# Modeling and Analysis of Queuing Systems in Banks: (A Case Study of Banque Commerciale du Congo-BCDC/Mbujimayi)

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# Modeling and Analysis of Queuing Systems in Banks: (A Case Study of Banque Commerciale du Congo-BCDC/Mbujimayi)

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**ABSTRACT**

This study examined the application of queue theory in the banking system in Democratic Republic of Congo, with particular reference to BCDC (Banque Commerciale du Congo)/Mbujimayi. The queuing characteristics of the bank were analyzed using a Multi-Server Queuing Model.
The obvious implication of customers waiting in long and winding queues could result to prolonged discomfort and economic cost to them; however increasing the service rate will require additional number of tellers which implies extra cost to management. Data for this study was collected at BCDC bank for one week through observations and was formulated as multi-server single line queuing model. The data was analyzed using TORA optimization Software as recommended software for operational research. The performance measures of different queuing systems were evaluated and analyzed. The results of the analysis showed using a six-teller system was better than a five in terms of average waiting time.

**KEYWORDS:** Queue theory, Banking System, Multi-Server Queuing Model, Economic cost, Service rate.

## 1. INTRODUCTION

### a. Study context

Current globalization is characterized by intense and growing competition that does not exclude the banking industry. Managers continue to face tough challenges to the survival of their businesses.

As commercial banks are a major component of the financial system, an intermediary between the surplus and deficit sectors of the economy, they are still the center of attraction of many customers who want to carry out one or the other transaction through the services provided by them.

Banks in the city of Mbujimayi are generally characterized by congestion; this often leads to a low level of customer satisfaction and encourages customer movements from one bank to another, in search of the services provided without much delay.

According to (CHRISTOPHER M & D., 1997), the survival of organizations depends on their ability to get closer to their clients and to understand the needs and desires of the client. For a business to succeed, it must focus on meeting the needs of customers by organizing itself to respond to them and target customers more effectively.

For many years, the subject of customer satisfaction has been on the agenda of many organizations, so satisfaction has become a crucial element and a concern for customers and organizations. Banks are among the organizations for which customer satisfaction is the key factor for success and a major source of competitiveness.

Contact systems should take a close look at the theory and psychology of queues to take advantage of client participation to avoid the negative effects of delays and other psychological factors on the quality of service. A key determinant of customer satisfaction is ease of access, which includes the location of the service facility, its hours of operation, and its minimum wait time to receive service.

Waiting times are the main source of dissatisfaction. Indeed, since the customer enters a system to receive a service, and leaves the premises after being served, it is important to address the problem of queues.

The lack of professional resources can be the cause or the source of dissatisfaction felt by the customers; this feeling gives them the impression of being poorly served and creates a feeling of discomfort or even insecurity at home, which can harm the quality of the service.

To help decision-makers make optimal decisions, mathematical models are applied to find a solution to organizational problems and to optimize economic techniques.

The queuing theory is thus among those mathematical models that analyze and deal with the organizational difficulties faced by organizations with files to manage and organize.

### b. Objectives of the research

More specifically, the objectives of this study are:

- ✓ Build a clear idea about the use of one of the quantitative methods of operational research that is the theory of queues, in support of managers to make their decisions.
- ✓ Identify the need for commercial banks in the DRC in general, and commercial banks in Mbujimayi in particular, to use queuing theory in organizing the queues of their wickets;
- ✓ Apply empirically the model of multi-channel queues with exponential Poisson arrivals and service times (M / M / S), in the context of the Mbujimayi banks.

## 2. EMPIRICAL LITERATURE

(GRACE, 2012), basing his research on: "Waiting lines management and customer satisfaction in Banks in Kenya".

The main objective of this research was to determine the extent to which queue management affected client satisfaction in Kenya banks.

To achieve the main objective, the study determined the effect of queue management on customer satisfaction, how commercial banks manage the queues and the challenges they face in queue management. The search consisted of a census of all 43 commercial banks registered in Kenya.

The study concludes that the majority of commercial banks in Kenya are not satisfied with queuing management. The main ones are the cases where the customers are dissatisfied, it is the perceived expectation. In addition, bank customers are satisfied with the information provided in the waiting room and the waiting environment within the bank. Clients are not satisfied with management measures such as the use of physical barriers, automated queuing systems, online banking, Internet banking, mobile banking and agencies banking.

(FARAYIBI, 2016), is conducting his study under the theme: "Investigating the Application of Queue Theory in the Nigerian Banking System".

The author examined the application of queuing theory in the Nigerian banking system, with particular reference to GTBank and the Ecobank Idumota branch in Lagos, Lagos State.

Queued bank characteristics were analyzed using a multiserver model. The analysis of performance measures, including bank standby and operating costs, was done to determine the optimal level of service.

At the end of its analyzes, the results revealed that traffic intensity was higher in GTBank with P = 0.98 than in Ecobank with P = 0.78. In addition, the potential use showed that Ecobank was well below efficiency compared to GTBank. Looking at the waiting time of online customers and the time spent in the system, that is (Wq + W), he discovered that Ecobank's customers spent more time before being served both in the queue and in the system as those of the bank GTBank.

The study concluded by highlighting the relevance of the queue theory for the efficient delivery of banking sector services in Nigeria.

(YUSUF, BLESSING, & KAZEEM, 2015), base their studies on: "Queuing Theory and Customer Satisfaction: A Review of Performance, Trends and Application in Banking Practice (A Study of First Plc Gwagwalada, Abuja Branch)".

The main objective of this study is to examine how queue theory has been used to provide satisfactory service to customers.

The study revealed that most bank customers are not satisfied with the queue they are experiencing and that the study advocated the effective and efficient application of the queue theory, this can be particularly advantageous for banks with high exchange rates.

## 3. METHODOLOGICAL FRAMEWORK

### 1. Description of the queuing theory

Kendall's notation makes it possible to summarily designate a waiting girl system: A / S / P / K / D, its terms are as follows (F.A, 2014):

A: the law of inter-arrivals or the arrival process.

S: the law of service.

P: the number of servers.

K: the capacity of the system that is the room.

D: the discipline or service policy, that is, how and in what order clients are served.

Waiting discipline is the priority rule determining the order in which clients will access the resource modeled by the server. The standard waiting disciplines, as well as their acronyms, are:

FIFO: first in first out "first come, first served" is the service discipline used most often and it will be accepted by default.

So the characteristics of the queuing theory are:

- The average customer arrival rate ($\lambda$) follows the Poisson distribution.
- The average service rate ($\mu$) follows the exponential distribution.
- $\lambda < \mu$.
- Service discipline is based on FCFS (first come first served).

Since it is necessary to define the parameters of the queuing theory:

- n: represents the number of individuals in the system (in the queue and in the service)
- P represents the probability of n individuals in the system (BOUGUERRA, 2007).

## 4. METHOD OF DATA COLLECTION

Basically, the data used for this study were obtained from primary sources. The method of data collection is through direct observation. A wrist watch, a pen and a notepad were requirements needed for the recording of relevant information such as; number of customers the arrival times of customers, waiting time, and service time. The observation was made during the working hours (8am – 4pm). The recorded information was used to calculate average waiting time, average service time and the utilization factor.

## 5. METHOD OF ANALYSIS

The method of analysis for this study is the multi-server queuing modeling system which follows (M/M/K): ($\infty$/FCFS) specification. In the case, the performance measure analysis including, the arrival time, waiting time service time, priority level, for average customers and the number of servers available were computed using the appropriate tools. Secondly, the graphical representation of the generated performance measure values was done.

1. **Queuing model notation**:

$\lambda$ : Mean arrival rate

$\mu$ : Mean service rate

$k$ : Number of service channels

$n$ : Number of customers

$Ls$ : Average number of customers in the system (waiting or being served)

$Lq$ : Average number of customers waiting in the queue

$Ws$ : Average time customers spend in the system

$Wq$ : Average time customers wait in the queue

$\rho$ : System utilization

$P0$: The probability that there are zero customers in the system

$Pw$:The probability that a customer has to wait

$Pn$: The probability that there are n customers in the system

2. **Multiple-Server Queuing Model with Poisson Arrivals and Exponential Service Times (M/M/k)**

The model adopted in this paper is multiple channel queuing system, in which two or more servers or channels are available to handle arriving customers. Let still assume that customers waiting service form one single line and then proceed to the first available server. For this queuing system, it is assumed that the arrivals follow a Poisson probability distribution with rate λ. Each of these channels has an independent and identical exponential time distribution with mean $\frac{1}{\mu}$.

Equations for Multi-channel queuing Model:

Utilization factor

$$p = \frac{\lambda}{k\mu} \quad (1)$$

The probability that there are zero customers in the system:

$$Po = \left[\sum_{n=0}^{k-1} \frac{1}{n}\left(\frac{\lambda}{n!}\right)^{k} + \frac{1}{n}\left(\frac{\lambda}{\mu}\right)^{k} \frac{k\mu}{k\mu - \lambda}\right]^{-1} \quad (2)$$

The probability that there are n number of customers in the system:

$$Pn = \begin{cases} \left(\frac{P^{n}}{n!}\right) Po, if\ n < k \\ \left(\frac{P^{n}}{k!k^{n-k}}\right) Po, if\ n \geq k \end{cases} \quad (3)$$

Probability that a customer has to wait:

$$Pw = \frac{1}{k!}\left(\frac{\lambda}{\mu}\right)^k \frac{k\mu}{k\mu-\lambda} Po \; (4)$$

The average number of customers in the system:

$$Ls = \frac{\lambda\mu\left(\lambda/\mu\right)^k}{(k-1)!(k\mu-1)^2} Po + \frac{\lambda}{\mu} \; (5)$$

The average number of customers in the queue:

$$Lq = \frac{\lambda\mu\left(\lambda/\mu\right)^k}{(k-1)!(k\mu-1)^2} Po \text{ Or } Lq = Ls - p \; (6)$$

The average time a customer spends in the system:

$$Ws = \frac{\lambda\mu\left(\lambda/\mu\right)^k}{(k-1)!(k\mu-1)^2} Po + \frac{1}{\mu} = \frac{Ls}{\lambda} \; (7)$$

The average time a customer spends in the queue:

$$Wq = \frac{\mu\left(\lambda/\mu\right)^k}{(k-1)!(k\mu-1)^2} Po \text{ Or } Wq = Ws - \frac{1}{\mu} = \frac{Lq}{\lambda} \; (8)$$

## 3. Economic Analysis of Queuing Systems

Queuing models can be used to determine operating performance of a queuing system. In economic analysis of queuing systems, we seek to use the information provided by the queuing model to develop a cost model for the queuing systems under study. The two basic types of costs associated with queuing systems are the costs involved in operating each service facility like the costs for equipment (including maintenance), materials, labor, etc. these cost increases as the number of service facilities put into operation increases and the opportunity costs associated with causing customers to wait in the system. As the number of service facilities in operation increases, the time the customer has to wait in the system, on the average, decreases, hence the cost associated. The two types of cost are in conflict because an increase in one automatically causes a reduction in the other or vice versa. The total of these two basic types of costs goes to a minimum at some specific number of facilities. This then is the optimum number of service facilities which should be operated by the manager- optimum because it minimizes the total cost of both operating the service facilities and waiting time in the system. The total cost model includes the cost of waiting and the cost of service:

$$TC = CwLs + Csk$$

Where:

Cw= the waiting cost per time period for each customer

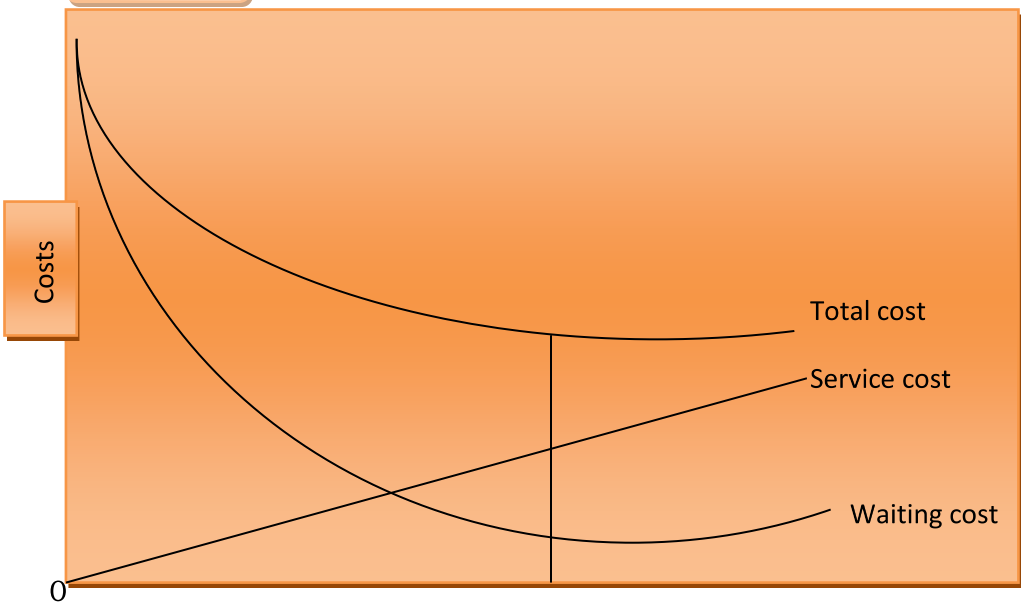
Ls=average number of customers in the system

Cs= the service cost per time period for each channel

k = the number of channels

TC= the total economic cost per time period

Figure 1




Optimal level of service

## 6. RESULTS AND DISCUSSION

The multiple channel queuing system at Banque Commerciale du Congo with mean arrival rate (λ) = 70 customers/hr., service rate (μ) = 20 customers/hr. and with number of Tellers (k) = 5 has been solved using TORA optimization software to evaluate the measures of performance of the queuing system at the bank results were obtained as shown in Table 1.

**Table 1. Summary of Analysis of Multiple-Server Queuing Model at Banque Commerciale du Congo (BCDC)**

| Performance measure | 5 Tellers | 6 Tellers |
|---|---|---|
| **Arrival rate (λ)** | 70 | 70 |
| **Service rate (μ)** | 20 | 20 |
| **System Utilization ($\rho$)** | 70.00% | 58.333% |
| $L_s$ | 4.382 | 3.748 |
| $L_q$ | 0.882 | 0.248 |
| $W_s$ **(hours)** | 0.063 | 0.054 |
| $W_q$ **(hours)** | 0.013 | 0.004 |
| $P_o$ | 2.59% | 2.896% |
| $P_w$ | 37.78% | 17.74% |

From the queue performance measures, increasing the number of teller points to 6 from the **table 1** show a decrease in the waiting time in the queue and system would reduce to 0.004 hours and 0.054 hours respectively as against the present situation where each customer has to in the queue and system for 0.013 and 0.063 hours respectively. As a result each teller will be busy 58.33% that is 41.67% of the time it is idle.

The waiting situation should normally be as defined in the table above. It was however noted during the period under study that, due to the non respect of the discipline of the file and the slowness in the chief of the waiters, a customer wait more than 45 minutes before being service and the time spent in the system fluctuates around one hour; which represents a very long duration of waiting and creates dissatisfaction in the bank customer's lead.

Already we observe that the rate of service is largely very low compared to the arrival rate is 20 customers < 70 customers / hour. This will inevitably create enthusiasm in front of the bank and reinforces the discontent of the customers in terms of the opportunity costs they face waiting too long.

## 7. CONCLUSION AND SUGGESTIONS

In this study, we presented the concept of the banking system of BCDC/Mbujimayi (Banque Commerciale du Congo), as a multiple-channel queuing model with fish arrivals and exponential services. The analysis of the queuing systems shows increasing the numbers of teller points up to 6 in the queue and system. This will also increase the efficiency of the establishment and customer satisfaction. Based on the summary of the analysis of different types of management, we recommend the management should adopt a six-server model to reduce economic cost.
Some managerial recommendations for managing queues within the BCDC:

- First, an application of queue theory within the BCDC is a necessity;
- Determine a tolerable wait time for clients and set goals based on what is acceptable;
- Try to entertain customers while waiting. Music, coffee, magazines, television are all sources of distraction that make customers wait;
- Inform clients of the length of the wait. This is particularly important when the wait is likely to be long. Explain to customers why the wait is abnormally long, and what the manager is doing to fix it;
- Keep visible employees away from the service. There is nothing more frustrating for a person waiting in line than to see an employee busy doing other things than coming to meet the waiting customers;
- Segment the customer. If a group of customers can be served quickly, create a special queue to keep them waiting longer than necessary;
- Create a wicket on university sites to facilitate the payment of academic fees by students;
- Train and sensitize staff to kindness. In addition to the daily smile and the warm, even personalized welcome, the staff must be able to face difficult

situations and react in such a way as to relax the atmosphere when customers become impatient;

- Encourage guests to come during dead times. Inform customers about less busy periods. The manager of a Saint-Laurent city bank branch suggested that his older clients come on Wednesday, the least busy day, so that he could devote more time to them;
- Have a long-term vision regarding the management of waiting. Put in place a process of continuous;
- improvement to reduce waiting times;
- Think about ways to speed up the process of treating customers. Automate when possible without eliminating custom contact. We always need a little attention.

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