APPLICATION OF QUEUING MODELS IN ENHANCEMENT OF BANK SERVICES AT AFRAM COMMUNITY BANK LIMITED (MAAME-KROBO BRANCH)

Inusah mahama and Salifu Katara

Bolgatanga Polytechnic, Department of Statistics, P. O. Box 767, Ghana -West Africa,
and
University for Development Studies, Department of Statistics, Navrongo Campus, Ghana-West Africa

IJASR 2019
VOLUME 2
ISSUE 6 NOVEMBER - DECEMBER **ISSN: 2581-7876**

Abstract – Queuing problems is an important problem to our everyday life. In general, customers are not willing to wait for long before services are rendered.

The analysis of the queuing model (m/m/1) shows that, if the number of servers is increased to two or more, the highest utilization factor of 82.57% for m/m/1 will be decreased to 41.29% for m/m/2 and a more decreased to 27.52% for an m/m/3 model. That is, the more the servers, the lesser the busy time of the servers, the lesser the time customers spend in the queue and in the system and finally the lesser the number of customers in the system and in the queue.

Moreover, the results suggest that, the network system and service charges are to be worked on by management to improve on the services delivered to increase customers' satisfactions. The analysis further indicates that, customers are preferred to be in the banking hall for a maximum time period of 5-10 minutes

Keywords: Queues, Queuing models, Services.

Introduction and background of study

In other to maintain peace, discipline and to avoid congestion at service centers, queues are used to achieve these purposes. Queues or waiting lines are very common to our everyday life. These waiting lines can be observed in the Banks, Hospitals, Supermarkets, Telephone exchange, etc. The first problems of queuing theory were raised by telephone calls.

A.K Erlang (1909) was the first to treat congestion problems in the beginning of the 20th century. Queuing theory is a branch of mathematics that studies and models the act of waiting in lines in order to be served.

Queuing theory known by various other names such as Congestion theory, Mass service theory and Traffic theory (Copper, 1981) is a mathematically based technique for analyzing waiting lines (queues). In queuing theory, queuing models are used to estimate a real queuing situation, so that the queuing behavior can analyzed mathematically. Customers arriving at a service facility, waiting in a queue (line) if all servers are busy, then receiving services and finally departing from the service facility when he/she has been served is also term as queuing system. Queuing system is based on a set of customers, a set of server(s) and the order whereby these customers arrived and are given service or processed.

Whenever the demand for a service exceeds its supply, then queues are formed. Long waiting time in Banking is considered an indicator of poor quality and need improvement. Managing waiting lines create a great problem for managers who are seeking to improve upon quality bank services and customer satisfaction.

Banking is a business activity of accepting and safeguarding money owned by other individuals and entities and then lending out this money in other to earn a profit. And a Bank as defined by the Encarta World Dictionary refers to a business that keeps money for individuals or companies, exchange currencies, give loans and offer other financial services.

In 1976, the Ghana Government through the Bank of Ghana (BoG) established rural and community Banks to channel credit to productive rural ventures and promote Rural Development. The underlining aim was to make credit institutions available to help promote growth and development in our rural areas. As at April 2016, there are one hundred and forty (140) licensed Rural and Community Banks in Ghana. The other queuing disciplines are the Last Come First Served (LCFS) and Service in Random Order (SIRO).

Another factor that has an important effect on the behavior of a queuing system is the method that customers use to determine which line to join. In this study, customers are bound to join a single queue or line due to the existence of a single Server or Teller. In other Banks where there are several Servers or Tellers, customers have the option to choose or join the line they prefer.

However, this study is designed to help the management of Afram Community Bank Limited about Employer efficiency and also help reduce customers waiting time in the Banking Hall. Most customers are not comfortable waiting or queuing (Olaniyi, 2004). According to Elegalam (1978), customers are not prepared to spend cost on queuing. The time wasted on the queue would have been judiciously used elsewhere (the opportunity cost of time spent in queuing).

Notwithstanding that, despite all the efforts made by Banks, queues continues to exist in Banking Halls (Mbuvi, 2013). The existence of long queues in the banking halls for several hours leads to waste of time, limit productivity and create less patronage. Since banks plays a vital role in the Economic Development of the country (Ghana), a slight decline in performance affects the country's economy at large.

Before the introduction of banking system in Ghana, there was already an existence of Mathematical models which were used for Forecasting or predicting the consequences or outcome of queues (waiting lines) in banks. During an analysis on a formal data I carried out at the Afram Community Bank Limited on a sample of customers. It was revealed that most or majority of the customers complained of being in the queue for long due to the following problems below;

i. Network problem in the banking hall
ii. The existence of only one Server or Teller
iii. High bank service charges on customers

However, on the network problem, customers are obliged to be in the queue until the network is available for service to start. Also, with the event of high service charges which was mention as one of the problems in the Afram Community Bank which leads to long queue or keep customers waiting implies that, some customers who goes to the service desk sometimes spent much time trying to know how and where these charges are emerging from. By this, keeping the other customers in the queue for long. And the other factor which was the single server or teller issue also implies that, all customers must pass through the same server even when the queue is very long, before they can receive services. Hence, due to these findings obtained from the customers, it has become very prudent to use a mathematical model to check or analyze and reduce the queuing problems in Afram Community Bank Limited in order to enhance quality bank services and increase customer satisfaction.

Base on this study, these research questions helps to identify the major drawback of long queues or waiting lines in the Afram Community Bank Limited. It seeks to address the following questions;

i. Which services do customers perform most in the Afram Community Bank Limited?
ii. What major problems do customers normally encounter during services in the Afram Community Bank Limited?
iii. How much time do customers spend in the queue and in the system at the Afram Community Bank Limited?
iv. How do customers feel in the existence of only one server or teller in the Afram Community Bank Limited?

v. What is the attitude and performance of workers (Employees) to customers in the Afram Community Bank Limited?

The main focus of this study is to determine how effective single channel queuing model (M/M/1) is used to analyze the utilization factor and performance measure in the banking hall and how it relates to customer satisfaction.

RESEARCH METHODS

Test of Hypothesis:

H_0: Customers are not satisfied with the M/M/1 Queuing Model
H_1: Customers are satisfied with the M/M/1 Queuing Model
Questionnaire data is analyzed by computing percentages of customer's responses to each question.

Single-Channel Queuing Model with Poisson Arrivals and Exponential Service Time
Under this research, the single-channel queuing model is used because of the existence of only one server or teller in the banking hall of the Afram Community Bank Limited.

Single service facility

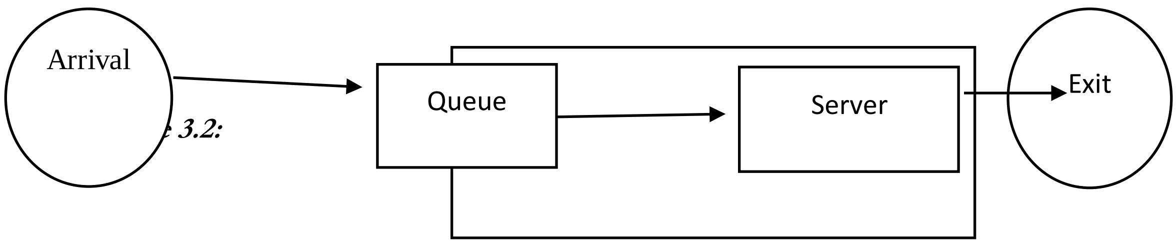

Figure 1.0: Single channel queuing system

Assumptions of the Model

We assume that the following conditions exist in this type of system.

i. Arrivals are served on a first-in-first-out (FIFO) basis and every arrival waits to be served regardless of the length of the queue.
ii. Arrivals are independent of preceding arrivals, but the average number of arrivals (arrival rate) does not change over time.
iii. Arrivals are described by a poison probability distribution and come from an infinite population.
iv. Service time varies from one customer to the next and is independent of one another, but their average rate is known.
v. Service times occur according to the negative exponential probability distribution.
vi. The service rate is faster than the arrival rate.

Equations of Single-Channel Queuing Model

Let $\lambda =$ Mean number of arrivals per time period = Mean arrival rate $= \frac{1}{E[r]}$

$\mu =$ Mean number of people or customers per time period = Mean service rate $= \frac{1}{E[s]}$

i. L_s=average number of units (customers) in the system

$$L_S = \frac{\lambda}{\mu - \lambda} \quad (3.2)$$

ii. W_s=average time a unit spends in the system (waiting time plus service time)

$$W_s = \frac{1}{\mu - \lambda} \quad (3.3)$$

iii. L_q=average number of units (customers) in the queue

$$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} \quad (3.4)$$

iv. W_q=average time a unit (customer) spends in waiting in the queue

$$W_q = \frac{\lambda}{\mu(\mu - \lambda)} \quad (3.5)$$

P=utilization factor of the system.

$$\varrho = \frac{\lambda}{\mu} \quad (3.6)$$

ϱ is the number of arrivals per mean service time.

If $\rho < 1$, then steady state probability exists.

If $\rho > 1$, the arrivals come at a faster rate than the server can accommodate.

When $\rho = 1$, steady state does not occur.

The Erlang Distribution

The Erlang distribution is used to model situations where the inter-arrival times do not appear to be exponential. It is a continuous random variable (T) whose density function is specialized by two parameters; a scale parameter, μ, and a shape parameter k (where k is a positive integer).

A random variable T with density function f_k is called Erlang distribution. When k=1 the Erlang and exponential distributions coincide. Suppose that T is the sum of the independent, exponential random variables $T_1\ldots, T_k$, each with parameter μ. Then T is Erlang distributed with density f_k, and its mean is

$$E(T) = E(T_1) + \ldots + E(T_k) = \frac{k}{\mu} \quad (3.7)$$

And its variance is also given as

$$Var(T) = Var(T_1) + \ldots + Var(T_k) = \frac{k}{\mu^2} \quad (3.8)$$

Probability Distribution

Probability of the number of customers in the system is often used to describe the behavior of a queuing system by means of estimating the probability distribution or pattern of the arrival times between successive customer arrivals (inter arrival times). There are many well-known probability distributions which are of great importance in the world of probability such as Poisson, exponential, binomial, geometric distribution, and many others. However, we will discuss the important distributions which have been found useful for this study.

Poisson Distribution

The Poisson distribution is used to determine the probability of a certain number of arrivals occurring at a given time with the simple model assumes that the number of arrivals occurring within a given interval of time t, follows a Poisson distribution with parameter λt. The Poisson process is an extremely useful process for modeling purposes in many practical applications such as to model arrival process of queuing models.

In this model it is assume that only arrivals are allowed at a rate λ per unit time. The assumption here is that, there is no one in the system at t = 0. We usually assume and try to determine how many arrivals might enter the system within some time (t). The arrivals of the customers can be assumed to follow Poisson distribution. That is n (t) is the number of customers or arrivals that has occurred from time 0 to time t.

The Poisson distribution is given as;

$P_n(t) = \frac{(\lambda t)^n}{n!} e^{-\lambda t}$ (3.9)

Where

- t describes the period 0 to t.
- n is the total number of arrivals in the period 0 to t.
- λ is the total average arrival rate.

Poisson distribution is said to hold when;

$E(n) = Var(n) = \lambda$ (3.10)

Exponential Distribution

The most commonly used queuing models are based on the assumption of exponentially distributed service times and inter arrival times. A random variable **X** has an exponential distribution with parameter λif the density of **X** is given by

$f(t) = \lambda e^{-\lambda t}$ if $(t \geq 0)$ (3.11)

Then

$$\left.\begin{array}{l} E(X) = \frac{1}{\lambda} \\ Var(X) = \frac{1}{\lambda^2} \end{array}\right\} \quad (3.12)$$

The exponential distribution has the no-memory property. This means, for instance, that if inter-arrival times are exponentially distributed with rate or parameter λ, then no matter how long it has been since the last arrival, there is a probability $\lambda\Delta t$ that an arrival will occur during the next Δt time units. Inter-arrival times are exponential with parameter λ if and only if the number of arrivals to occur in an interval of length *t* follows a Poisson distribution with parameter λt.

Results and discussion

4.2 Queuing Analysis: Single Server (M/M/1) Model

Table 4.2.1 Statistics of mean inter-arrival time on 17th march, 2018

Statistic	Value
Sample Size	19
Range	7
Mean	2.9474
Variance	6.0526
Std. Deviation	2.4602
Coef. of Variation	0.83471
Excess Kurtosis	-1.5034

Source: field survey march, 2018

The above table shows the descriptive statistics of customers' inter-arrival time on 17th march, 2018 in the Afram Community Bank Limited. It shows that, the mean inter-arrival time is 2.9474. This mean value of 2.9474 can be used to calculate the mean arrival rate (λ) using the formula for calculating lamda (λ) as stated in chapter three.

Table 4.2.2 Analysis of customer's mean service time on 17th march, 2018: ***Statistics of mean service time***

Statistic	**Value**
Sample Size	14
Range	1
Mean	2.2857
Variance	0.21978
Std. Deviation	0.46881
Coef. of Variation	0.2051
Std. Error	0.12529
Skewness	1.0665
Excess Kurtosis	-1.0341

Source: field survey march, 2018

The above table shows the results of customer's services time using Easy Fit software. The results show that, the mean service time is 2.2857. This mean service time of 2.2857 can also be used to calculate the mean service rate (μ) using the formula in chapter for calculating μ.

Table 4.2.3 Distributions of customer's inter-arrival time on 17th march 2018

#	Distribution	Parameters
1	Beta	$□_1$=0.04594 $□_2$=0.17355: a=8.5017E 16 b=7.0
2	Burr	k=3199.8 □=2.2593 □=160.73
3	Burr	k=2055.2 □=2.2627 □=131.59
4	Cauchy	□=1.9592 □=2.8959
5	Chi-Squared	□=4
6	Chi-Squared	□=2
7	Dagum	k=0.00364 □=668.18 □=7.1015
8	Dagum	k=0.00473 □=598.72 □=7.0176
9	Erlang	m=3 □=1.2105
10	Erlang	m=1 □=2.0536
11	Error	k=100.0 □=2.4602 □=2.9474
12	Error Function	h=0.28742
13	Exponential	□=0.33929
14	Exponential (2P)	□=0.33929 □=-1.0000E-14
15	Fatigue Life	□=0.55703 □=3.3831

From the table above, since the inter-arrival time follows an exponential distribution, the mean arrival rate (λ) is shown on the table as 0.33929. This mean arrival rate (λ) of 0.33929 is used in the estimation of the parameters of the utilization factor and performance measure values.

Table 4.2.4 Distribution of customers mean service time on 17/03/2018

#	Distribution	Parameters
1	Beta	□ $_1$=0.24714; □ $_2$=0.7002 a=2.0 b=41.986
2	Burr	k=48.434 □ =1.0215E+6 □ =2.0
3	Burr (4P)	k=0.75499 □ =1.2362: □ =8.9173E-6 □ =2.0
4	Chi-Squared	□ =2
5	Dagum	k=34.96 □ =39.984 □ =1.8312
6	Dagum (4P)	k=0.34236 □ =1.1842: □ =0.16523 □ =2.0
7	Erlang	m=23 □ =0.09615
8	Erlang (3P)	m=1 □ =0.2857 □ =2.0
9	Error	k=6.7122 □ =0.46881 □ =2.2857
10	Error Function	h=1.5083
11	Exponential	□ =0.4375
12	Exponential (2P)	□ =3.5 □ =2.0
13	Fatigue Life	□ =0.18365 □ =2.2478

Since customer's service time follows an exponential distribution, the table shows that, the mean service rate (μ) is 0.4375. This mean service rate of 0.4375 is used with the λ value of 0.33929 in Table 4.2.3 above for the estimation of the utilization factor and performance measures.

Table 4.2.5 Parameter Estimates on 17th march, 2018

INPUT	**TIME UNIT**
Arrival rate (λ)	0.3393
Service rate (μ)	0.4375
INTERMEDIATE CALCULATIONS	
Average inter- arrival time	2.9474
Average service time	2.2857
PERFORMANCE MEASURES	
Average server Utilization (rho)	0.7755
Probability that the service unit is Idle (p)	0.2245
Average number of customers in the system (L_s)	3.4552 customers
Average number of customers in the queue (L_q)	2.6797 customers
Average time a customer spends in the system (W_s)	10 minutes/customer
Average time a customer spends in waiting in the queue (W_q)	7.8976minutes/customer

The results on the above Table 2.2.5 shows that, the server would be busy 77.55% of the time and idle for 22.45% of the time. Also, there are 3.4550 customers in the system on average and the average number of customers in the queue is shown to be 2.6797 customers. Furthermore, the average time a customer spends in the system is 10 minutes/customer and the average time a customer spends in waiting in the queue is 7.8976 minutes/customer.

4.2.6 Computations of Parameters on 18th March, 2018 From

r = Inter-arrival time = time between two successive arrivals = 60

$E[r] = \frac{60}{21}$=2.8571

λ = Mean arrival rate = $\frac{1}{E[r]} = \frac{1}{2.8571}$= 0.3500

s =Mean service time =33

$E[s] = \frac{33}{15}$=2.2000

μ = Mean service rate = $\frac{1}{E[s]} = \frac{1}{2.2000}$ =0.4545

Utilization factor (ϱ) = $\frac{\lambda}{\mu} = \frac{0.3500}{0.4545}$ = 0.7701
Probability that the system is idle (P) = 1- ϱ = 1 – 0.7701 = 0.2299
Average number of customers in the system (L_s) = $\frac{\lambda}{\mu-\lambda} = \frac{0.3500}{0.4545-0.3500}$ = 3.3493 customers
Average number of customers in the queue (L_q) = $\frac{\lambda^2}{\mu(\mu-\lambda)} = \frac{0.3500^2}{0.4545(0.4545-0.3500)}$ = 2.5792 customers
Average time a customer spends in the system (W_s) = $\frac{1}{\mu-\lambda} = \frac{1}{0.4545-0.3500}$ = 9.5694 minutes/customer

Average time a customer spends in waiting in the queue (W_q) = $\frac{\lambda}{\mu(\mu-\lambda)} = \frac{0.3500}{0.4545(0.4545-0.3500)}$ = 7.3692 minutes/customer. The results calculated shows that, the server would be busy 77.01% of the time and idle 22.99% of the time. It also shows that, average number of customers in the system is 3.3493 and average number of customers in the queue is 2.5792. Moreover, the average time a customer spends in the system is 9.5694 minutes and average time a customer spends in the queue is 7.3692 minutes.

Table 4.2.7 Parameter Estimates on 18th march 2018

INPUT	UNIT MEASURE
Arrival rate (λ)	0.3500
Service rate (µ)	0.4545
Intermediate Calculations	
Average inter- arrival time	2.8571
Average service time	2.2000
Performance Measures	
Average server Utilization (rho)	0.7701
Probability that the service unit is Idle (p)	0.2299
Average number of customers in the system (L_s)	3.3493 customers
Average number of customers in the queue (L_q)	2.5792 customers
Average time a customer spends in the system (W_s)	9.5694 minutes/customer
Average time a customer spends in waiting in the queue (W_q)	7.3692minutes/customer

Source: field survey march, 2018

Table 4.2.8 Parameter Estimates on 19th march, 2018

INPUT	UNIT OF MEASURE
Arrival rate (λ)	0.3051
Service rate (µ)	0.400
Intermediate Calculations	
Average inter- arrival time	3.2778
Average service time	2.5000
Performance Measures	
Average server Utilization (rho)	0.7628
Probability that the service unit is Idle (p)	0.2373
Average number of customers in the system (L_s)	3.2150 customers
Average number of customers in the queue (L_q)	2.4522 customers
Average time a customer spends in the system (W_s)	10.5374minutes/customer
Average time a customer spends in waiting in the queue (W_q)	8.0374minutes/customer

Source: field survey march, 2018

Table 4.2.6 shows the results of data collected on the 19th march, 2018. It shows that the server was 76.28% busy of the time and 23.73% idle of the time.

Table 4.2.10 Analysis and Presentation of parameter Estimates on 23rd march, 2018

INPUT	UNIT MEASURE
Arrival rate (λ)	0.3220
Service rate (μ)	0.4516
Intermediate Calculations	
Average inter- arrival time	3.1053
Average service time	2.2143
Performance Measures	
Average server Utilization (rho)	0.7130
Probability that the service unit is Idle (p)	0.2870
Average number of customers in the system (L_s)	2.4846 customers
Average number of customers in the queue (L_q)	1.7715 customers
Average time a customer spends in the system (W_s)	7.7160minutes/customer
Average time a customer spends in waiting in the queue (W_q)	5.501 minutes/customer

Source: field survey march, 2018

Table 4.2.10 above shows that, the system will be busy 71.30% of the time and 28.70% idle of the time.

Table 4.2.12 Presentation of Summary of parameter estimates for the various six (6) days period

INPUTS	DATES						UNITS
	17/03/18	18/03/18	19/03/18	22/03/18	23/03/18	24/03/18	
Total time	1.00	1.00	1.00	1.00	1.00	1.00	
Λ	0.3393	0.3500	0.3051	0.3729	0.3220	0.2807	
μ	0.4375	0.4545	0.4000	0.4516	0.4516	0.4286	
Server(s)	1	1	1	1	1	1	
Model	M/M/1	M/M/1	M/M/1	M/M/1	M/M/1	M/M/1	
INTERMEDIATE CALCULATIONS							
Av.Int.Time	2.9474	2.8571	3.2778	2.6818	3.1053	3.5625	
Av.S.Time	2.2857	2.2000	2.5000	2.2143	2.2143	2.3333	
PERFORMANCE MEASURE							
RHO(ϱ)	0.7755	0.7701	0.7628	0.8257	0.7130	0.6549	
P	0.2245	0.2299	0.2373	0.1743	0.2870	0.3451	
L_s	3.4552	3.3493	3.2150	4.7382	2.4846	1.8979	Customers
L_q	2.6797	2.5792	2.4522	3.9125	1.7717	1.2430	Customers
W_s	10	9.5694	10.5374	12.7065	7.7160	6.7613	Minutes/c
W_q	7.8976	7.3692	8.0374	10.4921	5.5017	4.4281	Minutes/c

Table 4.2.5 shows the analysis of the various days data collected. The results show that, 22nd results gave the highest server's busy time of 82.57% and with the least idle time of 17.43%. It was followed by 17th with the server busy time of 77.55% and idle time of 22.45%, 18th with the busy time of 77.01% and idle time of 22.99%,

19th with busy time of 76.28% and idle time of 23.73%, 23rd with service busy time of 71.30% and idle time of 28.70% and 24th with the least service busy time of 65.49% and highest idle time of 34.51%.
Moreover, the results show that, the more the idle time, the lesser the average number of customers in the system and in the queue and the lesser the average time a customer spends in the system and waiting in the queue and vice versa.

Table 4.2.13 Comparison of Utilization Factors for M/M/1, M/M/2 and M/M/3 for the Various Days.

DATES	M/M/1	M/M/2	M/M/3
17th March, 2018	0.7755	0.3878	0.2585
18th March, 2018	0.7701	0.3850	0.2567
19th March, 2018	0.7628	0.3814	0.2543
22nd March,2018	0.8257	0.4129	0.2752
23rd March,2018	0.7130	0.3565	0.2377
24th March, 2018	0.6549	0.3275	0.2183

Source: field survey march, 2018

From table 4.2.6 above, on 17th march, the results show 77.55% busy time for a single server/teller (m/m/1), 38.78% busy time for two servers (m/m/2) and 25.85% busy time for three servers (m/m/3). Also, 18th march results show 77.01% busy time for a single server, 38.50% busy time for two servers and 25.67% busy time for three servers. Moreover, the remaining days follows the same routine. Hence, as the number of servers increases the utilization factor decreases.

Figure 4.2 Comparison of Utilization factors of m/m/1, m/m/2 and m/m/3 for the various days.

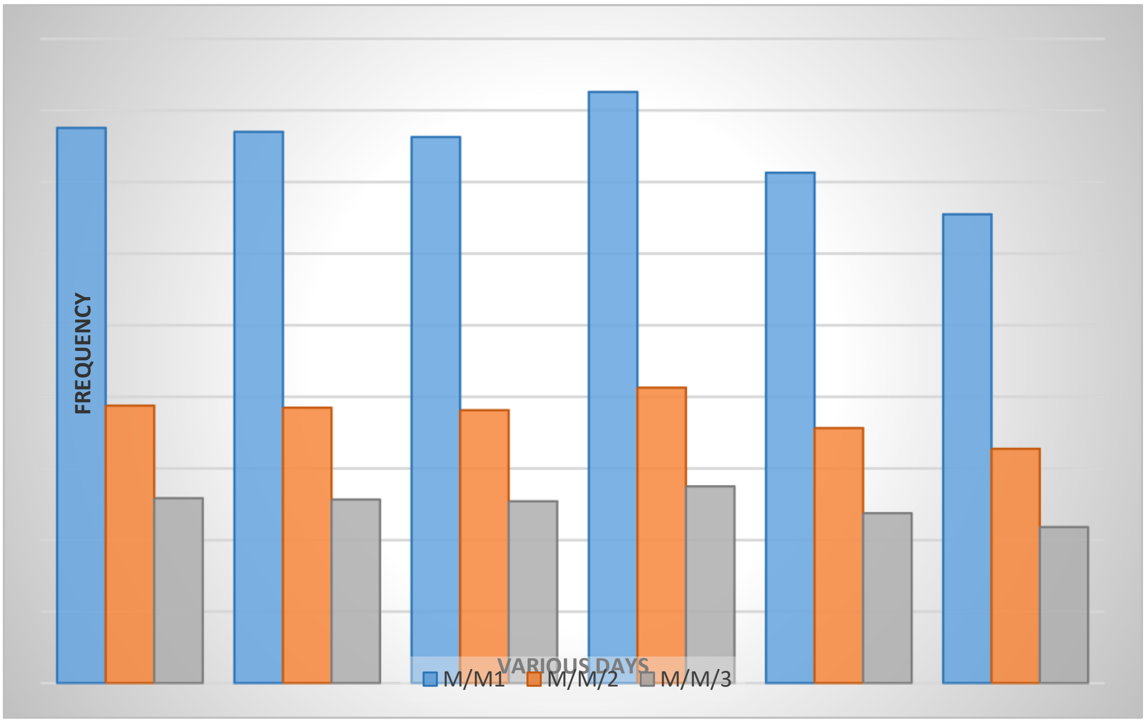

Figure 4.4 above shows the comparison of utilization factors using different types of queuing models. It is shown that, the single server model has the longest bars followed by the two servers' model and the three servers' model with the shortest bars. Indicating that, the less the servers, the higher the utilization factor and vice versa.

Analysis of Binary Logistics Regression

Atest on customers' satisfaction of the single server in the banking hall of Afram Community Bank Limited using Binary Logistics Regression

Hypothesis;

H_0: Customers are not satisfied with the single server in the bank
H_1: Customers are satisfied with the single server in the bank

Table 4.3.1 Omnibus Tests of Model Coefficients

	Chi-square	Df	Sig.
Step	14.742	2	.001
Block	14.742	2	.001
Model	14.742	2	.001

The -2 log likelihood (sometimes called, deviance) has a chi square distribution. The value for result of adding sex (gender) to the model is given in the above table with a value of 0.001 which is less than the conventional significance value of 0.005. Hence, we would conclude that adding sex (gender) is statistically significant, customers are not satisfied with the single channel queuing model.

Table 4.3.2 Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	145.082[a]	.166	.222

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

Table 4.3.3 Variables in the Equation

	B	S.E.	Wald	df	Sig.	Exp(B)
Sex (1)	1.134	.425	7.107	1	.008	3.108
Constant	-1.911	.523	13.337	1	.000	.148

The above shows that, a unit increase in females will lead to 3.108 times they are likely not to be satisfied with the single channel queuing model. If you want the odds that, the females will be satisfied with the single channel queuing model is the inverse of 3.108.

- Logistics Model

$$\log\left(\frac{p_i}{1-p_i}\right) = \text{logit}\,(p_i) = \beta_0 + \beta_1 x_i$$

Where; p_i = the probability of females not satisfied with the single channel queuing model.
The model can be written in terms of odds

$\frac{p_i}{1-p_i} = e^{(\beta_0+\beta_1 x_i)}$

$p_i = \frac{e^{(\beta_0+\beta_1 x_i)}}{1+e^{(\beta_0+\beta_1 x_i)}}$

- Conversely, the probability of females who are satisfied with the single channel queuing model is (1 - P_i)

$P_i = \frac{e^{(-1.911 + 1.134\,(2))}}{1+ e^{(-1.911+1.134\,(2))}} = \frac{1.42903587}{1+1.42903587} = 0.5883140252$

$1 – P_i = 1 – 0.5883140252 = 0.4116859748$

$\text{ODDS} = \frac{probability\ of\ success}{probability\ of\ failure} = \frac{0.5883140252}{0.4116859748} \approx 1.42903587$

- A Unit Increased in Females;

$P_i = \frac{e^{(-1.911 +1.134\,(3))}}{1+ e^{(-1.911+1.134(3))}} = \frac{4.441534834}{1+4.441534834} = 0.8162283196$

» $1+P_i = 1 – 0.8162283196 = 0.1837716804$

$\text{Odds} = \frac{0.8162283196}{0.1837716804} = 4.441534832$

$\text{ODDS RATIO} = \frac{4.441534832}{1.42903587} = 3.108063917 \approx 3.108$

Therefore, per the analysis above, we fail to reject the null hypothesis and conclude that, customers are not satisfied with the single channel queuing model.

Summary of Findings

The primary objective of this project was to determine how effective the single channel queuing model (M/M/1) can be used to analyze the utilization and performance measures and how it relates to customer satisfactions in the Afram Community Bank Limited.
From Table 4.1.2 the findings on the questionnaire data shows that, high service charge, long waiting time and network problems were responded by customers as their major problems faced during services in the Afram Community Bank Limited.

From table 4.2.5 the results on server utilization factors for the various days shows that, 22nd march, 2018 recorded the highest utilization factor of 0.8257. It was followed by 17th with a utilization factor of 0.7755, 18th with utilization factor of 0.7701, 19th with a utilization factor of 0.7628, 23rd with utilization factor of 0.7130 and 24th with the least utilization factor of 0.6549. The results shows that, as the utilization factors increases, there is a relative increased in the average number of customers in the system, increased in the average number of customers in the queue, increased in the average time a customer spends in the system increased in the average time a customer spends in waiting in the queue.
Table 4.2.6 shows the results of the analysis of different queuing models. The results show that, as the number of servers' increases, the corresponding utilization factors decreases. For instance, the utilization factor of a single server on the 17th was 0.7755, it decreases to 0.3878 when there are two servers and further decreases to 0.2585 when there are three servers.

A binary Logistics Regression was further used to test on customers satisfactions with the single teller/server in the bank. And the null hypothesis was failed to reject and hence it was concluded that, customers are not satisfied with the single server in the Afram Community Bank Limited (Maame-Krobo Branch).

Conclusion

The study looked at the application of single channel queuing model (m/m/1) to help reduce the waiting time of customers in the Afram Community Bank Limited to enhance bank services in other to increase customers' satisfaction.
The model was effectively used and the results obtained from the analysis were significantly encouraging. Though customers preferred time was between 6-10 minutes. The highest average waiting time of customers in the system and in the queue was 12.7065 minutes and 10.4921 minutes respectively. Also, the highest average number of

customers in the system and in the queue was 4.7382 customers/minute and 3.9125 customers/minute respectively. In conclusion, customers will remain loyal if and only if their satisfactions are met.

Recommendations

Based on the summary and conclusion on the findings of this study, the following recommendations have been made to help management improve upon customer satisfaction and also help reduce customers waiting time in the banking hall.

1. Management should improve on the network system in the banking hall of the Maame – Krobo branch of the Afram Community Bank Limited.
2. Management should adopt a two-teller or more system to help reduce the waiting time of customers in the banking hall during services.
3. Management should reduce the service charges on customers such that loyal customers will remain very reliable to the bank.

References

1. Bhat, U.N, (2008) An Introduction to Queuing Theory: *Modeling and Analysis in Application (Statistics for Industry and Technology).*
2. Brown, A.J. (2012). A study of queuing theory in Low to high rework environments with process availability. *Master's thesis, University of Kentucky.*
3. Coffman, E.G. Jr. and Hofri, M. (1986). *"Queuing Models of Secondary storage devices," Queuing Systems*, 1, 129-168.
4. Coffman, Jr, E.G and Donning, P. (1973). Operating Systems Theory, Prentice Hall, Englewood Cliffs, N.J.
5. Copper, R.B. (1981). Introduction of Queuing Theory. 2nd Ed. Elsevier North Holland, Inc, New York.
6. Davis, M.M, Aquilano M.J.N, Chase B.R (2003). Fundamentals of Operations Management.4th Edition.
7. Elegalan (1978). "Customer retention versus Cost reduction Technique" *a paper presented at the Bankers forum held at Lagos, pg. 9-10.*
8. Erlang's, A.K (1909). "The Theory of Probability and Telephone Conversations" (Nyt tidsskrift for mathematics, B, 20, P.33).
9. Estan, C and G.Varghese, (2002). "New directions in traffic measurement and accounting," in Proc. Acm Sigcomm, pp. 323-336.
10. Filipoiwicz B., K. J. (2008). Queuing systems and networks, models and Applications. Bull.Polish Acad. Sci.Tech. 56(4).
11. Gaver, D. P. Jr. (1968). "Diffusion approximations and models for certain congestion problems", J. Application of Probability. 5, 607-623.
12. Gurumurthi and Benjaafar, (2004). Modeling and Analysis of Felixible Queuing Systems. Naval Research Logistics, (vol.51), Wiley periodicals, Inc.
13. Iglehart, L, D. and Whitt, W. (1970). "Multiple channel queues in heavy traffic I", Adv. Appl. Prob., 2, 150-177.
14. Jackson, J. (1957). Network of waiting lines. Operations Research, 5:518-521.
15. Johannsen. (1907). Waiting time and number of calls. *Post Office Electrical Engineers Journal, London.*
16. Jong-hwan K., Hyunsoo Y., Ikjun Y. (2011). "Active Queue Management for Flow Fairness and stable Queue Length," IEEE Transactions on Parallel and Distributed systems. Vol. 22, (no.4) pp. 571-579.
17. Kendall, D.G (1953). Stochastic Process Occurring in the theory of Queues and Their Analysis by means of the Imbedded markov chain. *The Annals of Mathematical Statistics, 24, 338-354.*
18. Kingman, J.F.C (1965). "Heavy traffic approximations in the theory of queues", Proc. Symp. Congestion Theory (Eds. W.L. Smith and W.E. Wilkinson), Univ. of North Carolina, Chapel Hill, 137-169.