ST. MARY'S UNIVERISITY

SCHOOL OF GRADUATE STUDIES

ANALYSIS OF FACTORS THAT AFFECT THE PERFORMANCE OF QUEUING SYSTEM IN ETHIO TELECOM: THE CASE OF IT SERVIE DESK SYSTEM

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APPROVED BY BOARD OF EXAMINERS

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Internal Examiner	Signature

DECLARATION

I, the undersigned, declare that this thesis is my original work, prepared under the guidance of Dr. Maru Shete (Assoc Prof.). All sources of materials used for the thesis have been duly acknowledged. I further confirm that the thesis has not been submitted either in part or in full to any other higher learning institution for the purpose of earning any degree.

_________________ _________________

Name Signature

St. Mary's University, Addis Ababa **May, 2018**

ENDORSEMENT

This thesis has been submitted to St. Mary's University, School of Graduate Studies for examination with my approval as a university advisor.

________________________ ____________________

Advisor Signature

St. Mary's University, Addis Ababa **June 2018**

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LIST OF ABBREVIATIONS AND ACRONYMS

CTI--Computer Telephone Integration

ITIL---Information Technology Infrastructure Library

IT--Information Technology

ATM---------------------------------------Automatic Teller Machine

FIFO---First In First Out

LIFO--Last In First Out

PR: --Service Priority

CRM---Customer Relationship Management

IVR---Interactive Voice Response

BICP---Business Intelligence Central Platform

ITSM---IT Service Management

FRS---Functional Requirement Specification

IPCC--Internet Protocol Contact Center

NIST--National Institute of Standard and Technology

NSS---Number of Support Staff

RSP---------------------------------------Responding Calls within Target Time

AHT--Average Handling Time

AO--Agent Occupancy

ANOVA--------------------------------------ANalysis Of VAriance

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ABSTRACT

The study investigated the factors affecting the performance of queueing system of Ethio telecom IT service desk. It studied the current performance of the IT service desk and how it was affected by number of support staff working, the response speed to customer calls, the time taken to handle customer's call, agent occupancy, and the number of calls dropped per day. The study was geared towards helping the manager of the IT service desk to make reasonable decision regarding the first contact resolution rate. The researcher collected relevant data directly from the actual daily traffic reporting platform for 30 consecutive weeks. A sample of 167 daily records from all population Ethio telecom was randomly selected from which 121 (72.5%) of them were refined and used for analysis. Secondary data sources were also used to obtain the system design of IT service as queuing management system and description of every reporting parameters. Correlations and multiple regression analyses were performed using the pre-existing and refined data set. Erlang C calculator was used to predict the required staff for hotline channel. The researcher identified the top ten problem types that were not solved by first level and passed to next level support team. The main finding of this study showed that the average first contact resolution rate was about 72% which was better than the lower best-case benchmark (25%), but it was lower than the best-case benchmark of the industry (95%). The empirical outcome of the study shows number of support staff working, the time taken to respond to customer's calls within 40 seconds and agent occupancy positively influenced the first contact resolution rate of queuing system of Ethio telecom IT service desk. Time taken to handle customer problem while on telephone and number of calls drop negatively influenced to the first contact resolution rate of queuing system of Ethio telecom IT service desk. It is recommended that the IT service desk manager should take a proactive measure on the top ten problem types empowering IT service desk staff to solve at first contact.

Keywords: Queuing, Performance, IT Service Desk, First Contact Resolution Rate

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

According to Fredrick, Mark, Karl and Molly (2008) management science is defined as it is a discipline that attempts to support managerial decision making by applying a scientific approach to managerial problems that involve quantitative factor. The authors also added more that management science is based on strongly on some scientific fields including mathematics, social science, computer science because the field is concerned with the practical management of the organization. Operations research is the mathematical approach towards decision making under complete or partial information, with emphasis on the optimal design and operation of systems with scarce resources (Hillier and Lieberman, 2001). They have mentioned about the applicability of the operation research it was invented during World War II when British military leaders asked scientists and engineers to analyze several military problems such as the deployment of radar and the management of convoy, bombing, antisubmarine, and mining operations. The scientific approach to decision making usually involves the use of one or more mathematical models. A mathematical model is a mathematical representation of an actual situation that may be used to make better decisions or simply to understand the actual situation better.

Queuing theory deals with the study of waiting line. The aim of all investigations in queueing theory is to get the main performance measures of the system which are the probabilistic properties (distribution function, density function, mean, variance) of the following random variables: number of customers in the system, number of waiting customers, busy of agents or server, response time of a customer, waiting time of a customer, idle time of the server, busy time of a server (Sztrik , 2016).

According to Cannon (2011) a service desk is a functional unit made up of a dedicated number of staff responsible for dealing with a variety of service activities, usually made via telephone calls, web interface, or automatically reported infrastructure events. the main responsibility of service desk function are service provision as quick as possible, improved customer service perception and satisfaction by improving the first level support, increased accessibility to assistance/help through a single point of contact, communication, and information, better quality and quicker turnaround of customer/user requests, enhanced focus and a proactive approach to service provision and assign adequate and train service desk analyst. According to the best practice book Bryant (2016) at BMC third blog has discussed specific to service desk that the critical service desk measuring performances indicators are increase/decrease of incident re-assignments, decrease of incorrectly assigned incidents, increase in incidents responded within target, increase in incidents Resolved within target and reduction in aging incidents by priority (Backlog). Therefore; with the discipline of service operation, the performances of the service desk system was not analyzed. It was important to analyze the existing operational system using the queueing theory and ITIL best practice to identify an improvement area that benefit the service desk operational activity as well as the information system division.

1.1.2 Organizational Background of Ethio Telecom

Ethio telecom is a public integrated telecommunications service provider in Ethiopia. It is organized under the Ministry of communication and information technology of Ethiopia. The company, previously known as Ethiopian Telecommunication Corporate (ETC). The Ethiopia telecommunication corporation is the oldest public telecommunication operation in Africa. It started to operate to operate under the minster of post and communication. Since 1952 telecommunication services were separated from the postal administration and structured under the Mistry of transport and communication. The Ethiopian telecommunication corporation was replaced by the Ethio telecom by regulation number 197/2010 of council of ministers to which all the rights and obligation of the former Ethiopian telecommunication corporation were transferred to the company. According to the information available at the company website (www.ethiotelecom.et). The company is established to provide world-class, modern and high-quality telecom services for all citizens equitably so as to transform the many-sided development of the country to the highest level. The company provides mobile, internet, fixed line, call center hosting service, value added service, international and national voice services. The company has the value to provide quick response to their customers and internal employees in line with their interest and values, committed for quality and efficiency in order to ensure excellent customer experience. The company is structured broadly in groups such as technical, commercial, and internal support. Among the technical group the information system division is to deliver and manage services at agreed levels to business users and customers. The internal business process is automated through enterprise resource planning tool (ERP). The information system division ensures the efficient operations and support of internal IT network, corporate service and e-communication systems of the company. It is also responsible for the ongoing management of the technology that is used to deliver and support services. It implements and supports project to enable information system division to deliver projects faster, cheaper, with higher quality and expectations. The information system division manages around 7,200 personal computers centrally. The IT service desk functional unit which is organized under the information system division is responsible to receive the issues of these computers and business application and fixed by the IT service desk support staff. The IT service desk functional unit is managing customers (around 12, 000 employees) issues and managing the queuing using Computer telephone interfaced (CTI) system for hotline channel (Access Code #878).

1.2 Statement of the Problem

The IT service desk unit of Ethio Telecom is facilitated with computer telephone interface (CTI) system to receive the request and serve the users at the best level. It was organized when Ethio Telecom is reestablished as the transformation program of late Ethiopian telecommunication corporation in 2011 G.C. The internal customer satisfaction survey report of the company has shown that it is low customers satisfaction regarding the IT service delivery and support issues. In addition to this, there was significant logs or records of call from the system shows that there were significant customers problems not solved at first level and observed balk customers behavior at queuing system that was leaving the queuing system while they were waiting for service from IT service desk support staff. In addition to this the service desk manager has mentioned during face to face discussion, he was receiving complain from users regarding problems logged to service desk were not solved at the center mostly the issues were escalated to other section, call line busy, service desk support staff ability, delay to get solution. The author added that operational IT support request logged to the information system division are being managed by the IT service desk section. However, analysis of the factors affecting the first contact resolution rate against the industry benchmark was not yet done. The primary function of the Level 1 service desk agent is to deliver live support to the end users as quickly as possible, so no one is left on hold (Brain, 2015). Even though the customer has the patience to call back later, but their interest and trust to the service desk has been diminished. Service requester can be frustrated when they are insisted to wait for long time before they contact the service desk agent and not solved their problem at the first contact to support staff. Such situation brings dissatisfaction on the customers and push them to complain about the performance of the hot line service of service desk, particular to the Ethio Telecom context the employee working in front of the customers at sales center are impatient if they are forced to wait while calling to contact service desk.

Rumburg and Zbikowski (2013) come up to conclude the most common mistakes when it derives the performance measuring of the service desk system are "they track too many metrics "and "they do not exploit the full potential of their performance metrics as a diagnostic tool". Rather he strongly suggests for service desks to track the first level resolution rate because "it is a proxy for Total Cost of Ownership and is an overall indicator of Service Desk efficiency". Chowdhury, Rahman, and Kabir. (2013) discussed in their article that queue theory is helpful for business decision makers determining arrival pattern of customers of service stations and to get better understanding of waiting line that need to develop adequate resources with acceptable waiting line. Xu (2008) has also mentioned the queuing theory is used to measure the performance of the system at commercial service system, transportation service system, internal service system, and social service system. Chowdhury et al(2013) have also shown in their international journal article the queuing theory is applicable to a variety of situation for scheduling such mechanical transport fleet, scare defense equipment , issue and return of tools from tool cribs in plants, aircrafts at landing and take-off from busy airport , jobs in production control , parts and components in assembly line, routing sales persons , inventory analysis and control , replacement of capital assets, and minimization of congestion due to traffic delays at booths. Chinwuko et al (2014) had added the applicability of the queuing theory in their American journal of engineering research paper used to analysis the queue system of First Bank PLC, Nigeria and found the result that the servers are not adequate for the customer service. They suggest adding more server in order to improve the performance of their customer service facility. Similarly, Bassamboo, Randhawa, and Zeevi (2010) have also indicated at the management science that the queue theory was used to the capacity problem of a service system which was model as single class queue with multiple servers. Dhar and Rahman, (2013) are also used to apply the queuing theory to study the performance of queuing system of banking ATM. They have shown clearly at their international journal of mathematics published in May 2013 the queuing theory was used to solve the problem of losing customers due to a long wait on the bank service center. They have made their analysis using the queuing theory to identify the customer arrival rate, ATM machine utilization factor that determine the performance the queuing system.

Finally, they have proofed that the queuing theory is applicable to the banking ATM system. Hence the purpose of this study was identifying the factors that are affecting the performance of queuing system (first contact resolution rate) in case of Ethio telecom IT service desk. The researcher was therefore interested to carry out the research in identifying the cause of low first contact problem resolution that turn in to dissatisfying the customer. These impatient customers specially call coming from sales center when they need first line support for their computer related issue left without contacting and getting proper support from the service desk agents. the impact of reducing the first contact resolution rate was increase the customer complain and therefore it had been a major impact on the performance of the queuing system and reduce revenue and internal productivity of the company as well.

The analysis of the support staff availability which was the number of support staff working to provide an online support service , IT environment availability of service desk that means number of dropped calls by the system , support staff service level assurance or motivation level that the ability to answer the requested support within target time (40 second) , agent occupancy that means support staffs time that avail themselves or busy on call to provided support and avail themselves that are logged into the system to be available was important to the service desk system in order to identify the factors that causing the less performance of the service desk which was less first contact resolution rate. This problem causes losing of customer during the process of first line support and receiving complains related to the poor performance of service desk system in case of first line problem resolution.

1.2. Research objective

1.2.1. General research objective

The main objective of this case study was to analysis the factors that affect the performance of the queuing system: The case of Ethio Telecom IT service Desk.

1.1.1. Specific objectives

- To identify factors that can increase the level of service desk performance in case of first line support.
- To examine the impact of support staff busy on hotline channel, motivation of support staff to respond a requested support within target time, Skill and ability of support staff that time taken or talk time to resolve customer problem, number of dropped calls by networked system on the performance of first contact resolution rate .
- To propose the possible solution to improve the number of problems to be resolved at the first contact.

1.3. Research Questions

The research work should address the following question in order to achieve the objective of this research.

- What were the significant factors affecting the performance of first line support for call process channel?
- How positively the number of support staff working affect the first contact resolution rate?
- How positively the ability to answer a requested support within target time affect the first contact resolution rate?
- How the higher staffed time affect the first contact resolution rate?
- What was the time taken by support staff to solve a particular customer problem?

- What was the effect of dropped calls by the networked system on the first contact resolution rate?

1.4. Research hypothesis

Kothari (2004) defines that “the research hypothesis is a predictive statement that relates an independent variable to a dependent variable”. The following hypothesis were developed under this research study that show the importance of this research study.

- H1: There was a positive relationship between the number of support staff and first contact resolution rate.
- H2: There was a positive relationship between speed of service desk staff or ability to answer a requested support within target time and first contact resolution rate.
- H3: There was significant positive relationship between agent busy time on hotline channel and first contact resolution rate.
- H4: There was negative relationship between the time taken by the support staff to solve a particular customer problem and first contact resolution.
- H5: There was negative relationship between number of call drops by the network system and first contact resolution rate.

1.5. Definition of terms

The researcher has defined the following conceptual terms from the theoretical perspective.

- First contact resolution rate measures the percentage of all calls that are resolved on the first attempt, without the agent needing to refer the customer to a colleague, their manager, or calling the customer back (Gralla,2012).
- Agent Occupancy is the average percent of time all agent are actively occupied on call includes talk time and wrap-up time (Gralla, 2012).
- Access code #878: A customer dials the access code #878 and reaches the IT service desk hotline line service to handle the call (Ibrahim and Nagaraj, 2014).,
- ITSM tool: It is HP service manager application as a service desk solution that enables IT to work as a single organization, governed by a consistent set of processes to handle service delivery and support quickly and efficiently (Cannon, 2011).
- ITIL (Information Technology Infrastructure Library) is a set of detailed practices for IT service management (ITSM) that focuses on aligning IT services with the needs of business (Cannon, 2011)..

- IPCC: The IPCC system is a multi-media contact center launched by Huawei to meet the requirements of the telecom (Ibrahim and Nagaraj, 2014).
- IVR: Interactive Voice Response (IVR) is a telephony menu system that enables identification, segmentation and routing of callers to the most appropriate agent within support team(Ibrahim and Nagaraj, 2014).
- Staffed Duration: the duration of agent staffed (Logout Time – Login Time) (Ibrahim and Nagaraj, 2014).
- Talking Duration(m): The total duration of the conversation between customer and operator(Ibrahim and Nagaraj, 2014).
- Abandoned Calls During Ringing: Number of calls cancelled by the operator while ringing at an agent voice terminal(Ibrahim and Nagaraj, 2014).
- Talk Duration: Conversation duration of the outgoing call. It's only for answered calls.
- Calls in Queue: The total number of call who is in queue(Ibrahim and Nagaraj, 2014).
- Answered calls: Total calls answered by operator in a call center. Number of times that a call is successfully transferred to manual service (Ibrahim and Nagaraj, 2014).
- Total Staffed Time: The total time that the agents were logged in (staffed) for the specified time period in any skill. This does not include time the link was down. logout time – login time(Ibrahim and Nagaraj, 2014).
- Avg. Handle Time : Average handle time.(In Huawei IPCC, the talk time contain hold time. Handle time includes talk time and after call work (Ibrahim and Nagaraj, 2014).
- Transfer Abandoning Calls: The total calls that hang up by customer when transferring manual and waiting for queuing (Ibrahim and Nagaraj, 2014).
- Droped calls: The total unsuccessful calls. Dropped Calls = Transfer Abandoning Calls + Overtime Calls + failed calls of queue exceeded + Operator No Answer Calls + Agent Rejected Calls (Ibrahim and Nagaraj, 2014).
- Talking Duration(m): The total duration of the conversation between customer and operator Includes hold time (Ibrahim and Nagaraj, 2014).
- Average Talk Duration(s): The average duration of the conversation between customer and operator. Includes hold time. Talking Duration/ Answered calls (Ibrahim and Nagaraj, 2014).
- Total Staffed Time. The total time that the agents were logged in (staffed) for the specified

time period in any skill. This does not include time the link was down. logout time – login time (Ibrahim and Nagaraj, 2014).

- Agent Rejected Calls. The total Calls rejected by the operator after ringing (Ibrahim and Nagaraj, 2014).
- Operator No Answer Calls. The total calls that operator didn't answer after queuing finish (Ibrahim and Nagaraj, 2014).

1.6. Significance of the study

The performance analysis to the service desk function would benefit to identify the actual operational practice whether it was operating as per the company expectation. Besides the result of this research study may also help the decision maker to use the scientific finding in order to plan improvement for the first contact resolution rate according to the researcher's conclusion and recommendation. In specific terms, this study was believed to have the following importance.

- It helps to identify the level of significance of number of support staff availability, the average customer call handling time, the number of calls answered within the target time (40 second), agent occupancy, the number of customer call drops, in prevailing the first contact resolution rate of ethio telecom IT service desk and recommends possible solution on the causes factors
- The finding of the study and model developed might be used as source document for further similar study.

1.7. Scope of the study

Even though the IT service request management system is highly complex designed system and consisting of different channel to provide a requested service such as email channel, automatic system alert collecting and processing channel, hotline channel which is call processing channel. The different channels were designed based on type of the requester. The scope of the research work covered only the performance analysis of call processing support channel of the IT service desk system.

1.8. Organization of the thesis

This thesis is organized in to five chapters. chapter one discusses of about the research background, statement of the research problem, research objective, research hypothesis, research scope and limitation, and significance of the study. In chapter two we discussed a related literature about operational research, queue theory, key performance indicator of IT service desk and related past work on managerial application of queueing theory. The chapter three includes the research design and methodology as well as describes the data collecting and analysis methods used. chapter four describe the results and discussion on the data that were analyses on chapter three and chapter five presents the research founding’s obtained through the thesis methodology by showing how each of the research question has been answered and how these findings together contribute to the main purpose of the study.

CHAPTER TWO

REVIEW OF THE RELATED LITERATURE

2.0 Introduction

This part introduces fundamental knowledge along with thesis and empirical literature which is evidence later in research methodology. In this section the researcher presented the foundation of operation research and commonly used to analyze the factors that affect the performance measuring of service desk as queuing system in service facility and others commonly used the queuing theory. Additionally, the existing approach of queuing theory used by some researchers studied for managerial application.

2.1 Theoretical Literature Review of Queuing System

Queue theory is one of the mathematical model used to measure the performance of a waiting line. A queuing system can be described as customers arriving for service, waiting for service if the servers are occupied, and leaving the system after own service being finished. According to Taha (2007) queueing theory is not an optimization technique rather it determines the measures of performance of waiting line such as the average waiting time in the queue and the productivity of the service facility, which can then be used to design the service installation. Waiting to get service from service delivery organization is almost a daily life. Taha (2007) queue models utilize probability and stochastics model to analyze queueing system and estimate the measure of performance by imitating the real system. The aim of all investigations in queueing theory is to get the main performance measures of the system of the following random variables: number of customers in the system, number of waiting customers, busy of agents/server, response time of a customer, waiting time of a customer, idle time of the server, busy time of a server (Sztrik, 2016). The analysis of the queuing system gives the best balance between average delay in being serviced and the cost of providing that service. Queue in service operations are often the field where customers, service providers and managers establish contact, in order to jointly create the service experience (Mandelbaum, 2002). The queue models in support of quantitative management are typically analytical, and here focus on the subset of such models that originates in operations research in general and queueing theory in particular.

According to Taha (2007) designing a queueing system typically involves making one or a combination a decision to provide the appropriate level of service to provide such as number of servers at a service facility which is the determination of the size of support staff to support request service, efficiency of the servers which is how fast the servers are required and number of the service facility which is directly related with customer arrival rate at service facility. The view point of decision makers the cost of waiting probably involves primarily of the lost profit the loss of business may occur immediately because the customers grows impatient and leaves or in the future the customer becomes sufficiently irritated that the customer doesn't come again. This situation more applicable to estimate waiting cost if the customer is internal to the organization providing the service. the customer may be employees to the organization, it is therefore it is possible to identify directly some of or all the costs associated with the idleness of these customers. Typical what is missed by the idleness is productive output, in which case the waiting cost becomes the loss in profit from all lost productivity. According to Chormy et.al 2011 in Erlang C queueing theory that the call cannot be served immediately, the call is placed into the waiting queuing with unlimited length. if the release of one of the agents happens, it is automatically assigned to the following call from the queue. The Erlang C model (or the M/M/N queue) is a simple multi-server queuing system. If the waiting queue is empty, the agent is free, and he waits for next call. According to Hillier and Lieberman (2001) the call dropping is a probability an arrived call is dropped as buffer is full or occupied buffer is exceeding a certain level, which is closely related with unfinished work distribution and virtually waiting time. The authors added the call dropping is the most part to analysis for operation research as it is generally related to quality of experience which subjectively measure a customer experience with a service. The high call drops represent high level of congestion and therefore it can be viewed as represents quality of service perceived by the user. The only essential requirement for queuing theory to be applicable is that changes in the number of customer waiting for a given service occur just as though the physical situation or a legitimate counterpart prevailed (Hillier and Lieberman (2001) and Taha (2007). Most elementary queueing model assumes that the inputs (arriving customer) and outputs (leaving customers) of the queuing system occurs according to the birth-and-death process. In the context of queueing theory, the term birth refers to the arrival of a new customer into the queueing system, and death refers to the departure of a served customer .

According to Taha (2007), Hillier and Lieberman (2001) , (Mandelbaum, 2002) and Sztrik (2016) have discussed the application of queueing theory in a practical business operational environment can help the organization to get supporting model to manage the queuing system of the IT service desk.

2.1.2. Basic Structure of Queue Model

According to Hillier and Lieberman (2001) and Taha (2007), the queening systems was represented pictorially as follows:

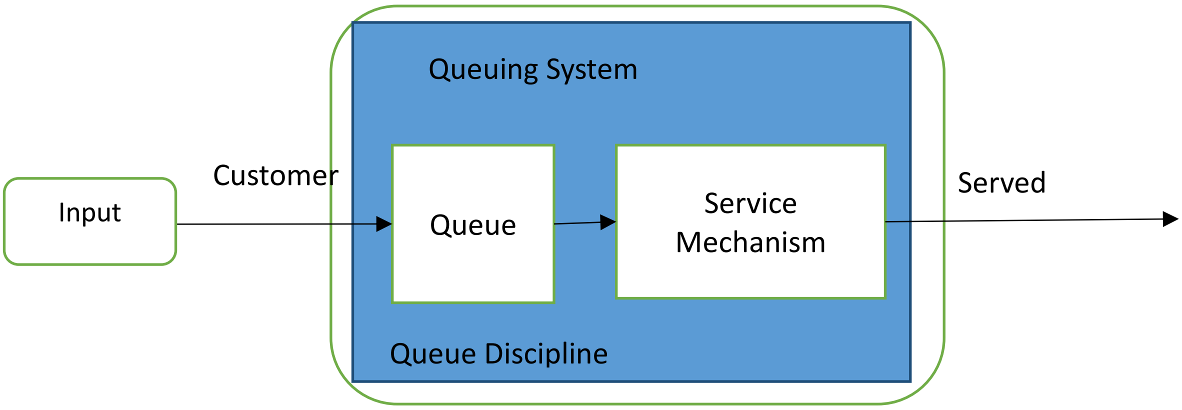

Figure 1: Basic Structure of Queue Model. Source: Hillier and Lieberman, 2001.

Input source (or source of arrivals or calling population) refers to the population from which arrivals to, waiting line come from. Size of input source is the total number of distinct potential customers. It could be finite (or exhaustible) or infinite (or inexhaustible). A customer may be balking, who refuses to enter the system and is lost if the queue is too long.

Queue is characterized by the maximum allowable number of customers that it can contain. This also could be finite or infinite. In most of the practical situations, it is finite. Queue discipline refers to the order in which members of the queue are selected for service. The order is usually first-cum-first-served. However, priority-discipline models give priority to rush jobs and important customers over others and follow random selection, priority selection or last in first out (LIFO).

The service mechanism consists of one or more service facilities, each of which contains one or more parallel service channels or stations called Servers. Service time (or holding time) is the time elapsed from the commencement of service to its completion for a customer at a service facility. Interval time is the time between consecutive arrivals of customers to waiting line. State of system is number of customers in queuing system and queue length refers to number of customers waiting for service. In other words, state of the system minus number of customers being served will give queue length.

2.1.3 Contact Center Viewed as Queuing System

In a queueing model of a contact center, the customers are callers, servers (resources) are telephone agents (support staff) or computer telephone equipment, and tele-queues consist of callers that await service by a system resource. The simplest and most-widely used such applicable model is the M/M/s queue, also known in contact center environment as Erlang C assumes out busy signals, customers impatience and services spanned over multiple visits (Mandelbaum, 2002). The primary service desk system role is that of providing first level support through taking calls and handling the resulting incidents or service Requests, using the incident management and request fulfillment processes, in line with Service Desk objectives (Cannon ,2011).

To summarize according to the queueing theory particularly M/M/S queueing model and supported by (Mandelbaum, 2002) and (Cannon ,2011).The service desk functional unit can be viewed as a queueing system because the service desk system is facilitated by the number employees to provide an online IT related services to their customer when the customer's call is enter into the waiting queueing buffer and served based on the first input first out (FIFO) or last input first out (LIFO) , or Priority request (PR)discipline .

2.1.4 General Performance Measures Of Queueing Systems

Operational service level is typically qualified in terms of customer request congestion or performance measure. The scientific approach in the practice of call center management, as queueing system is a quantitative approach often amounts to merely monitoring performance and intervening if that is considered necessary. The contact center manager tracks performance indicators and reacts when they reach unacceptable levels; for example, too many customers are waiting or too many agents are idle (Mandelbaum, 2002). Taha (2007) also added any queuing system can be measure by steady-state probability of having n customers in system, probability of n customers in system at time t, customer arrival rate, service rate of one server, server utilization. First contact resolution is a measure of how effectively any service desk conducts its business, and is a function of many factors, including the complexity and types of transaction handled, the experience of the service desk agents , the quality of agent training , and tools such as knowledge management and remote diagnostic that are available to the service desk agents (Rumburg and Zbikowski ,2012). Contact center analysts often use the Erlang C queueing model to determine the required employees for contact center (CHROMY et.al, 2011). The agent utilization is staffed time (Total Talk Time + Total Hold Time + Total Wrap Time + Total Avail Time) divide by paid time. Utilization would simply mean the percentage of time an agent is occupied with any productive or billable activities. In a more scientific approach, management is pro-active rather than reactive for example, ensuring that waiting is rare rather than adding agents when waiting becomes excessive (Mandelbaum, 2002 and Taha (2007)). When analyzing a system with a single queue, the most common performance measures are (i) Server utilization describes the fraction of time that the server is busy, or the mean fraction of active servers, in the case of multiple servers; (ii)

Throughput describes the number of jobs, whose processing is completed in a single unit of time; (iii) Queue length is the number of jobs waiting in the queue at a given time (iv) Waiting time is the time that the jobs spend in the queue waiting to be served;(iv)The number of jobs in the system at a given time;(v)The probability of a given number of jobs in the system (Xu, 2008). The essence of operations management in a contact center is the matching of service requests with resources. Performance analysis supports this tradeoff by calculating attained service level and resource occupancy/utilization as functions of traffic load and available support staff. The researcher started with describing the simplest such models and then expand to capture main characteristics of today's highly complex contact centers. According to Gralla(2012) has designed the global best practice of measuring the call center performance that concentrate to maximize the customer satisfaction and to maintain an efficient , a high performance call center are percentage of calls received by the center, calls that are response rate with target time, calls that are abandoned while the customer is waiting for a human agent, Accuracy of call forecasting, agent availability, agent occupancy, amount of time spent speaking to customers on the telephone, the time that an agent takes after the call has finished to complete the case (call wrap up time), agent absenteeism, staff turnover annually (attrition), Customer satisfaction, First call resolution rate, and quality of calls. The performance of contact centers depends importantly on the skills, abilities, and motivation not only of the frontline staff, but also of supervisors and managers (Batt et.al,2004).

According to Gralla(2012), Batt et.al(2004) and Rumburg and Zbikowski (2012), the main objective of the service desk system is to close customer's issue during the first contact. Customers don't want to wait to get service. As it is indicated above the first contact resolution rate is the main measuring performance of the service desk system. Therefore, the customer satisfaction will be improved when their cases are closed at first contact.

2.1.5 IT Service Desk Workflows

Contact centers can be categorized along many dimensions: (i) functionality as help desk, emergency, tele-marketing, or information providers, etc. (ii) size from a few to several thousands of agent seats, (iii) geography as single or multi-location, (iv) agents characteristics as lows killed or highly-trained, (Mandelbaum, 2002). According to Cannon (2011) a service desk is a functional unit made up of a dedicated number of staff responsible for dealing with a variety of service activities, usually made via telephone calls, web interface, or automatically reported infrastructure events. The high first contact resolution rate is almost associated with high level of customer satisfaction (Rumburg ,2011).

According to Ibrahim and Nagaraj (2014) the IT service desk workflow is depicted in the following figure 2 to handle the internal Ethio telecom staffs support request. operational data is typically collected by the Automatic Call Distributor (ACD), which is part of the telephony-switch infrastructure (typically software-based). Business data is gathered by the Computer Telephony Integration/Information (CTI) software, that connects the telephony-switch with company data-bases, typically customer (internal employees) profiles and business histories. The workflow is specified that the system is interfaced with customer information database to identify the internal customer number from the external customer, preconfigured specific access code (dial #878) in customer relation management (CRM) system to enable the call center to accept the call to the IT service desk IVR workflows. It records voice recognition for further quality assessment and perception of service level and working environment, Existing performance models are based on operational automatic call distribution (ACD) data. The objective, however, is to integrate data from the two sources ACD and CRM, which is essential if one is to understand and quantify the role of (operational) service-quality as a driver for business success.

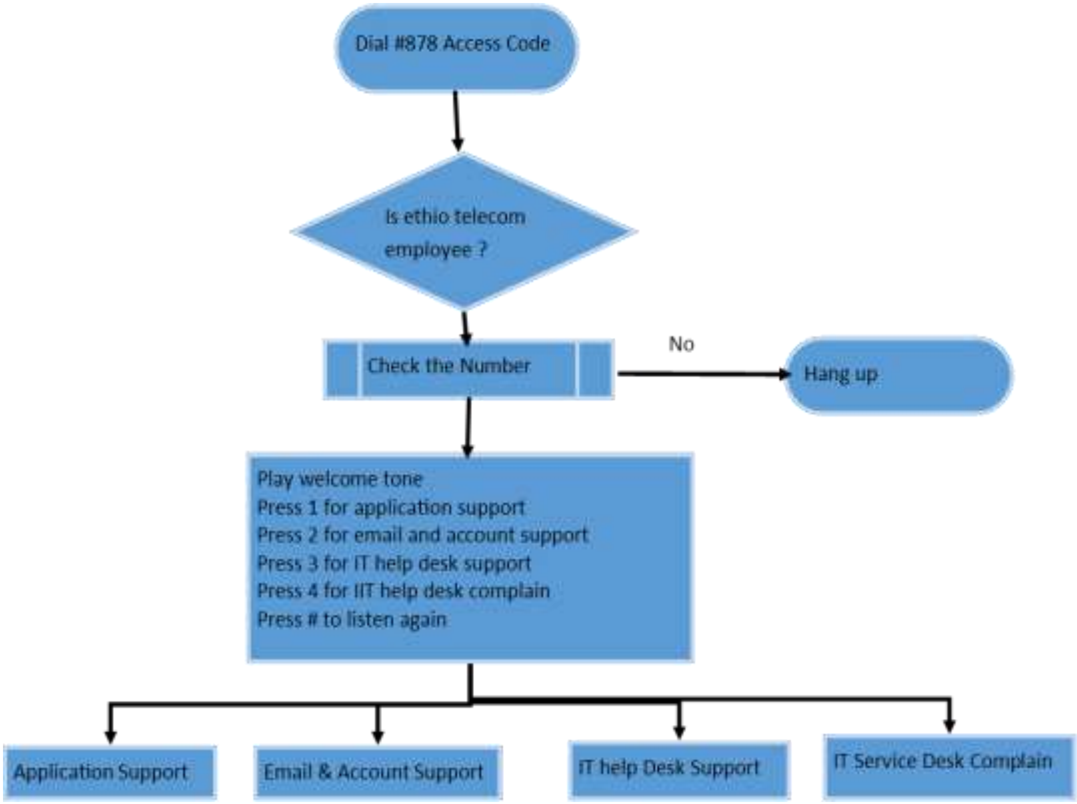

Figure 2.2: IT service desk workflows. (Source: Ibrahim and Nagaraj ,2014).

According to the Ibrahim and Nagaraj ,2014 the Ethio Telecom IT service desk system was designed based on the queueing structure modeling. The call from the internal customer are considered as an input to the system, the automatic call distribution (ACD) was consider the queue management, the support staffs which were grouped into application support, email and account support , IT help desk support and IT service desk complain group were considered as servers and first contact resolution rate was the output of the IT service desk system.

2.2 Empirical Studies On Queueing System

Frimpong (2015) described and investigate queueing management system at the credit customer pay point center and prepaid customer pay point center of the electricity company of Ghana at Dichamo branch. The researcher used a quantitative approach. The objective was to find the average number customers waiting in a queue and system and the average waiting time in a queue and system at the pay point. An excel spreadsheet was used to organize and analyze the data collected at the pay point. The main outcome performance measure of the queue system was used in the study were general idleness of the servers, average number of people in the queue, average number of customer in the system, average time spent by the customer in the queue, and average time spent by the customer in the system. At the queue management system customer arriving the service center, for which they need service. The researcher concluded that, the queueing management system increase in decreasing the waiting time in the queue and the waiting time in the system increase with an increase in the number of servers. Finally the researcher recommends the efficiency of the computer network system at both pay points centers must be enhanced to reduce the service time, the number of servers at the prepaid customer pay point center must be increased from one to two during peak hours of the day and months to reduce the service time, the manager of electricity company of Ghana must increase the number of pay points to reduce the number of customers that come to pay their bill and purchase credit to reduce the waiting time .

Najeeb (2006) has discussed based on different theory of queueing system along with its effective application. The study describes a queuing simulation for a multiple server process as well as for single queue models. The researcher used secondary quantitative research methodology. The study requires an empirical data which may include the variables like, arrival time in the queue of checkout operating unit (server), departure time, service time, etc. The objective was to discuss the application of queueing theory on different systems such as an application on health care systems, sales systems, computer systems and communication systems The researcher developed a model for a sales checkout operation in the supermarket after getting the main idea in the application of a mathematical model is to measure the expected queue length in each checkout sales service unit (server) and the service rate provided to the customers while checking out. An excel spreadsheet and simulation software was used to organize and analyze the data collected. In conclusion queuing theory has a much-diversified range of applications. The queueing theory also explains the mathematical, as well as, social study of waiting lines in everyday life. Through the prediction and analysis of waiting times in various organizations, management can extract effective results and strategies. . Finally, the researcher recommends organizations that actively integrate queuing analysis for the betterment of their organizational bodies should form strategies, which are not yet able to identify the worth of this queuing study.

Ekmekciu (2015) demonstrate the queueing management system and compare the theoretical performance forecasts of the Erlang C model to a call center simulation model in which a lot of the Erlang C assumptions are liberated. The researcher used a quantitative approach. The objective was as a queuing model generally used to examine call center. An excel spreadsheet was used to organize and analyze the data collected at the pay point. The main outcome performance measure of the queue system was used in the study were general idleness of the servers, average number of people in the queue, average number of customer in the system, average time spent by the customer in the queue, and average time spent by the customer in the system. At the queue management system customer arriving the service center, for which they need service. The researcher concluded that their analysis demonstrates that when the researcher tests the Erlang C model over a range of acceptable conditions forecasted performance measures were dependent to large errors. The Erlang C model works fairly well for large call centers with low to moderate usage rates, but factors that have the tendency to generate caller abandonment; like high usage, impatient callers, and small agent pools cause the model error to become quite large. The case that the model's tendency to give pessimistic estimates helps clarify its continued popularity. Forecast error is powerfully correlated with the abandonment rate thus the model works best in call centers with large numbers of agents and almost low utilization rates. Finally, the researcher recommends to concentrated on examining the increasingly popular Erlang A model and comparing its performance to the Erlang C model to test the growing agreement that Erlang A is a greater model for call center analysis.

Kamba (2011) investigate and develop simulation for queueing management system at Vodafone call center of Ghana telecommunication company limited which is a group international Vodafone. The focus of the research was the Vodafone information technology (IT) call center called IT help Desk. The IT help desk is part of this group and are responsible for handling complaint of internal IT customers. They are the first line of support for all IT related incidents. The researcher used a quantitative research approach. The object of the study was to model queue in the Vodafone call center using queueing theories, develop a forecast for the rate at which calls arrived at the call center and the average handling time, from data collected, and develop a simulation model which would be used in determining the minimum number of agents required to operate at a minimum staff and waiting cost. An excel spreadsheet was used to simulate and analyze the data collected at the at the IT help desk section of the Vodafone call center. the main outcome performance measure of the queue system was used in the study were service and arrival rate determined. At the queue management system customer arriving the service center, for which they need service.

Chowdhury et al (2013) describe several common queuing situations and present mathematical models for analyzing waiting lines following certain assumptions (i) arrivals come from an infinite or very large population, (ii) arrivals are Poisson distributed, (iii) arrivals are treated on a FIFO basis and do not balk or renege, (iv) service times follow the negative exponential distribution or are constant, and (v) the average service rate is faster than the average arrival rate Islamic Bank Bangladesh Limited, Chawkbazar Branch, Chittagong. The focus of the research was to illustrate model in this Bank for customers on a level with service is the multiple-channel queuing model with Poisson Arrival and Exponential Service Times (M/M/S in this Bank for customers on a level with service is the multiple-channel queuing model with Poisson Arrival and Exponential Service Times (M/M/S). using the queueing management system performance metric series of operating characteristics were computed, total expected costs are studied, total costs was the sum of the cost of providing service plus the cost of waiting time. The researcher used a quantitative research approach. An excel spreadsheet was used to analyze the data collected at the at the IT help desk. the main outcome performance measure of the queue system was to find the total minimum expected cost used in the study were service and arrival rate determined.

Nafees (2007), analysis of queuing systems for the empirical data of supermarket checkout service unit as an example. The study describes a queuing simulation for a multiple server process as well as for single queue models. The researcher used a quantitative approach. The study requires an empirical data which may include the variables like, arrival time in the queue of checkout operating unit (server), departure time, service time, etc The objective was to review queuing theory and its empirical analysis based on the observed data of checking out sales service unit of the supermarket. The researcher developed a model for a sales checkout operation in the supermarket after getting the main idea in the application of a mathematical model is to measure the expected queue length in each checkout sales service unit (server) and the service rate provided to the customers while checking out. An excel spreadsheet and simulation software was used to organize and analyze the data collected. The main outcome of the study was a model designed for this example is multiple queues multiple-server model. The model contains five servers which are checkout sales counters; attached to each server is a queue. This study indicated that the queueing system required an empirical data which included arrival time in the queue of checkout operating unit(server), departure time and service time.

Rumburg and Zbikowski (2012) investigate and design a new way of to increase the performance of first contact resolution at regional bank. The focused of the research was to improve the low level of customer satisfaction at the bank .The number contacts resolved on initial contact with the customer was low at only 61%. The researcher used a quantitative research approach. The object of the identify was to increase the first contact resolution. An excel spreadsheet was used to analyze the relation between the agent training and first contact resolution rate. the researcher has shown that the first contact resolution rate significantly drives the customer satisfaction level. the main outcome the study was to of the service center was used in the study were the common service desk metric such as first level resolution rate, the agent training and occupancy, service level responding customer call within 30 seconds, call quality and first contact resolution, agent productivity and call handling. they have indicated also after implementing the performance goal of first contact resolution, over the period of eight months the bank realized a substantial increase in first contact resolution and hence the customer satisfaction. They have concluded that among the top seven service desk metrics the one that have the greatest influence on cost and customer satisfaction is first contact resolution. These seven metrics represent the 80/20 rule when it comes to service desk performance: 80% of the value you receive from performance measurement and management in service desk can be derived from these seven-simple metrics. They have added also the biggest driver to the first contact resolution is the agent training. this implies that agent skills and ability pay off in terms of improved first contact resolution and that obtain improvement in customer satisfaction. They suggest tracking the first level resolution because it is a proxy for total cost of ownership and is an overall indicator of service desk efficiency.

According to Bryant (2016) first line resolution rate, call abandoned rate and response time for high priority incidents were mentioned the most critical factors to measure the actual performance of a service desk system. similarly, for hotline service such as call center organization the international finance corporate a sister company of world bank and member of world bank group has discussed the global best practice to measure the performance of call center are customer satisfaction, first contact resolution accuracy of call forecasting, agent occupancy, call duration, call wrap-up time, average speed to answer and abandoned calls.

Tamrat (2010) investigate fixed line service failure and recovery performance of Ethiopian Telecommunications Corporation. The focus of the research was to identify the cause service failure and maintenance delay in service recovery. The relevant data were collected through both secondary and primary sources. The researcher used a qualitative research approach. The object of the study was to model queue in the Vodafone call center using queueing theories, develop a forecast for the rate at which calls arrived at the call center and the average handling time, from data collected, and develop a simulation model which would be used in determining the minimum number of agents required to operate at a minimum staff and waiting cost. The data was analyzed using qualitatively and simple statistical tools like percentages, averages, frequency and totals. Cause and effect diagram was used in identifying the major causes of service failure and delay in service recovery. Aging of cables, poor quality of apparatus, theft, damages due to construction of roads and buildings, installation of water pipelines and electric lines by respective organization were found the major causes of fixed line service failure. The researcher has recommended that ETC should take proactive measures in relation to old network maintenance and should work closely with other organizations, providing customer service through call centers make customers to easily communicate with the service provider without the need to go to company premises, adequate resources both computers and personnel capable of handling complaints through 997 call centers.

According to a survey of Batt et.al (2004) shows that on-going training is an important part of workplace practices. On average, call centers provide about 2 weeks of on-going training each year that represents 3.8% of an employee's annual work time. This indicates that the level of skill of the support staff less time in handling user request and closed more issues at first contact.

From the above discussion, it can be concluded that the service desk system can be viewed as queuing system and the impact of first contact resolution rate may occur in overall service desk performance and customer satisfaction. The following subsections of this chapter aim to review the existing empirical literature concerning the benefits of recognition programs.

This chapter reviews the theoretical and empirical literature on queueing system and its application on different managerial application such as banking, telecommunication, call center, super market. The chapter first tries to explain the queueing system. Apart from that, theoretical approaches, related works to application of the queueing system, viewing the contact center as queueing system, performance the queueing system in relation to the service desk performance metrics. A brief overview of the IT service desks workflows in relation to the queueing system of study area, Ethio telecom, is also included in the chapter**.**

2.7 Conceptual Framework

Rumburg (2012) has provided a framework for designing a unique assessment that has a strong correlation with the first contact resolution strategy for quantifying a specific service desk low level of customer satisfaction. The performance of the service desk system which was first contact resolution rate can be increased when adequate number of support staff are assigned with the expected level of motivation and skill under proper IT infrastructure and monitoring. following the literature review in this chapter the relationship between the key element of service desk system independent variables and first contact resolution rate is depicted in the diagram below.

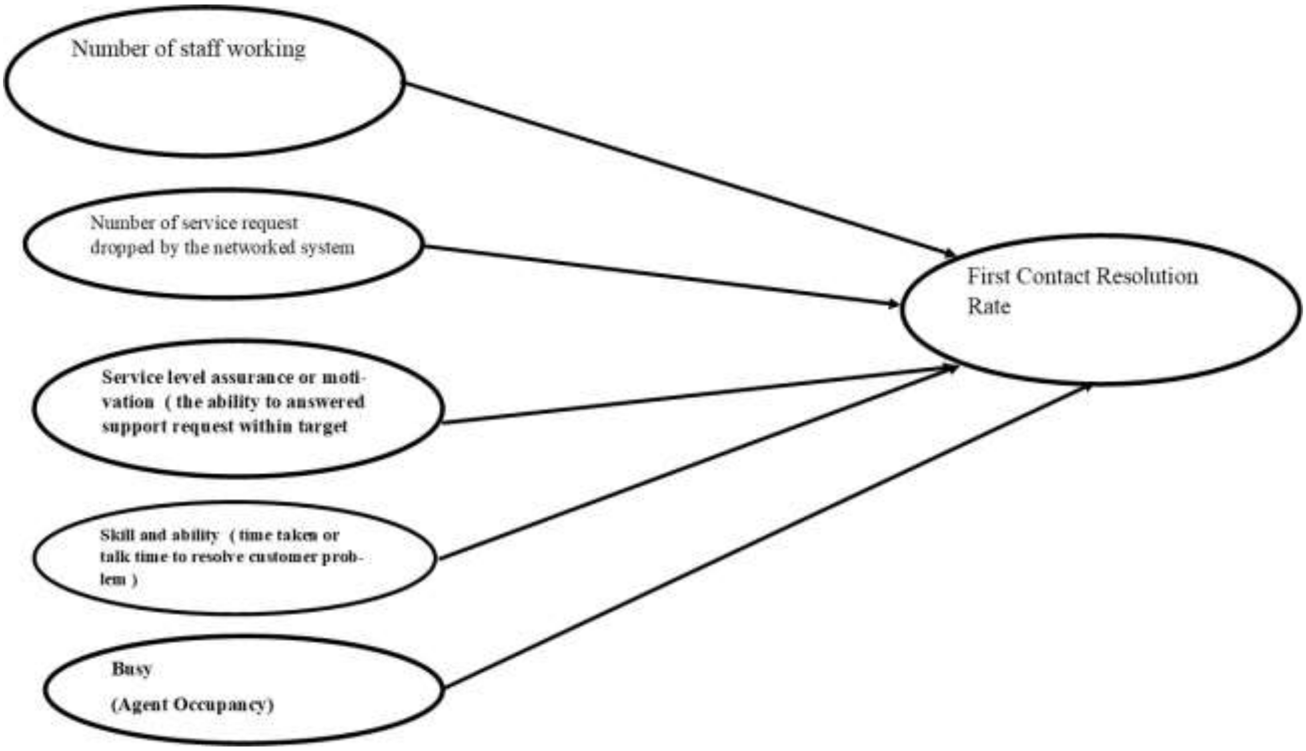

Figure 2.3: Conceptual framework of the thesis

Source: Adopted from Rumburg ,2012

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter deals with the research methodology that covers research approach, method, design, data collection, analysis method that was used in reaching the objective of the research. Hypotheses were formed after critical review of the relevant academic literatures and other research works to queuing management system and information technology(IT) service desk systems.

3.2 Research Approach and Design

This research used a quantitative research approach. A quantitative approach is one in which the investigator primarily uses post-positivism philosophy for developing knowledge, i.e., cause and effect relationship between variables of interest or it employs strategies of inquiry such as experiments and surveys and collect data on predetermined instruments that yield statistical data (Creswell, 2003). The service level expectation of the service desk system as queuing system problem is most often measured quantitatively. For this purpose, the actual performance of the service desk system such as the skill and ability of the support staff, occupancy rate of the service desk staff, accessibility of staff, the service level was considered to evaluate the influence on performance of service desk system (first contact resolution rate) were all measured quantitatively. The research was designed to identify the major factors that affect the performance of the service desk which cause customer dissatisfaction for the low hotline service provisioning. Specifically, the research work identified the factors causing the first contact resolution rate. Therefore, causal research design was adopted because it helps to identify the causes of the queuing system performance.

3.3.Variable, Data Sources and Data Collection Tools

3.3.1 Data Sources and Data Collection Tools

The researcher used the primary and secondary data. The primary data were used for the main research work of this study that was used to analysis the performance of the queuing system using the key performance indicator of IT service desk. The secondary data was the documents which were kept by the company for reference. The researcher used those documents such as technical document, design document, reports, journal or news and so on to study the existing IT service desk as queuing system which consists of the basic requirement of the queue theory for service desk system.

The researcher obtained data directly from the system logs and did the statistical analysis to identify the factors that affect the performance of queuing system (first contact resolution rate). This approach was ideal because of its accuracy in data collection and its being reliable and economical. Moreover, the study utilized interactive voice recognition (IVR) and service desk trouble ticketing system in the sense that all relevant data was collected at central computer system. The reason for using this cross section was because of the vast nature of the service desk system. The researcher began with the queuing theory and service desk benchmarking, collecting data on careful measurement and was analyzed using statistical procedure and hypothesis testing that explain the causes of the low first contact resolution rate. The data were collected from September 01, 2017 to March 31, 2018 covering a total of 167 observations from the online IT service desk system.

3.3.1.1 Primary data

The researcher has collected the primary date directly from the queuing management system that was recorded and not yet analyzed. The primary data collected from the IT service desk hotline channel report database as quantitative data in Microsoft excel. All data gathered from the two main systems (BICP and ITSM) were then presented in the table format in the data collection template designed for this research according to their use and defined in the research proposal.

3.3.1.2 Secondary data

Published secondary data were reviewed and discussed in order to get the appropriate information and the particular report types of the IT service desk hot line services. The researcher has tested the reliability of the information that were taken from the existing document. All documents were signed and last update. The documents are owned by the design team. The researcher has received the document from the project owner. The researcher has checked bias free. The adequacy of the data was checked by the researcher. The definition of every reporting functions and modules were taken from the functional requirement specification (FRS). The workflow of the IT service desk for hotline service was collected from the functional requirement specification (FRS). The researcher has cited different sources in order to get the international set standard or benchmark about IT service desk key performance indicators.

Table 3.1: List of Secondary Information

S/N	Document Name	Scope of the document
1	Ethio-FRS-IPCC-014-Report-V2.0.docx	Provide the detail description of Internet Protocol Call Center(IPCC) Report
2	Ethio-FRS-IPCC-002-V2.0-CTIPlatform.pdf	provided the functional description of computer telephone interface (CTI) platform.
3	Ethio-FRS-IPCC-003-CSPAgent-V2.0.pdf	Provided the function of agent framework, call control and service quality management.
4	Ethio-FRS-IPCC-013-IVRselfservice-V2.0.pdf	provided the functional description of IVR workflows for hotline service (Access Code #878).

3.3.2 Variables:

The researcher studied the following variables at this time. The performance of the service desk system (first contact resolution rate) is the dependent variable while the following are the lists of independent variables:

- Number of support staff working
- The number of customer calls answered within target time (40 second)
- The average call handling time
- Agent occupancy
- Number of dropped calls by the networked system

3.4 Population and Sampling

3.4.1 Target Population

The target of this study was Ethio telecom service desk system that providing different service for the internal employees when they were requesting first line support for information system tools to operate the company's economic activity and internal business processes. All service request and incidents logged to the service desk system was taken for research input. According to the service desk manager all Ethio telecom employees regardless of their responsibility were already granted system privilege that allow them to contact service desk agents when they were demanding service or logging when incident happened on their computer system. Hence all Ethio telecom employees contacting service desk system from September 01,2017 to March 31,2018 were the population of this study.

3.4.2 Controlled Observation and Sampling

When observation takes place according to definite pre-arranged plans, involving experimental procedure, the same is then termed controlled observation (Kothari 2004). The researcher developed specific template that standardized the service arrival time according to the case company working hours for service desk. The primary data was collected directly from the system and recorded daily from September 01, 2017 to March 31, 2018 for over 30 consecutive weeks totally 167 working days as per the template designed for this research work.

3.4 Techniques of Data Analysis

A record template was designed to take the time and the customers service support arrived or logged and the time taken by the service desk agent to provide the solution. The researcher had obtained daily report from ITSM and BICP. All the observed daily data were recorded on Microsoft excel and analyzed using different types of descriptive statistical tool such as mean, median, mode, variance, difference, and percentages. This was done to describe the first contact resolution rate, staff availability or the number of actual staff working, the motivation of support staff to respond to support call within target timeline (40 seconds), the skill and ability of support staff that the time taken or talk time to resolve a particular customer problem, and the number of calls dropped by IT environment of the service desk. Microsoft excel analysis ToolPak was used to describe the degree of relationship between the performance of the service desk system (first contact resolution rate), the number of support staff working, the motivation of the support staff to answer a support request within target time, the skill and the time taken by support staff to resolve customer's problem, and the staff time of IT service desk hotline service. Besides, inferential statistics (multiple regression) analysis was used to determine the casual relationship between the dependent variable and the independent variables

Besides, the qualitative reflection of the IT service desk users was taken through interviews. the purpose of this collecting information was to get their perception why the IT service desk users was left the queuing system while waiting service from the IT service desk support staff. This qualitative reflection of the IT service desk users was discussed and incorporated within the regression analysis based on sample taken to this research work.

3.4.1 **Data Cleaning Process Check and Remove Outliers From The Sample Data Set**

The main purpose of checking and removing outliers from the sample data is that those extreme data points can skew the result mostly causing misleading the outcome. There were certain values in the data which were very much different as compare to the other value of the data for the variables. According to NIST (2012), outliers are defined as an observation that lies an abnormal distance from other values in a random sample from a population. The researcher believes that removing those outliers can make the result better. The researcher has utilized Microsoft excel functionality. This Research uses the procedure to remove the outlier from the dataset (“https://www.Absentdata.Com”,2017), the quartile function in excel is represent how the data is broken up in to quarter. The quartile is a dividing point which splits the data into first quarter (1Q), second quarter (2Q) and third quarter (3Q). the first quarter (1Q) is the lower quarter, the second quartile (2Q) is the middle value and the third quartile (3Q) is the upper portion of the data. the range values from Q1to Q3are called the inter-quartile range (IQR). So, outlier is outside of the inner quartile range. by statistical definition, they exist 1.5 times below or above the inner quartile range. the following formula are used in excel 2007 and later to find the quartile. The equation was shown under appendix G. According to the result shown in appendix G, 28 (16.87%) sample records of number of employees working, 2 (1.2%) sample records of response to answer customer’s call within 40 seconds, 9 (5.4%) sample records of agent occupancy, 9 (5.4%) sample records of dropped calls and 3 (1.8%) sample records were identified as outlier. The researcher has refined all the sample data by removing the sample where outlier was identified in either of the variables. Finally, the research data set was synthesized to 121 samples.

3.4.2 **Normality of the Distribution Test**

Skewness is a measure of the extent to which the probability distribution of random variable places on any side of the mean of the variable. A probability distribution does not need to be a perfect bell-shaped curve. Positively skewed data is also called right skewed, right-tailed, skewed to the right. Negatively skewed data is also called left skewed, left-tailed, skewed to the left . Kurtosis is the measure of heaviness of the tails in a distribution known as peakdness or flatness of the distribution compare with the normal distribution. in normal distribution the score of kurtosis is zero.

The data collected in this research study was evaluated for normality, skewness, and kurtosis using quantitative analysis tool (Microsoft Excel Toolpak data analysis Add-In). the data has no problem if it is fall within the acceptable limit of skewness and kurtosis between -2 and +2 as cited by Janet (2016) in (Trochim & Donnelly, 2006; field, 2000&2009; Gravetter &Wallnau , 2014).The researcher has evaluated skewness and kurtosis of the determinant factor in the table below.

Table 3.2 Kurtosis and skewness of the variables

	Number of support staff	Answered with in 40 Sec	Avg. Handle Time (sec)	Agent occupancy	Dropped Calls in Manual Service	Performance of Service Desk (First Contact Resolution rate)
Kurtosis	0.02	0.42	0.78	-0.39	-0.26	-0.24
Skewness	-0.13	-0.76	0.61	-0.75	0.66	-0.43

The above table indicates that the kurtosis and skewness result were within the acceptable limit. Therefore, the researcher has concluded that data of all variables have no problem that shown the normal distribution and all the data of variables were considered reasonably for further analysis.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 **Introduction**

In this section the key finding of the study work was organized in such way that every finding alongside to the objectives set in chapter one was organized. The value of every finding toward the achievement of the objective was discussed against to the performance analysis of the IT service desk. In addition to the above statement the finding here in this case company was discussed beside to the other research work findings.

4.2 Descriptive Statistics of the Independent Variables

The contributing factors of Ethio telecom IT service desk performance were categorized and assessed based on the real data obtained from the automated system designed for IT Service desk hotline (Access code 878).

Based on the descriptive statistics various analysis related to the dependent and independent variables has been made. the independent variables were number of support staff, answer the customer call with business target time, average handling time of customer problem, agent occupancy, and dropped calls and the dependent variable is the first contact resolution rate. the discussion for this descriptive statistics part were prepared based on the data collected and synthesized as follows.

Table 4.1: Summary Statistics

	Number of support staff	*Answered with in 40 Sec*	*Avg. Handle Time(s)*	*Agent occupancy*	*Dropped Calls in Manual Service*	*Performance of Service Desk (First Contact Resolution rate)*
Mean	15.50	74.00%	248.58	8.49%	32	72%
Median	15	75.19%	248.00	8.27%	30	72%
Frequency	167	121	121	121	121	121
Percentage	100.00%	94.61%	94.61%	94.61%	100%	100%
Minimum	11	43.23%	178.00	3.46%	11	56.18%
Maximum	19	90.71%	372.00	21.81%	70	84.62%

4.2.1 **Descriptive Statics for Number of Support Staff Availability**

According to Goe (2015), accurate IT help desk staffing is critical to efficient and effective IT support and is supported by Erlang C Queue model. If actual number of calls enter to queueing line is higher than predicted, there will not be enough support staff to respond which will put pressure on the support team and impact the service level (Gralla, 2012). When customers were calling to the service desk hotline service (Access Code 878), the service desk staff must carry out initial diagnosis, solve, typically while the customer was still on telephone. The service desk staff should check that the problem is fully solved, and that the customer is satisfied and willing to agree the problem can be closed. The mean value is 15.5. this means that about 15 IT support staff was assigned and working to provide the first level support to Ethio telecom employees. The median was 15 and the most frequent value was also 15 (mostly 15 IT support staff was supporting per day).

4.2.2 **Descriptive Statistics for Responding Customer Calls Within Target Time (40 Second)**

According to the system design the minimum target time to respond a call is 40 seconds. The average value was 74%. this means 74% of customer calls were answered within the target time (40 second) set for IT service desk. The middle value of the distribution was 74.2% and the most frequent value was also 75% (in most days 75% of customer calls were answered by the IT service desk staff).

4.2.3 **Descriptive Statistics for Average Customer Call Handling Time**

According to Batt et al. (2004), the industry benchmark of average handling time for business and IT service is 282 seconds. the above table shows the average call handling value was 248.579 seconds. This indicates that the IT service desk staff took about 248 seconds to resolve the customer problem. The middle value of the distribution was 248 seconds and the most frequent value was also 209 seconds.

4.2.**4 Descriptive Statistics for Number of Customers' Call Dropped**

The average value was 32 calls dropped. This means the about 32 customer calls per day were dropped while customer want to contact the IT service desk support staff. The middle value of the distribution was 30 calls and the most frequent value was also 30 dropped calls. Positive skewness indicates a right skewed data.

4.2.5 **Description Statics for Agent Occupancy**

According to Gralla (2012), the agent occupation benchmark performance rage is defined as 60% as worst case and 80% as best case. The average value was 8.49% occupancy rate. this indicates that about 8.49% of the IT service desk support staff time were occupied on hotline service. The middle value the distribution was 8.27% and the most frequent value was 9.97%.

4.2.6 **Descriptive Statistics for First Contact Resolution Rate**

According to Rumberg (2013), the first contact resolution rate benchmark performance rage is defined as 25% as worst case and 95% as best case. The average value of first contact resolution rate was 71.70%. This indicted that 71.70% of customer problems were solved by IT service desk support staff and the remaining (28.30%) customer problem logged to IT service desk section were solved by the 2nd and third level support team. The middle value of the distribution was 72.09% and the most frequent value was also 70% (in most days 70% of customer problems were solved by the IT service desk staff).

4.3 **Results of Multiple Linear Regression**

Multiple linear regression analysis was a method used to model the linear relationship between the dependent and two or more independent variables. The dependent variable is sometimes also called "the predict" (response variable), and the independent variables are called the predictors (explanatory variables). The purpose of the analysis was to link each of the regression analysis to specific research question and hypotheses that were raised in the chapter one. This was achieved by iterating the regression analysis to find the influencing variable that help the researcher to explain the significant variation in the response variable called first contact resolution rate of IT service desk. If a number of significant predicators can be identified, then the service desk manager can manage the risks and maximize the chances of achieving the best-case industry benchmark.

The following empirical model was used to explain the data:

$Y=a+ß_1X_1+ ß_2X_2+ ß_3X3+ ß_4X4+ ß_5X5+ e$

Y=First Contact Resolution Rate (FCR)

Y=Dependent variable and X= factors affecting FCR (Independent variables)

X_1=Number of support staff (NSS)

X_2=answer calls within target time(ACTT)

X_3=average call handling time (AHT)

X_4=Agent Occupancy (AO)

X_5= number of customer call dropped (DROP)

A= intercept

$ß_1$--- $ß_5$= regression coefficient

e=Error terms

The researcher conducted a multiple regression analysis to assess the factors influencing the first contact resolution rate of the IT service desk.

4.3.1 Results of the Regression Model

According to Cameron (2009), the regression output consists of three parts such as the regression statistics, ANOVA and Regression coefficient results. The main information of Appendix H.1 table was to know the R square value .The multiple R was the correlation coefficient. It indicates how strong the linear relationship was. In this result it was strong relationship at all. R^2, the Coefficient of Determination. In this case, 0.811(81%) means that 81% of the variation of the first contact resolution rate around the mean were explained by the independent variables (number of support staff, answered within target time, agent occupancy, average handle time, and drop calls). In other words, 81% of the values fit the model. The adjusted R-square adjusts for the number of terms in a model. Standard error of the regression is an estimate of the standard deviation of the error. The standard error of the regression was the precision that the regression coefficient was measured; if the coefficient is large compared to the standard error, then the coefficient is probably different from 0. Observations are the number of observations in the sample. In this research study all the daily records that were checked and removed all records containing outlier in either of the determinant factors.

The second part of the analysis was the overall test of significance of the regression parameter. The researcher has tested the overall regression result whether the null hypothesis against the alternative hypothesis. Either of the coefficient value of all determinant factor are not equal to zero. From the ANOVA table of Appendix H.1 the F-test statistics was 98.10 with significance F value of 0.0000. Since the significance F value was less than 0.01, so the researcher has rejected the null hypothesis that the regression parameters are zero at significance level 0.01. therefore, the determinant factors (number of support staff, answer within target time, agent occupancy, average call handling time, and number call drops) are jointly statistically significant at significant levels 0.01.

When a researcher finds that there is relationship that is correlation between two variables, then it may be possible to predict one variable from knowledge of the other variable (Marczyk et al, 2005). The regression output of this part was vital important part. The AppendixH.1 table has provided very specific coefficient and associated output about the determinant factors. The researcher chose to put into the data analysis. Therefore, the first column shows the name of the determinant factors (number of support staff, answered within target time, agent occupancy, average handle time, and drop calls) according to what data the researcher put into the data collection worksheet. The second columns was Coefficient which shows how much the first contact resolution rate of the IT service desk (dependent variable) was expected to increase (positive coefficient) or decreased (negative coefficient) when the determinant factor increased or decreased by one unit keeping the other determinant factors were constant and in this case number of support staff, response within 40 seconds and agent occupancy have positive effect whereas, average handling time and dropped calls were having negative effect on the model .The third column was standard Error which gives the least squares estimate of the standard error , the fourth column was T Statistic and P value for the null hypothesis vs. the alternate hypothesis , the fifth column was the VIF which gives the variance inflation factor for the multicollinearity test and value, According to Cameron (2009) ,the most useful part of this section was that it provided the multiple regression equation:

Table 4.2 Regression Analysis Result

Variables	Coefficients	Std. Error	t Stat	VIF
Intercept	0.747	0.062	12.102***	
Number of support staff	0.114	0.033	3.435***	1.48
Responding Customer call with in 40 Sec	0.090	0.068	1.312	6.19
Agent occupancy	1.479	0.177	8.364***	2.92
Avg. Handle Time(s)	-2.565	0.339	-7.560***	1.69
Dropped Calls in Manual Service	-0.004	0.001	-7.875***	7.96

Note : *** Significant at $p<0.01$, and ** Significant at $p<0.05$

Source: Own estimation (2018)

The coefficient of determination explains the extent to which change in the dependent variable (number of support staff, answered within target time, agent occupancy, average handle time , and drop calls) can be explained by the change in the independent valuable (first contact resolution rate) or the percentage of variation in outcome (first contact resolution rate) that is explained by the five independent variables .The model is significant at1% significance level.

The R square (R^2) is the correlation coefficient square 0.81 also referred to as the coefficient of determination. This value indicates the percentage of the total variation of Y (First contact resolution rate) explained by the regression model consisting of independent variable. the R^2 value 0.81 means the model explains about 81% of the variability in first contact resolution rate of the IT service desk. There might be other factors not studied in this research study that contribute 19% of the first contact resolution rate in IT service desk of Ethio telecom. Therefore, further research should be conducted to investigate the other factors (19%) that influence first contract resolution rate of IT service desk of Ethio telecom. The t stat (t-statistics) for each coefficient to test the null hypothesis that corresponding coefficient is zero against the alternative that it is different from zero, given the other predictors in the model. The P-value of the F-statistics for number of support staff and dropped calls are greater than

0.01, so those variables were insignificant when the regression as whole is significant at the 1% significance level given the other terms in the model.

4.3.1.4 Test of Multicollinearity

The researched has observed from the regression output tabulated under appendix H.1 that the F value is significant, at the 0.01 level, the t-values were also significant, R square is high the overall model test was significant. Multicollinearity test has been performed if there was collinearity a problem. According to Joshi (2012) cited the rule of thumb "if any of variance inflator factors (VIF) exceeds 10 it implies that the associated regressions are poorly estimated because of multicollinearity (Montgomery, 2001)". The VIF can quantify the severity of the multicollinearity in the regression analysis. Hence the researcher has calculated the variance inflation factor (VIF) of the determinant factors (independent variables). Based on the regression analysis the average VIF were 4.08. The researcher has observed from the correlational matrix result that the high correlation coefficient (r= -0.82) between dropped calls and responding customer calls with 40 seconds suggest that these two variables may be collinear and the moderate correlation coefficient (r=0.56) between agent occupancy and drop customer calls suggest that moderate collinearity may appear on these two variables. Hence the researcher's conclusion on VIF was there was collinearity among the independent variables but all variables have not greater than 10 VIF values. Based on the VIF result indicates that collinearity was probably not a problem between the independent variables. Finally, the researcher make inference on the entire regression model.

4.3.2 Test Hypothesis of Zero Slope Coefficient ("Test of Statistical Significance") and Using P Value

A regression model was developed to test the developed hypothesis so as to determine the significant impact of the factors affecting the first contact resolution rate. The model consists of first contact resolution rate as dependent variable and number of support staff, responding customer's call with 40 seconds, average customer call handling , agent occupancy and drop calls. The coefficient of the determinant factors with estimated standard error, t-statics and P-values were tested the significance of the null hypothesis.

4.3.2.1 Hypothesis 1

H1: There was a positive relationship between the number of support staff and first contact resolution rate.

The regression output indicates the regression relationship between the number of support staff available and the first contact resolution rate has the P-value is 0.0008, and it was statistically significant at significance level α =0.01 as $p=0.0008<0.01$. Hence based on the result it can be inferred with confidence that the H1 was accepted. Therefore, the researcher rejects the null hypothesis for the first hypothesis(H1).

4.3.2.2 Hypothesis 2

H2: There was a positive relationship between speed of service desk staff or ability to a requested support within target time 40 seconds and first contact resolution rate.

The regression output indicates the regression relationship between the answering calls within target time and the first contact resolution rate has P-value was 0.1922 so it was statistically insignificant at significant level α =0.1 as $p=0.1922>0.1$. Hence based on the result it can not be inferred with confidence that the H2 was accepted Therefore, the researcher has didn't rejected the null hypothesis for the second hypothesis (H2).

4.3.2.3 Hypothesis 3

H3: There was significant positive relationship between agent occupancy/staff non-idle time and first contact resolution rate.

The regression output indicates the regression relationship between the agent occupancy and the first contact resolution rate has P-value = 0.0000 so it was statistically significant at significant level α =0.01 as $p=0.0394<0.05$. Hence based on the result it can be inferred with confidence that H3 was accepted. Therefore, the researcher has rejected the null hypothesis for the third hypothesis (H3).

4.3.4.4 Hypothesis 4

H4: There was negative relationship between the time taken by the support staff to solve a particular customer problem and first contact resolution.

The regression output indicates the regression relationship between the of average call handling time within target time and the first contact resolution rate has P-value was 0.0000 so it was statistically significant at significance level; α =0.01 as $P=0.0000<0.01$. Hence based on the result it can be inferred with confidence that H4 was accepted. Therefore, the researcher has reject the null hypothesis for the fourth hypothesis (H4).

4.3.4.5 Hypothesis 5

H5: There was negative relationship between number of call drops by the network system and first contact resolution rate

The regression output indicates the regression relationship between the of number of call drops and the first contact resolution rate has P-value was 0.0000 so it was statistically significant at significance level α =0.01 as P=0.0000<0.01. Hence based on the result it can be inferred with confidence that H5 was accepted. Therefore, the researcher reject the null hypothesis for the fifth hypothesis (H5).

4.3.5 Summarized value of FCR given regressors

According to Melton (2010), the following model statement for multiple regression was used to explain the data:

$Y=a+ß_1X_1+ ß_2X_2+ ß_3X_3+ ß_4X_4+ ß_5X_5+ e$

Y=First Contact Resolution Rate (FCR)

Y=Dependent variable and X= factors affecting FCR (Independent variables)

X_1=Number of support staff (NSS)

X_2=Responding calls within target time(RSP)

X_3=average call handling time (AHT)

X_4=Agent Occupancy(AO)

X_5= number of customer call dropped (DROP)

A= intercept

$ß_1$, $ß_2$, $ß_3$, $ß_4$, $ß_5$= regression coefficient

e=Error terms

FCR=0.747+0.114(SS)+0.090(RSP)-2.565(AHT))+1.479(AO)-0.004(DROP)+0.028

According to literature number of support staff has direct relationship with the performance of the queuing system. From the above summary indicates number of support staff with ß=0.117 and P-value =0.0000 significantly determines the performance of the first contact resolution rate at 1% level of significance. The result obtained on number of support staff supports the conclusion of Chinwuko et al (2014) and Dhar and Rahman, (2013) that number of servers affect the performance of queuing system. The result on responding customer call within 40 seconds (ß=0.090 and P-value =0.1962) shows that responding customer's call within 40 seconds doesn't significantly determines the first contact resolution. According to Rumburg and Zbikowski (2013) point of view number of calls answered within target time is one the major determinant to meet service desk service level assurance. However, in this research finding indicates that responding customer call with 40 seconds doesn't significantly determines the performance of first contact resolution rate. The result on average customer call handing time (ß=-2.565 and P-value =0.0000) significantly determines the performance of the first contact resolution rate at 1% level of significance. the negative sign represents that the average customer handling time has negative relationship with first contact resolution rate. This means as the support staff takes more time on one customer, the number of customers to be handled at the first level will be reduced. This result supports the conclusion Dhar and Rahman, (2013) that the problem of losing customers due to a long wait on the queuing system. The result on agent occupancy (ß=1.479 and P-value =0.0000) significantly determines the performance of the first contact resolution rate at 1% level of significance. That means the finding of this study shows there is positive relationship between occupancy and first contact resolution rate. The high coefficient indicates that the agent staff occupancy is the most determinant factor in the model. This supports with the conclusion of Rumburg and Zbikowski (2013) that more customers calls can be handle whensupport staff time is occupied on call. The result on call drops (ß=-0.004 and P-value =0.0000) significantly determines the performance of the first contact resolution rate at 1% level of significance. That means the finding shows there is negative relationship between call drops and first contact resolution . when more calls are dropped , the IT service desk can not receive customers complain hence unable to resolve customer problem. This result supports the conclusion of Rumburg and Zbikowski (2013) that call quality is the key driver of first contact resolution .

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CHAPTER FIVE:

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1. Summary the Findings

Here in this part the key study work which was supported by the finding was summarized. The key finding against the objectives set in the first chapter one also was summarized. The test cases used to test the hypotheses was also summarized.

- The average performance of IT service desk was around 72% which is lower than the best case of the industry benchmark.
- The researcher has identified the top ten problem type that were escalated to next level support team.
- The predicted maximum staff required based on the existing population calling average and target service level for hotline service was 8.
- The first contact resolution rate has been strongly affected by the factors called agent occupancy, number of customers' calls dropped, the time taken to handle customer problem on phone, umber of support staff and less significantly affected by responding customer call within 40 seconds .
- An average of 131 customers' calls per day were arrived into ethio telecom IT service desk queueing system and 103 calls per day were answered which were facilitated by the IT service desk support staff.
- The average of 15 number of support staffs per day were assigned to provide the first level IT support.
- An average of 74% ethio telecom employees' calls were responded within 40 second. When they were looking an IT support from IT service desk team using phone.
- An average of 28% of ethio telecom support request were solved by second and third level support staff.
- An average of 74% of ethio telecom IT service desk staff working time were used to support ethio telecom employees with hotline channel (Access code #878).
- An average of 248 seconds were taken by the IT service desk staff to solve customer problem while the customer was on telephone.
- An average of 32 customers' calls per day were dropped while the customer wants to contact an IT service desk.

- Agent occupancy was the major influencing factor to the model that explain 81% of variability in first contact resolution rate.
- An average of 15 customers per day were abandoning a call when they were contacting the IT service desk support staff.
- An average of 8 customers's call were rejected by the system when they were unable to select the appropriate support group (application group, email group, compliant receiving group).

The researcher has conducted an interview to obtaining a qualitative reflection on why customers were abandoning a call while they were calling to contact an IT service desk support staff. The summarized opinion of the service desk manager and managers outside the IT organization who were looking a service from IT service desk.

- The service desk manager claims that the customers were inpatient particularly from the managerial level. They prefer to quit the connection when the system asked them to wait even insignificant time.
- The roaming manager claims that the line was busy, and the system request him to waiting "un reasonable time" and finally he close the connection.
- The general attitude of the direct sales channer officer reveals that there was lack of skill among the first level IT support team.

5.2. Conclusion

The initial research question was reviewed. The advantage of analyzing the performance of queueing system in the case company was discussed. The results or key finding of the case analysis was indicated. The link between the queuing theory and major finding was shown, the conclusion was done according to the IT service desk set key performance indicators and the analyzed performance of service desk system. Finally, it was concluded whether the factors were influencing the performance of the service desk system for hotline.

The purpose of this study was to explain the determinant factors affecting the first contract resolution rate of Ethio Telcom IT service desk. To achieve this objective descriptive analysis to examine the determinant factors to the first contact resolution rate were used. An inferential statistic to evaluate the effect of the determinant factors on the first contact resolution rate of IT service desk was employed and tested the hypotheses that were raised in chapter one. Based on the data analysis result, the first contact resolution rate of the ethio telecom IT service desk was an average 71.7% which was lower than the best bench mark of the industry (95%). This result was mainly because of the support staff took high average call handling time, low agent availability on hotline channel, significant number of calls were dropped and low number of customer 's call was responded within target time (40 seconds). Top ten problem that were not solved at first contact but escalated to next level. The empirical findings of the study revealed, all the five treated determinant factors of the first contact resolution rate have positive and negative significant association with the first contact resolution rate of Ethio telecom IT service desk. The result of regression analysis for testing hypothesis indicated, responding customer's call has insignificant effect on the predicted factor which don't reject the null hypothesis at 90% confidence level. Whereas the average call handling time, number of support staff, and agent occupancy, call drop have significant effect on the predicted factor which support the alternative hypothesis at 99% confidence interval. The regression analysis finding indicated the importance of inducing the determinant factors appropriately had a positive and negative effect on the performance of the IT service desk (first contact resolution rate).

The most determinant factors which has a positive relationship and significant determination coefficient was agent occupancy. Responding customer's call has positive relationship but insignificant impact on the first contact resolution rate of the IT service desk.

In conclusion, the focused of information system division was to improve the performance of the service desk particularly the first contact resolution rate on support staff occupied on hotline service agent occupancy with positive and significant to solve customer problem on first contact. The researcher has identified that there was significant number of customer calls dropped which has strong negative relationship (r=-0.81) with agent occupancy ratio. The next important factor with high time to engage the support staff on hotline service to resolve the customer problem were the main reason to the current first contact resolution rate. Therefore, the agent occupancy ratio for hotline service, and train the staff on the top ten identified technologies that can enhance the skill of support staff to handle customer problem within short time should be the main focuses of Ethio telecom IT service desk.

5.3. **Recommendation**

In this section, the researcher has recommended the possible solution to the case company particularly to the IT service desk management based on the result found during the analysis. The purpose of this recommendation was to show the improvement area that help ethio telecom to apply in their operational activities as well as to develop any kind of operational plan.

- The model explains about 81% of the variability in first contact resolution rate of the IT service desk. There might be other factors not studied in this research study that contribute 19% of the first contact resolution rate in IT service desk of ethio telecom.

Therefore, further research should be conducted to investigate the other factors (19%) that influence first contract resolution rate of IT service desk of ethio telecom.

- The service desk manager should plan to minimize the call drops that affect directly the first contact resolution rate of IT service desk.
- There should be a daily review on the determinant factors.
- The agent occupancy was below the international benchmark however as Gralla (2012) mentioned the number should not be below 60%.
- The service desk manager should investigation on the top ten identified problems areas the reason why the service desk staffs not solved at first contact and prepare an immediate training program if not yet done.
- The service desk manager should not plan for additional head count but prepare a training program not only long-term training but also a daily basis that empower the support staff to get knowledge about situational issue.
- The service desk manager should develop communication plan to change the perception of the customer that there is capability to solve customer problem at first contact so that customer can understand the reasonable waiting time and reduce leaving customer from the queue.
- The service desk manager should plan to assess the system configuration that drop a call when customers are unable to select specific group. The research recommended to create a default rout that help the customer to contact service desk staff and this will reduce the number calls drop as a result retain customer to get service.
- The service desk manager should plan to develop a kind of centralized information that can be made by registering exceptional cases with their resolution guide by on duty support staff. this my help to share a knowledge and that help the support staff to resolve customer problem when it is requested by customer.

5.4. **Limitation of the Study**

In need a lot of commitment is employed in conducting an exhaustive and through study certain weaknesses were encountered. A major problem encountered by the researcher during information collection process is the missing of observed data from March 2 ,2018 to March 13 ,2018 from the system recorder, insufficient secondary researches and lack of documentation on IT service desk viewing as queueing system.

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Appendix A : Data Collection Template

Data Collection Template							
Samples		Determinant Factors of IT Service Desk System					
Samples to be taken		Number of Staff Working (Attendance)	Number of Calls Dropped	Number of request responded with target time (40 second)	Average Call Handling time	Agent Occupancy	Performance of Service Desk (First Contact Resolution Rate)
S/N	Date						
1	1-Sep-17						
2	2-Sep-17						
3	3-Sep-17						
4	4-Sep-17						
5	5-Sep-17						
6	6-Sep-17						
7	7-Sep-17						
8	8-Sep-17						
9	9-Sep-17						
10	10-Sep-17						
11	11-Sep-17						
-----12-Sep-17- to- 30-March-2018-----							
212	31-march-2018						

Appendix B: FCR Raw Data Collected and Prepared

Data Collection Template (FCR)					
Samples		Total Calls Arrived in a Queue	Calls Handled BY IT Service Desk Support Staff	Number of Calls escalated to Next Level	Performance of Service Desk (First Contact Resolution rate)
S/N	Date				
1	1-Sep-17	0	0	0	#DIV/0!
2	2-Sep-17	40	29	3	65%
3	3-Sep-17	0	0	0	#DIV/0!
4	4-Sep-17	195	141	12	66%
5	5-Sep-17	180	127	9	66%
6	6-Sep-17	155	103	5	63%
7	7-Sep-17	143	107	6	71%
8	8-Sep-17	113	76	6	62%
9	9-Sep-17	23	18	3	65%
10	10-Sep-17	0	0	0	#DIV/0!
11	11-Sep-17	0	0	0	#DIV/0!
12	12-Sep-17	90	65	13	58%
13-sep-17 -to – 30-March-2018					
212	31-March-2018				

Appendix C: Table 30: Final Data Input to Data Analysis

s/N	Sample (Recoded Date)	Number of support staff	Responded with in 40 Sec	Avg. Handle Time(s)	Dropped Calls in Manual Service	Agent Occupancy	Dropped Calls in Manual Service (Q6)	Performance of Service Desk (First Contact Resolution rate)
1	09/04/2017	17	50.26%	261	54	10.28%	54	66.15%
2	09/05/2017	15	55.56%	266	53	9.16%	53	65.56%
3	09/06/2017	14	43.23%	272	52	10.52%	52	63.23%
4	09/07/2017	14	55.94%	265	36	9.97%	36	70.63%
5	09/13/2017	15	59.88%	307	56	9.42%	56	60.47%
6	09/14/2017	14	69.79%	279	23	6.06%	23	69.79%
7	09/18/2017	15	61.20%	239	50	8.97%	50	67.21%
8	09/21/2017	13	50.00%	220	58	8.59%	58	62.94%
9	09/22/2017	13	57.25%	230	36	7.74%	36	64.12%
10	09/25/2017	17	75.00%	318	27	9.01%	27	72.32%
11	09/28/2017	16	56.10%	235	46	5.34%	46	60.16%
12	10/02/2017	15	80.11%	241	31	9.97%	31	76.14%
13	10/03/2017	12	73.79%	221	30	10.08%	30	73.10%
14	10/04/2017	13	80.42%	265	25	10.32%	25	74.13%
15	10/05/2017	15	76.12%	237	26	8.39%	26	73.88%
16	10/06/2017	13	66.34%	207	32	5.05%	32	61.39%
17	10/09/2017	14	69.36%	229	42	10.38%	42	68.79%
18	10/10/2017	14	58.43%	249	64	11.93%	64	56.18%
19	10/11/2017	16	75.00%	314	36	11.17%	36	69.08%
20	10/12/2017	17	68.36%	229	43	10.31%	43	71.19%
21	10/13/2017	16	72.95%	237	29	7.87%	29	72.13%
22	10/16/2017	15	63.98%	268	58	12.53%	58	60.75%
23	10/17/2017	17	62.35%	249	54	8.77%	54	60.49%
24	10/18/2017	15	76.32%	209	25	4.71%	25	71.93%
25	10/19/2017	14	67.19%	257	40	7.42%	40	56.25%
26	10/20/2017	15	74.58%	252	24	7.61%	24	72.03%
27	10/23/2017	16	65.03%	227	56	8.96%	56	62.30%
28	10/24/2017	16	72.09%	263	41	11.69%	41	68.60%
29	10/25/2017	15	72.02%	239	32	10.95%	32	75.00%
30	10/26/2017	15	70.73%	209	32	6.41%	32	67.48%
31	10/27/2017	15	62.50%	256	39	5.98%	39	60.71%
32	10/30/2017	15	72.30%	268	36	10.22%	36	70.27%
33	10/31/2017	16	62.84%	276	50	10.25%	50	63.51%
34	11/01/2017	15	74.21%	262	38	9.43%	38	71.07%

35	11/02/2017	16	72.09%	260	32	8.24%	32	65.12%
36	11/03/2017	12	81.25%	209	15	4.87%	15	77.50%
37	11/06/2017	14	77.57%	208	22	4.44%	22	68.22%
38	11/07/2017	15	75.61%	268	28	7.80%	28	71.54%
39	11/08/2017	16	68.56%	223	58	11.95%	58	69.87%
40	11/09/2017	15	67.09%	253	54	13.83%	54	67.09%
41	11/10/2017	16	57.92%	274	60	12.26%	60	59.02%
42	11/13/2017	19	82.27%	209	38	9.48%	38	78.18%
43	11/14/2017	19	83.93%	231	25	11.44%	25	82.14%
44	11/15/2017	15	83.47%	244	18	8.51%	18	76.86%
45	11/16/2017	16	79.19%	235	30	8.15%	30	72.48%
46	11/17/2017	14	67.35%	248	38	10.69%	38	70.75%
47	11/20/2017	16	82.10%	235	23	9.55%	23	81.48%
48	11/21/2017	17	83.92%	254	23	8.77%	23	74.83%
49	11/22/2017	19	75.88%	212	45	7.80%	45	72.36%
50	11/23/2017	18	88.89%	261	11	6.00%	11	76.77%
51	11/24/2017	18	83.76%	198	13	5.79%	13	84.62%
52	11/27/2017	16	78.85%	235	30	7.10%	30	75.00%
53	11/28/2017	18	75.00%	303	26	6.23%	26	72.58%
54	11/29/2017	18	84.96%	246	20	6.04%	20	76.69%
55	12/01/2017	19	85.82%	261	16	7.67%	16	78.36%
56	12/04/2017	16	82.14%	246	18	5.40%	18	74.11%
57	12/05/2017	15	88.37%	222	14	5.95%	14	79.07%
58	12/06/2017	15	90.71%	206	11	6.93%	11	81.43%
59	12/07/2017	17	89.78%	263	14	7.17%	14	79.56%
60	12/08/2017	17	78.46%	266	22	7.19%	22	73.85%
61	12/11/2017	15	84.62%	186	21	6.40%	21	79.72%
62	12/12/2017	15	78.99%	197	28	5.73%	28	71.74%
63	12/13/2017	15	76.32%	337	20	9.62%	20	77.19%
64	12/14/2017	13	80.83%	232	19	6.58%	19	78.33%
65	12/15/2017	15	74.55%	278	26	6.28%	26	70.00%
66	12/18/2017	16	83.48%	230	37	11.12%	37	73.91%
67	12/19/2017	17	80.89%	197	37	9.71%	37	80.49%
68	12/20/2017	18	78.26%	269	35	9.10%	35	72.28%
69	12/21/2017	18	76.33%	326	33	11.47%	33	69.23%
70	12/22/2017	16	82.86%	277	17	6.47%	17	77.14%
71	12/25/2017	16	81.82%	227	26	6.85%	26	79.02%
72	12/26/2017	18	77.16%	261	33	8.64%	33	72.84%
73	12/27/2017	14	79.70%	247	23	8.70%	23	75.94%
74	12/28/2017	14	76.74%	250	27	7.63%	27	76.74%
75	12/29/2017	13	73.72%	245	27	8.67%	27	70.80%
76	01/01/2018	15	84.38%	250	22	8.95%	22	79.38%
77	01/02/2018	18	74.44%	197	41	6.87%	41	70.00%
78	01/03/2018	18	61.43%	267	50	5.64%	50	58.57%
79	01/04/2018	15	80.18%	264	19	7.21%	19	70.27%

80	01/05/2018	15	77.36%	190	22	6.10%	22	76.42%
81	01/08/2018	11	77.32%	372	19	13.56%	19	73.20%
82	01/09/2018	15	81.51%	301	21	8.34%	21	76.47%
83	01/10/2018	15	80.31%	216	24	6.47%	24	72.44%
84	01/11/2018	15	65.04%	205	60	12.58%	60	71.05%
85	01/16/2018	17	68.44%	281	70	21.81%	70	71.09%
86	01/25/2018	11	60.48%	293	56	13.88%	56	59.88%
87	01/26/2018	11	62.00%	294	42	12.82%	42	69.33%
88	01/29/2018	17	74.00%	270	39	11.13%	39	76.50%
89	01/31/2018	17	71.20%	233	39	8.63%	39	76.96%
90	02/01/2018	14	59.87%	269	52	9.07%	52	63.06%
91	02/02/2018	15	74.83%	255	35	8.98%	35	70.20%
92	02/05/2018	15	68.75%	248	47	9.85%	47	70.31%
93	02/06/2018	16	75.00%	234	30	6.24%	30	67.97%
94	02/07/2018	14	69.64%	210	39	7.13%	39	72.02%
95	02/08/2018	13	75.19%	241	30	8.33%	30	72.09%
96	02/09/2018	13	74.34%	249	25	7.62%	25	71.68%
97	02/12/2018	13	86.67%	288	14	10.80%	14	82.50%
98	02/13/2018	13	73.75%	205	21	3.46%	21	70.00%
99	02/15/2018	14	78.52%	210	22	7.08%	22	77.04%
100	02/16/2018	14	64.93%	244	38	7.57%	38	67.16%
101	02/19/2018	15	81.75%	264	18	9.64%	18	81.02%
102	02/20/2018	15	80.00%	178	32	6.44%	32	78.18%
103	02/21/2018	14	79.63%	221	23	8.12%	23	76.54%
104	02/22/2018	17	87.39%	258	12	6.33%	12	77.48%
105	02/23/2018	16	79.82%	243	18	7.47%	18	78.90%
106	02/26/2018	18	84.72%	216	20	6.67%	20	79.86%
107	02/27/2018	17	76.13%	209	29	6.58%	29	70.32%
108	02/28/2018	19	80.54%	181	28	5.33%	28	72.48%
109	03/01/2018	15	69.71%	207	41	7.41%	41	72.57%
110	03/14/2018	16	74.44%	272	30	7.50%	30	64.66%
111	03/15/2018	16	77.17%	337	25	10.06%	25	67.72%
112	03/16/2018	16	77.98%	262	21	7.11%	21	72.48%
113	03/19/2018	17	71.53%	306	39	9.25%	39	63.89%
114	03/20/2018	19	89.19%	243	16	7.58%	16	83.11%
115	03/21/2018	16	83.66%	212	21	7.44%	21	76.47%
116	03/22/2018	17	75.18%	217	28	6.18%	28	70.07%
117	03/23/2018	16	60.00%	327	43	7.69%	43	58.26%
118	03/26/2018	17	81.58%	280	26	9.40%	26	73.68%
119	03/27/2018	18	78.23%	273	25	6.80%	25	74.19%
120	03/28/2018	16	67.72%	268	33	8.29%	33	70.87%
121	03/30/2018	16	76.07%	233	17	7.98%	17	82.91%

Appendix D: Table 33: Service Or Product Type That The Service Desk Employees Have Escalated

S/N	Service /PRODUCT_TYPE (That escalated from service desk staff to second level support team)	No of TT Created	%
1	MS Office Application	214	29.00%
2	Browser problem, IE related	123	16.67%
3	Ecaf ,Ecaf Signature pad	79	10.70%
4	Email Problem, account, new internal email account , archive,Data Lost,outlook configration, Outlook Problem	71	9.62%
5	Sales application, CRM, CRM problem	50	6.78%
6	ERP Application	49	6.64%
7	Java Application	48	6.50%
8	Printer Share , printer fail Count, printer driver, Printer privilege	28	3.79%
9	Admin request Count,add into group, create new group, Trust lost, profile change, Share folder ,profile corrupted	26	3.52%
10	PC OS , repair, Computer connection problem	14	1.90%
11	Adobe Reader	4	0.54%
12	Power Ge'ez	2	0.27%
13	U 2000 Count	2	0.27%
14	Antivirus Count	1	0.14%
15	IPCC ,IPCC related problem	2	0.27%
16	LAN connection Problem	1	0.14%
17	Laptop Charger	1	0.14%
18	switch failed	1	0.14%
19	unknown problem type (Others)	22	2.98%
	Total	738	

Appendix E: Result of Erlang C Calculator

Erlang Calculator - Day Planner

7.5Agents(Maximum), 7.9 Agents(Average), 10 Calls per Hour(Maximum), 136 Calls Per Day.

Day planner function shows a typical distribution of calls per day across the whole day, based on our analysis of multiple contact centers. You would require a Maximum of 7.5 Agents and an Average of 7.9 Agents when shrinkage is taken into account.

Assumptions: 136 calls per 8 hours - AHT Time 248 seconds - 99 % Answered in 40 seconds - Shrinkage 35 % - Max Occupancy 85 %.

Refine your results

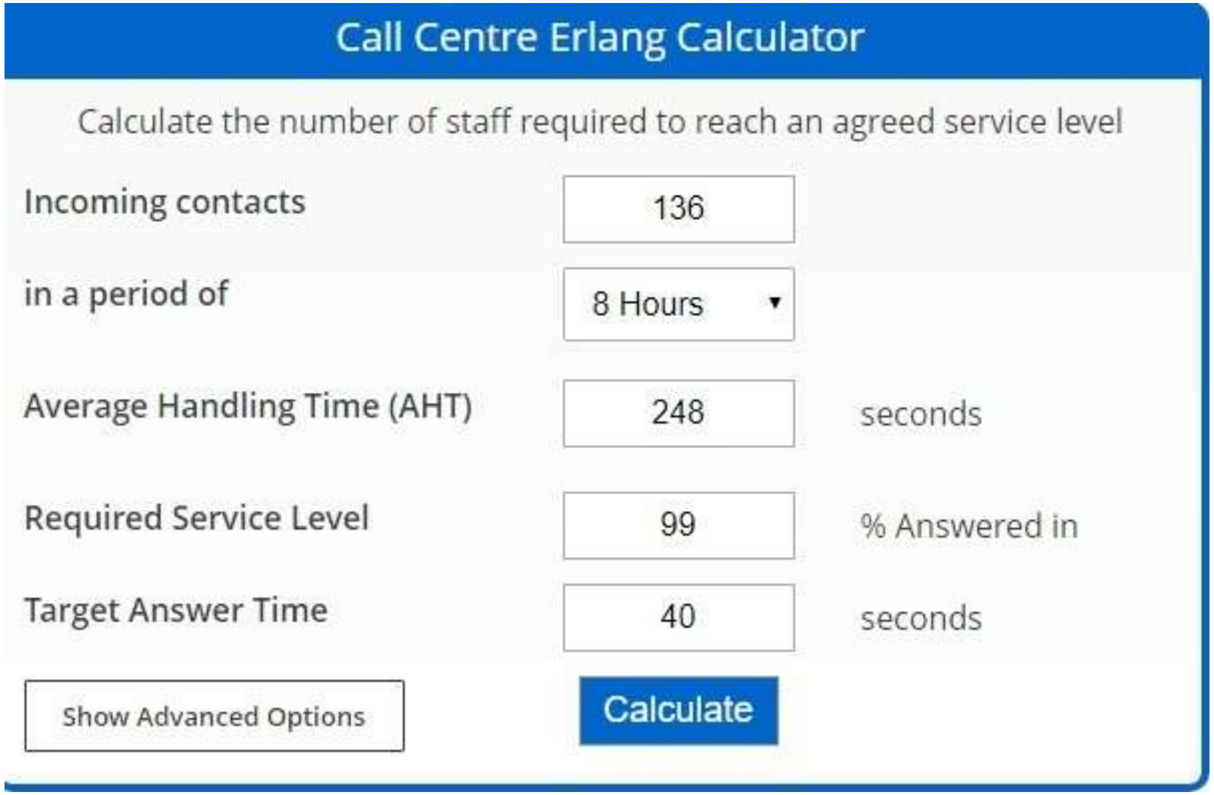

Figure Appendix E.1: Result Erlang C Calculator (Own Source)

Appendix F: Table Appendix F.1: Summarized Descriptive Statistics Output of Determinant Factors

Number of support staff (Q1)		Answered with in 40 Sec (Q2)		Avg. Handle Time(s) (Q4)		Agent Occupancy		Dropped Calls in Manual Service (Q5)		Performance of Service Desk (First Contact Resolution rate)	
Mean	15.50	Mean	74%	Mean	248.58	Mean	8.49%	Mean	32.31	Mean	72%
Standard Error	0.16	Standard Error	0.01	Standard Error	3.19	Standard Error	0.002	Standard Error	1.21	Standard Error	0.01
Median	15	Median	75%	Median	248.00	Median	8.27%	Median	30.00	Median	72%
Mode	15	Mode	75%	Mode	209.00	Mode	9.97%	Mode	30.00	Mode	70%
Standard Deviation	1.77	Standard Deviation	0.09	Standard Deviation	35.12	Standard Deviation	0.025	Standard Deviation	13.29	Standard Deviation	0.06
Sample Variance	3.12	Sample Variance	0.01	Sample Variance	1233.51	Sample Variance	0.00	Sample Variance	176.60	Sample Variance	0.00
Kurtosis	0.00	Kurtosis	0.42	Kurtosis	0.81	Kurtosis	6.00	Kurtosis	-0.26	Kurtosis	-0.26
Skewness	-0.14	Skewness	-0.76	Skewness	0.62	Skewness	1.505	Skewness	0.67	Skewness	-0.41
Range	8	Range	47%	Range	194.00	Range	18.35%	Range	59	Range	28%
Min	11	Minimum	43%	Minimum	178.00	Minimum	3.46%	Minimum	11	Minimum	56%
Maximum	19	Maximum	91%	Maximum	372.00	Maximum	21.81%	Maximum	70	Maximum	85%
Count	121	Count	121	Count	121	Count	121	Count	121	Count	121

Appendix G: Equation to Find the Outliers and Result of Each Variables

1st quartile (1Q) = QUARTILE (sample array, 1)

3rd quartile (1Q) = QUARTILE (sample array, 3)

Inner quartile range (IQR)= 3rd quartile(3Q) -1st quartile (1Q)

Lower range limit = 1st quartile (1Q) – (1.5* Interior quartile range (IQR))

Upper range limit = 3rd quartile (3Q) +(1.5*interior quartile range (IRQ))

Outlier = OR (sample data > upper limit, sample data < lower limit) , any data falls below or above these limits considers an outlier.

G.1 check and Remove outlier of sample data of number employee working

166 sample data of the independent variable for number of employee working were received.

Table 1Appendix G.1 Outliers removed from number of support staff working

Function	Description	Result
=QUARTILE(B2:B167,1)	1st Quartile (1Q)	13
=QUARTILE(B2:B167,3)	3rd Quartile (3Q)	16
=3Q-1Q	Interior Quartile Range (IQR)	3
=1Q-(1.5*IQR)	Lower Bound	8.5
=3Q+ (1.5*IQR)	Upper Bound	20.5
=OR(B2>upperbound,B2<LowerBound)	Outlier	True/False
=3Q+ (1.5*IQR)	Upper Bound	39.25
OR(B2>upperbound,B2<LowerBound)	Outlier	True/False
=CountA(B2:B167)	Count total sample Records	166
=CountIF(C2:C167, True)	Count total outliers	28

The above table indicates that, totally 28 (16.87%) sample records are identified as outlier. Hence the researchers has removed all those records for further analysis.

G.2 Check and Remove outlier from the sample data of responding the customer calls within 40s

166 sample data of the independent variable for number of calls answered within 40 second were received.

Table Appendix G.2 Outliers Removed From Number of calls answered within Target Time (40 second)

Function	Description	Result
QUARTILE(B2:B167,1)	1st Quartile (1Q)	62.09%
QUARTILE(B2:B167,3)	3rd Quartile (3Q)	79.96%
3Q-1Q	Interior Quartile Range (IQR)	17.87%
1Q-(1.5*IQR)	Lower Bound	35.29%
3Q+ (1.5*IQR)	Upper Bound	106.76%
OR(B2)> upperbound, B2<LowerBound)	Outlier	True/False
CountA(B2:B167)	Count Records	166
CountIF(C2:C167,True)	Count outlier	2

The above table indicates that, totally 2 (1.2%) sample records were identified as outliers. Hence the researcher has removed all those records for further analysis.

G.3 Check and Remove outlier from the sample data of Agent occupancy

166 sample data of the independent variable for agent occupancy were received.

Table Appendix G.3 Outliers Removed From Agent Occupancy

Function	Description	Result
QUARTILE(B2:B167,1)	1st Quartile (1Q)	7.73%
QUARTILE(B2:B167,3)	3rd Quartile (3Q)	9.06%
3Q-1Q	Interior Quartile Range (IQR)	1.33%
1Q-(1.5*IQR)	Lower Bound	5.75
3Q+ (1.5*IQR)	Upper Bound	11.06%
OR(B2>upperbound, B2<LowerBound)	Outlier	True/False
CountA(B2:B167)	Count Records	166
CountIF(C2:C167,True)	Count outlier	9

The above table indicates that, totally 9 (5.4%) sample records were identified as outliers. Hence the researchers have removed all those records for further analysis. Check and Remove outlier from the sample data of average handling time.

166 sample data of the independent variable for average handling time were received.

Table Appendix G.4 Outlier Removed From Average Call Handling Time

Function	Description	Result
QUARTILE(B2:B167,1)	1st Quartile (1Q)	227
QUARTILE(B2:B167,3)	3rd Quartile (3Q)	272
3Q-1Q	Interior Quartile Range (IQR)	45
1Q-(1.5*IQR)	Lower Bound	159.5
3Q+ (1.5*IQR)	Upper Bound	339.5
OR(B2>Upperbound, B2<LowerBound)	Outlier	True/False
CountA(B2:B167)	Count Records	166
CountIF(C2:C167,True)	Count outlier	10

The above table indicates that, totally 10 (6%) sample records were identified as outliers. hence the researcher has removed all those records for further analysis.

G.4 Checking and Refining the sample data of number of dropped calls

166 sample data of the independent variable for average handling time were received.

Table Appendix G.5 2Outliers Removed From Dropped Calls

Function	Description	Result
QUARTILE(B2:B167,1)	1st Quartile (1Q)	18
QUARTILE(B2:B167,3)	3rd Quartile (3Q)	40
3Q-1Q	Interior Quartile Range (IQR)	22
1Q-(1.5*IQR)	Lower Bound	-15
3Q+ (1.5*IQR)	Upper Bound	73
OR(B2>upperbound, B2<LowerBound)	Outlier	True/False
CountA(B2:B167)	Count Records	166
CountIF(C2:C167,True)	Count outlier	9
	outlier percentage	5.4%

The above table indicates that, totally 9 (5.4%) sample records were identified as outlier. Hence the researcher has removed all those records for further analysis.

G.5 Checking and Removing the sample data of performance of the IT service desk (First contact resolution rate) 166 sample data of the dependent variable for performance of the IT service desk (First Contact Resolution Rate) were received.

Table Appendix G.6 Outliers Removed from First Contact Resolution Rate

Function	Description	Result
QUARTILE(B2:B167,1)	1st Quartile (1Q)	64.05%
QUARTILE(B2:B167,3)	3rd Quartile (3Q)	76.47%
3Q-1Q	Interior Quartile Range (IQR)	12.42%
1Q-(1.5*IQR)	Lower Bound	45.42%
3Q+ (1.5*IQR)	Upper Bound	95.10%
OR(B2> upperbound, B2<LowerBound)	Outlier	True/False
CountA(B2:B167)	Count Records	166
CountIF(C2:C167,True)	Count outlier	3

The above table indicates that, totally 3 (1.8%) sample records were identified as outlier. hence the

Appendix H: Performance of Regression Model

Regression Analysis

Table Appendix H.1: Regression Analysis Output

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.901
R Square	0.811
Adjusted R Square	0.803
Standard Error	0.028
Observations	120

ANOVA					
	df	*SS*	*MS*	*F*	*Sig. F*
Regression	5	0.381	0.076	98.103	0.0000
Residual	114	0.088	0.001		
Total	119	0.469			

	Coef.	*Std.Error*	*t Stat*	*P-value*	*VIF*
Intercept	0.747	0.062	12.102	0.0000	
Number of support staff	0.114	0.033	3.435	0.0008	1.480
AHT (m)	-2.565	0.339	-7.560	0.0000	1.690
Responding with in 40 Seconds	0.090	0.068	1.312	0.1922	6.190
Agent occupancy	1.479	0.177	8.364	0.0000	2.920
Call Drops	-0.004	0.001	-7.875	0.0000	7.96

Mean (VIF)=	4.080

Appendix I : Testing Multicollinearity

Calculating Variant Inflation Factor (VIF)

$$\text{VIF}=\frac{1}{(1-R2)}$$

- Where VIF is for each determinant factor (independent variables)
- $\mathbf{R^2}$ is the coefficient of determination of the model that included all determinant factor (independent variable) except the targeted independent variable.

Table Appendix I.1: Correlation matrix

	Avg. Handle Time(s)	*Answered with in 40 Seconds*	*Number of support staff*	*Agent Occupancy*	*Dropped Calls in Manual Service*
Number of support staff	1				
Average Call Handling time	-0.05	1.00			
with in 40 Seconds	0.30	-0.18	1.00		
Agent occupancy	-0.11	0.42	-0.30	1.00	
Dropped Calls in Manual Service	-0.05	0.08	-0.82	0.57	1

Table Appendix I.2 Regression average handling time against the other independent factors

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.639
R Square	0.409
Adjusted R Square	0.388
Standard Error	0.008
Observations	120

VIF	1.691305569

ANOVA					
	df	*SS*	*MS*	*F*	*Sig.*
Regression	4	0.005	0.001165	19.9	0.0000
Residual	115	0.007	5.86E-05		
Total	119	0.011			

	Coefficients	*Std.Error*	*t Stat*	*P-value*
Intercept	0.12105	0.01265	9.56628	2.65087E-16
Answered with in 40 Seconds	-0.10031	0.01632	-6.14836	1.16401E-08
occupancy	0.32035	0.03832	8.35890	1.66406E-13
Dropped Calls in Manual Service	-0.00084	0.00013	-6.66139	9.77783E-10
Number of support staff	0.02749	0.00878	3.13293	0.002195794

Table Appendix I.3 Regression customer's call responding within 40 seconds against the other independent factors

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.915658
R Square	0.838429
Adjusted R Square	0.832809
Standard Error	0.037965
Observations	120

VIF 6.189218

ANOVA					
	df	*SS*	*MS*	*F*	*Sig F*
Regression	4	0.860116	0.215029	149.19	1.49E-44
Residual	115	0.165751	0.001441		
Total	119	1.025866			

	Coefficients	*st.error*	*t Stat*	*P-value*
Intercept	0.787253	0.040983	19.20949	1.1E-37
occupancy	1.547801	0.192921	8.022987	9.69E-13
Dropped Calls	-0.00712	0.000325	-21.8876	8.15E-43
Number of support staff	0.272843	0.037521	7.271818	4.64E-11
Average call handling	-2.46622	0.401119	-6.14836	1.16E-08

Table Appendix I.4 Regression number of support staff against the other independent factors

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.568377
R Square	0.323053
Adjusted R Square	0.299507
Standard Error	0.078093
Observations	120

VIF 1.47722

ANOVA					
	df	*SS*	*MS*	*F*	*Sig. F*
Regression	4	0.334686	0.083672	13.720	3.54E-09
Residual	115	0.701325	0.006098		
Total	119	1.036011			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-0.32736	0.170229	-1.92304	0.056948
Average handlin time	2.860138	0.912927	3.132931	0.002196
Answered with in 40 Seconds	1.154454	0.158757	7.271818	4.64E-11
occupancy	-2.08656	0.455813	-4.57766	1.2E-05
Dropped Calls in Manual Service	0.008282	0.001311	6.317284	5.2E-09

Table Appendix I.5 Regression Agent Occupancy against the other independent factors

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.81104
R Square	0.657787
Adjusted R Square	0.645883
Standard Error	0.014694
Observations	120

VIF	2.922153

ANOVA					
	df	*SS*	*MS*	*F*	*Sig. F*
Regression	4	0.047724	0.011931	55.26189	6.47E-26
Residual	115	0.024829	0.000216		
Total	119	0.072553			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-0.18203	0.027762	-6.55657	1.63E-09
Dropped Calls	0.002287	0.000191	11.97118	6.13E-22
Number of support staff	-0.07387	0.016137	-4.57766	1.2E-05
Average handling time	1.179778	0.14114	8.358897	1.66E-13
Answered with in 40 Seconds	0.231852	0.028898	8.022987	9.69E-13