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Application of Multi-Channel, Single Stage Queue Model to Optimize Service Delivery in Banking Industry (A Case Study of Diamond Bank PLC, Eziukwu Branch, Aba)

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Abstract— *In this paper, the problem of maximizing customer satisfaction and minimizing cost of providing service were examined with the view of establishing optimal service level that will cater for the tradeoff between the cost of providing banking service to customers and waiting cost. To achieve this, multichannel, single stage queuing (M/M/S) model was adopted and applied. The operating characteristics were calculated with the help of Microsoft Excel package and graph of total expected cost, expected service cost and expected waiting cost were plotted against service level. The data for this study were collected from Diamond bank Plc, Eziukwu Aba through observations and personal interview. The paper suggested an optimal service level of 7tellers for the case study used. The result of this study will be a guide to other operation managers of banks as the factors to be considered when deciding the number of service levels to use for optimal service to be achieved have been x-rayed.*

Keywords— *Multichannel, Queue, Service cost, Single stage, Total cost, Waiting cost.*

I. Introduction

Queuing is an everyday occurrence which everyone has experienced whether at fast food restaurant, at bank or in a hospital etc. In most cases, it is not quite a pleasant experience and can be frustrating. In a competitive economy like ours, long queues can be a signal to a potential loss of revenues and must be checked. Thus understanding the nature of queues and learning how to manage it is important in operations management.

A queuing system can be described as customers arriving for service, waiting for service if it is not immediate and if having waited for service, leave the system after being served. The term "customer" is used in the general sense of the word and not limited or restricted to human customers only.

According to [1] citing [6] queue theory has been used successfully in the study of queue behaviour problems, optimization problems and statistical inference of queuing system.

Queues develop because the service may not be delivered immediately it is needed at the service facility [2]. Inadequate and unsatisfactory service facility could cause queue to be formed. The only way the service demanded can be met with ease is to increase the service facility and increase the efficiency of the existing facility to a higher level [5]. However, this will increase the total cost of providing service if waiting cost remains constant.

The objective of queue theory is to strike a balance between two extremes – minimizing the service cost and maximizing customer satisfaction. Those involve in decision making must deal with the trade-off between the cost of providing good services and cost of customers' waiting time.

Optimizing service delivery by guarantying customer satisfaction and reducing service cost has been a major challenge to commercial banks in Nigeria, most especially at this era of competitive banking and stringent financial regulations. Queues has been a daily occurrence in most of commercial banks in the country due to poor queue management. According to [5], this reflects lack of the business philosophy of customer centric, low service rate of the system.

In this paper, we focused on how to using multichannel, single phase queue theory to optimize service delivery that will maintain a striking balance between minimize the service cost and maximize customer satisfaction.

A. *Multichannel Queue Model (M/M/S)*

Multichannel queue model approach is used in a situation where S-parallel channels that offer identical service are provided to serve intending customers from calling population.

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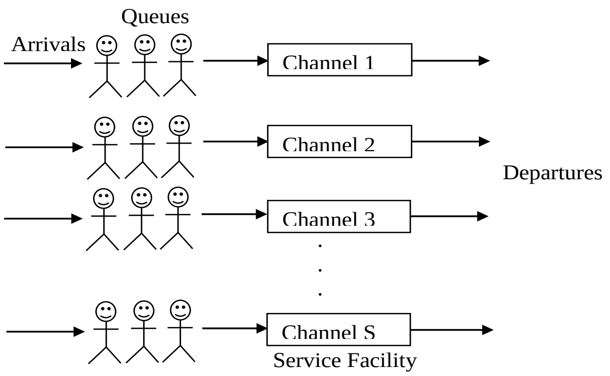

Fig. 1. Customer forming separate lines in front of each service.

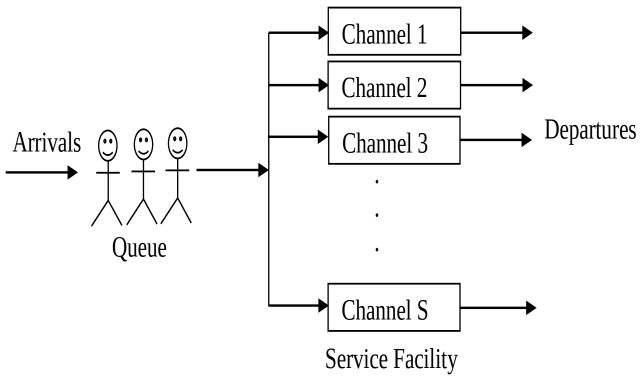

Fig. 2. Customer forming single line but separated into different lines inat the point of service.

Depending on the design of the system, customers may form separate lines in front of each service facility as in figure 1, (In this case, each service facility may be treated as M/M/1 model) or they may form a single line but separate into different lines at the point of service as in figure 2. This paper will focus on the later case which is the situation found in our case study (Diamond Bank Plc, Eziukwu, Aba).

II. MATHODOLOGY

Data used in this study were primary data collected from Diamond Bank Plc, Eziukwu Aba through direct observation and personal interview and questionnaire administered by the researchers. Data were collected for a period of 5weeks, one day per week for each days of the week. This is to account for busy days and non-busy days. The following assumptions were made while studying queue system at Diamond Bank Plc, Eziukwu Aba:

1. Arrivals follows Poisson distribution with mean arrival rate λ
2. Departures follows exponential distribution with mean service rate μ
3. Customers are served on First Come First Serve (FCFS) basis by any of the servers. There is no priority classification for any customer.
4. Waiting space is infinite. That is there is no limit to the number of the queue.
5. The service facility considered in this research were only the tellers
6. The tellers are utilized at full capacity
7. The tellers work at their normal pace. That is service rate is independent of queue length.

A. Formulation of Multichannel Single Queue (M/M/S) Model

In formulating M/M/S model, the following assumptions were made:

1. Arrivals follows Poisson distribution with mean arrival rate λ
2. Departures follows exponential distribution with mean service rate μ
3. Service discipline is First Come First Serve (FCFS) and customers are taken from a single queue. That is next customer in the queue will move to any teller that is free.
4. Mean arrival rate is greater than mean service rate
5. The mean arrival rate is not affected by the number of persons in the system.

B. Definition of Notation Used

n = number of customers in the system
P_n = probability of n customers in the system
S = number of parallel servers (S > 1)
λ = arrival rate of customers
μ = service rate of individual server.
$\lambda dt =$ Probability that a customer enters the system within time interval dt
$1 - \lambda dt =$ Probability that no customer enters the system within time interval dt plus higher order terms in dt
$\mu dt =$ Probability that a customer was served within time interval dt
$1 - \mu dt =$ Probability that no customer was served within time interval dt plus higher order terms in dt

In M/M/S model, when there are n customers in the system, the following two cases may occur:

1. $n < S$, there is no queue because all customers are being served as soon as they arrived. The service rate is given by:

$$\mu = n\mu \quad (1)$$

2. $n = S$, all servers will be busy and when$n > S$, there will be $(n - S)$ customers in the queue. Since all the servers are busy, the service rate is given by:

$$\mu = S\mu \quad (2)$$

Three cases to be considered in this system are:
i. When $n = 0$
ii. When $1 \le n \le S - 1$
iii. When $n \ge S$

The probabilities P_n of n customers in the system at time t, in each of these cases and hence values of other characteristics of multichannel queuing system are determined as follows:
In the first place we compute the probability of n customers in the system $P_n(t + dt)$ at time $t + dt$ with which we can use to compute the probability of n customers in the system $P_n(t)$ at time t. This can be done by summing up probabilities of all possible ways these cases can occur [4].

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Case I: When $n = 0$

This case can occur in two exclusive and exhaustive ways namely:

i. When there is no customer in the system at time t, and no customer arrived or was served at time dt so that at time $t + dt$ there is no customer in the system

ii. When there is one customer in the system at time t, and no customer arrived at time dt and one customer was served at time dt so that at time $t + dt$ there is no customer in the system

The difference equation of the system is derived as follows:

$$P_0(t+dt) = P_0(1 - \lambda dt) + P_1(1 - \lambda dt)(\mu dt)$$
$$= P_0 - P_0\lambda dt + P_1\mu dt - P_1\lambda\mu(dt)^2$$
$$= P_0 - P_0\lambda dt + P_1\mu dt \text{ (Since } (dt)^2 \to 0 \text{ as } dt \to 0)$$

Dividing both side by dt and taking the limit as $dt \to 0$

$$P_0' = P_1\mu - P_0\lambda \quad (3)$$

At steady state condition,

$$P_0' = 0 \quad (4)$$

Thus,

$$0 = P_1\mu - P_0\lambda \quad (5)$$

Therefore,

$$P_1 = P_0\frac{\lambda}{\mu} \quad (6)$$

Case II: When $1 \le n \le S - 1$

This case can occur in three exclusive and exhaustive ways namely:

i. When there are n customers in the system at time t, and no customer arrived or was served at time dt so that at time $t + dt$ there are n customers in the system

ii. When there are $n - 1$ customers in the system at time t, and 1 customer arrived at the system at time dt and no customer was served at time dt so that at time $t + dt$ there are n customers in the system

iii. When there are $n + 1$ customers in the system at time t, and no customer arrived at the system at time dt and 1 customer was served at time dt so that at time $t + dt$ there are n customers in the system

The difference equation of the system is derived as follows:

$$P_n(t+dt) = P_n(t)(1 - \lambda dt)(1 - n\mu dt)$$
$$+P_{n-1}(t)(\lambda dt)(1 - (n-1)\mu dt)$$
$$+P_{n+1}(t)(1 - \lambda dt)((n+1)\mu dt)$$
$$= P_n(t)(1 - (\lambda + n\mu)dt) + P_{n-1}(t)\lambda dt + P_{n+1}(t)(n+1)\mu dt$$

Dividing both side by dt and taking the limit as $dt \to 0$

$$P_n' = -P_n(t)(\lambda + n\mu) + P_{n-1}(t)\lambda + P_{n+1}(t)(n+1)\mu \quad (7)$$

At steady state condition,

$$P_n' = 0 \quad (8)$$

Thus,

$$0 = P_{n-1}\lambda - P_n(\lambda + n\mu) + P_{n+1}(n+1)\mu \quad (9)$$

Therefore,

$$P_{n+1} = \frac{-P_{n-1}\lambda + P_n(\lambda + n\mu)}{(n+1)\mu} \quad (10)$$

Putting $n = 1$ in (10) and recalling equation 4 above, we have

$$P_2 = \frac{1}{2!}\left(\frac{\lambda}{\mu}\right)^2 P_0 \quad (11)$$

Similarly, putting, $n = 2$, we have

$$P_3 = \frac{1}{3!}\left(\frac{\lambda}{\mu}\right)^3 P_0 \quad (12)$$

In general,

$$P_n = \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n P_0 \quad (13)$$

Case III: When $n \ge S$

Just as in case II, this case can occur in three exclusive and exhaustive ways and the difference equation of the system is derived as follows:

$$P_n(t+dt) = P_n(t)(1 - \lambda dt)(1 - n\mu dt)$$
$$+P_{n-1}(t)(\lambda dt)(1 - (n-1)\mu dt)$$
$$+P_{n+1}(t)(1 - \lambda dt)((n+1)\mu dt)$$
$$= P_n(t)(1 - (\lambda + n\mu)dt) + P_{n-1}(t)\lambda dt + P_{n+1}(t)(n+1)\mu dt$$

Dividing both side by dt and taking the limit as $dt \to 0$

$$P_n' = -P_n(t)(\lambda + n\mu) + P_{n-1}(t)\lambda + P_{n+1}(t)(n+1)\mu \quad (14)$$

At steady state condition

$$P_n' = 0 \quad (15)$$

Thus,

$$0 = P_{n-1}\lambda - P_n(\lambda + n\mu) + P_{n+1}(n+1)\mu \quad (16)$$

$$P_{n+1} = \frac{-P_{n-1}\lambda + P_n(\lambda + n\mu)}{(n+1)\mu} \quad (17)$$

Putting $n = S - 1$ in (17)

$$P_S = \frac{P_{S-1}(\lambda + (S-1)\mu) - P_{S-2}\lambda}{S\mu} \quad (18)$$

$$P_{S-1} = \frac{1}{(S-1)!}\left(\frac{\lambda}{\mu}\right)^{S-1} P_0 \quad (19)$$

$$P_{S-2} = \frac{1}{(S-2)!}\left(\frac{\lambda}{\mu}\right)^{S-2} P_0 \quad (20)$$

Substituting for P_{S-1} and P_{S-2} in (18) we have:

$$P_S = \frac{1}{S\mu}(\lambda + (S-1)\mu)\frac{1}{(S-1)!}\left(\frac{\lambda}{\mu}\right)^{S-1} P_0 - \frac{\lambda}{S\mu}\frac{1}{(S-2)!}\left(\frac{\lambda}{\mu}\right)^{S-2} P_0$$
$$= \frac{\lambda}{S\mu}\frac{1}{(S-1)!}\left(\frac{\lambda}{\mu}\right)^{S-1} P_0 + \frac{\mu}{S\mu}\frac{(S-1)}{(S-1)!}\left(\frac{\lambda}{\mu}\right)^{S-1} P_0 - \frac{\lambda}{S\mu}\frac{1}{(S-2)!}\left(\frac{\lambda}{\mu}\right)^{S-2} P_0$$
$$= \frac{\lambda}{S\mu}\frac{1}{(S-1)!}\left(\frac{\lambda}{\mu}\right)^{S-1} P_0 + \frac{\lambda}{S\mu}\frac{1}{(S-2)!}\left(\frac{\lambda}{\mu}\right)^{S-2} P_0 - \frac{\lambda}{S\mu}\frac{1}{(S-2)!}\left(\frac{\lambda}{\mu}\right)^{S-2} P_0$$

$$P_S = \frac{1}{S!}\left(\frac{\lambda}{\mu}\right)^S P_0 \quad (21)$$

Similarly, substituting $n = S + 1$ in equation 8 and simplifying we have:

$$P_{S+1} = \frac{\lambda}{S\mu}P_S = \frac{\lambda}{S\mu}\frac{1}{S!}\left(\frac{\lambda}{\mu}\right)^S P_0 = \frac{1}{S.S!}\left(\frac{\lambda}{\mu}\right)^{S+1} P_0 \quad (22)$$

$$P_{S+2} = \frac{1}{S^2.S!}\left(\frac{\lambda}{\mu}\right)^{S+2} P_0 \quad (23)$$

In general,

$$P_n = \frac{1}{S^{n-S}.S!}\left(\frac{\lambda}{\mu}\right)^n P_0 \quad (24)$$

Hence,

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$$P_n = \begin{cases} \frac{1}{S!}\left(\frac{\lambda}{\mu}\right)^S P_0, & 1 \le n \le S-1 \\ \frac{1}{S^{n-S}S!}\left(\frac{\lambda}{\mu}\right)^n P_0, & n \ge S \end{cases} \quad (25)$$

Next we compute P_0 in terms of λ, μ and S

Recall,

$$\sum_{n=0}^{\infty} P_n = 1 \quad (26)$$

$$\sum_{n=0}^{s-1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n P_0 + \sum_{n=s}^{\infty} \frac{1}{s^{n-s}s!}\left(\frac{\lambda}{\mu}\right)^n P_0 = 1 \quad (27)$$

$$P_0\left[\sum_{n=0}^{s-1} \frac{(\lambda/\mu)^n}{n!} + \sum_{n=s}^{\infty} \frac{s^s}{s^n s!}\left(\frac{\lambda}{\mu}\right)^n\right] = 1 \quad (28)$$

$$P_0\left[\sum_{n=0}^{s-1} \frac{(\lambda/\mu)^n}{n!} + \frac{s^s}{s!}\sum_{n=s}^{\infty}\left(\frac{\lambda}{s\mu}\right)^n\right] = 1 \quad (29)$$

$$P_0\left[\sum_{n=0}^{s-1} \frac{(\lambda/\mu)^n}{n!} + \left\{\begin{matrix} \left(\frac{\lambda}{s\mu}\right)^s + \left(\frac{\lambda}{s\mu}\right)^{s+1} \\ + \left(\frac{\lambda}{s\mu}\right)^{s+2} + \cdots + \infty \end{matrix}\right\}\right] = 1 \quad (30)$$

$$P_0\left[\begin{matrix} \sum_{n=0}^{s-1} \frac{(\lambda/\mu)^n}{n!} \\ + \frac{s^s}{s!}\cdot\left(\frac{\lambda}{s\mu}\right)^s\left\{1 + \frac{\lambda}{s\mu} + \left(\frac{\lambda}{s\mu}\right)^2 + \cdots + \infty\right\} \end{matrix}\right] = 1 \quad (31)$$

$$P_0\left[\sum_{n=0}^{s-1} \frac{(\lambda/\mu)^n}{n!} + \frac{(\lambda/\mu)^s}{s!}\cdot\left(\frac{1}{1-\lambda/s\mu}\right)\right] = 1 \quad (32)$$

$$P_0 = \left[\sum_{n=0}^{s-1} \frac{(\lambda/\mu)^n}{n!} + \frac{(\lambda/\mu)^s}{s!}\cdot\left(\frac{1}{1-\lambda/s\mu}\right)\right]^{-1} \quad (33)$$

C. M/M/S Operating Characteristics

The following operating characteristics will be used to analyze the data obtained.

1. Expected mean number of customers in the queue (L_q):

By definition,

$$E(x) = \sum_{i=1}^{\infty} x_i P_i \quad (34)$$

$$L_q = \sum_{n=S}^{\infty}(n-S)P_n = \sum_{n=S}^{\infty}(n-S)\frac{1}{S^{n-S}S!}\left(\frac{\lambda}{\mu}\right)^n P_0$$

$$= \left(\frac{\lambda}{\mu}\right)^S \sum_{n=S}^{\infty}(n-S)\frac{1}{S^{n-S}.S!}\left(\frac{\lambda}{\mu}\right)^{n-S} P_0 \quad (35)$$

Let $n - S = m$ (36)

Thus,

$$\left(\frac{\lambda}{\mu}\right)^S \sum_{n=S}^{\infty}(n-S)\frac{1}{S^{n-S}.S!}\left(\frac{\lambda}{\mu}\right)^{n-S} P_0$$

$$= \left(\frac{\lambda}{\mu}\right)^S \sum_{m=0}^{\infty} m\frac{1}{S^m S!}\left(\frac{\lambda}{\mu}\right)^m P_0$$

$$= \frac{\left(\frac{\lambda}{\mu}\right)^S P_0}{S!}\sum_{m=0}^{\infty} m\frac{1}{S^m}\left(\frac{\lambda}{\mu}\right)^m$$

$$= \frac{\left(\frac{\lambda}{\mu}\right)^S P_0}{S!}\left[0 + \frac{\lambda}{\mu}\frac{1}{S} + 2\left(\frac{\lambda}{\mu}\right)^2\frac{1}{S^2} + 3\left(\frac{\lambda}{\mu}\right)^3\frac{1}{S^3} + \cdots\right] \quad (37)$$

Therefore

$$L_q = \frac{\left(\frac{\lambda}{\mu}\right)^S P_0}{S!}\left[\frac{\frac{\lambda}{S\mu}}{\left(1-\frac{\lambda}{S\mu}\right)^2}\right] = \frac{1}{S!}\left(\frac{\lambda}{\mu}\right)^S P_0\left[\frac{S\mu\lambda}{(S\mu-\lambda)^2}\right]$$

$$= P_0\left[\frac{\lambda\mu\left(\frac{\lambda}{\mu}\right)^S}{(S-1)!(S\mu-\lambda)^2}\right] = P_0\left[\frac{\lambda\mu\left(\frac{\lambda}{\mu}\right)^S}{(S-1)!(S\mu-\lambda)^2}\right] \quad (38)$$

2. Expected (mean) number of customers in the system (L_s):

$$L_s = L_q + \frac{\lambda}{\mu} = P_0\left[\frac{\lambda\mu\left(\frac{\lambda}{\mu}\right)^S}{(S-1)!(S\mu-\lambda)^2}\right] + \frac{\lambda}{\mu} \quad (39)$$

3. Expected waiting time of customer in the system W_s:

$$W_s = \frac{L_s}{\lambda} = P_0\left[\frac{\mu\left(\frac{\lambda}{\mu}\right)^S}{(S-1)!(S\mu-\lambda)^2}\right] + \frac{1}{\mu} \quad (40)$$

4. Expected waiting time of customer in the queue W_q:

$$W_q = \frac{L_q}{\lambda} = P_0\left[\frac{\mu\left(\frac{\lambda}{\mu}\right)^S}{(S-1)!(S\mu-\lambda)^2}\right] \quad (41)$$

5. Probability that a customer has to wait:

$$P(n \ge S) = P_0\left[\frac{\mu\left(\frac{\lambda}{\mu}\right)^S}{(S-1)!(S\mu-\lambda)}\right] \quad (42)$$

6. Utilization factor

$$\rho = \frac{\lambda}{S\mu} \quad (43)$$

7. Number of Idle service channel

$$\bar{\rho} = S(1-\rho) \quad (44)$$

D. Queue Theory Cost Model

In deciding the optimal number of service facilities in the system, two opposing costs must be considered – service cost and waiting time cost. Economic analysis of these costs helps the management to make a trade – off between increase costs of providing better service and the decrease waiting time costs of customers derived from providing that service [3]. We define the total operating cost for multichannel queue with S service facilities as:

Total Operating Cost = Total Service Cost + Total Waiting Time Cost

That is:

$$C = TC_s + TC_w \quad (45)$$

Where,

TC_s = Total service Cost

TC_w = Total waiting time cost

C = Total Expected Operating Cost

Total service cost is a function of number of service facilities (tellers) in the system and service rate. Hence for S service facilities and service cost per unit of service facility C_s:

$$TC_s = S\mu C_s \quad (46)$$

Similarly, Total waiting time cost is a function of queue length. Hence for the queue length L_q and waiting time cost per unit time per customer C_w

$$TC_w = L_q C_w \quad (47)$$

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Thus from (46) and (47), (45) becomes

$$C = S\mu C_s + L_q C_w \quad (48)$$

The objective function is:

$$Min\ C = S\mu C_s + L_q C_w \quad (49)$$

And this will be minimized if

$$\frac{dc}{d\mu} = 0 \quad (50)$$

III. Data Presentation and Analysis

Table I shows the summary of data collected.

TABLE I. Summary of collected data.

Day	Date	Time	Arrival	Departure (Service)
Mon	`02-10-17	8.00am-12.00pm	1025	255
Tue	10-10-17	8.00am-12.00pm	725	212
Wed	18-10-17	8.00am-12.00pm	792	209
Thur	26-10-17	8.00am-12.00pm	972	225
Fr	03-11-17	8.00am-12.00pm	897	289
	Total		5193	1190

Source: Field Survey, 2017

From the data collected, the average arrival rate and service rate were calculated as in table II. Service cost was calculated based on the monthly salary of the tellers. To obtain the waiting cost, the depreciation cost per month of all the air conditioners and other furniture and fittings in the banking hall plus the monthly salary of the cleaners that clean the banking hall at regular interval were used. The for using these cost items was that they were considered to be cost incurred while making the banking hall conducive enough for customers to wait for a longer time without leaving.

TABLE II. Results obtained.

Arrival Rate Λ (Per hr)	260
Service Rate M (Per hr)	60
Service Cost C_s (₦/Per hr)	45.46
Waiting Cost C_w (₦/Per hr)	40166.7

Table III shows the results of operating characteristics of multichannel queuing model obtained from data collected at Diamond Bank Plc Eziukwu Aba.

Fig. 3 is the graph of expected costs associated with queue versus service level.

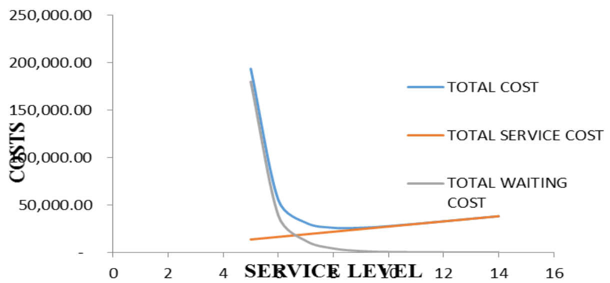

Fig. 3. Associated costs against service level.

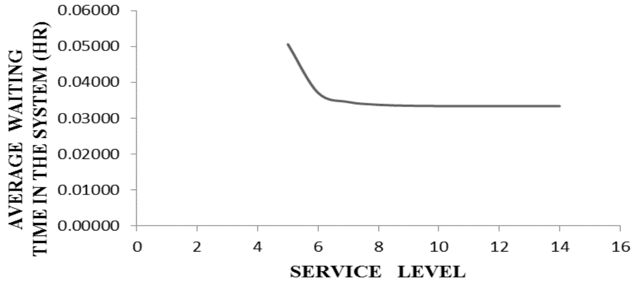

Fig. 4. Expected waiting time against service level.

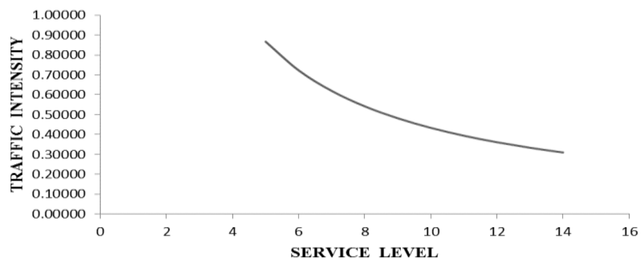

Fig. 5. Traffic intensity against service level.

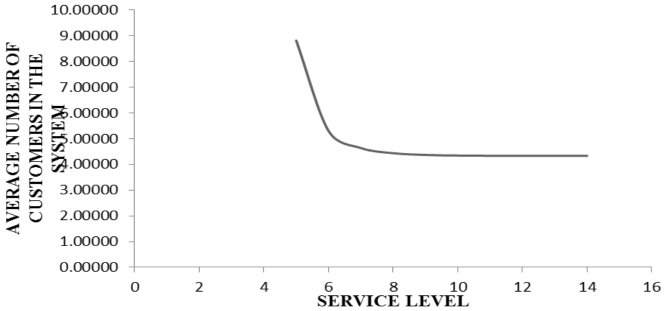

Fig. 6. Average number customer in the system against service level.

IV. Discussion of Result

The results obtained from the model as shown in table III and figure 3 shows that at service level of 5 tellers (current service level at which the bank operates) approximately 1teller is idle at any given time, and tellers are 87% utilized but with high total expected operating cost of ₦193,691.12. Though service level of 9 tellers have lowest total expected operating cost of ₦25,940.66 and utilization factor is 48%, it may not be considered as the optimal service level since it gives approximately 5 idle tellers at any given time. In between service level of 6tellers and service level of 7tellers, the service costs and waiting costs are expected to be equal. Therefore, service level of 7tellers is considered best service level considering the facts that it has approximately 3 idle tellers, utilization factor of 62% and total expected operating cost of ₦31, 306.28.

It is also observed that total expected operating cost started increasing again after service level of 9 tellers. Also total service cost increases as the service level increases while total waiting cost decreases with increase in service level.

TABLE III. Results of operating characteristics of multichannel queue model.

Number of Service Tellers S	5	6	7	8	9	10	11	12	13	14
Traffic Intensity ρ	0.86667	0.72222	0.61905	0.54167	0.48148	0.43333	0.39394	0.36111	0.33333	0.30952
Number of Idle Tellers $\bar{\rho}$	0.66667	1.66667	2.66667	3.66667	4.66667	5.66667	6.66667	7.66667	8.66667	9.66667
Probability (% of time) System Is Empty P_0	0.00722	0.01126	0.01252	0.01293	0.01306	0.01311	0.01312	0.01312	0.01312	0.01312
Average Number of Customer In The Queue L_q	4.48269	0.96915	0.30412	0.10283	0.03474	0.01138	0.00357	0.00106	0.00030	0.00008
Average Number of Customer In The System L_s	8.81602	5.30249	4.63745	4.43616	4.36807	4.34471	4.33690	4.33440	4.33363	4.33341
Average Waiting Time In The Queue W_q	0.01724	0.00373	0.00117	0.00040	0.00013	0.00004	0.00001	0.00000	0.00000	0.00000
Average Waiting Time In The System W_s	0.05057	0.03706	0.03450	0.03373	0.03347	0.03338	0.03335	0.03334	0.03333	0.03333
Total Expected Operating Cost C (₦)	193,691.12	55,291.28	31,306.28	25,948.36	25,940.66	27,729.77	30,143.23	32,769.95	35,466.61	38,185.05
Total Service Cost TC_S (₦)	13,636.36	16,363.64	19,090.91	21,818.18	24,545.45	27,272.73	30,000.00	32,727.27	35,454.55	38,181.82
Total Waiting Cost TC_w (₦)	180,054.76	38,927.64	12,215.37	4,130.18	1,395.21	457.05	143.23	42.68	12.06	3.23

V. CONCLUSION

Banking in the recent time is increasingly competing not only in cost, but also in customer satisfaction. Bank operation managers have the problem of maximizing the customer satisfaction and at the same time minimizing the cost of providing the service.

This paper used the queue theory based approach to optimize banking services. To determine the optimal service level, the operating characteristics at Diamond Bank Plc Eziukwu, Aba were calculated using M/M/S model. Also, service costs and waiting costs were calculated with a view to establish the optimal service level at the bank. From the results obtained, in between service levels of 6tellers and 7tellers, the service cost is expected to be equal to waiting cost. Thus to deal with the trade-off between the service cost and the waiting cost, the operations manager at the bank may have to consider using the service level of 7tellers instead of 5tellers currently in use in the bank, since the service level of 5tellers has high operating cost and the waiting time in the system reduces as the service level increases.

It can also be seen that the waiting time in the system averaging two minutes at this service level is in line with the bank's policy of turnaround time of five minutes.

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