0.09	0.03
6	**Total Economics Cost**	**450**	**360**	**304**

Interpretation of the Table Relating to the Queuing Model

The table outlines several performance measures for a queuing system with 2, 3, and 4 service channels (servers). These performance measures provide insights into the efficiency of the system as the number of servers increases. Below is the interpretation of each row in the context of a queuing model:
Probability of the Idleness of the System
2 Channels: 229% (2.29), **3 Channels**: 170% (1.70), 4 **Channels**: 100% (1.00)
2 Channels: At 229%, the system is heavily underutilized with two servers, meaning the servers are idle a significant amount of time.
3 Channels: The probability of idleness decreases to 170%, indicating better utilization but still some inefficiency with the servers idle less often.
4 Channels: At 100%, the system becomes perfectly balanced. With four servers, there is no excess idle time, suggesting the system is now optimally utilized.

Average Number of Customers in the System (Ls), 2 Channels: 1.06, 3 Channels: 1.22, 4 Channels: 1.42
This metric represents the average number of customers in the system (both being served and waiting). As the number of channels increases, the system holds more customers, which could mean a slightly higher system utilization.

Expected Time that Customer Waits for Service (Ws), 2 Channels: 0.80, 3 Channels: 0.51, 4 Channels: 0.52
This is the average time a customer spends in the system, including waiting and service time. Adding a third channel significantly reduces this time (from 0.80 to 0.51). However, increasing to four channels doesn't make a big difference (0.51 to 0.52), suggesting diminishing returns with additional servers.

Average Number of Customers in the Queue (Lq), 2 Channels: 0.11, 3 Channels: 0.08, 4 Channels: 0.07
This metric indicates the average number of customers waiting in the queue. As more channels are added, fewer customers are left waiting. The system becomes more efficient with 4 channels, with only 0.07 customers on average waiting.

Average Time a Customer Spends in the Queue (Wq), 2 Channels: 0.24, 3 Channels: 0.09, 4 Channels: 0.03
This is the average time a customer spends waiting in the queue. With 2 channels, customers spend 0.24 units of time waiting. Adding more channels significantly reduces this waiting time, especially with 4 channels where the wait time drops to almost negligible (0.03).
Total Economics Cost, 2 Channels: 450, 3 Channels: 360, 4 Channels: 304
This is the total economic cost associated with running the queuing system, factoring in both service costs (additional serving point) and customer waiting costs. As more channels are added, the total cost decreases from 450 (2 channels) to 304 (4 channels), indicating that adding more servers reduces the overall economic cost of the system.

Overall Interpretation:

- Adding more service channels (from 2 to 4) leads to improvements in customer experience metrics, such as reduced wait time in the queue (Wq) and a lower average number of customers in the queue (Lq).
- System idleness decreases as the number of servers increases, meaning the system becomes more balanced in terms of workload.
- The total economic cost of the system reduces as more servers are added, suggesting that increasing the number of servers (up to a point) is cost-effective.
- The findings in this work are in line with the stipulated objectives of this study as can be seen in Tables 1, 2, 13, 14 and 15 at pages 13,20,21, and 22 respectively which agrees with objective (i) of this research work. Also, the results obtained as shown in Tables 7 and 12 agrees with objective (ii) towards analyzing the efficiency and effectiveness of the queuing model in predicting and managing customers' flow in the banking sectors in page 16 and 20. Objective (iii) was also achieved as presented in Tables 1, 2, 3, 4, 5, 6, 8, 9, 10, 11 and 16 on pages 13,14,15, 16,17,18,19,20 and 24 respectively.
- Furthermore, the problem identified in this study was also solved adapting queue discipline of first-come first- served (FCFS). The Arrival and Service time follows exponential distribution. Hence, adding more service channels from 2 to 4 leads to improvements in customer experience metrics, such as reduced waiting time in the queue (Wq) and a lower average number of customers in the queue (Lq). In terms of cost reduction, the total economic cost of the system reduces as more servers are added, suggesting that increasing the number of servers (4 Channels), the system gives a 100% cost-efficiency, the system becomes perfectly balanced as presented in table 16.

Summary

Queuing theory is the mathematical study of waiting lines of customers in a service system such as fuel stations, supermarket check-out counters, post offices, cafeteria, and banking halls. In queuing theory, a model is constructed so that important queuing characteristics of the service systems can be obtained as a measure of the service performance of the systems (Nah & Siau, 2020). Examples of such characteristics are queue lengths (number of customers waiting to be served), the waiting times involved etc. Obtaining a good model for a queuing system requires an understanding of key components of the queuing system from which the system characteristics are derived.

The aim of this study, is to determine the average waiting time of customers in the banking sector by using queuing model data to estimate the average waiting time. objective one is to develop a queuing model specific to the banking sector that accurately represents the flow of customers in banking operations. Objective two to analyze the efficiency and effectiveness of the model in predicting and managing customers' flow in some banks. (Gross and Harris, 2021). Chapter two show related literatures with the study close to this study which says Queuing theory is also a set of tools and techniques for analyzing, providing service to customers so as to have balance of the cost of waiting and cost of servicing customers in a line. The contribution to knowledge of this study is including customers satisfaction and the cost of adding extra serving channels.

According to Etaga *et. al.* (2019), they found out that adding more channels (i.e. adding more service facilities), it is possible to minimize the sum of the costs of channels. Therefore, in this study, it is aimed at striking a middle ground between cost on one hand and benefits of improved service/customer satisfaction on the other hand studied through the methods presented in chapter 3. Chapter 4 shows the result of this study and how the stipulated objectives are achieved as shown in Tables 1, 2, 13, 14 and 15 at pages 13, 20, 21 and 22 respectively which agrees with objective (i) of this research work. Tables 7 and 12 agrees with objective (ii) towards analyzing the efficiency and effectiveness of the queuing model in predicting and managing customers' flow in page 16 and 20. Objective (iii) was achieved as presented in Tables 1, 2, 3, 4, 5, 6, 8, 9, 10, 11 and 16 on pages 13,14,15,16,17,18,20 and 24, respectively.

Conclusion

In the fiercely competitive financial services market of today. The usefulness of structured analysis in addressing common issues seen in customer service environments, such as lengthy wait times, dissatisfied customers, and wasteful resource use, has been brought to light by this research of customer flow utilizing the queuing model in banks. By utilizing models such as M/M/1 (single-server) and M/M/c (multi-server), banks are able to model and predict client behavior by simulating real environments. Key performance indicators that are necessary for efficient service management are provided by these models. Examples of these indicators are average waiting times, average queue lengths, and service system usage.
From the analysis of customer flow in the study, several conclusions can be drawn:

I. Enhanced Customer Satisfaction: Banks can greatly improve the customer experience by cutting wait times and streamlining consumer traffic overall.
II. Operational Efficiency: Queuing models allow banks to optimize staffing levels. By aligning the number of available tellers or service agents with expected customer traffic, banks can avoid the inefficiencies of overstaffing or understaffing. This helps banks manage costs while maintaining high service levels. This aids banks in cutting expenses while preserving good service standards.
III. Informed Decision-Making: Provides data-driven insights that enable banks to make well-informed decisions. For example, banks might employ more staff to handle the

flow of clients during peak hours, or they can encourage customers to use other channels, such internet banking, to cut down on in-person lines.

IV. Strategic Planning: Banks can estimate future consumer flow patterns and create long-term operational improvement initiatives by using queuing models. Banks are able to modify their procedures in response to shifting market conditions and client demands by regularly analyzing queue metrics.

V. However, there are additional difficulties in putting queuing models into practice. Traditional queuing models' basic presumptions, such stable arrival and service rates, might not always line up precisely with the dynamic and occasionally unpredictable character of actual banking environments. Standard queuing models can be difficult to use in situations when there are erratic spikes in client arrivals, impatient customers, or service outages. In addition, new factors like the ratio of in-branch to online traffic have been added to customer service management with the advent of digital banking

Notwithstanding these obstacles, the queuing model is nevertheless a potent method for evaluating client flow. By utilizing this instrument to its full potential, banks may optimize their service delivery procedures and strike a balance between client happiness and operational efficiency(cost). To sum up, employing queuing models to evaluate customer flow provides banks with a methodical and analytical way to enhance service effectiveness

Recommendations

By utilizing advancements in technology and organizational design, this study recommends following:

I. **Optimizing Staffing Levels:** Queuing models are a useful tool for banks to monitor peak customer arrival times and modify staffing numbers appropriately.

II. **Introducing Digital Queuing Systems:** Digital solutions that banks can use to optimize customer flow, decrease in-person lines, and enhance overall experience include mobile queue management and online appointment systems.

III. **Promoting Alternative Channels:** In the context of managing customer flow in banks using the queuing model technique, "Promote Alternative Channels" refers to encouraging customers to use non-traditional, digital, or self-service options instead of physically visiting bank branches for services. This strategy is aimed at reducing the pressure on in-branch services and alleviating long waiting times during peak periods. Banks that effectively include and advertise these choices now will be in a better position later on to handle increasing customer demand, enhance service effectiveness, and sustain high customer satisfaction levels.

IV. **Regular Monitoring and Adjustment:** Banks should regularly review customer flow data and modify their service procedures in response to real-time observations from the study of queuing models.

Implementing Training for Staff: Make sure that bank employees are proficient in employing technologies that streamline the queue process and have received training on how to manage large customer volumes.

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