# A Queuing Theory Approach to Improve Service Quality of Banking Systems: A Case Study of a Bank in Laguna, Philippines

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## Abstract

This study applies queuing theory approach to improve service quality of banking systems in Laguna, Philippines. Banking industry has been affected by the pandemic but, in comparison to other industries such as food, clothing, etc., it has been affected in other factors such as establishment capacity, and service quality. The researchers used data observed from 9:00am - 3:00pm, which was analyzed using Inferential Statistics and Queuing Theory. Results show that waiting time for customers (Senior/PWD) significantly differs from waiting time of regular customers. In addition, since the bank has 2 operational counters, it showed no significant difference between the waiting and service time of the 2 counters unless Senior/PWD citizens are served. Last, the type of probability distribution of the waiting, service, and total time in the system was determined using ProModel 2016's Autofit function. Initially, the type of probability is lognormally distributed, however since exponential probability is included in the top three, the data was deduced to fit as exponentially distributed. Even without simulation testing, queuing analysis could be applied. It is recommended to utilize additional counter for all transactions where the management may continue the use of existing queuing behavior but with the reduction of waiting time.

## Keywords

Queuing Theory, Banking System

## 1. Introduction

The success of the different service sectors has been heavily dependent on the perceived service quality. Service quality of the service sectors could be affected by various categories, this includes customer satisfaction and customer loyalty. In the banking industry – studies have shown that service quality is the main determinant of its success. Thus, its continuous improvements are vital in order for the bank branch to progress and ensure its competitiveness.

As mentioned, service quality is mainly affected by customers satisfaction and this may include several elements from mechanic to humanic clues. However, in the banking sector, a recent study has shown that to improve the bank's service quality, customers waiting and serving time are the most common factors that measures customers' satisfaction. With regards to the customers' waiting time, is the perceived queue length. Studies have also shown that customers waiting time and queue length have a negative effect on customers' satisfaction, thus, creating a negative perception towards their service quality. In this particular industry, different bank transactions are available which takes different amount of time to accomplish, thus, resulting to longer queues. In addition to that, given the current situation, the capacity limit that is implemented on establishments, commercial banks cannot accommodate customers the same manner as compared to the pre-pandemic era.

The global health crisis has taken its toll on commercial banking as the Department of Health and the Covid-19 Inter-Agency Task Force for the Management of Emerging Infectious Diseases (Covid-19 IATF) have set capacity limits for every establishment in accordance with quarantine guidelines that may vary per region to practice minimum health standards and reduce physical contact from customers and employees. The capacity limit set for establishments with a threshold of 50% is highly dependent on the announcement from the national government which is recommended by the Covid-19 IATF. However, according to the memorandum released by the Department of Trade and Industry, business establishments such as banks, money transfer services, pawnshops, microfinance institutions, and credit cooperatives are allowed to increase operational capacity to 100% under the General Community Quarantine (GCQ) but majority of the establishments are still following strict protocols, such as lowering operational capacity, to prevent or reduce the risk of transmission until community transmission is contained and herd immunity is attained.

The researchers aim to conduct this study specifically in a bank located in Laguna, Philippines. All data used are gathered with the approval of respective personnel from the said branch. Hence, the data and findings that this study will produce can only be used as a framework for other banks to improve queuing management in the new normal – Thus, it cannot be entirely depended on due to possibility of disparities may arise. With that, the researchers only intend to cover the available transaction windows available for payment, withdrawal, fund transfer, and cash deposits. In addition to this, other factors including tangible factors (bank equipment, facility layout, etc.) and humanic factors (tenure level of employee, age of the customers) have be excluded from the study. While some studies have linked that queuing system could improve the overall perceived service quality, these studies have been set during the pre-pandemic years and is mostly done in other East-Asian countries, as well as in Africa and in the Middle Eastern countries. Thus, there is a lack of existing literatures that pertains the use of queuing theory to provide a queuing system model in the Philippine setting during the pandemic.

The reduced capacity due to minimum health standards have caused longer queuing time for customers which may then result to declining customer satisfaction since waiting time greatly affects the perceived service quality in the end of customers. By conducting this study, the researchers will be able to determine causes of prolonged queuing time and in turn, can be resolved using engineering controls such as optimization. This is to address the causes of recurring issues and increase efficiency of the banking system to improve overall service quality by reducing queuing time, in accordance with the target queuing time of 5 minutes , which may aid to the accommodation of a greater number of customers on average.

### 1.1 Objectives

The main purpose of the study is to be able to analyze the queuing system of a bank in Laguna, Philippines and develop an improved queuing system that conforms to the target waiting time according to the management and that also adheres to the minimum health standards that has been set by the Department of Health and Covid-19 Inter-Agency Task Force for the Management of Emerging Infectious Diseases (Covid-19 IATF). In line with these, the following are the objectives of the study: (a) to obtain the average standard time of queuing time and service time for one (1) banking day during the quarantine implementation in the Philippines; (b) to determine and apply Queueing Theory on gathered data, and (c) to develop and propose methods to improve the current system that is aligned to the minimum health standards.

## 2. Literature Review

### 2.1 Capacity Limit during Quarantine

Capacity limit of an establishment has never been an issue before. However, in today's time because of the pandemic, establishments in all industries are required to implement the limitation of the number of customers allowed in a certain space at a certain amount of time. The particular reason for this circumstance is to prevent or minimize the risk of transmission of the virus which correlatedly results to the reduction of the number of cases infected by the virus. Perlman and Yechiali (2020) developed a study wherein they constructed and analyzed a two models that can be utilized to optimize the size of the queue and the waiting time of a random store in order to lessen and avoid infection of COVID-19. This study focuses on the time spent on shopping and payment. Perlman and Yechiali proposed a novel approach by which they are able to calculate the risk of a customer being infected by the virus while queueing outside. It is also determined that the risk of being infected is proportional to the number of customers occupying a certain amount of space.

In addition to that, one factor that affects the customer capacity of an establishment is due to the implementation of physical distancing. According to World Health Organization (2021), it is recommended to maintain at least 1 meter (6 feet) distance between others to reduce the risk of infection. Social distancing is necessary to prevent the rapid spread of a highly contagious disease, such as COVID-19, at least until a vaccine is found and mass-produced. By reducing the probability of an uninfected person coming close or in physical contact with an infected one, the disease transmission in the community can be suppressed. Unfortunately, not all establishments are capable of implementing such measure due to the structural design of the area. Therefore, industrial establishments such as banks, drug stores, department stores, shopping malls, etc., resorts to the application of capacity limitation in order for the customers to maintain said distance and reduce the risk of transmission of the virus (Kyritisis & Diaz, 2020)

A method that was implemented by the Tasmanian Government to guarantee that physical distancing is achieved is through the limitation of the number of customers allowed in a certain space at a certain amount of time which is one person per two square meters. In addition to that, each person must have a distance of at least 1.5 meters. Another, is to develop a plan wherein number of customers is maximized per area such as aisles, waiting rooms, etc. Other than that, the government implements to station one employee at every entrance and exit points of an establishment to count the customers entering and leaving such place to maintain the maximum capacity of the area. Last, consider one-way aisles to continuously maintain physical distancing. If applicable, number of parking areas must be aligned with the maximum limited capacity of the establishment. (Tasmanian Government, 2020). Although there is a memorandum that states that business establishments or activity such as banks, money transfer services, pawnshops, microfinance institutions, and credit cooperatives are allowed to increase operational capacity to 100% under the General Community Quarantine (GCQ). It is still advised to implement such measures which is to maintain physical distancing of at least 1 meter, and to minimize or limit the number of establishment capacity (Department of Trade and Industry, 2020). With that, the capacity limit in establishments due to the pandemic has not yet been studied in the past queuing analysis of banking systems, especially in the Philippines.

## 2.2 Service Quality in the Banking Sector

The banking industry has indeed showed growth and is continuously developing by improving and expanding their services to cater more customers. According to Borak Ali (2011), the quality of service is the most important factor when it comes to customers' bank standard preference, as well as determinant for the success of today's modern banking industry. The service quality in banks can also directly influence customers' satisfaction as well as customers' loyalty. This could be supported by the study of Cronin et al., (2000), to which they have stated that service quality is the "driving force" of customers' satisfaction that can have an impact to customers' loyalty in the bank sectors (Cronin et al., 2000, as cited in Khan & Fasih, 2014). In addition, Dr. Al-Azzam (2015) have stated that the importance of service quality in the banking sector is due to the fact that banks have placed customer relationship to have a great importance in both commercial and retail customers. And due to this, Portela and Thanassolis (2006) have stated that the survival of the bank branches is dependent on their service quality (Portela & Thanassolis, 2006, as cited in Kheng et al., 2010). Thus, with studies showing that service quality is interrelated with customer satisfaction and customer loyalty, one way to improve service quality could be done by improving customers satisfaction and which would then increase customers' loyalty.

In order to do so, several studies have already determined factors that may influence the overall service quality of a bank. Flavian et al. (2004), have identified the services offered, the security of the bank, reputation, and its ease of access to their services as the tangible factors that can contribute to the overall service quality in banking industry (Flavian et al., 2004 as cited in Borak Ali, 2011). Furthermore, the study by Lee (2011) have discovered that while the SERVQUAL model that is most commonly used in order to measure the determine the overall service quality – speed can now be considered as another factor that can affect the perceived service quality of banks. Speed in the banking sector may often be related to the customers' waiting time and customers' service time; to support this, a more recent study by Mutingi, Mapfaira, Moakofi, Moeng and Mbohwa (2015) have identified that the most common measure of customer satisfaction in banking sectors is through the customers' average waiting time and service time. In addition, the authors have also stated that the perceived queue length may also affect customers' satisfaction which can also affect their perceived service quality of the bank.

Thus, in the current situation in the Philippines, service industries - including banks are obliged to follow the new normal when it comes to their operations. As they are required to follow the minimum health standards, their overall service quality should not be affected in order for the banking industry to continuously progress at these trying time. Therefore, there is a need to develop a new queuing system that would adhere to the minimum health standards without affecting the consumers' satisfaction and loyalty and would retain its perceived service quality.

## 2.3 Queuing Theory to Improve Service Quality

The banking system has always yielded an above average time for waiting alone which causes dissatisfaction in the end of the customers. Olafemi et al. (2015) gathered data through survey with a sample of 300 customers and employed statistical analysis, particularly regression analysis, to establish the relationship between customer satisfaction and queuing. It was seen that customers from the sample take a long time before getting attended to. The mentioned study only provided the relationship of customer satisfaction and queuing time without actually applying the concepts and calculations appropriate for queuing theory per se. With that, this establishes that queuing theory is a significant concept to improve the overall service quality since it is aligned with the findings of Pakurár et al. (2019) – where they stated the dimensions of service quality that majorly influence customer satisfaction specifically in the banking sector based on the SERVQUAL model and it was explicitly stated that the access to service in particular is affected by the waiting time and convenience of the services provided by commercial banks.

Sheikh et al. (2013) conducted a study in India wherein the existing queuing model of the bank observed was converted to another type of queuing model to determine which is more efficient in the reduction of queuing time to optimize the efficiency of the commercial banking system. Originally, the queuing model used was the M/M/Z/∞ (FCFS) model in which there are number of servicing stations available in parallel layout where the customer may be served by more than one servicing statin. The said model was then altered into a M/M/1/∞ (FCFS) model to analyze the queuing management in its simplest terms since this model only contains one (1) servicing channel. Through that, the queuing number, servicing channels, and service rate were improved which means that the efficiency of the current system has been increased and the optimization model was deemed feasible since customer satisfaction is increased due to minimized waiting and servicing time. Overall, the said results can be relevant in analyzing the existing queuing management of the bank observe in this study since banks are essentially built with similar features due to the services they offer.

Similar to the mentioned study, Shyfur et al. (2013) then gave a more detailed explanation of the concepts of the application of queuing theory upon settling long waiting time in line specifically for depositing cash in a bank located in Bangladesh. Since the researchers only focused on cash deposit transactions and not the entirety of available services, the queuing model used was M/M/1 (FIFO) which is a single servicing channel with Poisson arrivals and exponential servicing time. It was then stated that the utilization of queuing theory in the banking sector makes it capable for management to determine customer arrival pattern in which it is then possible to identify the number of servicing stations the bank may offer. Furthermore, the application of the said theory aids in the development of provision of service with reasonable and tolerable queues. Given the detailed identification of factors needed to be assessed in understanding the queuing management of banks, it can also be applied to the study since the mentioned factors are staple during the assessment for banks.

Farayibi and Oladapo (2016) also applied queuing theory to examine a bank in Nigeria with respect to the multi-server queuing model. The multi-server queuing model is also applicable to the bank in Laguna used in this study since there are more than one (1) operating channels provided by the bank. The same methodology for data gathering from Farayibi and Oladapo (2016) will also be used by the researchers since data are obtained from primary sources. With that, data gathered from the cited study were analyzed using the M/M/S/∞ (FCFS) model and customer arrival time, waiting time, servicing time, priority level, number of customers, and number of available servers were considered for this model – in which are also applicable for this study. However, traffic intensity and effectivity were also measured along with their corresponding operating and waiting costs. The construction of the queuing model in line with the traffic intensity were deemed to be applicable in the Nigerian bank operations since it was concluded that unnecessary queue and idle time in the bank hall would be reduced when the optimal model is applied. With that, the factors considered will be of help in determining the optimal queuing model which will be further simulated and assessed if it is fit for optimization in this case.

Furthermore, since the studies cited all unequivocally achieved their objectives in applying queuing theory to reduce queuing time and improve service quality in the banking sector from a global perspective, the researchers intend to dive in more in the utilization of queuing theory with a proposed solution in a reference bank in Laguna, Philippines to take into consideration the capacity limit due to the on-going health crisis to address the research gap of not having enough studies that tackle the queuing management systems of banks during the global health crisis where minimum health standards must be followed.

# 3. Methods

## 3.1 Conceptual Framework

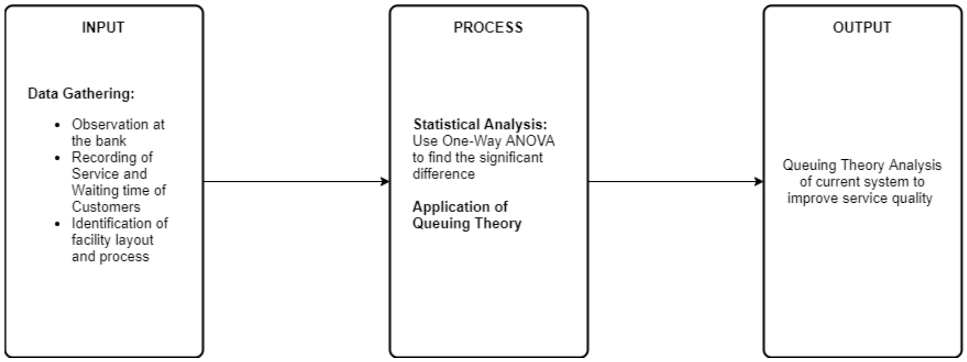


Figure 1. Conceptual Framework

The conceptual framework in figure 1 is grounded on the stated research objectives. The input of the study involves on the data that has been gathered through the observation at the bank, to which the research has recorded the service and waiting time of the customers as well as identifying the facility layout particularly the number of tellers that is available and their overall process. The next step is to test the recorded data by using One-Way ANOVA to determine whether the data gathered are significantly different and that the data is exponentially distributed. If the data is exponentially distributed, the application of the queuing theory models may be used, to produce the overall output the study – which is the queuing theory analysis of the current system that adheres to the minimum health standard where it can be used to improve the overall service quality of the bank.

## 3.2 Treatment of Data

The statistical treatment of data in this study involves inferential statistics, specifically One-Way ANOVA, to test which factors may have significant difference in terms of waiting time since the management mainly targets to reduce the waiting time of customers. This will be used to determine areas of improvement of the existing queuing system of the bank.

## 3.3 Analysis/Evaluation of Queuing Model

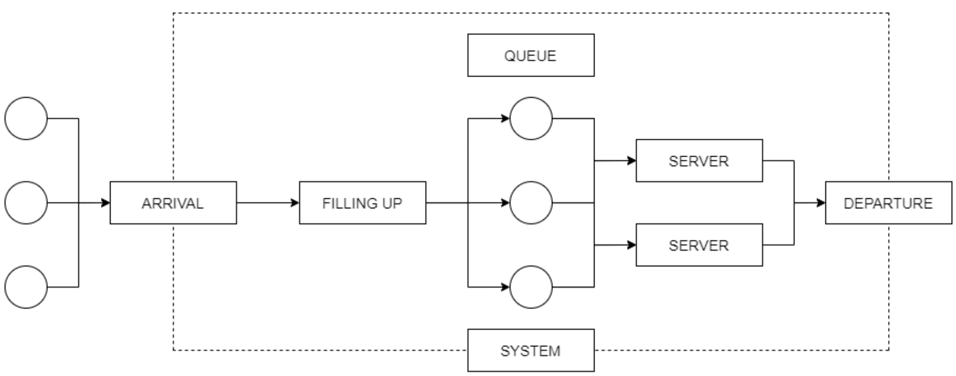


Figure 2. Multiple Server Queuing System

The Queuing Model of the existing system of the bank of choice for common transactions, such as cash deposit, fund transfer, and withdrawal, is considered as M/M/s/∞/∞ - where there are two (2) operating servers or windows, as depicted in figure 2, that may accommodate customers that are categorized as either regular or senior citizens.

In this case, the queuing behavior for the existing system is a combination of First Come, First Serve (FCFS) and Priority (PR) since operating servers cater to both where those who are priority customers such as senior citizens, do not need to get a queuing number as they can go to the available server upon their arrival, in comparison to regular customers who need to wait in queue for their turn. However, facility layout is excluded in this study due to managerial constraints by the bank. Thus, only the queuing system model will only be used.

## Assumptions of M/M/s/∞/∞ Model

1. It is assumed in this model that interarrival times are independently and identically distributed in accordance with the exponential probability distribution.
2. Service times are independent and are also identically distributed according to exponential distribution.
3. The number of servers is known as s, where it is a positive integer.
4. The presence of a limited number of customers does not exist.

In this study, the following formulas are used:

1. s = number of servers
2. λ = arrival rate (customers per minute)
3. μ = service rate (customers per minute)
4. Utilization factor

$$\rho = \frac{\lambda}{\mu}$$

5. Utilization rate of the system

$$\rho_s = \frac{\lambda}{s\mu}$$

6. Probability that the system will be idle or will have zero customers

$$P(0) = \frac{1}{\sum_{i=0}^{s-1} \frac{\rho^i}{i!} + \frac{\rho^s}{s!\,(1-\rho_s)}}$$

7. Average number of customers in the system (bank)

$$L = L_q + \rho$$

8. Average number of customers waiting in queue

$$L_q = \frac{P(0)(\rho)^s \rho_s}{s!\,(1-\rho_s)^2}$$

9. Average time spent of customers in the system (bank)

$$W = W_q + \frac{1}{\mu}$$

10. Average time spent of customers waiting in queue

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

## 4. Data Collection

The data used in this study was obtained through time study and observation wherein the researchers observed the branch of choice from Laguna, Philippines for one (1) whole banking day from 9:00AM to 3:00PM with management approval. The number of customer arrivals per hour was noted along with the time it takes for customers to fill out necessary forms (arrival in the system), wait in queue (queuing time), and the transaction proper (servicing time).

## 5. Results and Discussion

### 5.1 Numerical Results

Table 1 Summary of Customer Arrival (Revised)Table 4.14

| Time | Window 1 | Window 2 |
|---|---|---|
| 9:00 - 10:00 AM | 8 | 10 |
| 10:00 -11:00 AM | 13 | 8 |
| 11:00 - 12:00 NN | 10 | 10 |
| 1:00 - 2:00 PM | 8 | 10 |
| 2:00 - 3:00 PM | 9 | 8 |
| Total | 48 | 46 |

Table 1 summarizes the revised data that fits to the requirements of exponential probability distribution. Minimal changes were done where outliers in the first few observations were removed. The data for waiting time, service time, and total time in the system was assessed in ProModel 2016 using the AutoFit function to determine the type of probability distribution. This is to ascertain if the proposed model shall require a simulation approach. Initially, the data is lognormally distributed. However, since the exponential probability distribution is in the top three (3) list as seen in figure 1, it can be deduced that the data may be possibly converted to an exponential distribution since the sample is only needed. Upon minimal distribution, the data is then fit for exponential probability distribution which means that queuing analysis may be applied without further simulation testing. Therefore, the final summary includes 48 customers from window 1 and 46 customers from window 2, with a total of 94 customers for one (1) whole banking day.

Table 2 Results of One-Way ANOVA

| One-Way ANOVA (Welsch's Test) | | | | |
|---|---|---|---|---|
| Source | DF Num | DF Den | F-Value | P-Value |
| Factor | 3 | 47.6524 | 49.76 | 0.0000 |

It was noticed by the researchers that the two (2) operating windows for common transactions, such as cash deposits, fund transfers, and withdrawals, give priority to senior citizens and automatically proceed with their transactions upon their availability regardless the time of arrival of senior citizens – as compared to regular customers who fall in line and wait for their number to be presented in the digital queuing board. This, in turn, generates a longer waiting time for regular customers, where the management aims to limit I to 5 minutes. To prove that there is a significant difference with the waiting time for both types of customers, a One-Way ANOVA test was conducted. The result from the statistical test is shown in table 2 where it can be seen that the p-value is less than 0.05 – this makes the waiting time of senior citizen customers significantly different when compared to the waiting time of regular customers. Furthermore, the results from the Post-Hoc test show that the waiting time of regular customers from window 1 and 2 do not differ from each other, but they significantly differ to the waiting time of senior citizens from both windows. Thus, the matter at hand can be narrowed down into the priority of customers. In addition, the type of transaction of customers did not have any bearing regarding the waiting time, service time, or the total time in the system. Therefore, the researchers will only focus on solving the excessive time spent in queue of regular customers.

Table 3, Summary of Customer Arrival – Senior Citizens

| Time | Window 1 | Window 2 | Average |
|---|---|---|---|
| 9:00 - 10:00 AM | 3 | 4 | 3.5 |
| 10:00 -11:00 AM | 1 | 3 | 2 |
| 11:00 - 12:00 NN | 6 | 3 | 4.5 |
| 1:00 - 2:00 PM | 1 | 5 | 3 |
| 2:00 - 3:00 PM | 1 | 4 | 2.5 |
| Total | 12 | 19 | 15.5 |

Table 4. Summary of Customer Arrival – Regular Customers

| Time | Window 1 | Window 2 | Average |
|---|---|---|---|
| 9:00 - 10:00 AM | 5 | 6 | 5.5 |
| 10:00 -11:00 AM | 12 | 5 | 8.5 |
| 11:00 - 12:00 NN | 4 | 7 | 5.5 |
| 1:00 - 2:00 PM | 7 | 5 | 6 |
| 2:00 - 3:00 PM | 8 | 4 | 6 |
| Total | 36 | 27 | 31.5 |

Tables 3 and 4 shows the summary of customer arrival of senior citizens and regular customers for both windows along with the average from the revised data, respectively. The average will be used since it was analyzed in the Post-Hoc test that there is no significant difference between the time in terms of window 1 versus window 2 and the types of transactions made by the customers. Therefore, it is safe to say that the primary analysis will be done on the queuing of senior citizens and regular customers.

Table 5. Summary of Average Time Recorded (mins) – Senior Citizens

| Time | Window 1 | Window 2 | Average |
|---|---|---|---|
| Waiting Time | 3.408 | 4.129 | 3.768 |
| Service Time | 8.503 | 6.613 | 7.558 |
| Time in System | 15.466 | 14.870 | 15.168 |

Table 6. Summary of Average Time Recorded (mins) – Regular Customers

| Time | Window 1 | Window 2 | Average |
|---|---|---|---|
| Waiting Time | 7.865 | 9.502 | 8.683 |
| Service Time | 5.779 | 5.519 | 5.649 |
| Time in System | 17.134 | 18.530 | 17.832 |

Tables 5 and 6 outlines the necessary time need for the queuing analysis such as waiting time, service time, and total time in the system for senior citizens and regular customers, respectively. The average from the operating windows was also calculated and will be used in the calculation of variables needed for the analysis of the current system. The waiting time is defined by the point when the customer finishes filling up necessary forms and wait for their transaction. The service time is identified to be the time when the customer arrives and leaves at the server for transaction. The total time in the system is the sum of the time spent filling up necessary forms (arrival point), waiting time, and service time.

## 5.2 Application of Queuing Theory on the Current System of a Bank in Laguna, Philippines

The bank has a total of three (3) counters but with only two (2) operating counters throughout the whole operation in every banking day. The two (2) operating windows handle common transactions which are cash deposits, fund transfers, and bank deposits. In this part, equations from the Queuing Theory for the M/M/s/∞/∞ model are utilized to identify the necessary information that are vital to improve the service quality of the bank.

Table 7 Queuing Theory Analysis of Current System (M/M/s/∞/∞)

| Variables | Representation | Senior Citizens | Regular |
|---|---|---|---|
| s | Servers | 2 | 2 |
| $\lambda$ | Arrival Rate | 0.258 customers/minute | 0.525 customers/minute |
| $\mu$ | Service Rate | 0.265 customers/minute | 0.354 customers/minute |
| $\rho$ | Utilization Rate | 0.976 or 97.6% | 1.483 or 148.3% |
| $\rho_s$ | Utilization Rate of System | 0.488 or 48.8% | 0.741 or 74.1% |
| P(0) | Probability that the system will be idle or will have zero customers | 0.344 or 34.4% | 0.148 or 14.8% |
| L | Average number of customers in the system (bank) | 1.282 customers | 3.293 customers |
| $L_q$ | Average number of customers waiting in queue | 0.305 customers | 1.810 customers |
| W | Average time spent of customers in the system (bank) | 15.168 minutes | 17.832 minutes |
| $W_q$ | Average time spent of customers waiting in queue | 3.768 minutes | 8.683 minutes |

Based on the calculations done in accordance with the Queuing Theory with multiple servers or M/M/s/∞/∞ model as summarized in table 7 for senior citizen and regular customers, it is computed that overall, senior citizen customers has an arrival rate of 0.258 customers per minute with a utilization rate of 97.6% and a utilization rate of the system of 48.8%. Furthermore, the probability that the bank will have zero senior citizen customers is 34.4%, the average number of senior citizen customers in the bank is 1.282 customers, the average number of senior citizen customers waiting in queue is 0.305 customers, the average time spent of customers in the bank is 15.158 minutes, and the average time spent of senior citizen customers waiting in queue is 3.768 minutes.

In comparison to the analysis of regular customers, the arrival rate is 0.525 regular customers per minute, the service rate is 0.354 regular customers per minute, the utilization rate is 148.3% and the utilization rate of the system is 74.1%. For further analysis, the probability that the bank will have no regular customers is 14.8%, the average number of regular customers in the system is 3.293 customers, the average number of regular customers waiting in line is 1.810 customers, the average time spent of regular customers in the bank is 17.832 minutes, and the average time spent of regular customers while waiting in line is 8.683 minutes.

When analyzed, it can be deduced that the arrival rate of regular customers is greater than its service rate, considering that there are two (2) servers available, which is why its utilization rate exceeded 100%. This means that regular customers arrive in greater numbers as compared to the accommodation of the tellers upon transaction. On the other hand, the arrival rate of senior citizen customers is less than its service rate, which is the ideal situation. This means that the servers provide service to senior citizen customers quicker due to the priority behavior. Another factor to consider is that senior citizen customers are high risk in terms of being infected of the virus, which is why the servers prioritize them. That behavior resulted to a lesser time spent waiting in queue for the senior citizen customers, which is 3.768 minutes that is ideal and conforms to the target waiting time of 5 minutes set by management. However, regular customers spend 8.683 minutes waiting in line, which then significantly affects the service quality of the bank since it contributes to the higher time spent in the system.

## 5.3 Proposed Queuing System of a Bank in Laguna, Philippines

Since it was depicted in the calculations that regular customers spend an average time above the target waiting time set by management, the proposed queuing system may include the utilization of three (3) operational servers, since it was mentioned that only (2) are currently operational. With that, the management may continue the queuing behavior of having a mixed First Come, First Serve (FCFS) and Priority (PR) since senior citizens has a high probability of no customers, in order to utilize all counters for regular customers.

Table 8 Queuing Theory Analysis of Proposed System (M/M/s/∞/∞)

| Variables | Representation | Senior Citizens | Regular |
|---|---|---|---|
| s | Servers | 3 | 3 |
| $\lambda$ | Arrival Rate | 0.258 customers/minute | 0.525 customers/minute |
| $\mu$ | Service Rate | 0.397 customers/minute | 0.531 customers/minute |
| $\rho$ | Utilization Rate | 0.651 or 65.1% | 0.989 or 98.9% |
| $\rho_s$ | Utilization Rate of System | 0.217 or 21.7% | 0.330 or 33% |
| P(0) | Probability that the system will be idle or will have zero customers | 0.520 or 52% | 0.368 or 36.8% |
| L | Average number of customers in the system (bank) | 0.668 customers | 1.075 customers |
| $L_q$ | Average number of customers waiting in queue | 0.017 customers | 0.087 customers |
| W | Average time spent of customers in the system (bank) | 5.104 minutes | 3.931 minutes |
| $W_q$ | Average time spent of customers waiting in queue | 2.585 minutes | 2.048 minutes |

The calculations done in table 8 utilized the data from the current system in terms of arrival rate, waiting time, service time, and total time in the system. Since the proposed solution includes utilization of three (3) operational servers, the computations done is based on the change from s = 2 to s = 3. With that, it can be seen that the waiting time and time spent in the system for both senior citizen and regular customers have been reduced and falls under the target waiting time of 5 minutes set by the bank management itself.

## 6. Conclusion

Queuing Theory is vastly used to solve issues that may reduce service quality since it is mainly affected by queuing time. With that and due to the lack of studies conducted in the Philippines with considerations of the capacity limit brought upon by the pandemic, this study is conducted in a bank in Laguna, Philippines where time study and observation was used to gather data that aided in the analysis of the current queuing system. The standard time of queuing and servicing time were identified and utilized to determine the areas of improvement of the current system.

The target waiting time set by the management of the bank played a huge role in the analysis of data where it was stated that management has a target waiting time of 5 minutes in order to reduce exposure of the customers to the virus and to satisfy customers by not making them wait for an excessive amount of time in the bank. With that, it was determined in the queuing analysis of the current system that the root cause of longer time in the system is that there is no proper segregation for the accommodation of senior citizen and regular customers of only two (2) operating counters even though there is a total of three (3) counters in the system. Since the bank follows a First Come, First Serve (FCFS) and Priority (PR) queuing discipline, regular customers wait for their turn for transaction while senior citizen customers are automatically being catered once a server is available for transaction, regardless if the customer just arrived.

The researchers mainly used the arrival rate, service rate, utilization rate, and waiting time in line as a performance measure to compare the data from both types of customers. It was proven in the calculation of queuing analysis that the waiting time of senior citizens is significantly different to the waiting time of regular customers. It was found that the arrival rate of regular customers is greater than its service rate, which means that number of regular customer arrivals magnifies faster yet they get stuck in the queue since the service rate does not compensate for the arrival rate, thus, resulting to a prolonged waiting time and total time in the system, which then elevates the risk of regular customers of being exposed to the virus.

With that, the proposed solution or queuing management system involves the utilization of three (3) fully operational servers for the whole day where the management may continue the queuing behavior of serving senior citizens upon availability, that will not affect the waiting time of regular customers since there is an additional counter. Once the available servers are fully operational, this will significantly reduce queuing time and total time in the system of both customers that will conform to the target waiting time of 5 minutes set by the management since the service rate will be increased, which may then cater to the arrival rate of regular customers.

Since it was found that the proposed queuing management system will reduce overall waiting time and total waiting time for senior citizen and regular customers, this will reduce the risk of exposure of customers generally since they will not have to stay in the system for an unreasonable amount of time – thus, will improve service quality in terms of queuing time and may lead to an accommodation of more customers on a daily basis.

## 7. Recommendation

For the bank, since the arrival rate is significantly higher than the serving time of the customers – this means that the current system is considered to be a slow paced. Thus, creating longer queuing line and longer waiting time for the customer. Thus, the utilization of the third counter should be implemented that would be used as an additional counter where management may proceed with the current queuing behavior. By doing so, serving regular customers will have a continuous flow instead of having interruptions because senior citizens would then be needed to served first which causes longer waiting time for regular customers.

For the future researchers, since the scope of this study is only to apply queuing theory to improve the queueing system of the bank based on the transactions of deposit, withdrawal, and fund transfer, it is recommended to widen the scope and include different transactions that concerns higher-level employees transactions such as debit/credit account opening/closing, claiming of pension/senior citizen funds, large amount deposit/withdrawal/fund transfer, acquisition of insurance account, etc.,. Lastly, to include all excluded tangible and humanic factors of this study to further discuss such effects of the excluded factors on the result of the future study.

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