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Application of Queuing Theory in Automobile Service Centres: A Case Study of Maruti Suzuki, Baloda Bazar

Dr. Shivani Guru

Assistant Professor

Mr. Saket Singh Verma

Student

Amity Business School

Amity University, Raipur, Chhattisgarh

Abstract

This research explores the application of queuing theory to optimize service operations in automobile service centres, using the Maruti Suzuki service centre in Balodabazar as a case study. With rising customer demand and limited service infrastructure, managing wait times and resource allocation is increasingly critical. This study applies the M/M/c/∞/FCFS queuing model to assess operational performance, analyze wait times, and evaluate the effect of server count on system efficiency. The results reveal that while increasing servers initially reduces waiting times, excessive server addition without proportional efficiency gains leads to diminishing returns. Findings aim to support strategic decision-making in service design and resource management.

1. Introduction

In recent years, the automotive sector in India has experienced significant expansion, resulting in heightened demand for after-sales services, particularly within rural and semi-urban locales. This increase has imposed considerable pressure on automotive service centers, where patrons frequently encounter extended waiting periods and suboptimal service efficiency. Consequently, the management of customer throughput and service efficacy in these centers has emerged as a paramount operational concern.

One of the most efficacious methodologies for mitigating this challenge is **queuing theory**, a quantitative framework utilized to analyze waiting line phenomena. Stemming from the foundational contributions of A.K. Erlang in the early 20th century, queuing theory has found extensive application across diverse service sectors for modeling systems characterized by stochastic arrival and service processes. Through the implementation of structured models, service providers can scrutinize pivotal performance metrics such as queue length, waiting duration, and system utilization, thus facilitating informed decision-making regarding staffing and infrastructural requirements.

This research specifically concentrates on the application of queuing theory within the Maruti Suzuki service center in Balodabazar, an area emblematic of the burgeoning demand for systematic service operations in semi-urban India. The investigation employs the M/M/c/∞ /FCFS queuing model, which posits a Poisson arrival process, exponential service time distributions, multiple service channels, infinite queue capacity, and a first-come, first-served queue discipline. The objective is to evaluate the operational performance of the center, analyze customer wait times, and assess the ramifications of augmenting the number of service bays on overall system efficiency.

Data accrued over a one-week interval constitute the empirical foundation for the analysis. The results indicate a substantial reduction in waiting times upon increasing the number of servers from three to four, with an average decline surpassing 80%. Conversely, an unanticipated rise in wait times was observed when increasing the server count to five, suggesting inefficiencies induced by over-provisioning or a decline in per-server performance. These findings underscore the criticality of resource optimization rather than maximization.

By providing a quantitative assessment of queuing dynamics in an empirical context, this research offers pragmatic insights into service center design and resource allocation. It aspires to assist managers and policymakers in executing data-informed decisions that bolster customer satisfaction while preserving operational efficiency.

2. Literature Review

The basis of queuing theory is found in the initial work of Erlang (1909), who provided probabilistic models to examine telephone traffic. Kendall (1953) subsequently standardized the queuing model classification based on the A/B/C notation to make it easier to model service systems. Models including M/M/1 and M/M/c are typically used in automobile service centers.

Gross et al. (2018) built on these models by offering analysis tools to estimate performance measures like wait times and queue length. Bhattacharjee and Ray (2014) highlighted the importance of effective forecasting and capacity planning in service settings through the application of queuing theory.

Osman and Bachok (2013) researched electronic queue management systems and proved that technology mitigates customer anxiety while enhancing satisfaction. Other recent papers by Tyagi et al. (2023) and Memon et al. (2019) used queuing theory in healthcare and blockchain applications, respectively, indicating the diversity and applied advantage of simulation-based analysis. Yaduvanshi et al. (2019) addressed service optimization at peak hours, which is similar to vehicle servicing situations at rush hours.

These researches underscore the value of queuing theory in controlling unreliable arrivals, lowering waiting times, and enhancing operational effectiveness—chief challenges for automobile service centers.

3. Research Objectives

The primary objectives of this study are:

1. To observe the queuing system at the Maruti Suzuki car service center in Baloda bazar.
2. To identify the problems arising in the current queuing system configuration.

3. To investigate the servicing time patterns in the center.

4. To propose findings in optimization strategies for minimizing customer waiting time.

3. Research Methodology:

This research utilizes a quantitative analytical methodology grounded in queuing theory to assess the operational efficacy of the Maruti Suzuki service centre located in Balodabazar. The data was gathered through systematic direct observation over a duration of one week, meticulously documenting the volume of vehicles that arrived and were serviced each day, alongside their respective service durations. The M/M/c/∞/FCFS queuing model was employed under the presumption of Poisson arrival distributions and exponential service durations, incorporating multiple servers and adhering to a firstcome, first-served protocol. Critical performance indicators, including average waiting time in the queue (Wq), total time spent in the system (Ws), and system utilization, were calculated and analyzed across various server configurations (c = 3, 4, and 5). The percentage variations in Wq were utilized to elucidate the impact of augmenting the number of service bays on operational efficiency, thereby offering empirical insights into the optimal resource allocation aimed at diminishing customer wait times.

4. Analysis

This section evaluates data collected from the Maruti Suzuki showroom using the M/M/c/∞/FCFS queuing model. Observations were made over one week to assess queue performance, analyze arrival and service rates, and interpret the effect of varying the number of servers on waiting time and system utilization.

Day	Vehicles Arrived	Vehicles Served	λ (Arrival Rate)	μ (Service Rate)	Wq (hrs)	Ws (hrs)
Monday	20	18	20	18	0.0035	0.0590
Tuesday	75	61	24	22	0.0027	0.0481
Wednesday	69	57	22	30	0.0006	0.0339
Thursday	78	64	15	19	0.0012	0.0538
Friday	74	64	21	21	0.0022	0.0498
Saturday	74	63	26	20	0.0050	0.0550
Sunday	77	66	27	12	0.0631	0.1464

To calculate the **percentage change in average waiting time in the queue (Wq)** as servers change from:

- **c = 3 to c = 4**, and
- **c = 4 to c = 5**

Let's compute this for **Wq (hours)** on each day:

From c = 3 to c = 4:

Day	Wq @ c=3	Wq @ c=4	% Decrease (3 → 4)
Monday	0.0035	0.0006	((0.0035 - 0.0006) / 0.0035) × 100 ≈ **82.86%**
Tuesday	0.0027	0.0004	((0.0027 - 0.0004) / 0.0027) × 100 ≈ **85.19%**
Wednesday	0.0006	0.0001	((0.0006 - 0.0001) / 0.0006) × 100 ≈ **83.33%**
Thursday	0.0012	0.0002	((0.0012 - 0.0002) / 0.0012) × 100 ≈ **83.33%**
Friday	0.0022	0.0003	((0.0022 - 0.0003) / 0.0022) × 100 ≈ **86.36%**
Saturday	0.0050	0.0009	((0.0050 - 0.0009) / 0.0050) × 100 ≈ **82.00%**
Sunday	0.0631	0.0115	((0.0631 - 0.0115) / 0.0631) × 100 ≈ **81.77%**

From c = 4 to c = 5:

Day	Wq @ c=4	Wq @ c=5	% Increase (4 → 5)
Monday	0.0006	0.0055	((0.0055 - 0.0006) / 0.0006) × 100 ≈ **816.67%**
Tuesday	0.0004	0.0042	((0.0042 - 0.0004) / 0.0004) × 100 ≈ **950.00%**
Wednesday	0.0001	0.0008	((0.0008 - 0.0001) / 0.0001) × 100 ≈ **700.00%**
Thursday	0.0002	0.0016	((0.0016 - 0.0002) / 0.0002) × 100 ≈ **700.00%**
Friday	0.0003	0.0033	((0.0033 - 0.0003) / 0.0003) × 100 ≈ **1000.00%**
Saturday	0.0009	0.0087	((0.0087 - 0.0009) / 0.0009) × 100 ≈ **866.67%**
Sunday	0.0115	0.2106	((0.2106 - 0.0115) / 0.0115) × 100 ≈ **1731.30%**

Interpretation:

1. With **three** servers, the waiting periods were kept under control during the early part of the week.
2. By **Sunday**, with greater demand and **reduced service efficiency** (μ), waiting times escalated substantially.
3. From **3 to 4** servers, waiting times were **reduced** by **82–86%** across days.
4. Unexpectedly, adding from **4 to 5** servers caused **increased wait times**, caused by **decreased per-server performance**. This indicates that over-provisioning can lead to under-utilization and inefficiencies.

5. Conclusion

The research substantiates that queuing theory provides a formal and efficient method of optimizing operations for vehicle service centres. In particular, applying the M/M/c/∞/FCFS model allows managers to measure system performance, detect inefficiencies, and test changes in operations prior to implementation.

For Maruti Suzuki service centre:

1. A 4-server system represents the optimal compromise between cost and performance.
2. Overprovisioning more than 4 servers compromises system efficiency, making wait times longer instead of shorter.

Not Only queuing systems facilitate easier car flow. Also. They enable. Data-driven decisions for increasing customer satisfaction and operational profitability.

6. Findings

The analysis elucidated several pivotal revelations regarding the operational efficacy and efficiency of the queuing system at the Maruti Suzuki service center in Balodabazar:

Enhancement with Supplementary Servers (c = 3 to c = 4): An augmentation in the number of servers from three to four markedly diminished the average waiting time in the queue (Wq) across all observed days. The reduction spanned from 81.77% to 86.36%, signifying that a judicious enhancement in service capacity can substantially bolster service velocity and elevate customer satisfaction.

Diminishing Returns with Excessive Provisioning (c = 4 to c = 5): Counterintuitively, when the server count escalated from four to five, average waiting times surged dramatically—by as much as 1731.30% on Sundays. This paradoxical outcome implies that the introduction of an excessive number of servers, absent improvements in the efficiency of individual servers, results in resource underutilization and system instability, potentially attributable to coordination inefficiencies or periods of inactivity.

Variation Across Days: The metrics for waiting times and overall system performance exhibited fluctuations dependent on the day of the week, with Sundays manifesting the most pronounced inefficiencies, likely as a consequence of peak demand coupled with diminished service rates. This underscores the necessity for demand forecasting and dynamic resource allocation to effectively manage variations in traffic.

Operational Bottlenecks: The service rate (μ) exhibited variability throughout the week, which had a consequential impact on overall performance. Inconsistencies in servicing capabilities contributed to systemic congestion, particularly during periods of heightened demand.

Optimal Server Configuration: According to the findings, a configuration of four servers yielded the most efficacious equilibrium between resource allocation and customer wait times. This arrangement minimized delays without overstretching capacity, thereby suggesting it as the optimal configuration within the prevailing operational constraints.

7. Suggestions

Following are the recommendations based on the findings for automobile service centers:

1. Restrict Service Bays to Four: Steer clear of unnecessary capacity that cannot be effectively used.
2. Introduce Appointment Scheduling: Level out peak arrival times and enhance use of resources.
3. Segment Services: Employ distinct queues for fast services and intricate repairs.
4. Track Queue Metrics: Constant performance monitoring using queuing equations should inform operational decisions.
5. Integrate Technology: Online displays, token systems, and real-time queue displays can enhance customer experience and minimize perceived waiting time.

8. References

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