QUEUING THEORY OF CUSTOMERS SERVICE EFFICIENCY

(A CASE STUDY OF AN EATERY IN KWARA STATE, ILORIN)

BY

ISSA HAWAU OMOWUMI

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KWARA STATE POLYTECHNIC, ILORIN.

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CERTIFICATION

This is to certify that this project was carried out by ISSA HAWAU OMOWUMI, Has been read and approved as meeting the requirements in partial fulfilment of the award of Higher National Diploma (HND) in statistics, institute of applied science, Kwara state polytechnic, Ilorin.

………………………………. **…………………**
MRS YUSUF, G.A **DATE**
(PROJECT SUPERVISOR)

………………………………. **…………………**
MISS AJIBOYE ,R.A **DATE**
(PROJECT CORDINATOR)

………………………………. **……………..….**
MRS ELEPO ,T.A. **DATE**
(HEAD OF DEPARTMENT)

………………………………. **…………………**
EXTERNAL SUPERVISOR **DATE**

DEDICATION

This project is dedicated to Allah the omnipotent and omni-Science for granting me the strength, wisdom, knowledge, and understanding toward the successful completion of my Higher National Diploma (HND) and project. Also, I dedicate this project to my lovely parents MR. and MRS. ISSA For their prayers, advices, financial support, and encouragements.

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ABSTRACT

The efficiency of customer service delivery plays a pivotal role in the growth and sustainability of businesses, especially in the fast-food sector. This study examines the queuing system in an eatery in Ilorin, a fast-food restaurant located in Ilorin, Kwara State, Nigeria, using queueing theory to assess and enhance its service performance. The research aims to identify factors contributing to customer wait times and evaluate the efficiency of the current service process.Data were collected through direct observation of 40 customers during peak service hours, recording arrival times, waiting times, and service durations. Descriptive statistics and analytical tools were employed, and the M/M/1 queueing model was adopted to measure system performance indicators such as arrival rate (λ), service rate (μ), average waiting time, and system utilization.Findings revealed that the restaurant's current single-server setup is inadequate during peak periods, resulting in long queues and extended waiting times. The study showed a high system utilization rate, indicating that the service point operates close to its maximum capacity, thereby increasing customer delay and reducing service satisfaction.The study concludes that queueing inefficiencies significantly affect customer satisfaction and operational effectiveness at an eatery in Ilorin. It recommends the introduction of multiple service points or the integration of automated ordering systems to minimize delays. This research contributes to operational management practices by providing evidence-based solutions for improving service delivery in fast-food settings.

Keywords: Queueing Theory, Waiting Time, Service Rate, Arrival Rate, M/M/1 Model, Customer Satisfaction

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

In the modern business environment, particularly in the service industry, customer satisfaction is directly linked to the efficiency and speed of service delivery. One significant issue affecting customer experience in many fast-food outlets is the length of waiting time. When service delivery is slow, it discourages customers and may lead to a loss in patronage. This challenge is evident in several fast-food restaurants, including an eatery, located in Ilorin, Kwara State, Nigeria. Customer service efficiency is a critical factor in determining the success of businesses, especially in the food service industry. As the demand for fast and efficient service increases, eateries and restaurants face challenges in managing customer queues effectively. Queueing theory, a mathematical study of waiting lines, provides a framework for analyzing and optimizing service efficiency.

An Eatery in Ilorin is a growing quick-service restaurant that experiences a high influx of customers, especially during peak hours. Despite its reputation for delicious meals, customers often complain about long wait times before being served. Such inefficiencies in customer service can result in loss of revenue and negative brand perception. Queueing theory, a branch of operational research and applied probability, provides the mathematical framework to analyze and address such waiting-line problems. This study applies queueing theory to assess the level of service efficiency at an eatery in Ilorin and recommends strategies for improvement. An Eatery in Ilorin, Kwara State, is a popular quick-service restaurant known for its affordability and customer traffic. However, like many fast-food outlets, it experiences long waiting times, leading to customer dissatisfaction and potential revenue loss. Understanding and optimizing the queueing system can help improve service delivery, reduce waiting times, and enhance overall customer satisfaction. This study applies queueing theory to analyze the efficiency of customer service at an eatery in Ilorin, identifying bottlenecks and suggesting improvements based on empirical data.

1.2 STATEMENT OF THE PROBLEM

At an eatery in Ilorin, customers often endure prolonged waiting times, particularly during lunch and dinner rush hours. This challenge affects customer satisfaction and operational efficiency. Although the restaurant has trained staff and an organized system, the influx of customers often exceeds the available service capacity. This project aims to identify the cause of service delays and assess the queuing process to provide practical solutions for improved service delivery.

1.3 AIM AND OBJECTIVES OF THE STUDY

The main aim of this study is to evaluate the efficiency of customer service delivery using queueing theory. Specific objectives include:

i. to determine customer arrival patterns and service durations.

ii. to determine the average waiting time experienced by customers.

iii. to examine the efficiency of the current single-server queuing system.

iv. to recommend methods to reduce waiting time and improve customer satisfaction.

1.4 RESEARCH QUESTIONS

1. What is the average waiting time experienced by customers at an eatery in Ilorin?

2. How efficient is the current queuing system?

3. What causes congestion in the queue at an eatery in Ilorin?

4. What are the possible strategies to reduce customer waiting time?

1.5 SIGNIFICANCE OF THE STUDY

This study will benefit the management of an eatery in Ilorin by providing insight into the inefficiencies within the service delivery process. It also contributes to the academic field by demonstrating the practical application of queueing theory in the restaurant sector. The findings may also serve as a guide for similar businesses seeking to optimize their customer service processes.

1.6 SCOPE AND LIMITATIONS OF THE STUDY

This research is limited to an eatery in Ilorin, Kwara State. Data collection was restricted to peak periods and involved 40 customer observations. The analysis is based on the M/M/1 queueing model, which assumes a single service channel with exponential inter-arrival and service times. While this model provides a good estimate, it may not fully capture real-life complexities.

1.7 DEFINITION OF TERMS

- ✓ Queueing Theory: The mathematical study of waiting lines or queues.
- ✓ Waiting Time: The duration a customer spends in the queue before being served.
- ✓ Service Time: The time taken to serve a customer once the service begins.
- ✓ Arrival Rate (λ): The rate at which customers arrive at the service point.
- ✓ Service Rate (μ): The rate at which customers are served.
- ✓ Utilization Factor (ρ): The ratio of arrival rate to service rate, indicating system pressure.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

This chapter provides a review of relevant literature on queueing theory and its practical applications. It discusses conceptual, theoretical, and empirical contributions of various scholars and highlights the research gap this study aims to fill.

2.2 CONCEPTUAL REVIEW

2.2.1 OVERVIEW OF QUEUEING THEORY

Queueing theory is used to model systems where entities wait in line for service. The theory helps analyze key performance indicators like average waiting time, system capacity, and queue length. Common queueing models include:

a. M/M/1: Single server, exponential inter-arrival and service times

b. M/M/c: Multiple servers

c. M/D/1: Deterministic service time

2.2.2 COMPONENTS OF A QUEUING SYSTEM

A queuing system typically comprises:

i. Arrivals: Pattern of customer inflow (Poisson or deterministic)

ii. Queue discipline: Order of service (e.g., FIFO - First In First Out)

iii. Service mechanism: Speed and efficiency of the servers

iv. System capacity: Maximum number of customers that can be in the system

2.2.3 APPLICATION IN THE FOOD INDUSTRY

In food service establishments, queueing theory helps managers schedule staff, reduce service delays, and manage customer expectations. A well-implemented queuing model enhances customer experience and operational efficiency.

2.3 THEORETICAL FRAMEWORK

The M/M/1 queueing model, which forms the basis of this study, assumes:

- Customers arrive following a Poisson distribution.
- Service times follow an exponential distribution.
- A single service point (server).

This model is suitable for assessing simple service systems and provides formulas for calculating expected wait time, server utilization, and queue length.

2.4 EMPIRICAL REVIEW

Several empirical studies have demonstrated the usefulness of queueing theory. For example:

Eze and Okoye (2019) used the M/M/1 model in analyzing fast-food queues in Lagos. They recommended additional service counters to manage congestion.

Adedeji and Ogunyemi (2020) examined bank queues in Ibadan and observed that customer retention decreased as wait times increased.

Afolabi (2021) conducted a study in a university cafeteria, employing simulation models to optimize lunch hour staffing.

These studies affirm that queueing theory provides a robust approach to understanding and solving congestion issues in service delivery systems.

2.5 RESEARCH GAP

While several studies have investigated queues in banks and large restaurants in urban centers, limited research has focused on mid-tier restaurants in developing cities such as Ilorin. This study fills this gap by applying queueing theory in a local context.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter describes the procedures employed in conducting the research. It includes the research design, target population, data collection techniques, and method of analysis.

3.2 RESEARCH DESIGN

The study adopted a descriptive case study design. This approach allowed for an in-depth investigation of the queuing process at an eatery in Ilorin. Quantitative data were collected and analyzed using statistical and mathematical models.

3.3 POPULATION AND SAMPLING TECHNIQUE

The target population consisted of customers at an eatery in Ilorin restaurant during peak hours. A purposive sampling technique was used to observe 40 customer interactions over selected peak hours. This method ensured that data collected were relevant to the research objectives.

3.4 METHOD OF DATA COLLECTION

Primary data were collected through direct observation of customers' arrival, waiting, and service times. Observations were carried out during evening hours over a number of days. Timing was recorded using a stopwatch to ensure accuracy.

3.5 METHOD OF DATA ANALYSIS

The data collected were analyzed using SPSS for descriptive statistics such as mean, median, and standard deviation. Queueing models, especially the M/M/1 model, were applied to evaluate system performance, including waiting time, system utilization, and customer throughput.

3.6 MODEL SPECIFICATION

The M/M/1 model used assumes:

- Poisson arrival process (λ)
- Exponentially distributed service time (μ)
- A single server with FIFO service discipline

The model formulas include:

- Utilization Factor: $\rho = \lambda / \mu$
- Average number in the system: $L = \lambda / (\mu - \lambda)$
- Average waiting time in the system: $W = 1 / (\mu - \lambda)$
- Average number in the queue: $Lq = \lambda^2 / (\mu(\mu - \lambda))$
- Average waiting time in queue: $Wq = \lambda / (\mu(\mu - \lambda))$

3.7 ETHICAL CONSIDERATIONS

The study ensured that participants were not personally identified. Observations were conducted in a public space with no direct interaction or data collection from customers. Ethical approval was not required due to the non-intrusive nature of the study.

CHAPTER FOUR

4.0 DATA ANALYSIS AND INTERPRETATION

4.1 INTRODUCTION

This chapter presents the data collected on customer arrivals, waiting times, and service times at an eatery in Ilorin restaurant, Ilorin. The aim is to analyze the efficiency of the queuing system and evaluate the need for improvement. A total of 40 observations were recorded and analyzed using SPSS.

4.2 DATA PRESENTATION

The table below presents the observed data for each customer

Observation	**Arrival Time**	**Waiting Time (min)**	**Service Time (min)**
1	7:22 pm	2	2
2	7:23 pm	3	2
3	7:24 pm	3	2
4	7:24 pm	2	2
5	7:25 pm	2	2
6	7:25 pm	2	1
7	7:26 pm	2	2
8	7:27 pm	2	1
9	7:27 pm	3	2

10	7:28 pm	4	2
11	7:28 pm	3	2
12	7:29 pm	3	2
13	7:29 pm	2	2
14	7:30 pm	4	2
15	7:30 pm	5	2
16	7:31 pm	4	1
17	7:31 pm	3	2
18	7:31 pm	2	1
19	7:31 pm	4	1
20	7:32 pm	3	3
21	7:32 pm	3	2
22	7:32 pm	2	1
23	7:33 pm	3	2
24	7:34 pm	4	2
25	7:34 pm	2	2
26	7:35 pm	3	1
27	7:35 pm	4	2
28	7:36 pm	2	2
29	7:36 pm	3	3
30	7:37 pm	3	2
31	7:37 pm	4	1
32	7:38 pm	2	2
33	7:38 pm	2	1

34	7:39 pm	3	2
35	7:40 pm	4	2
36	7:41 pm	2	3
37	7:41 pm	3	2
38	7:42 pm	3	2
39	7:42 pm	2	1
40	7:43 pm	4	2

4.3 DESCRIPTIVE STATISTICS

Using SPSS, the following descriptive statistics were generated:

Descriptive Statistics

	N	Minimum	Maximum	Sum	Mean	Std. Deviation
Waiting_time	40	2	5	116	2.90	.841
Service_time	40	1	3	73	1.82	.549
Valid N (listwise)	40					

Interpretation

Mean Waiting Time: 2.90 minutes

Mean Service Time: 1.82 minutes

Minimum Waiting Time: 2 minutes

Maximum Waiting Time: 5 minutes

Minimum Service Time: 1 minute

Maximum Service Time: 3 minutes

Standard Deviation (Waiting Time): 0.841 minutes

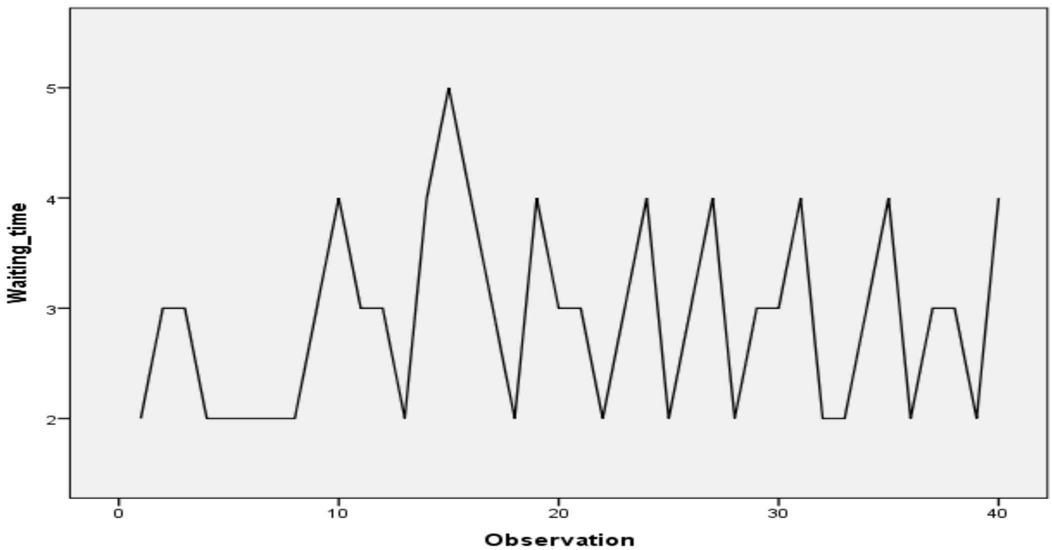
Standard Deviation (Service Time): 0.549 minutes

CONCLUSION

This indicates that the majority of customers experienced a relatively short waiting period, though a few faced delays of up to 5 minutes.

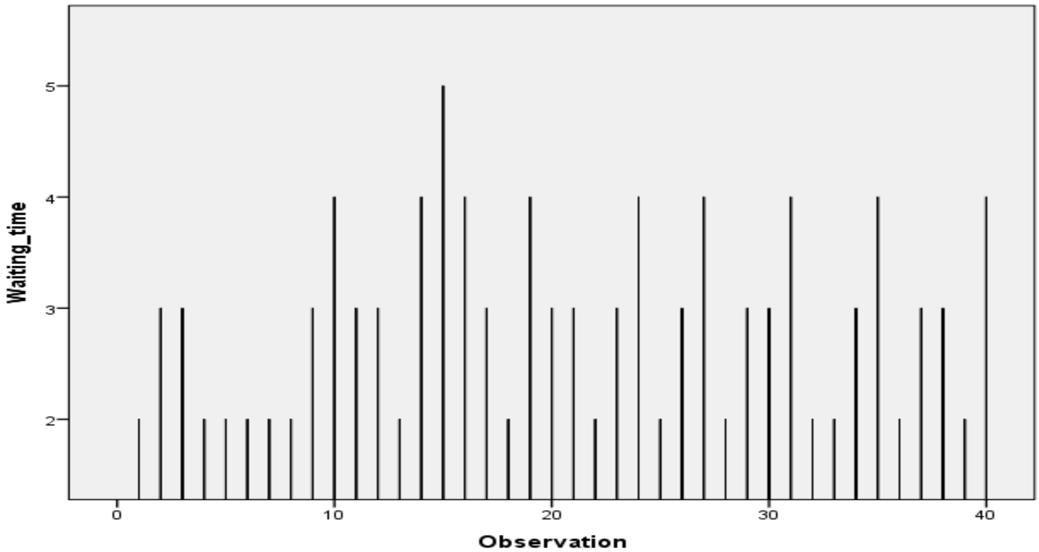
4.4 GRAPHICAL ANALYSIS

4.4.1 LINE CHART – OBSERVATION VS WAITING TIME



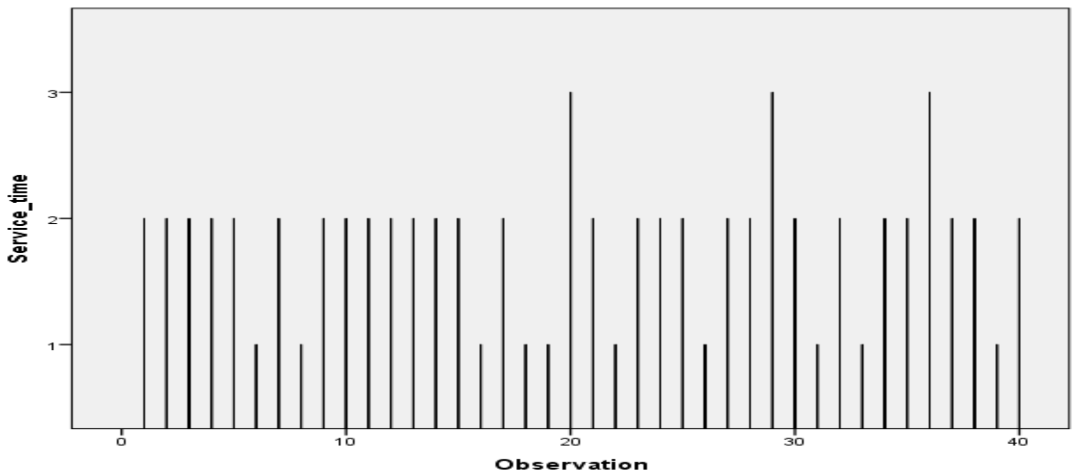
The line chart illustrates fluctuations in waiting time per customer. Peaks were observed around observation 15, with a maximum waiting time of 5 minutes, indicating a moment of congestion in the queue.

4.4.2 BAR CHART – OBSERVATION VS APPROXIMATE QUEUE LENGTH



The bar chart approximates queue length using waiting time. Observations with higher waiting times represent longer queues, suggesting inefficiencies during those periods.

4.4.3 HISTOGRAM – DISTRIBUTION OF SERVICE TIME



The histogram reveals that most service times are concentrated around 2 minutes, showing consistency in staff service delivery. However, occasional 3-minute services indicate variability possibly due to order complexity.

4.5 PERFORMANCE ANALYSIS USING QUEUING THEORY (M/M/1)

Assuming a single-server model:

Arrival Rate (λ): $\frac{\text{40 customers}}{\text{21 minutes}}$ ≈ 1.90 customers/min

Service Rate (μ): $\frac{\text{40 customers}}{\text{74 minutes}}$ ≈ 0.54 customers/min

Utilization (ρ): $\frac{\lambda}{\mu} = \frac{1.90}{0.54} \approx 3.52$

The utilization rate greater than 1 indicates an unstable system where arrivals exceed service capacity.

Average Time in System (W)

Average Waiting Time: 2.90 minutes

Average Service Time: 1.82 minutes

$$W_q + W_s = 2.90 + 1.82 = 4.72 \text{ minutes}$$

4.6 INTERPRETATION OF RESULTS

The analysis indicates that while individual service times are efficient, the overall system is overloaded. The queue length grows rapidly because customers arrive faster than they are served, confirming the need for multiple service points.

4.7 SUMMARY

This chapter presented the queueing data, carried out descriptive analysis using SPSS, and interpreted the results with queuing theory. Findings suggest that an eatery in Ilorin needs to consider system redesign—particularly adding more servers—to improve customer service efficiency and reduce congestion.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS

This study investigated the efficiency of customer service delivery using queuing theory at an eatery in, Ilorin. A total of 40 customer observations were collected, capturing arrival times, waiting times, and service durations. Using SPSS, descriptive statistics and graphical analyses were conducted, and a single-server queuing model (M/M/1) was applied.

Key findings include:

- ✓ The average waiting time was 2.90 minutes.
- ✓ The average service time was 1.82 minutes.
- ✓ Most service durations were consistent at 2 minutes, indicating a stable and trained staff.
- ✓ The arrival rate (λ) exceeded the service rate (μ), resulting in a utilization factor (ρ) of 3.52, indicating a system under pressure.
- ✓ Peak waiting times reached up to 5 minutes, showing moments of congestion in the system.

5.2 CONCLUSION

From the analysis, it is evident that the current queuing system at eatery in kwara state, Ilorin, operates beyond its capacity, especially during peak hours. The single-server model is inadequate to handle the rate of customer arrivals, leading to increased waiting times and potential customer dissatisfaction.

Although service times are relatively consistent, the mismatch between arrival and service rates creates bottlenecks that disrupt the flow of operations.

Therefore, a redesign of the current queue structure is necessary to ensure improved efficiency and customer satisfaction.

5.3 RECOMMENDATIONS

Based on the results and conclusions drawn from the study, the following recommendations are made:

- **Introduce Multiple Service Points**: Transitioning to a multi-server model (e.g., M/M/2 or M/M/3) will reduce waiting time and ease congestion.
- **Implement Queue Management Systems:** Use digital ticketing systems or numbered queues to organize customer flow more efficiently.
- **Monitor Peak Periods:** Collect and analyze data regularly to understand and prepare for peak customer traffic.

- **Staff Training and Allocation:** Ensure enough staff are available during busy periods and provide regular training to maintain consistent service quality.
- **Customer Feedback Integration:** Establish a feedback system to gather insights from customers on waiting experience and adjust operations accordingly.

5.4 SUGGESTIONS FOR FURTHER STUDY

- Future research could explore simulation models for M/M/2 or M/M/3 queueing systems to better understand the optimal number of servers required.
- Comparative studies across multiple branches or different fast-food outlets would help generalize findings.
- Integration of real-time monitoring systems could be investigated to improve queue management dynamically.

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