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Comparative Analysis of Average Waiting Time in Public vs Private Banks & Determining Optimal Number of Banking Servers

M K Gandhi[1]
Professor, Operations Department
Symbiosis Institute of Management Studies
Pune – India

Amandeep Singh[2]
Research Scholar
Symbiosis Institute of Management Studies
Pune – India

Ankush Rana[3]
Research Scholar
Symbiosis Institute of Management Studies
Pune – India

Abstract: ***Proper management of queue in any service industry not only improves the operational efficiency of the system but also increases customer satisfaction level. This paper performs a comparative analysis of average waiting time in a queue for Public vs Private sector banks in India. Also, this paper highlights the optimal number of service counter required by banks to maintain desired customer satisfaction level. The manager of the bank has to perform a trade-off between customer waiting cost and service operation cost to come at an optimum number of server required by any particular bank branch. In this research, two banks were taken into consideration, one branch each of Public and Private sector bank and their waiting times were compared using ANOVA test. Further, ANOVA showed the variation in the waiting time with respect to the duration of the day. Apart from ANOVA testing, the data collected was analyzed based on parametric calculation as well. The queuing theory was used to develop a mathematical model to determine an optimal number of servers required for any bank branch. Thus, queuing theory plays a major role in developing queue management strategy for not only banks but also for any other service industry.***

Keywords: Waiting Time, Service Time, utilization, Service Industry, Queuing theory, Service operations, Optimal service level.

I. INTRODUCTION

The push by the government of India to have inclusive growth has sensitized many people to open their bank accounts. As such it has put a lot of pressure on the banking system to provide better services to their customer in terms of convenience and comfort. Banks have a challenge of limited infrastructure which is growing slowly in terms of reach and capacity to handle the huge crowd. So, it becomes the responsibility of the Bank managers to utilize the available space effectively and have optimum utilization of the resource involved.

When a customer visits his Bank, his top priority is to have better service which is convenient to his location and time and quicker in delivery. So, the customer prefers bank which can provide banking services with minimal waiting time in the queue. As such it becomes a challenge for Banks to provide their customers with the best infrastructure that can meet all their desired requirements. The Bank manager further have to be agile enough to design an efficient layout of bank branch for customer conveniences. The more the number of customer service counters, the quicker is the service delivery to the customer and less is the waiting time in queue for customers visiting the bank to avail the banking services. Adding a new facility to the existing

system comes with the cost and certainly, it becomes a huge trade-off between cost and customer satisfaction level. There exists a great variation in a number of customer service counter in Public and Private sector banks and thus it puts a lot of variation in average waiting time a customer has to spend standing in the queue before availing banking services. Also, the average number of customers visiting bank branch daily has a great role to play in changing the average waiting time in the queue.

Through our study, we will try to find out the variation in average waiting time a customer has to spend while standing in the queue before availing banking services in Public and Private sector Banks and also, the role of duration of the day i.e., morning or evening in changing the average waiting time in the queue. We will also derive a formula to judge the optimal number of servers required to be maintained in any bank branch depending on customer satisfaction level.

II. Literature Review

Queuing theory is known by different names in different literature, some call it traffic theory, some congestion theory and some mass service theory (Copper, 1981). Queuing theory is the most commonly used mathematical tool for analyzing the waiting time in a queue. In queuing theory, we approximate the real-time situation into the mathematically derived equations to analyze different characteristics of the queue. Many types of research in the different field have adopted this methodology to understand problems related to queuing behavior. The formulas used in queuing theory are used to find an optimized solution for queuing problems and also, many statistical inferences can be drawn out of it (Xiao and Zhang, 2009). Practical life examples of the queue can be seen in oil refiling stations or at retail stores or at supermarkets. At the time of demonetization, what we could observe is long queues at ATM and bank branches. These lines get develop when there is already some other customer availing service and the client arriving to avail the service has to wait prior to being served (Ford, 1980). Proper scheduling of the visiting clients can help in avoiding the formation of a long queue. But in reality, this doesn't happen, clients or customers visit their service centers in a random or uncontrolled manner (Aldajani and Alfares, 2009). When a customer visiting the service centers, discovers a queue in the service station either tend to leave the system or waits to stand in the queue until his or her turn comes. The behavior of customer plays a major role in customer leaving the system or joining it on discovering a queue in service system (Abhor, 2005). The most problematic of all is unmanaged queues that are detrimental to the efficient operation of the service system. The speed of the service system is critical at peak hours, it should be maintained at such levels to avoid queues getting longer. As it can make the customer go impatient, eventually leaving the system (Musara and Fatoki, 2010).

III. Research Objective

The research objectives of this study are:

- To compare the average waiting time in queue to avail Banking services in Public Sector Bank vs Private Sector Bank.
- To develop a mathematical model to determine the optimum number of banking servers required for any particular Branch.

IV. Research Methodology

A. Data Collection

The research centers around the waiting area and transaction counter of the bank hall of ICICI Bank and SBI Bank. The data was collected primarily by direct observation of the service counter at the banks. Thus, the researcher recorded the following events as it happened in the system using a timer:

- The time of arrival of each customer.
- The time the service commences for each customer in the system.
- The time the customer leaves the system.

A data sheet was designed for this exercise and the above-required information was recorded in the form. The readings were collected for one complete week. The readings were collected for six random customers each day, three each during Morning and Evening shifts. A total of 72 readings were collected from both the banks combined.

B. Method of Data Analysis

Two-way ANOVA test was used to study the correlation of average waiting time with respect to time of day, bank branch and also between the branch and the time of day. It showed the variation in the average waiting time with respect to any of these attributes. The Parametric test was also conducted on the data collected through observation and the results were compared with the outcome of the ANOVA test. A mathematical equation was formulated based on queuing theory and the optimal number of counters was determined, that are required for a particular bank branch to meet its customer satisfaction level.

C. Model Assumption

The following assumptions were considered while implementing the queuing theory:

- Service rate follows exponential distribution Pattern
- Identical service rendering at all service counters
- No customer leaves the queue without being served
- Customers are served on First come and First Serve Basis

V. RESULTS AND DISCUSSIONS

We go ahead with SPSS analysis of data collected through observations at respective bank branches. Firstly, Two-way ANOVA test was performed on the data collected with variables as listed below:

- Independent Variable

a) Bank (i.e., ICICI Bank & SBI)

b) Time of Day (i.e., Morning & Evening)

- Dependent Variable

a) Waiting Time

b) Service Time

A. Correlation of Waiting Time with Respect to Bank and Time

The first study is based on analysis of change in waiting time with respect to the bank and the time of the day. A customer visiting the Public-sector bank has to wait more than customer visiting the private sector bank to avail the same service as prevalent from the results obtained.

Table 1 Descriptive Statistics: Waiting Time

Bank	Time of Day	Mean	Std. Deviation	N
ICICI Bank	Evening	1.89	1.491	18
	Morning	2.28	2.109	18
	Total	2.08	1.811	36
SBI	Evening	8.72	3.121	18
	Morning	5.83	1.689	18
	Total	7.28	2.875	36
Total	Evening	5.31	4.221	36
	Morning	4.06	2.607	36
	Total	4.68	3.540	72

The descriptive statistics show that then mean waiting time of ICICI bank which is 2.08 minutes and is comparatively less than SBI's 7.28 minutes. There can be multiple reasons for this variation in waiting time. One can be, fewer customers pay visits to Private sector Banks, as they promote digital payment means of transaction. The customers of Public sector bank find it more reliant to visit the bank than performing digital banking transactions. Moreover, on doing further analysis, it was observed that the waiting time increases from the mean of 5.83 minutes in morning to 8.72 minutes in evening in case of SBI. But in case of ICICI Bank, the opposite trend was observed, the mean waiting time got reduced from 2.28 minutes to 1.89 minutes. As this difference is quite small it will be inappropriate to say waiting time differ significantly with the duration of the day.

SPSS analysis of the data collected provides another way to interpret the data.

The hypothesis for waiting time is as stated:

H_{o1}: *There is no difference in the mean waiting time between different Banks.*

H_{o2}: *There is no difference in the mean waiting time between the different time of the day.*

H_{o3}: *There is no interaction between the two independent variables of Bank and Time of the day.*

H_{a1}: *There is a difference in the mean waiting time between different Banks.*

H_{a2}: *There is a difference in the mean waiting time between the different time of the day.*

H_{a3}: *There is an interaction between the two independent variables of Bank and Time of the day.*

Table 2 ANOVA Test: Waiting Time

Source	Type III Sum of Squares	df.	Mean Square	F	Sig.
Corrected Model	562.153[a]	3	187.384	38.907	.000
Intercept	1577.347	1	1577.347	327.510	.000
Bank	485.681	1	485.681	100.844	.000
Time of Day	28.125	1	28.125	5.840	.018
Bank * Time of Day	48.347	1	48.347	10.039	.002
Error	327.500	68	4.816		
Total	2467.000	72			
Corrected Total	889.653	71			

The results obtained from the SPSS shows that the waiting time varies from Bank to Bank. The p-value for the first hypothesis is .000 which is significant (as $p< 0.05$). Hence, we accept our first research hypothesis (H_a1) that waiting time varies from bank to bank.

Coming to the other part of the research to understand whether waiting time varies with time of day. It was observed that p-value is .018 (< 0.05), which is significant. Therefore, we accept our second alternate hypothesis (H_a2) that there is a significant difference in waiting time depending on the time of day.

The last hypothesis is to judge whether there is any interaction between time of day and bank. As the results obtained shows that p-value .002 is significant. Hence, we reject our null hypothesis and accept our alternate hypothesis (H_a3) that there is an interaction between time of day and bank on waiting time. This means that waiting time differs between SBI and ICICI in the morning as well as evening.

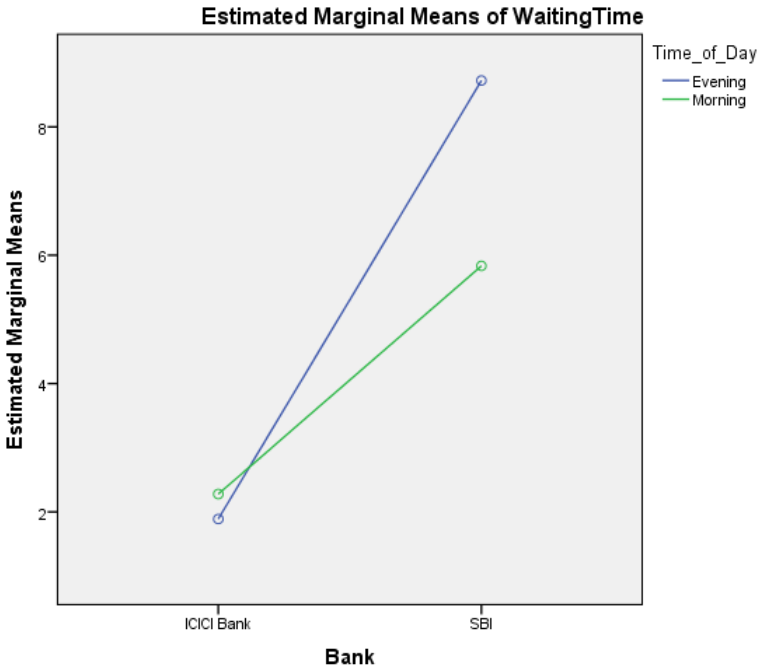

Figure 1: Waiting Time Graph

The profile plot clearly explains that waiting time changes from bank to bank and also from time to time. Even the same time of day has different waiting time for both the banks.

B. Correlation of Service Time with Respect to Bank and Time

The second study is based on analysis of change in service time with respect to the bank and the time of the day. The customer service pattern observed was FCFS (first come first serve) basis. The pattern of service doesn't show any variation depending on the bank as well as the time of day. The analysis of result obtained from SPSS will help us clearly differentiate between the fact.

Table 3 Descriptive Statistics: Service Time

Bank	Time of Day	Mean	Std. Deviation	N
ICICI Bank	Evening	3.28	.752	18
	Morning	3.22	.732	18
	Total	3.25	.732	36
SBI	Evening	4.06	1.056	18
	Morning	3.33	.840	18
	Total	3.69	1.009	36
Total	Evening	3.67	.986	36
	Morning	3.28	.779	36
	Total	3.47	.903	72

The descriptive statistics show that then mean service time of ICICI bank, 3.25 minutes is very close to SBI's 3.69 minutes. Hence from our study, we can't say that a customer visiting the Private bank shall be served in different or same time as compared to Public Sector Bank. As the banking operations have become much of standardized, the time taken by the person sitting at service counter is almost same at every bank. Moreover, on doing further analysis, it was observed that this service time almost remains same at the time of the day.

SPSS analysis of this trend shall provide a correct relationship between waiting time with a time of day and the bank.

The hypothesis for service time is as stated:

H_{o4}: *There is no difference in the mean service time between different Banks.*

H_{o5}: *There is no difference in the mean service time between the different time of the day.*

H_{o6}: *There is no interaction between the two independent variables of Bank and Time of the day.*

H_{a4}: *There is a difference in the mean service time between different Banks.*

H_{a5}: *There is a difference in the mean service time between the different time of the day.*

H_{a6}: *There is an interaction between the two independent variables of Bank and Time of the day.*

Table 4 ANOVA Test: Service Time

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	8.278a	3	2.759	3.778	.014
Intercept	868.056	1	868.056	1188.479	.000
Bank	3.556	1	3.556	4.868	.031
Time of Day	2.722	1	2.722	3.727	.058
Bank * Time of Day	2.000	1	2.000	2.738	.103
Error	49.667	68	.730		
Total	*926.000*	*72*			
Corrected Total	*57.944*	*71*			

The results obtained from the SPSS shows that the service time varies from Bank to Bank. The p-value for the fourth hypothesis is .031, which is significant (as $p< 0.05$). Hence, we accept our fourth research hypothesis (H_{a4}) that service time varies from bank to bank. This shows that the employee in the private banks works more efficiently, also they have fewer customers to cater and the workforce is more young and dynamic. Moreover, there is a reason for job risk as well that makes them work with more dedication.

Coming to the other part of the research to understand whether service time varies with time of day. It was observed that p-value is .058 which is more than α of 0.05. Hence the result is insignificant. Therefore, we fail to reject our null hypothesis and accept our fifth null hypothesis (H_{o5}) that there is no significant difference in service time depending on the time of day.

The last hypothesis is to judge whether there is any interaction between time of day and bank. As the results obtained shows that p-value .103 is insignificant. Hence, we fail to reject our null hypothesis and accept our null hypothesis (H_{o6}) that there is no interaction between time of day and bank on waiting time.

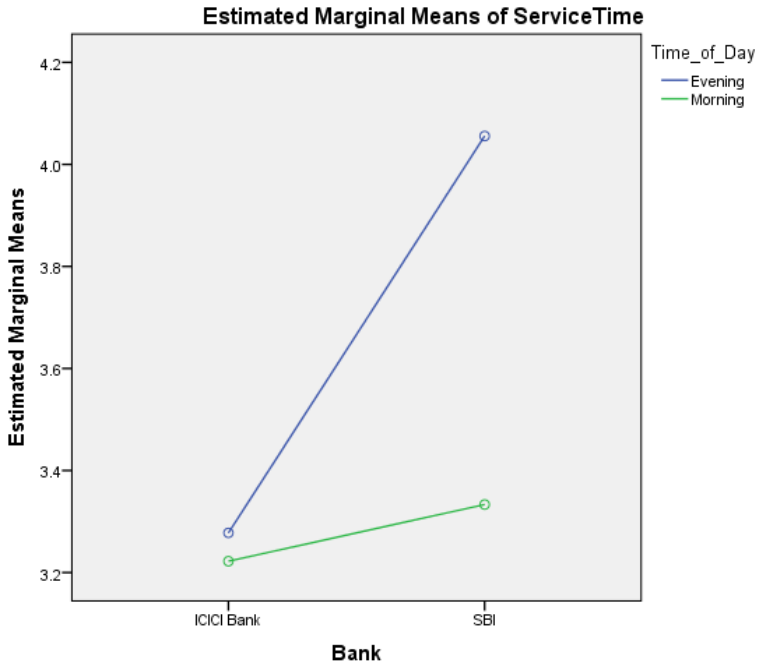

Figure 2: Service Time Graph

The graph here represents how service time is varying from bank to bank and time of day invariantly. The graph correctly shows that service time is varying with duration of the day.

C. Parametric Calculations

The formulas of the queuing theory were used to calculate the Arrival rate, Service rate, and other factors as listed below in the table. The data collected through observation at bank branches act as an input for the same.

Table 5 Parametric Calculations

Bank →	ICICI Bank			State Bank of India		
Duration →	Morning	Evening	For Entire Day	Morning	Evening	For Entire Day
Arrival rate, λ (customer/second)	0.004347826	0.00285714	0.0034482	0.004255	0.003448	0.00380952
Service rate, μ (customer/second)	0.005172414	0.00508474	0.0051282	0.005	0.00410958	0.00451127
Utilization, ρ (=λ/ μ)	84.06%	56.19%	67.24%	85.11%	83.91%	84.44%
Length of Queue, Lq = ρ2/ (1-ρ)	4.4321	0.7207	1.38	4.8632	4.3752	4.584

D. Optimisation of Number of Service Counters

Although the decision to keep the optimum number of counters, to provide service to the customer is purely managerial. But it has the element of the cost involved in it that can be used to justify the decision. Customer satisfaction is the most important factor that has to be kept in mind while formulating any mathematical model for calculating the operational cost.

a) Cost Model for Optimum Queuing System (Proposed)

We define the total cost as the summation of total operating cost as well as the cost of customer waiting in the queue.

$TC = TC_s + TC_w$

Where,

TC = Total cost for operating the banking queuing system with n servers

TC_s = Total operating cost of n servers at the bank

TC_w = Cost if customer is waiting in queue

$TC_s = s^* Cs$

Where, s = Number of serving counters at the bank

C_s = Operating cost of one service counter

Also, $TC_w = Lq * C_w$

Where, Lq = Length of queue

C_w = Wait cost

Wait cost is the cost of losing a customer. A customer becomes unhappy if he sees long queue standing in front of him.

b) Optimal Number of Servers

The aim is to come at a cost which is optimal while considering wait cost of the customer and costs involved in providing the service to the customer. Considering SBI, we got utilization factor 84.44 %. If we increase one service counter the service rate will be doubled and utilization of the server will get reduced by 50%. Parallelly, we got the length of queue getting changed with a reduction in utilization factor. It makes an overall effect on wait cost of the customer. But the operation cost gets increased as we increase the number of service counters. On discussion with the bank manager of the branch, the average customer deposit was approximately rupees 80,000 (C_w). This amount is the business that a person may take away from the bank if he or she changes the bank account to another bank. Moreover,

we have an operational cost which is equivalent to the salary of a new employee sitting on the service counter. These assumptions are taken for ease of calculation to give a clear picture of how we can come to the conclusion of an optimum number of servers.

Table 6 Optimum Server vs Cost: SBI

Server (s)	New Utilization (ρ)	Length of Queue (Lq)	Customer Wait Cost (C_w)	Total Wait Cost ($TC_w = Lq * C_w$)	Operation Cost of one Server (C_s)	Operation cost ($TC_s = s * C_s$)	Total Cost ($TC = TC_w + TC_s$)
1	0.8444	4.5841	□ 80,000	□ 3,66,730	□ 50,000	□ 50,000	□ 4,16,730
2	0.4222	0.3085	□ 80,000	□ 24,684	□ 50,000	□ 1,00,000	□ 1,24,684
3	0.2815	0.1103	□ 80,000	□ 8,822	□ 50,000	□ 1,50,000	□ 1,58,822
4	0.2111	0.0565	□ 80,000	□ 4,520	□ 50,000	□ 2,00,000	□ 2,04,520
5	0.1689	0.0343	□ 80,000	□ 2,746	□ 50,000	□ 2,50,000	□ 2,52,746
6	0.1407	0.0231	□ 80,000	□ 1,844	□ 50,000	□ 3,00,000	□ 3,01,844
7	0.1206	0.0165	□ 80,000	□ 1,324	□ 50,000	□ 3,50,000	□ 3,51,324

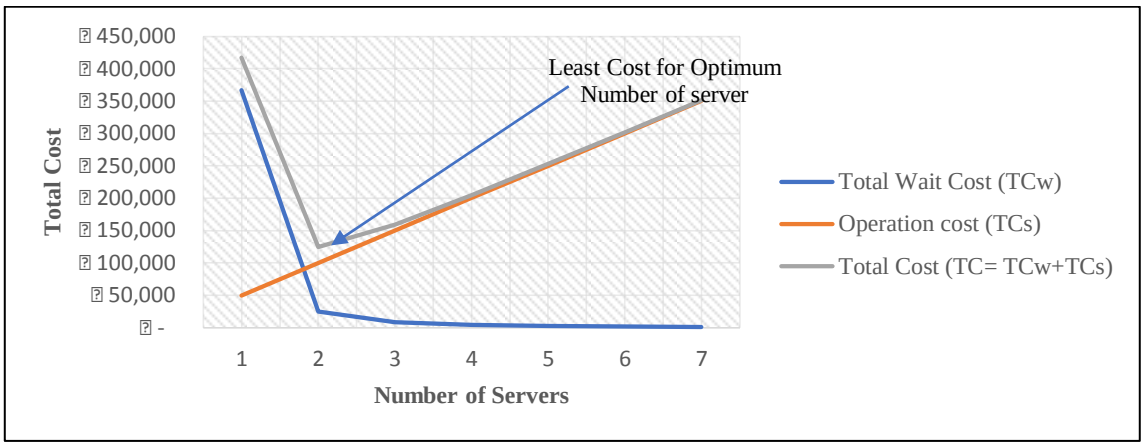

Figure 3: Optimum Server vs Cost Graph- SBI

To reduce the waiting time, we need to increase the number of servers. This has to be done with minimum cost born by the system. Therefore, for SBI we come at an optimum number of servers to be around 2.

Table 7 Optimum Server vs Cost: ICICI Bank

Server (s)	New Utilization (ρ)	Length of Queue (Lq)	Customer Wait Cost (C_w)	Total Wait Cost ($TC_w = Lq * C_w$)	Operation Cost of one Server (C_s)	Operation cost ($TC_s = s * C_s$)	Total Cost ($TC = TC_w + TC_s$)
1	0.6724	1.3802	□ 42,000	□ 57,969	□ 50,000	□ 50,000	□ 1,07,969
2	0.3362	0.1703	□ 42,000	□ 7,152	□ 50,000	□ 1,00,000	□ 1,07,152
3	0.2241	0.0648	□ 42,000	□ 2,720	□ 50,000	□ 1,50,000	□ 1,52,720
4	0.1681	0.0340	□ 42,000	□ 1,427	□ 50,000	□ 2,00,000	□ 2,01,427
5	0.1345	0.0209	□ 42,000	□ 878	□ 50,000	□ 2,50,000	□ 2,50,878
6	0.1121	0.0141	□ 42,000	□ 594	□ 50,000	□ 3,00,000	□ 3,00,594
7	0.0961	0.0102	□ 42,000	□ 429	□ 50,000	□ 3,50,000	□ 3,50,429

For ICICI bank as the average length of the queue is less than one. It doesn't seem appropriate for the bank to increase the number of servers. Increasing the number of the server will only prove to be an economic burden rather than a factor of customer delight. This is understood from the graph as well from where we get an optimum number of the server to be around one only.

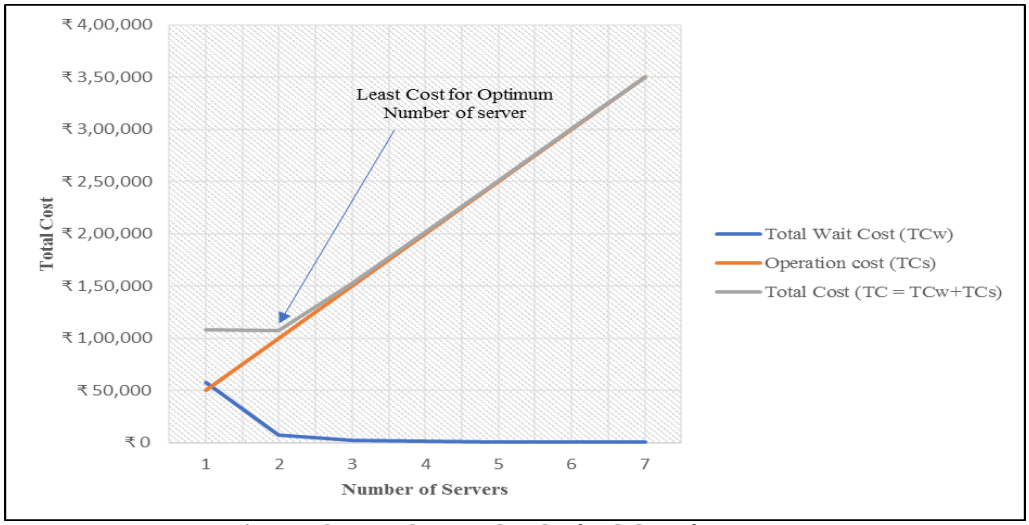

Figure 4: Optimum Server vs Cost Graph- ICICI Bank

VI. Findings and Conclusions

The study revealed that the average waiting time for the customers visiting ICICI Bank is quite less as compared to SBI. The longevity of average waiting time remains same for ICICI Bank during any time of the day (i.e., morning or evening) but when we talk about SBI this trend has a significant difference with the duration of the day. Usually, in SBI a customer has to wait more during evening hours as compared to morning hours.

The formula for calculating an optimal number of service stations in a bank branch was formulated and it was observed that for the selected ICICI Bank branch, there is no need to increase the number of service counter to improve their service level. But in case of the selected SBI branch, it was observed that there is an urgent need to increase the number of counters to provide better services to their customers at optimal cost. In this case, the selected SBI branch needs to increase their service counter number by one unit.

In the end, it is up to the manager of the bank to decide at what service level he has to benchmark his branch keeping in mind the customer satisfaction level and optimal operational cost of operating a new server.

We can conclude that it's the demography of the society that decides the tolerance level of the customer. Sometimes the customer is willing to wait for more time and still is satisfied with the service and sometimes he is so impatient that he cannot consider a single customer standing in the queue before him. So, it gets very difficult to map down the customer's expectation and satisfaction level which they derive from banking services. Still, we did our bit to come up with a mathematical model to take into account all possible aspects of customers mind frame.

VII. Limitations

The sampling done is convenient in nature, as both the bank branches were near to the place of the researcher. Moreover, the samples were taken from one branch each of both the Public and the Private sector bank. The size of the sample was also limited to 72 readings and the time period during which the readings were recorded was only for one week. The queue discipline was assumed to be present. Thus, customer behaviors like Balking, Jockeying, and Reneging was absent. The service pattern was considered to be first in first out (FIFO). We also considered that there was Poisson's distribution for arrival rate and exponential distribution for service rate.

VIII. Recommendations

The researcher recommends that SBI Branch should consider opening a new counter to address long waiting queue problem. The new server will reduce queue length thereby improving customer satisfaction level.

Few more points which can be considered are discussed below

- Appointing a service person to coordinate in customer-employee interactions. The waiting time which a customer Perceives gets reduced when an employee greets them directly, show interest in knowing the purpose of their visit and then guides them to further processes. These interactions make customers feel as if they are immediately entertained and their needs are being addressed right away.
- Engaging customers with something while they are waiting in the line. When customers in line are being engaged, their perceived wait time decreases. Televisions near waiting lines and areas or magazines kept at checkout aisles are classic examples of customer engagement. Putting sign boards nearby, directing customers regarding steps to be taken while preparing for their transactions.
- Be "FAST." Even after customers are out of line and at the point of employee interaction, the perceived wait time can be diminished. It all depends on the employee-customer interaction. Customers are happier and have lower perceived wait times when employees are "FAST" - Friendly to customers, Accurate during transactions, Sympathetic to customers' emotions about waiting and Thankful for customers' time and patronage.

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