Queuing Modeling for Comparative Study of Banking System on Commercial Bank of Ethiopia Tona Branch and Dashen Bank: the Case of Wolaita Zone, Ethiopia

Bereket Tessema Zewude

Wolaita Sodo University, College of Natural and Computational Sciences, Department of Statistics, Wolaita Sodo, Ethiopia

Abstract

In order to deliver service in quality specially in banking system the queuing model was appropriate in order to suggest waiting time, service rate and etc for efficient service delivery of better implementation of banking system. Comparative study of two selected banks (Commercial Bank of Ethiopia & Dashen Bank) in Wolaita zone of Ethiopia was investigated. The queuing model was employed for both banking system in order to measure the behavioral queuing characteristics of customers in terms of their arrival and service rate respectively. The data for the arrival and service rate of the two banks were collected by observation methods for two days of a week simultaneously. The result revealed that on average 10.2 and 8.6 customers arrive and served per hours, respectively in Commercial Bank of Ethiopia Tona branch. The average waiting time in queue and in system was 0.0001 minutes and 0.43 minutes, respectively in Commercial Bank of Ethiopia Tona branch. When comparing to Dashen Bank, on average 7.125 and 6.125 customers per hour arrive and served, respectively. Regarding the average waiting time in queue and in system was 0.216 minutes and 0.828 minutes, respectively in Dashen Bank. Findings indicated that Dashen Bank has a more waiting service time value which may have a negative significant effect on customers on waiting line compared to Commercial Bank of Ethiopia Tona branch; we realize Commercial Bank of Ethiopia Tona branch has an advantageous effect of service time value which will have a positive significant effect on customers in experiencing little or no queue at all. Also Dashen bank has the highest waiting probability service when compared with Commercial Bank of Ethiopia Tona branch this result may clearly suggests that for optimum efficiency in the banks, there is need to increase the number of servers since increasing servers will reduce the waiting lines of customers. The analysis of this study may suggest reviewing for better efficiency and performance of banking system in general.

Keywords: Arrival rate, Banking system, Customer, Commercial Bank of Ethiopia, Dashen Bank, Ethiopia, Queuing Model, Waiting service time, Wolaita zone

Introduction

Queues (or waiting lines) are general phenomenon in everyday life of human endeavor. Queues are usually seen at post offices, bus stops, hospitals, bank counters, gas stations etc. Queues are formed when customers (human or object) demanding service have to wait because their number exceeds the number of servers available; or the facility does not work efficiently or takes more than the time prescribed to service a customer done by Kasum et al (2006) . Some customers wait when the total number of customers requiring service exceeds the number of service facilities, some service facilities stand idle when the total number of service facilities exceeds the number of customers requiring service.

Pei-Chun *et al*., (2006) defines queue as simply a waiting line, while Tian *et al*., (2011) put it in similar way as a waiting line by two important elements: the population source of customer from which they can draw and the service system. The population of customer could be finite or infinite. The banking sector which is the largest and most competitive unit of Ethiopian's financial sector, acting as a financial intermediary between the surplus and deficit agents of the economy has always been the center of attraction to many customers that want to carry out one transaction or the other through the services provided by these banks. However, the major problem is the inability of the banks to match their service facilities to the needs of customers without much delay. The common experience in Ethiopian bank is that most banks do not have fulfilled facilities and capacities to service the number of customers without much delay on the part of the customers. The problem in this regard had been that though bank customers for instance, have always been desirous of spending the least possible time in banking transactions, this age-long desire is yet to be met by the banks. Banks on the other hand, want to attract, retain customers and at the same time optimize profit.

Challenges encountered by most public as well as private business organization are the problem of waiting lines. It is so serious that most customers complained of lack of special treatment and care by the management of the organization. There is need to give customers a special care during service delivery because when a particular customer is satisfied to a certain level, all available customers are attracted to the organization, this brings about the expected high profit. Kasum *et al.,* (2006) conducted research in Nigeria banks in queue efficiency of comparative analysis of old and new generation banks. Their findings indicated that time spent on

Research Journal of Finance and Accounting
www.iiste.org
ISSN 2222-1697 (Paper) ISSN 2222-2847 (Online)
Vol.7, No.21, 2016

queue for services in old generation bank are in aggregate longer than in the new generation bank. Similarly, their findings showed that new generation banks are more efficient in timely service delivery than the old generation banks.

Pei-Chun *et al.,* (2006) finding suggested that some bank should add more ATMs to reduce customer waiting time. Tian *et al.,* (2011) examined the queuing system of bank based on business process re engineering. They evaluated the bottleneck problems of bank queuing as well as the concept, classification and methodologies of business process re engineering. They used simulation method to analyze the number of open servers of the bank system. Their findings showed that if the bank use simulating method to determine the number of open servers by referring to dynamic statistics; it will improve much in flexibility and make full use of the current resources.

Toshiba *et al.,* (2013) finding showed that the efficiency of commercial banks is improved by the queuing number, the service stations number, and the optimal service rate. Therefore, conducting such research in banking system of Ethiopia context may suggest effective and practical, and increasing customer satisfaction with relation to profit maximization in line with realizing the objective of measuring the behavioral queuing characteristics of customers in terms of their arrival and service rate, respectively in banking system.

Methodology
Description of study area
The study was carried out in some selected branches of Commercial Bank of Ethiopia and Dashen Bank of Wolaita Sodo branch of Ethiopia. Commercial Bank of Ethiopia comprises more than five branches in Wolaita Sodo area and Dashen Bank consist one branch in the town. Wolaita Sodo town found in temperate region of South Nation Nationalities and Peoples (SNNP) regional state in Wolaita zone capital town of Sodo. Sodo town is located (54^0N latitude and 380^0 S longitude) and 396km south of Addis Ababa and 130km from regional town Hawassa. Wolaita Sodo town was center for economic activities as well as financial sector by junctioning more than five road corders in the regional state.

Study Design
The research design was qualitative as well as quantitative research design can be employed.

Source of population
All customers admitted in banks of two days follow up simultaneously were considered as population.

Method of Data Analysis
For study purpose the analysis employed here is Multi Server Queuing Model that is (M/M/X): (∞/FCFS). This is the extensional form of single server model where customer in a waiting line can be served by more than one server simultaneously. There are n numbers of customers in the queuing system at any point in time. If $n < X$, (number of customers in the system is less than the number of servers), then there will be no queue. However, $X - n$ number of servers will not be busy. If $n \geq X$ (number of customers in the system is more than or equal to the number of servers) then all servers will be busy and the maximum number of customers in the queue will be $n - X$. The combined service rate will be $n\mu = X\mu$; $if\ n \geq X$.

Assumptions in queuing theory:
- Poisson arrival rate of λ customers per unit of time.
- Exponential service times of μ customer per unit of time.
- Queue discipline is first come first served basis by any of the server.
- The waiting line has two or more identical servers.
- There is no limit to the number of the queue (infinite).
- The average arrival rate is greater than average service rate.

Following are the properties of the Multi-Server Queuing Model: Utilization factors i.e. the fraction of time servers are given by:

$$\rho_X = \frac{\lambda}{X\mu}$$ ………………………………………… (1)

The probability of having n customers in the system is given by:

$$P_0 = \left[\sum_{n=0}^{X-1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n + \frac{1}{X!}\left(\frac{\lambda}{\mu}\right)^X \frac{X\mu}{X\mu-\lambda}\right]^{-1}$$ ………… (2)

$$P_n = \begin{cases} \left(\frac{\rho^n}{n!}\right)P_0, & if\ n \leq X \\ \frac{\rho^n}{(X!X^{n-X})P_0}, & if\ n > X \end{cases}$$ ……………….. (3)

When $n \geq X$, it is that the number of customers in the system is not smaller than the number of servers, the next customers must wait, that is,

$$C(X, \rho) = \sum_{n=X}^{\infty} P_n = \frac{\rho^X}{X!(1-\rho_X)} P_0 \quad \text{...............} \quad (4)$$

Expected number of customers waiting on the queue is given by:

$$L_q = \left[\frac{1}{(X-1)!} \left(\frac{\lambda}{\mu}\right)^X \frac{\mu\lambda}{(X\mu-\lambda)^2} \right] P_0 \quad \text{...................} \quad (5)$$

Expected number of customers in the system is given by:

$$L_s = L_q + \frac{\lambda}{\mu} \quad \text{.......................................} \quad (6)$$

Expecting waiting time of customers in the queue is given by:

$$W_q = \frac{L_q}{\lambda} \quad \text{..} \quad (7)$$

Expecting waiting time of customers in the system is given by:

$$W_s = \frac{L_s}{\lambda} \quad \text{...} \quad (8)$$

Data Analysis

Presented in table 1 shows the arrival and service rate for the two banks collected simultaneously for two days as the same time range.

Table 1: Commercial Bank of Ethiopia (Tona Branch) arrival and service rate

Arrival rate	Service rate
85	70
78	67

Source: Own computation

Overall arrival rate of the Commercial Bank of Ethiopia (Tona Branch) bank system is:

$\lambda_t = \lambda = \lambda_1 + \lambda_2$

$\lambda = 85 + 78$

$\lambda = 163$ is the overall arrival rate of customers in Commercial Bank of Ethiopia Tona branch for two days simultaneously observed.

Overall service rate of the Commercial Bank of Ethiopia (Tona Branch) bank system is:

$\mu_t = \mu = \mu_1 + \mu_2$

$\mu = 70 + 67 = 137$ is the overall service rate of customers in Commercial Bank of Ethiopia Tona branch for two days simultaneously observed.

Table 2: Dashen Bank arrival and service rate

Arrival rate	Service rate
63	56
51	42

Source: Own computation

Overall arrival rate of Dashen bank system is:

$\lambda_t = \lambda = \lambda_1 + \lambda_2$

$\lambda = 63 + 51$

$\lambda = 114$ is the overall arrival rate of customers in Dashen Bank for two days simultaneously observed.

Overall service rate of Dashen bank system is:

$\mu_t = \mu = \mu_1 + \mu_2$

$\mu = 56 + 42$

$\mu = 98$ is the overall service rate of customers in Dashen Bank for two days simultaneously observed.

The numbers of server (X) for the two banks are not the same. For Commercial Bank of Ethiopia (Tona Branch), the number of servers is 6, while for Dashen bank; the number of servers is 4. Estimating Queuing Parameters for Commercial Bank of Ethiopia (Tona Branch) assuming that 6 waiting lines for the customer in the bank. From the above result we observe that there is difference in arrival and service rate for Commercial Bank of Ethiopia Tona branch and Dashen Bank, respectively. For further analysis of waiting time and system of two banks for customers were presented as follows.

When there is a line let be: $X = 6, \lambda = 163, \mu = 137, \rho = \frac{\lambda}{\mu} = \frac{163}{137} = 1.19, \quad X = 0,1,2,3,4,5$

$$P_0 = \left[\sum_{n=0}^{X-1} \frac{1}{n!} \left(\frac{\lambda}{\mu} \right)^n + \frac{1}{X!} \left(\frac{\lambda}{\mu} \right)^X \frac{X\mu}{X\mu - \lambda} \right]^{-1}$$

where: $\sum_{n=0}^{5} \frac{1}{n!} \left(\frac{\lambda}{\mu} \right)^n = \frac{1}{0!} \left(\frac{163}{137} \right)^0 + \frac{1}{1!} \left(\frac{163}{137} \right)^1 + \cdots + \frac{1}{5!} \left(\frac{163}{137} \right)^5 = 3.28$

$$P_0 = \left[\sum_{n=0}^{X-1} \frac{1}{n!} \left(\frac{\lambda}{\mu} \right)^n + \frac{1}{X!} \left(\frac{\lambda}{\mu} \right)^X \frac{X\mu}{X\mu - \lambda} \right]^{-1}$$

$$P_0 = \left[3.28 + \frac{1}{6!} \left(\frac{163}{137} \right)^6 \frac{6 \times 137}{6 \times 137 - 163} \right]^{-1}$$

$$P_0 = [3.28]^{-1}$$

$$P_0 = 0.30$$

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

$$L_q = \left[\frac{1}{5!} \left(\frac{163}{137} \right)^6 \frac{137 \times 163}{(6 \times 137 - 163)^2} \right] \times 0.30$$

$$L_q = 0.00037$$

$$L_s = L_q + \frac{\lambda}{\mu}$$

$$L_s = 0.0037 + \frac{163}{137}$$

$$L_s = 1.190$$

$$W_q = \frac{L_q}{\lambda}$$

$$W_q = \frac{0.00037}{163}$$

$$W_q = 0.0000023$$

$$W_s = \frac{L_s}{\lambda}$$

$$W_s = \frac{1.190}{163} = 0.0073$$

When there are two lines, $X = 2$, $\frac{\lambda}{2} = \frac{163}{2} = 81.5$, $\mu = 137$, $\rho = \frac{\frac{\lambda}{2}}{137} = \frac{81.5}{137} = 0.5949$.

L_s, L_q, W_s and W_q are given respectively.

$$L_s = \frac{\rho}{1-\rho} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(9)$$

$$L_q = \frac{\rho^2}{1-\rho} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(10)$$

$$W_s = \frac{1}{\mu - \lambda} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (11)$$

$$W_q = \frac{\rho}{\mu - \lambda} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (12)$$

Employing the above formula of equation (8) to equation (11), we can compute for lines $2,3,4,5$ and 6, respectively. i.e $X = 2,3,4,5,6$. Then the computation as follows:

For : $X = 2$, $L_s = 1.47$, $L_q = 0.87$, $W_s = 0.018$, $W_q = 0.0107$

$X = 3$, $L_s = 1.519$, $L_q = 0.63$, $W_s = 0.0121$, $W_q = 0.0048$

$X = 4$, $L_s = 0.4232$, $L_q = 0.603$, $W_s = 0.0104$, $W_q = 0.0031$

$X = 5$, $L_s = 0.3123$, $L_q = 0.743$, $W_s = 0.0096$, $W_q = 0.0023$

$X = 6$, $L_s = 0.2473$, $L_q = 0.0490$, $W_s = 0.0091$, $W_q = 0.0018$

Table 3. Summary of the queuing parameter characteristics of Commercial Bank of Ethiopia (Tona Branch).

Waiting line (X) or server	λ	μ	ρ	L_s	L_q	W_s	W_q
1	163	137	1.1898	1.1900	0.00037	0.0073	0.0000023
2	81.5	137	0.5949	1.4700	0.8700	0.0180	0.0107
3	54.3	137	0.3964	1.5190	0.6300	0.0121	0.0048
4	40.8	137	0.2978	0.4232	0.6030	0.0104	0.0031
5	32.6	137	0.2379	0.3123	0.7430	0.0096	0.0023
6	27.2	137	0.1985	0.2473	0.0490	0.00091	0.0018

Probability that an arriving customer or customers will have to wait for service at the bank is given by the formula:

$$P_w = \left(\frac{\lambda}{\mu}\right)^X \frac{P_0}{X!\left(1-\frac{\lambda}{X\mu}\right)} \dots\dots\dots\dots\dots\dots\dots\dots (13)$$

$$P_w = \left(\frac{163}{137}\right)^6 \frac{(0.30)}{6!\left(1-\frac{163}{6 \times 137}\right)}$$

$P_w = 0.00095$ or 0.095%

From table 3, the result indicates that increasing the number of server will reduce the waiting time which is evidenced from waiting time of customers in the system shows decreasing pattern when number of servers increased. We suggest that the preferable queue model for Commercial Bank of Ethiopia Tona Branch is M/M/6 model and the probability that an arriving customer have to wait for service is also 0.00095 or 0.095%.

In the same fashion we can compute queuing parameters of the Dashen bank when the number of servers is 4.

$P_0 = 9.2937$, $L_q = 0.4100$, $L_s = 1.5733$, $W_s = 0.0138$, $W_q = 0.0036$

When there are two lines, $X = 2$, $\frac{\lambda}{2} = \frac{114}{2} = 57$, $\mu = 98$, $\rho = \frac{\frac{\lambda}{2}}{98} = \frac{57}{98} = 0.5816$.

L_s , L_q , W_s and W_q are computed respectively.

For $X = 2$, $L_s = 1.3900$, $L_q = 0.8084$, $W_s = 0.0244$, $W_q = 0.0142$

$X = 3$, $L_s = 0.6334$, $L_q = 0.2457$, $W_s = 0.0167$, $W_q = 0.0065$

$X = 4$, $L_s = 0.4100$, $L_q = 0.1192$, $W_s = 0.0144$, $W_q = 0.0042$

Table 4. The queuing system characteristics (parameters) of Dashen Bank

Waiting line (X) or server	λ	μ	ρ	L_s	L_q	W_s	W_q
1	114	98	1.1633	0.4100	1.5733	0.0138	0.0036
2	57	98	0.5816	1.4700	0.8700	0.0180	0.0107
3	38	98	0.3878	0.6334	0.2457	0.0167	0.0065
4	28.5	98	0.2908	0.4100	0.1192	0.0144	0.0042

Source: Own computation

Probability that an arriving customer or customers will have to wait for service at the bank is given by the formula and substituting the results in the given formula, we obtained the result for Dashen bank is given by:

$$P_w = \left(\frac{\lambda}{\mu}\right)^X \frac{P_0}{X!\left(1-\frac{\lambda}{X\mu}\right)} = 0.0999 \text{ or } 9.99\%$$

From Table 4, the result reveal that for using multi-server or four servers, the waiting time of customers was preferable model than that of the one server model. Also probability that an arriving customer have to wait for service is also 0.0999 or 9.99% and suggesting that to use M/M/4 Models.

Results and Discussion

The result revealed that on average 10.2 and 8.6 customers arrive and served per hours, respectively in Commercial Bank of Ethiopia Tona branch. The average waiting time in queue and in system was 0.0001 minutes and 0.43 minutes, respectively in Commercial Bank of Ethiopia. When comparing to Dashen Bank, on average 7.125 and 6.125 customers per hour arrive and served, respectively. The average waiting time in queue and in system was 0.216 minutes and 0.828 minutes, respectively in Dashen Bank. From this result we deduce that there is longer waiting time in queue and in system in Dashen Bank as compared to Commercial Bank of Ethiopia Tona branch this may be the influence of having the number of servers.

The comparative analysis of the two banks under review differs significantly with respect to the queuing theory. The result of the respective banks shows that waiting lines is highly reduced if the number of

servers is drastically increased so as to satisfy customers at an optimum advantage. Based on the number of servers of the two banks, when an arriving customer will have to wait until he or she is attended to, Dashen bank has the highest waiting probability service value (9.99%) when compared with Commercial Bank of Ethiopia Tona branch value (0.095%). This value indicates that for optimum efficiency in the bank, there is need to increase the service station. This gave Commercial Bank of Ethiopia Tona branch has a practical advantage over Dashen bank that no queue exists in their banking system. That is, the probability that a customer will have to wait is very infinitesimal when compared with Dashen bank. This can also be seen in the parameters of the queuing theory under consideration that the expected number or waiting time of customers on the queue or in the banking system reduces irrespective of the waiting lines. The higher the number of servers, the lesser the waiting lines, the lower the number of servers, the more the waiting lines. This is the practical cause of the two banks in this research study for comparison purpose.

Conclusion

The queuing number or waiting line, the number of servers, and the optimal probability service as investigated by means of queuing theory are the three measures that improve the efficiency of selected banks for study purpose. The analysis in this study as carried out by the two banks is effective and practical. It was also investigated that the optimal queuing model is feasible in general**.**

Recommendations

➢ To satisfy customers, increasing number of servers must since it reduces the waiting time which has a significant effect on profit.

➢ To increase customer satisfaction other alternatives should be needed like ATM, mobile banking, etc in order to reduce the waiting time.

REFERENCES

Kasum, A. S., Abdulraheem, A., & Olaniyi, T.A., (2006): "Queue Efficiency in Nigeria Banks: A Comparative Analysis of Old and New Generation Banks". *Ilorin Journal of Sociology*, Vol.2, No.1, pp 162-172. ISSN II7-9448I.

Pei-Chun, L., & Ann, S.Y., (2006): "Service efficiency evaluation of automatic teller machines- a study of Taiwan financial institutions with the application of queuing theory". *Journal of Statistics and Management Systems,* Vol.9, No.3, pp 555-570.

Tian, H., & Tong, Y., (2011): "Study on Queuing System Optimization of Bank Based on BPR". 3rd *International Conference on Environmental Science and Information application Technology (ESIAT),* pp 640-649.

Toshiba, S., Sanjay, S., & Anil, K.K., (2013): "Application of Queuing Theory for the Improvement of Bank Service". *International Journal of Advanced Computational Engineering and Networking*, Vol. 1, issue 4, pp 15-18. ISSN 2320-2106.