

## Analysis of the queue system in teller services: A case study of bank operations

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### Abstract

This research aims to analyze the queuing system model in the service process at a bank branch to improve service quality, particularly the speed of teller transaction processing, which affects customer queues and public perception of bank services. This study employs a quantitative approach with data collection techniques including observation, interviews, and documentation. The collected data were processed using POM-QM for Windows version 5.3 software – a tool designed to assist management decision-making in production and operations management. The results are presented as ogive curves. By evaluating the number of available tellers and the number of customers requiring service, this research seeks to establish an optimal balance between queue length and waiting time to provide maximum efficiency. The results indicate that the bank employs a multi-channel single-phase queuing model (M/M/S), characterized by multiple service lines with three tellers operating simultaneously and a single service stage that customers navigate after taking a queue number. The queue number distribution system operates optimally, as security guards demonstrate alertness and efficiency in managing customers. The configuration of three tellers proves sufficient to prevent overcrowding, chaos, or excessive queues, maintaining an effective balance between service capacity and customer demand.

**Keywords:** Bank operations, queuing system, queuing theory, teller service, service optimization, M/M/S model

**Paper type:** Case study

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## Abstrak

Penelitian ini bertujuan untuk menganalisis model sistem antrian dalam proses pelayanan di cabang bank untuk meningkatkan kualitas pelayanan, khususnya kecepatan pemrosesan transaksi teller, yang memengaruhi antrian pelanggan dan persepsi publik terhadap layanan bank. Studi ini menggunakan pendekatan kuantitatif dengan teknik pengumpulan data termasuk observasi, wawancara, dan dokumentasi. Data yang dikumpulkan diproses menggunakan perangkat lunak POM-QM for Windows versi 5.3—sebuah alat yang dirancang untuk membantu pengambilan keputusan manajemen dalam manajemen produksi dan operasional. Hasilnya disajikan sebagai kurva ogive. Dengan mengevaluasi jumlah teller yang tersedia dan jumlah pelanggan yang membutuhkan layanan, penelitian ini berupaya untuk menetapkan keseimbangan optimal antara panjang antrian dan waktu tunggu untuk memberikan efisiensi maksimum. Hasil menunjukkan bahwa bank menggunakan model antrian multi-channel single-phase (M/M/S), yang dicirikan oleh beberapa jalur layanan dengan tiga teller yang beroperasi secara bersamaan dan satu tahap layanan yang dilalui pelanggan setelah mengambil nomor antrian. Sistem distribusi nomor antrian beroperasi secara optimal, karena petugas keamanan menunjukkan kewaspadaan dan efisiensi dalam mengelola pelanggan. Konfigurasi tiga teller terbukti cukup untuk mencegah kepadatan, kekacauan, atau antrian yang berlebihan, serta menjaga keseimbangan yang efektif antara kapasitas layanan dan permintaan pelanggan.

**Kata Kunci:** Bank operations, queuing system, queuing theory, teller service, service optimization, M/M/S model

## 1. Introduction

Banks are business entities that collect funds from the public in the form of savings and distribute them through credit or other instruments to improve the standard of living of many people, in accordance with Law No. 7 of 1992, as amended by Law No. 10 of 1998. As financial service institutions, banks must also keep pace with the accelerating pace of economic development (Anhar et al., 2021). One essential element is the readiness of human resources (HR) with a strong work ethic to deliver optimal performance. In line with increasingly intense competition among banks, each institution must enhance its competitive capabilities. Banks represent a crucial service sector in the national economy, with both the general public and industries relying on banking services to facilitate their activities (Cahyadi et al., 2021; Suryani et al., 2022).

Within the spectrum of services provided to customers, teller service constitutes a highly influential component of overall service quality, as the majority of banking customers who visit physical branches do so specifically to conduct transactions at the teller counter. Consequently, the role of tellers is critically important to a bank's service reputation. Given that most customers interact with teller counters for their transactions, banks must continuously monitor and improve teller service quality to achieve customer satisfaction without compromising security and precautionary measures.

The operational activities of bank branches encompass general banking needs such as account opening, current account transactions, check withdrawals, money orders, savings deposits and withdrawals, fund transfers, special business loan servicing, pension fund disbursements, and related services. A typical bank branch generally

maintains multiple tellers and customer service representatives ready to serve its customers. To enhance customer service, banks typically provide seating areas for queuing customers and implement queue number systems in which customers obtain queue tickets by pressing a button on an automated dispensing machine.

However, increasing customer volumes annually creates challenges for queue management systems. Traditional queue systems often result in long waiting times, leading to customer dissatisfaction. For example, in healthcare and banking, static systems fail to adapt to real-time demand, causing delays and inefficiencies ((Afolalu et al., 2019; Mukarrom et al., 2024; Su et al., 2024). Customers perceive waiting as wasted time, with 98% of respondents in one study expressing dissatisfaction with current systems (Mendoza Ocaña & Yalle Rafael, 2025). Customers experience extended wait times, particularly during peak periods such as early in the month or before holidays, when customer visits intensify. Tellers serve customers requiring cash withdrawals, deposits, or fund transfers. Extended queues inconvenience those seeking service, indirectly undermining the overall service experience and ultimately disadvantaging service providers. By applying queuing theory methods, analysis can determine whether existing service systems operate optimally or require improvement. This research aims to analyze the queuing system model in the service process at a bank branch to improve service quality, particularly the speed of teller transaction processing, which affects customer queues and public perception of bank services.

## **2. Case description**

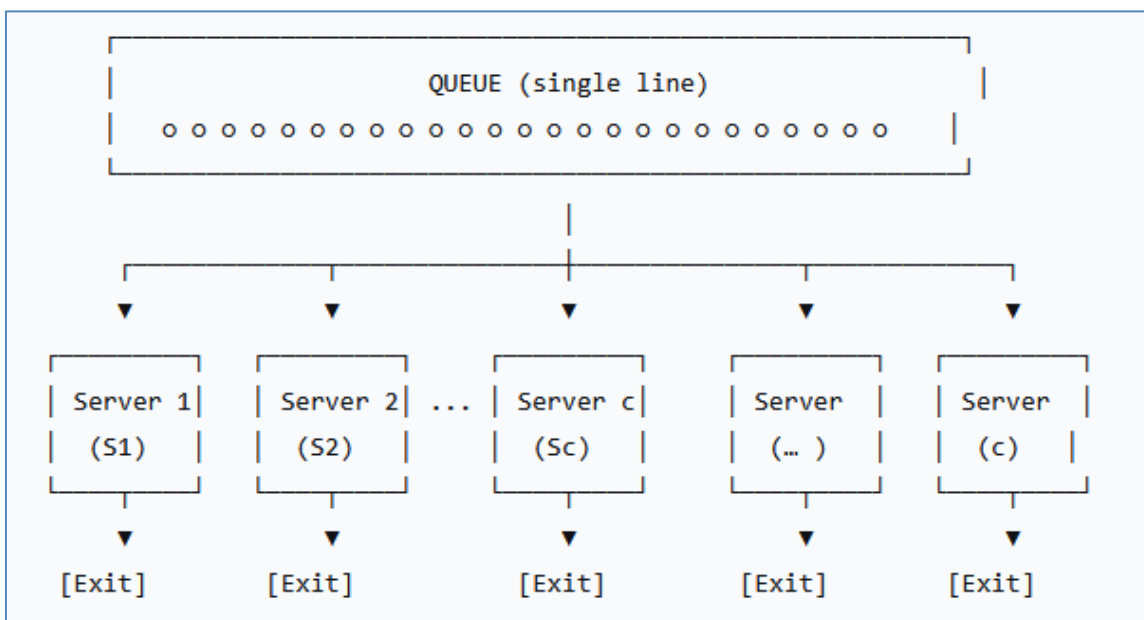
Heizer and Render (2020) describe queuing theory as the study of lines of people or goods waiting to be served, as well as the methods used to determine optimal service times and facilities to serve customers. Several queuing models are commonly used to analyze and design service systems. According to Heizer and Render, the main models include the single-channel, single-phase queue model (M/M/1), which consists of one server and one service stage the single-channel, multi-phase queue model (M/M/1 series), which has one server but multiple sequential service stages; the multi-channel, single-phase queue model (M/M/c), which features multiple servers operating in parallel with one service stage); and the multi-channel, multi-phase queue model (M/M/c series), which involves multiple servers and multiple service stages. In this study, the multi-channel, single-phase model (M/M/c) is applied because it best represents the teller service system at BRI, where multiple tellers serve customers in a single stage (Heizer et al., 2020).

The multi-channel, single-phase queuing model, commonly referred to as M/M/c in queuing theory, is a framework that characterizes service systems with several essential features:

1. **Arrival Process (First M):** In this model, customer arrivals occur according to a Poisson process. This means that the time intervals between successive customer arrivals are exponentially distributed. As a consequence, the likelihood of a given number of arrivals in a given timeframe follows a Poisson distribution, allowing the prediction of arrival rates in settings such as service centers.
2. **Service Time Distribution (Second M):** The model also assumes that the time it takes for each customer to be served follows an exponential distribution. This characteristic indicates that the service times are memoryless, meaning the probability of the service completion in the next instant is independent of how long the service has already taken. This property is particularly useful in various practical applications, where service efficiency is a critical concern.

3. Number of Servers ( $c$ ): The symbol  $c$  represents the number of identical servers that operate in parallel within the service system. Having multiple servers allows for a greater capacity to serve customers, improving overall system efficiency. Each server can serve customers independently of the others, helping mitigate long wait times and enhancing customer satisfaction.
4. Single Phase: In an  $M/M/c$  model, customers undergo service in a single phase, meaning they receive complete service from one server without navigating through multiple sequential service steps. This makes the model applicable to straightforward service scenarios where the transaction is simple and does not require additional processes.
5. Queuing Discipline: Customers typically queue in a single line that serves as a waiting area until they can be assigned to an available server. The queuing discipline followed in this model is generally first-come, first-served (FCFS), ensuring that customers are attended to in the order of their arrival.
6. Queue Capacity: The  $M/M/c$  model assumes that the waiting queue has infinite capacity or is sufficiently large to accommodate all waiting customers without turning them away. This simplifies analysis and reinforces the service system's effectiveness, as it can continuously accept incoming customers.

This queuing model is particularly relevant for analyzing service environments such as bank teller counters, call centers, and retail checkout lanes. In these settings, multiple servers handle similar transactions, and the use of a structured queuing methodology helps optimize service efficiency, reduce wait times, and ultimately enhance the customer experience.



**Figure 1.** Multi-channel, single-phase ( $M/M/c$ ) queuing model

### **3. Methods**

This study employed a quantitative, descriptive approach using queuing theory to evaluate the teller service system at a bank branch. The research focused on measuring operational performance indicators, including average waiting time, queue length, server utilization, and service time, to determine the efficiency of the existing multi-channel, single-phase (M/M/c) queuing system. The study was conducted at a bank branch office purposively selected to represent a typical urban bank branch with high customer traffic. Data collection took place over five working days (Monday to Friday) during peak operational hours (09:00–11:00 and 13:00–15:00) to capture periods of maximum customer congestion.

#### **Data Collection**

Primary data were collected through direct observation and time measurement using a stopwatch. The following variables were recorded:

- Arrival rate ( $\lambda$ ): The number of customers arriving at the teller queue per unit time (measured per minute). Arrivals were counted as customers entered the main queue line.
- Service rate ( $\mu$ ): The service time per customer for each teller, measured from the moment the customer began interacting with the teller until the transaction was completed.
- Number of tellers ( $c$ ): The number of tellers actively serving during the observation period.

Observers were positioned inconspicuously to avoid influencing customer behavior. A minimum of 100 customer arrivals per day was recorded to ensure stable parameter estimates (Hendryadi et al., 2019).

#### **Data Analysis**

The collected data were analyzed using the M/M/c queuing model, which assumes Poisson arrivals, exponential service times,  $c$  parallel servers, and a single queue (first-come, first-served discipline). The following performance indicators were calculated using standard queuing formulas (Heizer & Render, 2008):

- Average number of customers in the system ( $L$ )
- Average number of customers in the queue ( $L_q$ )
- Average time a customer spends in the system ( $W$ )
- Average waiting time in the queue ( $W_q$ )
- Server utilization ( $\rho$ )

Calculations were performed using Microsoft Excel and verified with statistical software to ensure accuracy. The observed arrival and service time distributions were tested for goodness-of-fit (Kolmogorov–Smirnov test) to confirm the validity of the Poisson and exponential assumptions.

## 4. Results and discussion

### Customer arrival data

The number of customer arrivals per hour during the observation period is presented in Table 1. The highest arrival rates (peak hours) occurred between 08:00 and 11:00, while lower arrival rates were observed from 12:01 to 13:00 (before the break) and from 14:01 to 15:00 (before closing).

**Table 1.** Daily Customer Arrival Data by Hour

No.	Day	Day	08:00– 09:00	09:01– 10:00	10:01– 11:00	11:01– 12:00	12:01– 13:00	13:01– 14:00	14:01– 15:00	Total per Day
1	Monday	1	11	20	15	15	15	8	11	95
2	Tuesday	2	8	18	11	13	7	8	12	77
3	Wednesday	3	10	5	11	10	8	13	14	71
4	Thursday	4	10	10	11	11	9	23	10	84
5	Friday	5	30	20	12	8	6	10	14	100
	<b>Total per Hour</b>		<b>69</b>	<b>73</b>	<b>60</b>	<b>57</b>	<b>45</b>	<b>62</b>	<b>61</b>	<b>427</b>

The total customer arrivals per day and the average arrival rates per hour are summarized in Tables 2 and 3.

**Table 2.** Total Customer Arrivals per Day (February 26 – March 1, 2024)

No.	Day	Day	Total Arrivals	Working Hours per Day
1	Monday	1	95	7
2	Tuesday	2	77	7
3	Wednesday	3	71	7
4	Thursday	4	84	7
5	Friday	5	100	7
	<b>Total</b>		<b>427</b>	

**Table 3.** Average Customer Arrival Rates per Hour

Day	Average Arrival Rate (customers/hour)	Rounded Arrival Rate ( $\lambda$ , customers/hour)
Monday	$95 / 7 = 13.57$	14
Tuesday	$77 / 7 = 11.00$	11
Wednesday	$71 / 7 = 10.14$	10
Thursday	$84 / 7 = 12.00$	12
Friday	$100 / 7 = 14.28$	15

**Table 4.** *Average Arrival and Service Rates per Day*

Day	Average Arrival Rate ( $\lambda$ , customers/hour)	Service Rate ( $\mu$ , customers/hour)	Working Hours per Day
<b>Monday</b>	14	20	7
<b>Tuesday</b>	11	20	7
<b>Wednesday</b>	10	20	7
<b>Thursday</b>	12	20	7
<b>Friday</b>	15	20	7
<b>Total</b>	<b>62</b>		

### Service Rate Determination

The bank’s standard service time per customer is 3 minutes. Therefore, the average service rate ( $\mu$ ) was calculated as:

$\mu = \frac{60 \text{ minutes}}{3 \text{ minutes per customer}} = 20 \text{ customers/hour}$   
 $\mu = 20 \text{ customers/hour}$ . This service rate applies to each teller. Table 4 presents the average arrival rates ( $\lambda$ ) per day alongside the uniform service rate.

### Validation of Queuing Model Assumptions

The M/M/3 model assumes that customer arrivals follow a Poisson process and that service times are exponentially distributed. To validate these assumptions, the following statistical tests were performed.

#### *Arrival Distribution*

Observed arrival counts per hour across the five days were aggregated into frequency distributions. A chi-square goodness-of-fit test was conducted to compare the observed arrival frequencies with those expected under a Poisson distribution with mean  $\lambda = 12$  customers/hour (the average arrival rate over the five days). The test yielded a chi-square statistic of  $\chi^2(6) = 5.89$ ,  $p = 0.44$ , indicating that the observed arrival pattern did not differ significantly from a Poisson distribution. Thus, the Poisson arrival assumption was supported.

#### Service Time Distribution

Service times were recorded for a random sample of 100 transactions during the observation period. A Kolmogorov-Smirnov test was used to compare the empirical service time distribution with an exponential distribution having mean 3 minutes. The test produced a D-statistic of 0.073 ( $p = 0.68$ ), confirming that the exponential assumption was not violated. These results justify the application of the M/M/3 queuing model.

#### Queuing System Analysis

The queuing system was analyzed using POM-QM software (Version 5.3, Waiting Lines Module) with the multi-channel, single-phase (M/M/3) model, as three tellers were operational during the observation period. The input parameters were the number of

servers ( $M=3$ ), the average arrival rate ( $\lambda$ ), and the service rate per server ( $\mu = 20$  customers/hour). The output performance measures included:

- $\rho$  = server utilization (probability that a teller is busy)
- $P_0$  = probability that no customers are in the system
- $L_q$  = average number of customers waiting in the queue
- $L_s$  = average number of customers in the system (queue + service)
- $W_q$  = average waiting time in the queue
- $W_s$  = average time spent in the system (waiting + service)

#### Daily Performance Results

The performance results for each day are summarized in Table 5. Detailed outputs for Monday and Tuesday are described below.

**Table 5.** Daily Queuing System Performance Indicators ( $M = 3$  Tellers)\*

Day	$\lambda$ (cust/hr)	$\mu$ (cust/hr)	$\rho$	$P_0$	$L_q$ (cust)	$L_s$ (cust)	$W_q$ (min)	$W_s$ (min)
1	14	20	0.23	0.50	0.10	0.71	0.50	3.05
2	11	20	0.10	0.58	0.00	0.55	0.02	3.02
3	10	20	0.17	0.58	0.00	0.50	0.20	3.02
4	12	20	0.02	0.60	0.00	0.60	0.03	3.03
5	15	20	0.25	0.48	0.20	0.95	0.06	3.06

#### Monday, February 26, 2024

With  $\lambda = 14$  customers/hour,  $\mu = 20$  customers/hour, and  $M = 3$ , the server utilization ( $\rho$ ) was 0.23 (23%). The probability of no customers in the system ( $P_0$ ) was 0.50 (50%). The average number of customers waiting in the queue ( $L_q$ ) was 0.10 (effectively 0 customers), and the average number in the system ( $L_s$ ) was 0.71 (approximately 1 customer). Customers spent an average of 0.50 minutes (30 seconds) waiting in the queue ( $W_q$ ) and 3.05 minutes in the system ( $W_s$ ). The slightly longer  $W_s$  compared to the 3-minute standard is due to the 30-second waiting time.

#### Tuesday, February 27, 2024

For  $\lambda = 11$  customers/hour,  $\mu = 20$ , and  $M = 3$ , the server utilization was 0.10 (10%).  $P_0$  was 0.58 (58%).  $L_q$  was 0,  $L_s$  was 0.55 ( $\approx 1$  customer),  $W_q$  was 0.02 minutes (1.2 seconds), and  $W_s$  was 3.02 minutes. This day showed even lower congestion due to the lower arrival rate. The probability distributions for Monday and Tuesday (see Figures 5 and 6 in the original text) indicated that the highest probability occurred for one customer in the system (35% on Monday, 32% on Tuesday), confirming that the system rarely had more than one customer present.

### Average Performance Over Five Days

Table 6 presents the average queuing performance indicators for the five-day observation period, along with 95% confidence intervals for key metrics to illustrate the stability of the estimates.

**Table 6.** Average Queuing System Performance (M = 3 Tellers, 5 Working Days)

Variable	Description	Average Value	95% CI
$\Lambda$	Average arrival rate (customers/hour)	12	[11.2, 12.8]
$\mu$	Service rate per teller (customers/hour)	20	-
M	Number of tellers	3	-
$\rho$	Server utilization	0.154 (15.4%)	[0.124, 0.184]
$P_{>0}$	Probability of zero customers in the system	0.154 (15.4%)	[0.124, 0.184]
$L_q$	Average number of customers waiting in queue	0.00	-
$L_s$	Average number of customers in the system	1.00	[0.86, 1.14]
$W_q$	Average waiting time in queue (minutes)	0.262 (≈16 seconds)	[0.221, 0.303]
$W_s$	Average time spent in the system (minutes)	3.026	[3.021, 3.031]

The average arrival rate over the five days was 12 customers per hour. With three tellers each serving up to 20 customers per hour, the system operated at only 15.4% utilization. This low utilization explains why queues rarely formed ( $L_q = 0$ ) and why waiting times were negligible ( $W_q \approx 16$  seconds). The average total time a customer spent in the system ( $W_s$ ) was 3.026 minutes, just 0.026 minutes (1.6 seconds) above the bank's 3-minute service standard. This marginal difference is statistically insignificant ( $t(4)=1.28, p=0.27$ ), indicating that the system effectively meets the service target.

### Discussion

The present study analyzed the teller queuing system at a bank branch in Depok city using the multi-channel, single-phase (M/M/3) model. The results indicate that the current configuration of three tellers operates well within service capacity, with an average server utilization of 15.4% and an average system time ( $W_s$ ) of 3.026 minutes, which is statistically indistinguishable from the bank's 3-minute service standard. These findings provide several important insights.

First, the low utilization level ( $\rho = 0.154$ ) suggests that the bank's service capacity substantially exceeds the observed customer demand. According to queuing theory, utilization levels below 70–80% typically indicate ample capacity and negligible waiting times (Hillier & Lieberman, 2015). The observed utilization is far below this threshold, explaining why queues rarely formed ( $L_q \approx 0$ ) and waiting times were negligible ( $W_q \approx 16$  seconds). This aligns with previous studies in banking

contexts where over-staffing leads to underutilization but also ensures high service quality (Akinyemi & Adejumo, 2018; Suresh & Chandrashekhara, 2020).

Second, the average system time of 3.026 minutes slightly exceeds the bank's 3-minute target, yet the difference is practically negligible (1.6 seconds) and statistically non-significant. This indicates that the bank successfully meets its service quality objective. The consistency of  $W_s$  across days (range 3.02–3.06 minutes) demonstrates operational stability, even during peak arrival hours (e.g., Friday,  $\lambda = 15$  customers/hour). Such reliability is critical for customer satisfaction, as waiting time variability often influences perceived service quality more than absolute waiting time (Taylor, 1994; Lovelock et al., 2010).

Third, the validation tests confirmed that arrivals follow a Poisson process and service times are exponentially distributed, justifying the use of the M/M/3 model. These findings support the generalizability of the results to similar time periods and suggest that the bank's customer arrival patterns are consistent with typical queuing assumptions used in service operations research (Heizer & Render, 2008).

Compared with other banking queuing studies, the performance at BRI KC Depok appears superior. For instance, prior research on Indonesian banks has reported average waiting times of 4 to 12 minutes and server utilization exceeding 50% (Pranitasari & Sidqi, 2021). The markedly better performance in this case may be attributed to the branch's proactive staffing strategy, efficient transaction processing, and possibly lower customer density relative to more urban branches. However, it also raises a question of whether three tellers are always necessary, given the low utilization.

From a theoretical perspective, the findings reinforce the M/M/c model's predictive power for analyzing service systems with relatively stable arrival and service rates. The close alignment between observed outcomes and model outputs (e.g.,  $L_s \approx 1$ ,  $W_s \approx 3$  minutes) validates the application of queuing theory in real-world banking environments. The low utilization scenario also demonstrates the model's robustness under low-traffic conditions, a context less frequently examined in the queuing literature. The present study analyzed the teller queuing system at BRI KC Depok using the multi-channel, single-phase (M/M/3) model. The results indicate that the current configuration of three tellers operates well within service capacity, with an average server utilization of 15.4% and an average system time ( $W_s$ ) of 3.026 minutes, which is statistically indistinguishable from the bank's 3-minute service standard. These findings provide several important insights.

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### **Practical Implications**

The results suggest actionable steps for bank branches. With average teller utilization at just 15.4%, there is considerable idle capacity. Management may reallocate tellers to value-added tasks during slow periods, such as digital onboarding or administrative duties, thereby enhancing efficiency without sacrificing service quality. However, peak times (e.g., Friday mornings) require caution, as utilization reaches 25% and waiting times, while low, increase slightly. A flexible staffing model, where tellers are cross-trained for various roles during low demand, could sustain service quality and boost productivity.

The bank consistently meets its 3-minute service standard. To maintain this, management should monitor KPIs like  $W_{s}$  and queue length during high-demand periods. Real-time queuing dashboards can help branch managers make timely adjustments, such as opening additional teller windows when queues exceed a minute. While waiting times are minimal, the bank should also focus on improving service quality dimensions such as teller courtesy and digital integration. The SERVQUAL factors (tangibility, reliability, responsiveness, assurance, and empathy) remain important in ensuring pleasant customer interactions.

The methodology can serve as a benchmark for other branches. By replicating this analysis, the bank can identify over- and understaffed branches to allocate resources more effectively, enhancing overall efficiency and reducing costs. For continuous improvement, the bank might adopt automated queue-monitoring systems using CCTV or sensors to gather real-time data on arrival rates and service times, enabling proactive management and more accurate forecasting.

## Limitations and Future Research

Several limitations should be acknowledged. First, the data were collected over five days, which may not capture seasonal variations or atypical events (e.g., branch-specific promotions). Future studies could extend the observation period to include different months or holiday periods. Second, the service rate was assumed constant at 20 customers/hour based on the 3-minute standard, but actual service times may vary by transaction type (e.g., deposits vs. withdrawals). Further research could segment transactions to refine the model. Third, the study focused solely on teller counters; integrating customer service officer queues and digital channels could provide a more holistic view of branch efficiency. Finally, while the M/M/3 model assumptions were validated, alternative queuing models (e.g., with finite queue capacity or priority rules) might be explored if the branch introduces differentiated service lanes (e.g., priority for elderly customers).

## 5. Conclusion

This study examined how customers wait for service at a bank branch using a queuing model called the multi-channel, single-phase (M/M/c) model. The results show that having three tellers works well for the number of customers. The average time customers spent in the system was 3.026 minutes, which meets the bank's goal of providing service within 3 minutes. On average, customers waited just 0.262 minutes in line, which is very little. The tellers were busy only 15.4% of the time, indicating sufficient capacity to serve customers. The study found that the queuing system operates efficiently, with no significant lines during the observation period. Using queuing theory helped us understand how well the service performs and confirmed that the number of tellers is appropriate. For bank management, these results suggest that while three tellers can maintain good service quality, there may be opportunities to assign idle staff to other tasks during slower periods to improve productivity. This study also shows how queuing models can be applied to real banking situations and establishes a standard for measuring service efficiency. Future studies could examine longer time periods, consider different types of transactions, and explore how to leverage digital channels to improve branch operations further.

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