STATISTICAL ANALYSIS OF THE PERFORMANCE OF CITY-BUSES IN ADDIS ABABA IN 1990 E.C.

BY

SAMUEL ABEBE

JUNE, 1999
Addis Ababa

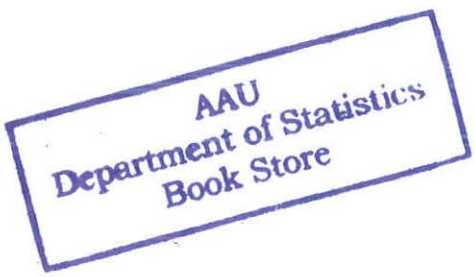
STATISTICAL ANALYSIS OF THE PERFORMANCE OF CITY-BUSES IN ADDIS ABABA IN 1990 E.C.

BY

SAMUEL ABEBE

ADVISOR: ATO GEMECHIS DILBA (M.Sc.)

SUBMITTED TO : DEPARTMENT OF STATISTICS SCIENCE FACULTY ADDIS ABABA UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENT OF THE DEGREE OF BACHELOR OF SCIENCE IN STATISTICS



JUNE, 1999

Addis Ababa

ACKNOWLEDGMENT

I would like to express my heartfelt appreciation for my advisor Ato Gemechis Dilba for his invaluable suggestions and comments in developing this paper.

I am also indebted to RPO (Research and Publications Office) of the Addis Ababa University for its financial support to cover the cost of preparing this paper.

Samuel Abebe

TABLE OF CONTENT

page

CHAPTER ONE

INTRODUCTION

1.1. INTRODUCTION

The availability of adequate and efficient infrastructure facilities such as transportation networks, health services, schools, etc; are very important for developing countries like Ethiopia.

This paper deals with one aspect of infrastructure facilities called the urban transportation, specifically, the performance of city-buses in Addis Ababa. The vast majority of the dwellers of the city of Addis Ababa such as factory workers, students, and civil servants within low income groups are users of city-buses. Therefore, conducting research on city-buses means finding ways for facilitating the efficient use of the buses by the public.

Osman (1996) collected and analysed the data on 42 city-buses. He estimated the average income per kilometer, the average number of passengers carried per trip and tested whether the average number of passengers per trip agrees with the expectation of the office (average of 100). He found out that city-buses numbered 3, 14, 29, 36, 41 and 42 carry on the average less than the expected number of passengers per trip and city-buses 18, 30, 31, 32, 37 and 40 carry on average 100 passengers per trip. The remaining twenty-eight buses

carry significantly more than the expected number of passengers per trip.

The inter-arrival times of some selected city buses are also studied by different individuals.

Recent report of the enterprise indicates that the Anbessa City-Buses Service Enterprise has 365 city-buses under operation in 80 different routes by the beginning of 1991 E.C.

In this research paper, buses operating in 75 routes (1,2,...,75) are taken into account.

1.2. Objective of the Paper

The general objective of this paper is to study the performance of city-buses in Addis Ababa. To make the study, data on income per km (revenue per km) and number of passengers carried per trip for each route (1 to 75) are taken from the office of Anbessa City-Bus.

The specific objectives are :

1. Estimating the average income per km
2. Estimating the average number of passengers carried per trip (Point and confidence interval estimate)
3. Testing hypothesis about the average number of passengers carried per trip.

1.3. Organization of the Paper

The paper is divided into five chapters. The first chapter deals with the introduction and objectives of the paper, the second chapter deals with the way data is collected and its presentation, the third chapter deals with the statistical methods that will be used to analyse the data. The methods of analysis include simple descriptive statistics and inferential statistics, the fourth chapter is analysis of the data. After describing the data by the aid of some descriptive values such as the average and measure of variation, tests will be done for certain hypothesis, and finally, chapter five deals with the conclusions and recommendations.

CHAPTER TWO

DATA COLLECTION AND PRESENTATION

Data is the fundamental element in drawing some statistical information, collection of data is the first step in statistical treatment of a problem. The numerical facts (data) are the raw materials upon which the statistical conclusions will be based.

2.1. Collection of Data

The important thing in this regard is that the work of collecting data should be undertaken with great care. Otherwise, the facts collected may fail to serve the purpose for which they are collected and a lot of time and money may be wasted. There are two sources of data, namely, primary and secondary source of data.

a) Primary source : The term primary data refers to the statistical material which the investigator observes for the purpose of statistical analysis. Primary method of data collection consists of direct personal observation, or of direct communication with people either orally or in written form, such as by preparing questionnaires.

b) Secondary source : The term secondary data on the other hand refers to that statistical material which is not originated by the investigator himself, but which he obtains from other records.

Many institutions have such records and they collect and publish statistics as a part of their routine duties.

Each source of information has its own merits and demerits. The selection of a particular source is dependent upon variety of factors such as :

- the purpose of investigation,
- time required,
- the accuracy required,
- funds available,
- other facilities available.

2.2. Source and Method

In this paper the data is secondary. It is obtained from the record produced by the Office of Anbessa City-Bus service. The office has record of standardized figures, average income per km, and average number of passengers carried per trip for twelve months (Meskerem to Nehase).

Income per km per bus for a month depends on :

A. number of passengers carried in a month,
B. distance from departure to terminal,
C. frequency (number of trips) in a month,
D. charge levied on a passenger in a single trip,

E. number of buses on service.

A. Number of passengers carried in a month

The number of passengers carried in a month is available in daily records of tickets sold. The office keeps records of daily sales of tickets for each bus, and in order to get the number of passengers carried in a month, the daily number of tickets in that particular month is summed up. So the number of tickets sold is equivalent to the number of passengers.

B. Distance from departure to terminal

This is predetermined by the office. Each bus has got a fixed point of departure and terminal, and also specific route to take. Table 2.1. shows the distance traveled by each bus (fixed distance) from departure to terminal in kilometers and the charge levied for a single trip, in Birr.

C. Frequency (number of trips) in a month

The frequency of travel (number of trips) each bus travels per day is compiled from a format designed for this purpose and filled by the ticket seller at the end of each trip. The daily records of number of trips is summed up to get the monthly number of trips.

D. Charge levied on a passenger in a single trip

The charge levied on a passenger in a single trip is also a fixed amount irrespective of the distance a passenger travels in that particular trip. Table 2.1. Shows the pint of departure of the terminal, the distance and the charge for a single trip.

Table 2.1
Distance from departure to terminal of each city bus and the charge levied for a single trip

Bus No.	Departure	Terminal	Distance (in Kms)	Charge (in Birr)
1	Dil-ber	Saris	15.4	0.50
2	Mecanissa	Merkato	9.1	0.25
3	Total-Jimmaber	Minilik-Adebabay	8.8	0.25
4	Kaliti	Merkato	18.3	0.50
5	Mecanissa	Minilik-Adebabay	8.1	0.25
6	Kera	Semin Gebeya	9.4	0.25
7	Alemgenna	Merkato	19.0	0.50
8	Kechene	Merkato	7.0	0.25
9	Bole High school	Piassa	9.4	0.25
10	Lamberet	Piassa	8.8	0.25
11	Messalemia	Minilik Hospital	6.5	0.25
12	Ferensaigh	Merkato	6.7	0.25
13	Bella	Merkato	8.5	0.25
14	Gotera	Piassa	7.8	0.25
15	Kazanchis	Enderasie Hotel	8.0	0.25
16	Kidanemihret	Merkato	7.5	0.25
17	Kuskuam	Merkato	8.8	0.25
18	Keraneo	Merkato	7.9	0.25
19	Asco	Piassa	9.1	0.25
20	Dil-ber	Merkato	6.3	0.25
21	Fetnoderash	Merkato	5.5	0.25
22	Bole Air Port	Merkato	11.6	0.50
23	Lamberet	Merkato	12.1	0.50
24	Burayu	Piassa	16.0	0.50
25	Akaki	Legehar	18.6	0.50
26	Sebeta	Merkato	22.6	0.65
27	Saris-Abo	Legehar	7.8	0.25
28	Asco	Merkato	8.5	0.25
29	Gotera	Merkato	7.0	0.25
30	Sululta	Merkato	24.4	1.000.25
31	Shiro-Meda	Legehar	7.2	0.25
32	Lamberet	Legehar	9.1	0.25
33	Kotebe	Arat-kilo	9.6	0.25
34	Goffa	Merkato	9.6	0.25
35	Cherchos	Messalemia	6.3	0.25
36	Alemgenna	Legehar	12.1	0.50
37	Keraneo	Minilik-Adebabay	9.6	0.25

Source: Anbessa City-Bus Service Enterprise (1991 E.C)

Table 2.1 continued

Bus No.	Departure	Terminal	Distance (in Kms)	Charge (in Birr)
38	Goffa	Minilik-Adebabay	8.3	0.25
39	Kazanchis	Merkato	6.8	0.25
40	Cara-Alo	Merkato	18.0	0.50
41	Eyesus	Merkato	8.4	0.25
42	Megenagna	Legehar	9.1	0.25
43	Menagesha	Merkato	30.0	1.00
44	Legedadi	Merkato	30.0	1.00
45	Dil-Ber	Minilik-Adebabay	5.5	0.25
46	Gergi	Kazanchis	8.5	0.25
47	Shegolle	Merkato	6.1	0.25
48	Bole	Minilik-Adebabay	8.5	0.25
49	C.M.C	Megenagna	6.4	0.25
50	Total-Jimma-Ber	Megenagna	11.7	0.50
51	Behere-Tsege	Legehar	7.4	0.25
52	Gergi	Merkato	14.0	0.50
53	Bole	Sidist-kilo	9.2	0.25
54	Goffa-EELPA	Legehar	7.2	0.25
55	Ayertena	Ferensaigh	15.9	0.50
56	Saris-Abo	Shiromeda	13.1	0.50
57	Cara-Alo	Legehar	13.8	0.50
58	Dukem	Legehar	34.0	1.25
59	Agusta	Minilik-Adebabay	8.5	0.25
60	Debrezeit	Legehar	44.0	2.00
61	C.M.C	Legehar	13.7	0.50
62	Alemgenna	Legehar	23.0	0.50
63	Bole-Michael	Legehar	8.5	0.25
64	Sidist-Kilo	Megenagna	7.8	0.25
65	Megenagna	Kotebe-Gebriel	9.0	0.25
66	Berchico-Fabrica	Minilik-Adebabay	7.3	0.25
67	Mecanissa	Legehar	7.3	0.25
68	Lideta	Minilik Hospital	7.2	0.25
69	Atena-Tera	Shiromeda	11.3	0.50
70	Kazanchis	Ayertena	10.54	0.50
71	Bole High school	Mexico	6.7	0.25
72	Saris-Addisu-Sefer	Legehar	8.5	0.25
73	Legehar	Atena-Tera	7.1	0.25
74	Gurd-Sholla	Merkato	12.8	0.50
75	Sidist-Kilo	Gotera	8.8	0.25

Source: Anbessa City-Bus Service Enterprise (1991 E.C)

2.3. Presentation of the Data

The data, which are collected from Anbessa City-Bus Service Enterprise, are placed in Appendix I and II in a form that is suitable for further analysis. The table is presented in such a way that the horizontal (rows) represent the months of the year 1990 E.C. (Meskerem to Nehasae) and the vertical (columns) represent the route number of the city-buses (bus number). The numbers (observations) in Appendix I indicate the average income per km and the numbers in Appendix II indicate the average number of passengers carried per trip. In the tables, the figures for some buses are missing because the buses did not give service in those particular months.

CHAPTER THREE

METHOD OF ANALYSIS

3.1. Descriptive Statistics

Given a raw data, we would like to find some descriptive values. The most common descriptive statistics are measures of central tendency and measures of variation. Graphs and diagrams are also used to describe a given data. Measures of central tendency are simply measures of centre, (a representative value), commonly known as the average. In descriptive statistics, to be calculated is there are several measures of central tendency such as arithmetic mean, mode, median, etc. After estimating a representative value through one that measures the variation of the data. This measure is commonly known as measure of variation. The most commonly used measures of variation are standard deviation and the range.

3.1.1. Average

The objective of measuring centre or calculating average is to determine a single figure which represents the entire data set. This figure facilitates comparison of several groups of observations. The arithmetic mean or simply the mean, is defined as the sum of all values divided by the number of values.

The sample mean denoted by $\overline{X}$ can be expressed mathematically as follows

$$\overline{X} = \sum_{i=1}^{n} \frac{X_i}{n}$$

Where, X_i = i^{th} observation

n= number of observations (sample size)

3.1.2. Measure of variation

The most useful measure of variation is the standard deviation or root - mean square deviation about the mean. It measures how the given set of data very about the centre (mean).

The variance of n observations X_1, X_2, ... X_n is defined as

$$s^2 = \sum_{i=1}^{n} \frac{(X_i - \overline{X})^2}{n-1}$$

And the standard deviation denoted by S is the square root of the variance.

The standard deviation is a non-negative quantity. A value of zero will happen when there is no variation in the values of

X_i's (i.e. if $X_1 = X_2 = \ldots = X_n$)

For computational purpose we use

$$S^2 = \sum_{i-1}^{n} \frac{X_i^2 - n\overline{X}^2}{n-1}$$

3.2. Inferential statistics

The observed sample values are useful in making some generalizations or conclusions about the characteristics of the entire population. There are two interrelated ways of making statistical inference. These are known as interval estimation and hypothesis testing. while interval estimation also known as confidence interval deals with identifying the upper and lower limits of the values of the unknown parameter, hypothesis testing deals with the issue of making a statement concerning a particular value of a parameter, and then following certain statistical procedure with the eventual aim of accepting or rejecting the statement. Unlike mathematical statements, statistical statements can not be proved because we are dealing with empirical observations and one can not prove but verify with some

degree of confidence whether a given statement is acceptable or not. This verification of a given statement either through a confidence interval or hypothesis testing is valid only for a certain period of time.

In the estimation of confidence interval as well as hypothesis testing the sampling distribution of a given statistic plays a decisive role.

3.2.1. Confidence Interval for the population mean when population variance is unknown

When the population variance δ^2 is unknown, we estimate it by the sample variance (S^2). for a small sample size n, if the parent population is distributed according to the normal curve, the statistic

$$\frac{\overline{X} - \mu}{S/\sqrt{n}}$$

has a student t-distribution with (n-1) degrees of freedom. From this distribution, a (1-α) 100% confidence interval for the population mean μ can be shown to be

$$(\overline{X} - t_{\frac{\alpha}{2}}(n-1)\frac{S}{\sqrt{n}},\quad \overline{X} + t_{\frac{\alpha}{2}}(n-1)\frac{S}{\sqrt{n}})$$

The quantity (1 -α) 100% is called the level of confidence. The chance is (1 -α)that the population mean lies in the interval.

3.2.2. Hypothesis testing about single mean

Hypothesis testing is the second major area of statistical inference. The relationship between lest of hypothesis and confidence interval helps us to determine if a statement concerning specific value of the parameter is supported by the information obtained from the sample data.

3.2.2.1. Hypothesis testing for the mean (μ) when δ^2 is unknown:

Suppose that we want to test Ho:μ = μ_0 against the two - sided alternative H1 : $\neq \mu_0$ where μ_0 is the hypothesized value of the mean.

After taking a random sample of say size n we calculate the test statistic

$$t_{cal} = \frac{\overline{X} - \mu_0}{S/\sqrt{n}}$$

This test statistic has a t-distribution with (n-1) degrees of freedom provided that the parent population has a normal distribution. For a two-tailed test, the rejection region at α level of significance is

$$t_{cal} \leq -t_{\frac{\alpha}{2}}(n-1) \quad or \quad t_{cal} \geq t_{\frac{\alpha}{2}}(n-1)$$

The rejection region is the range of values of the test statistic for which we reject the null hypothesis $H_0 : \mu = \mu_0$

The above rejection region is equivalent to

$$\overline{X} \leq \mu_o - t_{\frac{\alpha}{2}}(n-1)\frac{S}{\sqrt{n}}, \quad or \quad \overline{X} \geq \mu_o + t_{\frac{\alpha}{2}}(n-1)\frac{S}{\sqrt{n}}$$

Which is in turn equivalent to reject H_0 if μ_0 is not in the interval

$$(\overline{X} - t_{\frac{\alpha}{2}}(n-1)\frac{S}{\sqrt{n}}, \quad \overline{X} + t_{\frac{\alpha}{2}}(n-1)\frac{S}{\sqrt{n}})$$

Thus, a (1-α) 100% confidence interval for μ can be used to make decision.

CHAPTER FOUR

ANALYSIS OF DATA

In the previous chapter we have seen the methods used to calculate descriptive values the method of hypothesis testing. Here we shall make use of these methods to assess the level of performance of the buses.

4.1. The Average and Variability of Income per km

From the raw data in Appendix I the average and variability in income per km are calculated. Table 4.1 contains these values.

From Table 4.1 we see that city bus number 21 (which gives service between Fetno-Derash and Merkato) has the highest average income per km (4.57 Birr) followed by bus number 12 which has an average of 4.39 Birr per km. In addition, the table shows that the least income per km is generated by bus number 75 (which gives service between Sidest Kilo and Gotera) with an average of 1.94 Birr per km.

We also see that bus number 70 has the highest variation (s.d of 1.70 Birr per km). And the lowest variability is shown by bus number 7 with s.d = 0.07 Birr per km.

4.2. The Average and Variability of number of passengers carried per trip

The average number of passengers and their corresponding variability per trip are another subject of interest. Table 4.2 contains the calculated average number of passengers carried per trip along with the variability.

From the table we see that bus number 6 (which gives service between Kera and Semen Gebeya) has the highest average number of passengers per trip (139). This indicates that city-bus number 6 is very crowded. Later on we shall test whether this average is significantly greater than the expectation of the office. On the other hand, bus number 58 serving between Kechene and Merkato, has the lowest average number of passengers carried per trip. This indicates that the bus is the least crowded.

From the calculated standard deviation we see that there is high variability in terms of the number of passengers carried per trip for buses 23 which has standard deviation of 25.73. It is followed by bus number 22 and 50 having standard deviations of 24.10 and 22.06, respectively. And the least variability is observed for bus number 21. It has a standard deviation of 2.33 passengers per trip.

Table 4.1
Average and Variability of Income Per Kilometre

Bus Number	Average	s.d	Bus Number	Average	s.d
1	2.81	0.19	41	3.10	0.20
2	3.00	0.18	42	2.93	0.10
3	3.17	0.09	43	2.94	0.16
4	3.05	0.41	44	2.84	0.29
5	3.24	0.28	45	3.67	0.10
6	3.70	0.08	46	3.07	0.10
7	2.68	0.07	47	3.11	0.13
8	3.91	0.18	48	2.80	0.13
9	2.83	0.14	49	2.06	0.22
10	2.92	0.17	50	3.17	0.20
11	4.14	0.13	51	2.68	0.10
12	4.39	0.16	52	3.77	0.30
13	2.80	0.61	53	2.45	0.10
14	3.17	0.16	54	2.65	0.14
15	3.34	0.13	55	3.23	0.25
16	3.91	0.26	56	3.29	0.10
17	3.62	0.27	57	3.08	0.15
18	3.82	0.20	58	1.97	0.29
19	2.94	0.18	59	1.79	0.29
20	3.26	0.10	60	3.42	0.13
21	4.57	0.09	61	2.14	0.33
22	2.69	0.09	62	2.28	0.22
23	3.32	0.17	63	2.64	0.12
24	2.22	0.12	64	2.90	0.22
25	2.91	0.35	65	2.83	0.34
26	2.75	0.12	66	2.90	0.43
27	3.41	0.19	67	3.59	0.97
28	3.01	0.13	68	3.35	1.44
29	3.70	0.35	69	2.82	0.78
30	3.70	0.39	70	4.17	1.70
31	3.75	0.15	71	2.83	0.36
32	3.49	0.11	72	2.81	0.17
33	3.00	0.11	73	3.85	0.23
34	2.91	0.29	74	2.74	0.33
35	3.28	0.12	75	1.94	0.30
36	3.21	0.32			
37	3.13	0.30			
38	3.17	0.08			
39	3.53	0.20			
40	3.09	0.18			

Table 4.2

Average and Variability of Number of Passangers carried Per Trip

Bus Number	Average	s.d	Bus Number	Average	s.d
1	87	5.79	41	104	6.93
2	109	6.74	42	107	3.63
3	112	3.07	43	88	4.82
4	120	14.13	44	84	6.89
5	105	8.97	45	81	2.39
6	139	3.20	46	105	3.52
7	112	12.86	47	76	3.10
8	86	3.87	48	95	4.38
9	106	5.39	49	70	7.56
10	103	6.12	50	93	22.06
11	108	3.35	51	91	3.43
12	118	4.36	52	106	8.39
13	95	20.59	53	90	3.69
14	89	4.67	54	87	4.81
15	107	4.14	55	100	12.61
16	117	7.73	56	86	2.87
17	128	9.44	57	85	4.17
18	121	6.27	58	53	7.73
19	107	6.42	59	93	8.25
20	82	2.53	60	77	2.88
21	92	2.33	61	57	8.85
22	81	24.10	62	78	4.72
23	103	25.73	63	90	3.78
24	71	3.98	64	91	6.62
25	109	12.85	65	69	6.58
26	107	13.87	66	86	13.98
27	107	5.81	67	77	11.63
28	103	9.93	68	80	8.61
29	103	9.93	69	59	10.38
30	104	12.03	70	57	7.74
31	108	4.49	71	64	12.05
32	103	3.31	72	97	5.76
33	115	4.48	73	103	6.27
34	112	11.07	74	59	7.32
35	83	3.06	75	66	10.32
36	96	16.47			
37	120	11.91			
38	106	2.71			
39	96	5.25			
40	111	6.39			

4.3. Confidence Interval on the Average Number of Passengers per trip

In the case of our data, there are 12 observations for all of the city buses except for buses 1, 60, 61, 62, ..., 75. Since each observation is an average (which is tabulated in Appendix II). And since the total number of trips in a given month is large, by Central Limit Theorem the 12 observations under each bus can be regarded as random sample from normal population. In fact, there is an implicit assumption that the distribution is the same in the given year. Now since the sample size is small ($n \leq 12$) and the variance is not known we shall make use of t-distribution. Confidence interval on the average number of passengers carried per trip for all buses (1 – 75) is given in Table 4.3.

The confidence interval for the expected number of passengers carried per trip (μ) for a given bus is computed as follows

$$(\overline{X} - t_{\frac{\alpha}{2}}(n-1)\frac{S}{\sqrt{n}},\quad \overline{X} + t_{\frac{\alpha}{2}}(n-1)\frac{S}{\sqrt{n}})$$

Where $\overline{X}$ = average number of passengers carried per trip for a given bus

$t_{\frac{\alpha}{2}}(n-1)$ is t-value (from t-table)

for $n=12$, $t_{0.025}(11)=2.201$

S = standard deviation for number of passengers carried per trip by the bus

A computer programme which gives a 95% confidence interval for a given $\bar{x}$, t-value, s and n was written to easily construct the confidence intervals for the 75 buss (see Appendix III)

As can be seen from Table 4.3 the 95% confidence interval for the average number of passengers carried per trip for bus number 1 is (83,91). This implies that we are 95% sure that the average number of passengers carried per trip for this bus lies between 83 and 91.

In like manner, the other confidence intervals can be interpreted.

Table 4.3
Confidence Interval on the average number of passengers carried per trip

Bus Number	Confidence Interval	Bus Number	Confidence Interval	Bus Number	Confidence Interval
1	(83,91)	26	(98,116)	51	(89,93)
2	(105,113)	27	(103,111)	52	(100,111)
3	(110,114)	28	(97,109)	53	(88,92)
4	(111,129)	29	(97,109)	54	(84,90)
5	(99,111)	30	(96,112)	55	(92,108)
6	(137,141)	31	(105,111)	56	(84,88)
7	(104,120)	32	(101,105)	57	(82,88)
8	(84,88)	33	(112,118)	58	(48,58)
9	(103,109)	34	(105,119)	59	(88,99)
10	(99,107)	35	(81,85)	60	(75,79)
11	(106,110)	36	(86,106)	61	(51,63)
12	(115,121)	37	(112,128)	62	(75,81)
13	(82,108)	38	(104,108)	63	(87,93)
14	(86,92)	39	(93,100)	64	(86,96)
15	(104,110)	40	(107,115)	65	(64,74)
16	(112,122)	41	(100,109)	66	(75,97)
17	(122,134)	42	(105,109)	67	(69,85)
18	(117,125)	43	(85,91)	68	(74,86)
19	(103,111)	44	(80,88)	69	(52,66)
20	(80,84)	45	(79,83)	70	(51,63)
21	(91,93)	46	(103,107)	71	(55,73)
22	(66,97)	47	(74,78)	72	(93,101)
23	(87,119)	48	(93,98)	73	(98,108)
24	(69,73)	49	(65,75)	74	(53,65)
25	(101,117)	50	(79,107)	75	(55,77)

4.4. Hypothesis testing about the average number of passengers carried per trip

The office expects an average of 100 passengers per trip. Therefore, the hypothesis of interest is:

$H_0 : \mu_i = 100$

$H1 : \mu_i \neq 100$ i=1, 2,.....,75

At 5% level of significance the 95% confidence intervals in Table 4.3. can be used in order to decide whether to reject H_0 or not. For instance, the 95% confidence interval for μ_1 does not contain the hypothesized mean 100.

Therefore we reject H_0 and conclude that the average number of passengers carried per trip by bus number 1 is not 100. However, the 95% confidence interval for bus number 5 is (99,111) passengers per trip, which contains the hypothesized mean 100. Therefore, we accept H_0 and conclude that the average number of passengers carried per trip for bus number 5 is 100.

In like manner we can test the hypothesis about the average number of all other buses. If a confidence intervals in Table 4.3 contains 100, we accept the null hypothesis of $\mu = 100$. For buss number 5, 10, 13, 23, 26, 28, 29, 30, 36, 41, 50, 55, 72 and 73, at 5% level of significance, we conclude that the average number of passengers

carried per trip is 100. For the other buss the average is not 100 (i.e less than 100 or greater than 100 passengers per trip).

CHAPTER FIVE
SUMMARY AND CONCLUSION

The objective of the paper was to study performance of the city buses in Addis Ababa in 1990 E.C. To make the study, data on income per km (revenue per km) and number of passengers carried per trip for each route (1-75) were taken from the office.

The average income per kilometer and the average number of passengers carried per trip were estimated along with their variability. We found that city bus number 21, which gives service between Fetno-Derash and Merkato, has the highest average income per km (4.57 Birr). It is the followed by bus number 12(average of 4.39 Birr per km). And the least income per km is generated by bus number 75, which gives service between Sidest Kilo and Gotera, with an average of 1.94 Birr per km. We also found that bus number 70 has the highest variability (s.d of 1.70 Birr per km), and the lowest variability is shown by bus number 7 (s.d = 0.07 Birr per km). In addition we found that bus number 6 (which gives service between Kera and Semen Gebeya) has the highest average number of passengers per trip (139). On the other hand bus number 58 serving between Kechene and Merkato, has the lowest average number of passengers carried per trip (53). The highest variability in terms of the number of passengers carried per trip is observed for bus number 23 and 21 with standard deviation of 25.73 and the lowest variability is observed for bus number 21 with standard deviation of 2.33

passengers per trip. Tests of hypothesis are also performed to check whether the average number of passengers carried per trips agree with the expectation of the office (average of 100). We found out that city buses numbered: 5, 10, 13, 23, 26, 28, 29, 30, 36, 39, 41, 50, 52, 55, 72, and 73 carry on average 100 passengers per trip at the 5% level of significance. And buses 2, 3, 4, 6, 7, 9, 11, 12, 15, 16, 17, 18, 19, 25, 27, 31, 32, 33, 34, 37, 38, 40, 42, and 46 carry significantly more than the expected number of passengers per trip. The remaining buses carry significantly less than the expected number of passengers per trip.

The analysis indicates that many city buses (24 buses) carry more than the expected number of passengers per trip. This has a negative effect on the users of the city-buses in terms of being crowded. On the other hand, the majority of the city buses (35 buses) carry less than the expected number of passengers per trip. That is they are under utilized.

We hope that the results of this analysis are useful for the Anbessa city Buses Service Enterprise to effectively allocate buses in such a way that both the users and the office are mutually benefited.

References

1. Asmerom Kidane and Tessema Astatkie(Sept.1989)
   Statstical Methods (Part I)
   Addis Ababa
2. Cochran (Third Edition)
   Sampling Techniques
3. Snedecor, G.W And Cochran, W.C. (1967):
   Statistical Methods
   Sixth edition IOWA State University Press,Ames, IOWA

4. Osman (1996) Assesment of the performance of city buses in Addis Ababa in 1987 E,C(Under graduate Research Paper , A.A..U)

Appendix I:
Average Income per kilo meter

Month	Bus Number														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Meskerem	-	3.10	3.20	2.99	3.66	38.3	2.70	4.00	2.96	2.85	4.16	4.35	3.28	3.47	3.35
Tikmit	-	2.93	3.15	2.23	3.44	3.62	2.79	4.10	3.05	2.72	4.18	4.33	3.28	3.38	3.37
Hidar	-	2.91	3.18	2.63	3.47	3.61	2.65	3.65	2.91	2.84	4.02	4.16	2.72	3.25	3.29
Tahssas	2.44	3.20	3.25	3.34	3.52	3.68	2.61	3.71	2.68	2.81	4.08	4.28	2.07	3.21	3.19
Tir	2.70	2.70	2.97	3.37	3.36	3.67	2.68	3.80	2.53	2.75	3.91	4.12	1.84	3.34	3.02
Yekatit	2.81	2.81	3.26	3.40	3.23	3.73	2.73	3.78	2.78	3.23	4.11	4.34	2.14	3.10	3.31
Megagit	2.81	2.81	3.23	3.43	3.83	3.74	2.64	3.94	2.80	3.03	4.23	4.36	2.05	3.00	3.35
Miazia	2.96	2.96	3.19	3.30	2.86	3.76	2.59	3.98	2.69	3.18	4.26	4.51	2.95	3.12	3.38
Ginbot	2.91	2.91	3.15	2.40	2.95	3.68	2.78	3.67	2.91	3.08	4.42	4.56	3.19	3.03	3.47
Sene	2.71	2.71	3.04	3.01	2.93	3.54	2.69	4.13	2.87	2.82	4.20	4.62	3.26	2.94	3.47
Hamle	3.10	3.10	3.26	3.28	3.41	3.80	2.61	4.09	2.93	2.93	4.13	4.51	3.41	3.09	3.47
Nehase	2.89	2.89	3.20	3.21	3.21	3.73	2.72	4.02	2.83	2.76	4.03	4.52	3.42	3.09	3.45

Appendix I: (continued)

Month	Bus Number														
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Meskerem	3.83	3.39	3.90	3.25	3.22	4.71	2.70	3.24	2.37	2.02	2.72	3.29	3.16	3.78	3.20
Tikmit	3.84	3.46	3.98	3.32	3.39	4.65	2.78	3.21	2.21	3.50	2.73	3.23	3.19	3.94	3.24
Hidar	3.59	3.34	3.79	3.00	3.17	4.53	2.73	3.16	2.11	3.23	2.69	3.16	3.02	3.63	3.10
Tahssas	3.61	3.47	3.76	2.96	3.21	4.50	2.70	3.25	2.09	2.85	2.73	3.20	2.90	3.71	3.40
Tir	3.53	3.23	3.29	2.77	3.30	4.56	2.64	3.18	2.09	2.99	2.74	3.39	2.85	3.77	4.22
Yekatit	3.89	3.51	3.68	2.83	3.13	4.58	2.70	3.41	2.16	3.02	3.04	3.45	2.86	3.66	3.94
Megagit	4.00	3.56	3.89	2.87	3.11	4.68	2.80	3.35	2.18	3.00	2.92	3.25	2.88	3.83	3.96
Miazia	4.02	3.74	3.81	2.90	3.25	4.53	2.70	3.37	2.11	2.97	2.75	3.45	2.97	3.87	4.24
Ginbot	4.27	4.08	3.91	2.90	3.33	4.51	2.55	3.02	2.25	2.81	2.64	3.72	3.14	3.84	3.97
Sene	3.94	3.80	3.88	2.82	3.28	4.60	2.50	3.53	2.24	2.75	2.59	3.49	3.17	2.62	3.75
Hamle	4.07	3.90	4.11	2.78	3.41	4.61	2.70	3.59	2.47	2.90	2.67	3.67	3.03	3.84	3.63
Nehase	4.37	3.95	3.96	2.83	3.35	4.37	2.76	3.49	2.33	2.90	2.74	3.63	2.95	3.93	3.73

Appendix I: (Continued)

Month	Bus Number														
	31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**
Meske	4.05	3.47	3.24	2.93	3.23	2.95	3.17	3.24	3.46	3.00	3.11	3.03	3.03	3.34	3.51
Tikmit	3.65	3.48	2.85	3.10	3.27	2.97	3.37	3.31	3.50	2.91	2.98	3.03	2.85	3.35	3.71
Hidar	3.60	3.30	2.95	3.05	3.18	2.86	3.32	3.18	3.43	3.02	2.99	2.89	2.93	2.55	3.66
Tahssas	3.65	3.43	2.93	2.95	3.22	2.76	3.31	3.10	3.51	2.89	3.05	2.86	2.96	2.55	3.68
Tir	3.68	3.54	2.88	2.95	3.10	2.92	2.46	3.12	3.14	2.82	3.16	3.15	3.13	2.77	3.62
Yekatit	4.05	3.57	3.08	2.95	3.18	3.73	3.03	3.15	3.33	3.11	3.20	2.92	3.17	2.66	3.77
Megagit	3.87	3.57	3.07	3.02	3.30	3.37	3.14	3.06	3.44	2.97	2.82	2.91	3.07	2.88	3.68
Miazia	3.74	3.65	3.06	2.97	3.21	3.44	3.18	3.18	3.55	3.30	3.14	2.93	2.99	3.16	3.69
Ginbot	3.74	3.48	3.07	2.94	3.45	3.35	2.59	3.13	3.72	3.28	2.80	2.97	2.94	2.87	3.56
Sene	3.64	3.29	3.00	2.01	3.29	3.09	3.18	3.06	3.74	3.13	3.10	2.81	2.66	2.71	3.82
Hamle	3.70	3.50	3.01	3.06	3.41	3.57	3.37	3.28	3.82	3.39	3.44	2.90	2.67	2.53	3.85
Nehase	3.67	3.57	2.86	2.94	3.80	3.45	3.41	3.25	3.74	3.20	3.46	2.76	2.84	2.70	3.73

Appendix I: (Continues)

Month	Bus Number														
	46	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
Meske	3.51	3.26	2.81	2.36	3.03	2.72	3.38	2.44	2.61	3.06	3.29	3.10	259	2.63	-
Tikmit	3.08	3.13	2.95	2.51	2.92	2.67	3.47	2.49	2.55	2.88	3.23	3.03	2.10	1.50	3.34
Hidar	2.96	3.13	2.91	2.34	2.97	2.62	3.35	2.36	2.36	2.88	3.15	2.85	2.09	1.58	3.47
Tahssas	3.11	3.20	2.50	2.14	3.15	2.61	3.50	2.27	2.63	3.32	3.18	3.05	1.91	1.65	3.36
Tir	3.25	3.36	2.92	1.94	3.27	2.85	3.62	2.49	2.57	3.20	3.31	3.15	2.05	1.65	3.55
Yekatit	3.02	3.16	2.84	1.98	3.51	2.73	3.86	2.63	2.64	3.78	3.80	3.28	2.06	1.75	3.61
Megagit	3.08	3.05	2.78	1.87	3.36	2.56	3.85	2.51	2.64	3.29	3.38	2.90	2.21	1.76	3.46
Miazia	3.13	3.01	2.63	1.91	3.42	2.82	3.93	2.44	2.65	3.29	3.38	3.22	1.94	1.66	3.55
Ginbot	3.16	3.16	2.72	1.92	3.13	2.69	3.99	2.47	2.73	3.31	3.26	3.20	1.72	1.75	3.43
Sene	3.09	2.99	2.81	1.95	2.92	2.51	3.93	2.43	2.64	3.05	3.15	3.04	1.56	1.80	3.19
Hamle	3.17	291	2.91	2.00	3.25	2.69	4.21	2.51	2.85	3.40	3.34	3.25	1.65	1.90	3.26
Nehase	2.93	3.00	2.87	1.83	3.10	2.73	4.18	2.31	2.93	3.32	3.33	2.85	1.70	1.89	3.37

Appendix I: (Continued)

Month	Bus Number														
	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
Meskerem	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tikmit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hidar	2.05	2.86	2.40	2.52	3.38	-	5.80	7.34	3.97	2.50	3.34	2.45	-	-	-
Tahssas	2.05	2.21	2.49	2.68	2.72	3.61	4.70	3.73	4.41	2.15	2.35	2.74	-	-	-
Tir	2.18	2.04	2.65	2.63	2.19	2.36	2.67	3.09	2.21	1.81	2.31	2.80	3.51	2.00	-
Yekatit	1.29	2.24	2.69	3.02	2.57	2.58	2.65	2.53	1.96	2.47	2.39	2.77	3.77	2.57	-
Megagit	2.21	2.20	2.71	2.92	2.65	2.47	3.07	2.84	2.35	5.37	2.78	2.80	4.05	2.84	1.41
Miazia	2.54	2.26	2.74	2.86	2.85	2.57	3.38	2.84	2.84	5.36	2.92	2.86	3.91	2.81	2.09
Gingot	2.36	2.18	2.74	3.11	2.91	3.32	3.44	2.66	2.59	5.20	2.97	2.84	4.18	2.77	1.88
Sene	2.19	2.20	2.74	3.01	2.78	3.16	3.26	2.56	2.60	5.12	2.96	2.80	3.55	2.87	1.86
Hamle	2.33	2.29	2.63	3.12	3.23	3.08	3.48	2.96	2.82	5.88	3.14	3.05	3.87	3.06	2.14
Nehase	2.20	2.34	2.57	3.06	3.05	2.92	3.54	2.91	2.47	5.86	3.14	3.03	3.93	3.00	2.27

Appendix II:

Average Number of Passengers Carried Per Trip

Month	Bus Number														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Meskerem	-	113	113	147	118	144	128	88	111	100	108	117	111	97	107
Tikmit	-	107	111	110	111	136	132	90	115	96	109	116	112	95	108
Hidar	-	106	112	133	113	136	125	80	109	100	105	111	93	91	105
Tahssas	75	117	114	122	114	138	123	82	101	99	106	115	70	90	102
Tir	83	98	105	123	109	138	122	84	95	97	102	110	63	94	97
Yekatit	87	100	115	124	105	140	104	83	104	114	107	116	73	87	106
Megagit	86	101	114	126	92	141	100	87	105	107	110	117	70	84	107
Miazia	91	109	112	121	93	142	98	88	101	112	111	121	100	87	108
Ginbot	90	112	111	88	96	138	106	81	109	108	115	122	109	85	111
Sene	83	111	107	110	95	133	102	91	108	99	109	124	111	82	111
Hamle	95	117	115	120	110	143	99	90	110	103	107	121	116	87	111
Nehase	89	117	113	117	104	140	104	89	106	97	105	121	116	86	110

Appendix II: (continued)

Month	Bus Number													
	16	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**
Meskerem	115	119	123	118	81	94	110	135	77	76	123	103	107	106
Tikmit	115	122	123	121	85	93	113	134	72	131	123	101	108	110
Hidar	108	118	120	109	80	91	111	131	69	121	122	99	103	102
Tahssas	108	122	119	108	81	90	110	135	67	106	123	101	99	104
Tir	106	114	104	101	83	91	97	121	67	112	118	106	97	105
Yekatit	117	124	116	103	79	92	63	83	69	113	106	108	97	102
Megagit	120	125	123	104	78	94	65	81	70	112	102	101	98	107
Miazia	121	132	121	106	82	96	63	82	67	111	96	108	101	108
Gingot	128	144	123	106	84	90	59	73	72	105	92	116	107	107
Sene	118	134	122	103	83	92	58	85	72	103	90	109	108	73
Hamle	122	137	130	101	86	92	63	87	79	109	93	114	103	107
Nehase	131	139	125	103	85	87	64	84	75	108	95	113	100	110

Appendix II: (continued)

Month	Bus Number													
	30	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**
Meskerem	120	117	103	125	113	81	118	122	108	94	108	105	110	91
Tikmit	122	105	103	109	119	82	119	130	110	95	105	100	110	86
Hidar	116	104	98	113	117	80	115	128	106	93	109	100	105	88
Tahssas	117	105	101	113	113	81	110	127	103	96	104	102	104	89
Tir	103	106	105	111	113	78	105	94	104	86	102	106	114	94
Yekatit	96	117	106	118	113	80	90	116	105	91	112	108	106	95
Megagit	97	111	106	118	116	83	82	120	102	94	107	95	106	92
Miazia	104	108	108	118	114	81	83	122	106	96	119	106	107	90
Ginbot	97	108	103	118	113	87	81	99	104	101	118	94	108	88
Sene	92	105	97	115	77	83	75	122	102	102	113	104	102	80
Hamle	89	107	104	116	117	86	86	129	109	104	122	116	105	80
Nehase	91	106	106	110	113	88	83	131	108	102	115	116	101	85

Appendix II: (continued)

	Bus Number													
Month	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**
Meskerem	93	77	99	80	95	80	118	92	95	90	86	84	86	86
Tikmit	94	82	105	76	100	85	115	91	97	92	84	79	85	84
Hidar	77	81	101	76	99	80	116	89	94	87	77	79	83	79
Tahssas	76	81	106	78	85	73	123	89	98	83	86	106	83	84
Tir	83	80	111	82	99	66	117	97	101	92	84	102	87	87
Yekatit	80	83	103	77	96	67	82	93	108	97	87	120	92	91
Megagit	86	81	105	75	95	64	79	87	108	92	87	105	89	80
Miazia	95	81	106	74	90	65	80	96	110	90	87	105	89	89
Gingot	86	78	108	77	93	65	73	91	112	91	89	105	86	88
Sene	81	77	105	73	96	66	68	85	110	89	87	97	82	84
Hamle	76	85	108	71	99	68	76	91	118	92	94	108	87	90
Nehase	81	82	100	73	98	62	72	93	117	85	96	105	87	79

Appendix II: (continued)

	Bus Number																	
Month	**58**	**59**	**60**	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**
Meskerem	70	77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tikmit	57	83	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hidar	57	87	78	55	68	82	79	68	-	93	100	52	60	56	84	-	-	-
Tahssas	52	91	76	55	79	85	84	71	113	88	70	83	52	58	94	-	-	-
Tir	56	91	80	58	73	90	82	56	71	56	75	54	42	59	96	94	43	-
Yekatit	56	97	81	34	80	91	94	64	75	60	73	44	47	64	95	101	55	-
Megagit	60	97	78	59	79	92	93	66	72	72	82	53	60	74	96	109	61	48
Miazia	53	92	80	67	81	93	89	71	75	80	82	64	60	78	98	105	61	71
Gingot	47	97	77	63	78	93	97	72	97	81	77	58	58	80	98	112	60	64
Sene	42	99	72	58	79	93	94	69	92	77	74	59	57	79	96	95	62	63
Hamle	45	105	73	62	83	89	97	80	90	82	85	64	66	84	105	104	66	73
Nehase	46	104	76	58	84	87	96	76	85	83	84	56	66	84	104	105	65	77

Appendix III

Program Confidence - Interval

```
Var a, s, t, l, u: real ; { a is an average of
                            passengers carried per
                            trip  and s is the standard
                            deviation}

      n: byte;

Begin

      Writeln ("enter the sample mean, a");

      Readln (a);

      Writeln ( "enter the  value of s");
      Readln (s);

      Writeln (" enter the value of n");

      Readln (n);

            If n = 6 then t : = 2.571

            Else if n= 8 then t : = 2.365
```

```
Else if n = 9 then  t : = 2.306
Else if n = 10 then t : = 2.262
Else if n = 11 then t : = 2.228
Else if n = 12 then t : = 2.201;
l : = a - t*  S /SQRT (n)  { l is the lower confidence
                             limit}
u: = a +t* S /SQRT(n) { u is the upper confidence
                        limit}
Writeln (l, u);
Readln;
end.
```