Chapter 6
Input for Running the Model

After verify and validate the model, this chapter is to find out the inputs for the model. The inputs of this model consist of: service time distribution of IVR and agent, transfer time distribution, and probability of the customer who require contacting only IVR. The model requires these inputs for 9 periods (from 9:00 to 18:00).

6.1 Input For Determining the Appropriate Fixed Resource

To find the appropriate fixed resource, IVR ports and Telephone lines in this case, the maximum average IVR service time, transfer time, and agent service time are used as inputs because these fixed resources cannot adjusted based on time from example, we cannot reduce IVR port from 60 ports on workdays to 30 ports on holidays.

Input for 9:00 to 10:00

The average service times of IVR service time, transfer time, and agent service time of this period are shown as follows:

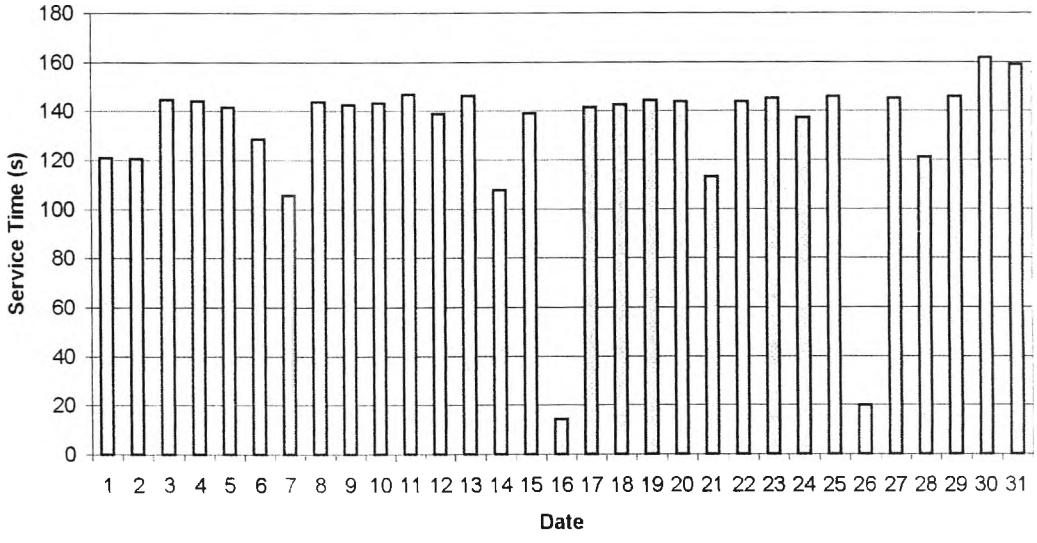


Figure 6-1: Average IVR Service Time at 9:00 to 10:00

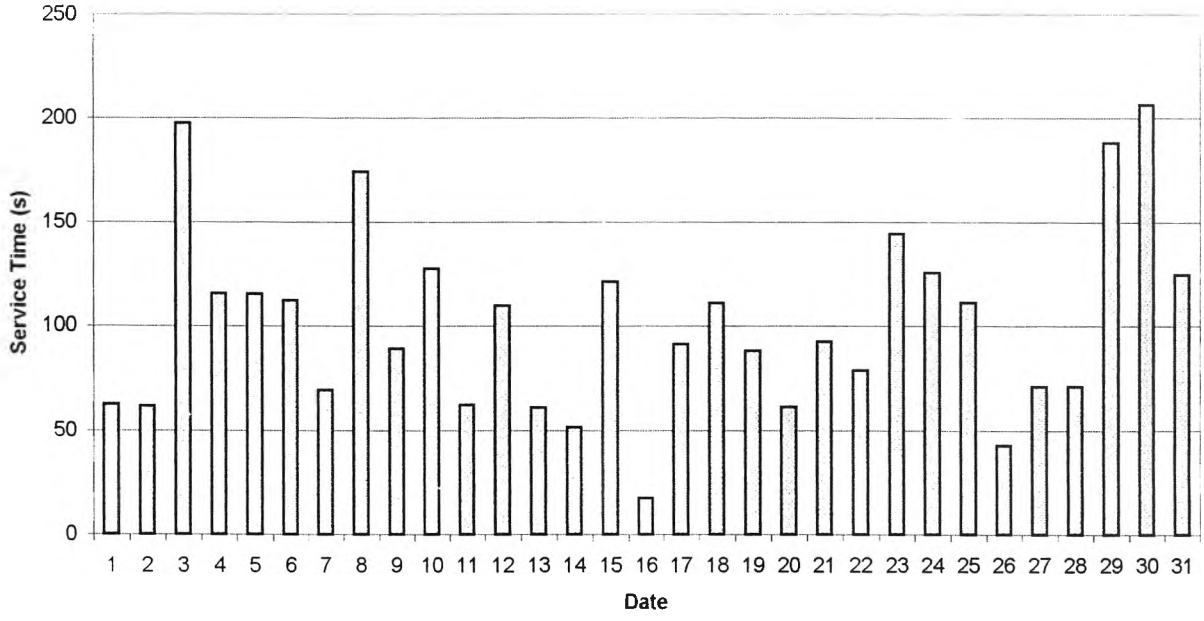


Figure 6-2: Average Transfer Time at 9:00 to 10:00

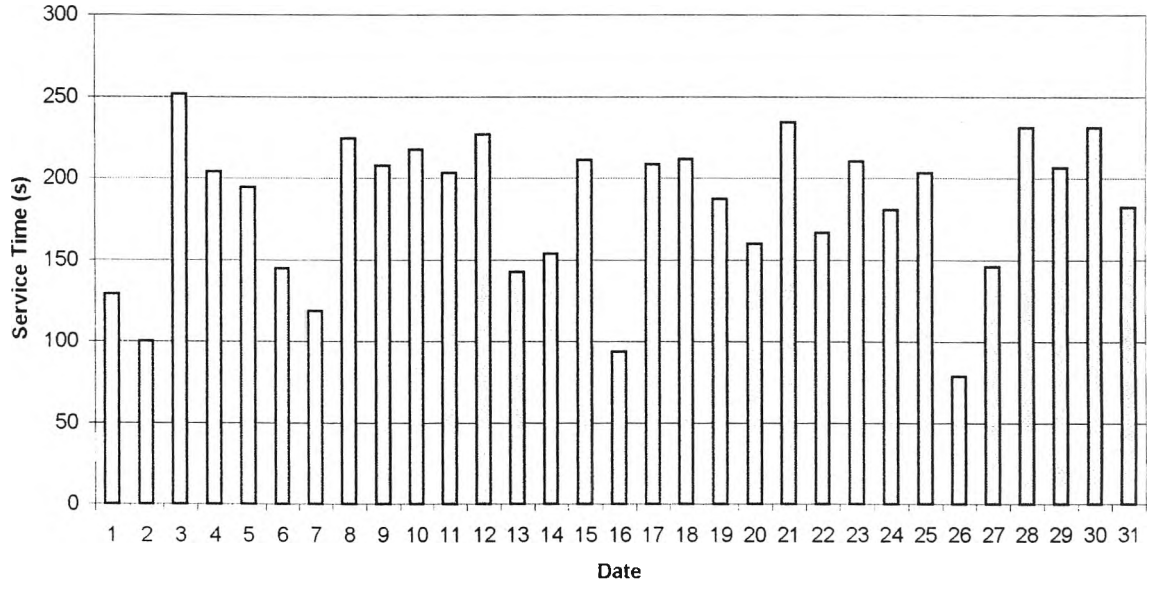


Figure 6-3: Average Agent Service Time at 9:00 to 10:00

From these figure, we choose the IVR service time on day 30, transfer time on day 30, and agent service time on day 3 as inputs for 9:00 to 10:00.

The distribution of these inputs is shown below:

Distribution Summary

Distribution: Erlang
Expression: 3 + ERLA(52.9, 3)
Square Error: 0.005763

Chi Square Test
Number of intervals = 13
Degrees of freedom = 10
Test Statistic = 56.8
Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
Test Statistic = 0.056
Corresponding p-value < 0.01

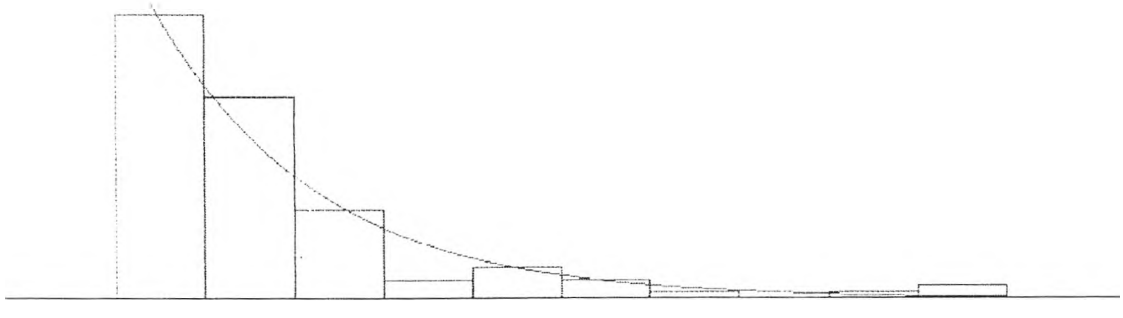
Data Summary

Number of Data Points = 1131
Min Data Value = 3
Max Data Value = 1.1e+003
Sample Mean = 162
Sample Std Dev = 100

Histogram Summary

Histogram Range = 3 to 1.1e+003
Number of Intervals = 33

Figure 6-4: IVR service time distribution on 30 January from 9:00 to 10:00



Distribution Summary

Distribution: Exponential
Expression: 15 + EXPO(191)
Square Error: 0.006562

Chi Square Test
Number of intervals = 4
Degrees of freedom = 2
Test Statistic = 4.93
Corresponding p-value = 0.0884

Kolmogorov-Smirnov Test
Test Statistic = 0.0954
Corresponding p-value > 0.15

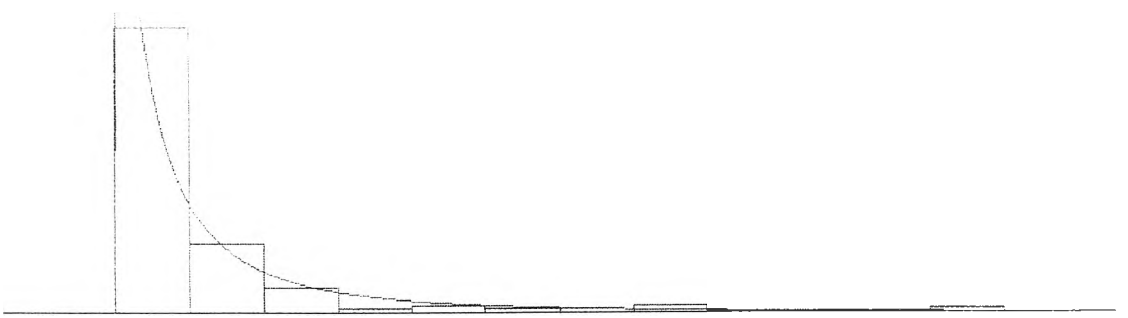
Data Summary

Number of Data Points = 106
Min Data Value = 15
Max Data Value = 1.07e+003
Sample Mean = 206
Sample Std Dev = 195

Histogram Summary

Histogram Range = 15 to 1.07e+003
Number of Intervals = 10

Figure 6-5: Transfer Time on 30 January, 9:00 to 10:00



Distribution Summary

Distribution: Lognormal
Expression: 10 + LOGN(341, 908)
Square Error: 0.004735

Chi Square Test
Number of intervals = 4
Degrees of freedom = 1
Test Statistic = 5.01

Corresponding p-value = 0.0254

Kolmogorov-Smirnov Test
Test Statistic = 0.127
Corresponding p-value = 0.0122

Data Summary

Number of Data Points = 156
Min Data Value = 10
Max Data Value = 2.32e+003
Sample Mean = 251
Sample Std Dev = 362

Histogram Summary

Histogram Range = 10 to 2.32e+003
Number of Intervals = 12

Figure 6-6: Agent Transfer Time Distribution on 30 January, 9:00 to 10:00

Input for 10:00 to 11:00

The average service times of IVR service time, transfer time, and agent service time of this period are shown as follows:

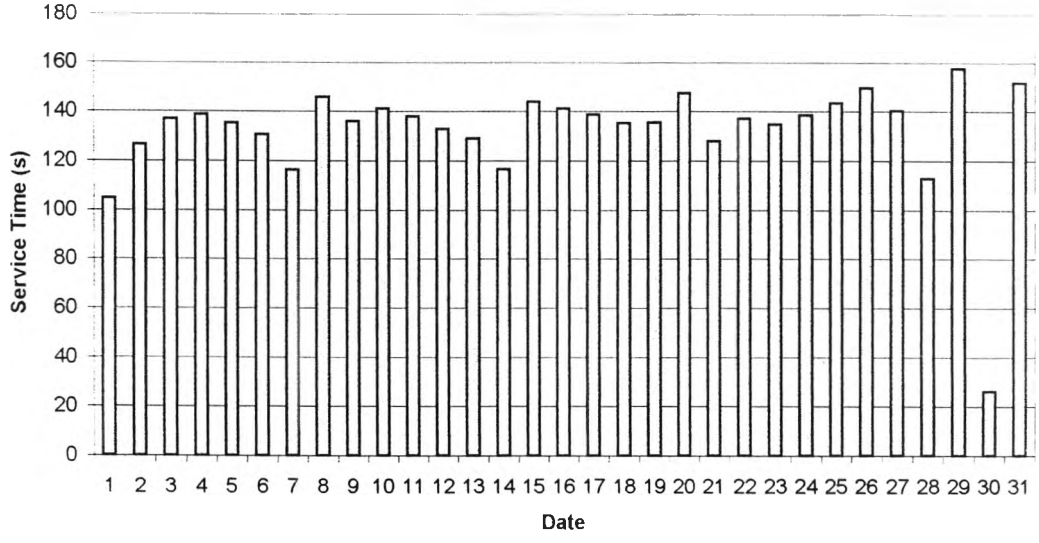


Figure 6-7: Average IVR service time at 10:00 to 11:00

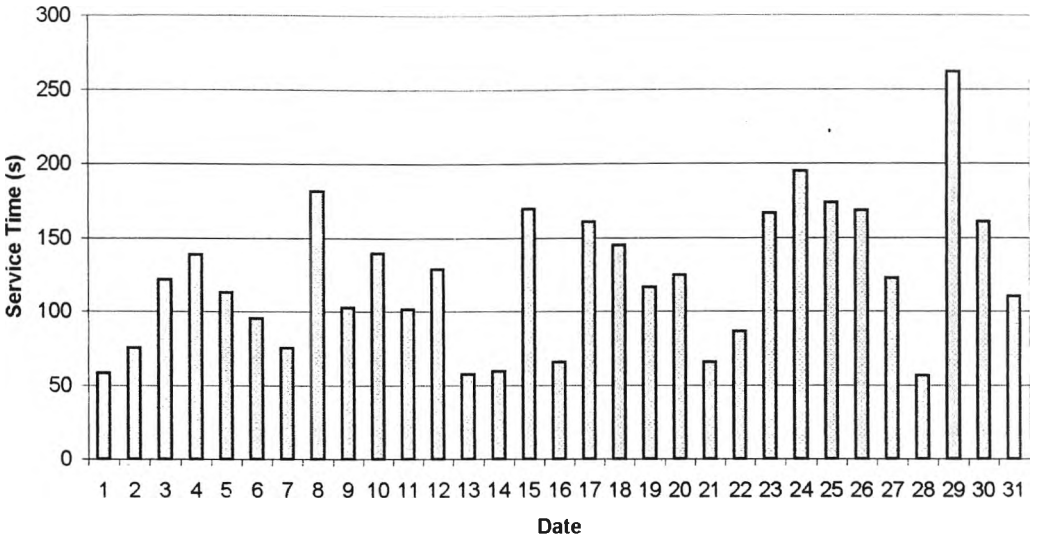


Figure 6-8: Average Transfer time at 10:00 to 11:00

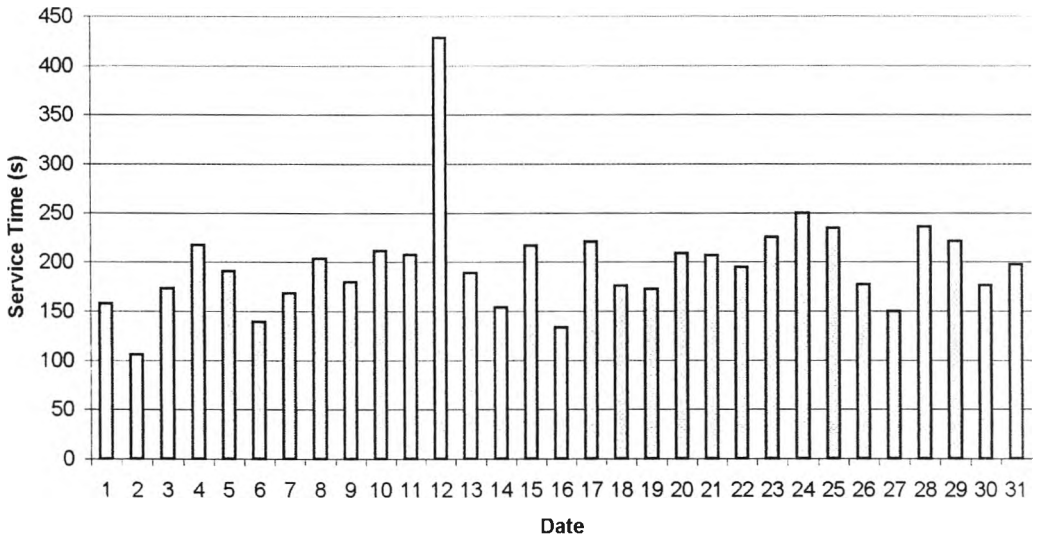
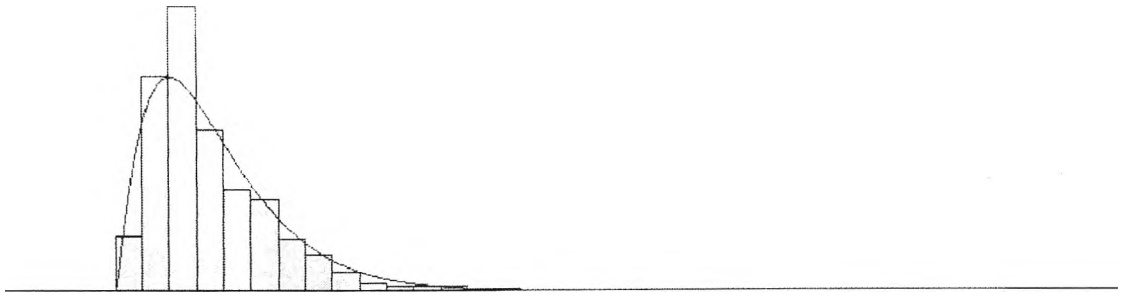


Figure 6-9: Average Agent Service Time at 10:00 to 11:00

From these figure, we choose the IVR service time on day 29, transfer time on day 29, and agent service time on day 24 (not choose day 12 because the value is significantly higher that that in workday) as inputs for 10:00 to 11:00.

The distribution of these inputs is shown below:



Distribution Summary

Distribution: Gamma
Expression: 3 + GAMM(69.7, 2.22)
Square Error: 0.007801

Chi Square Test

Number of intervals	= 12
Degrees of freedom	= 9
Test Statistic	= 67.6
Corresponding p-value	< 0.005

Kolmogorov-Smirnov Test

Test Statistic	= 0.0696
Corresponding p-value	< 0.01

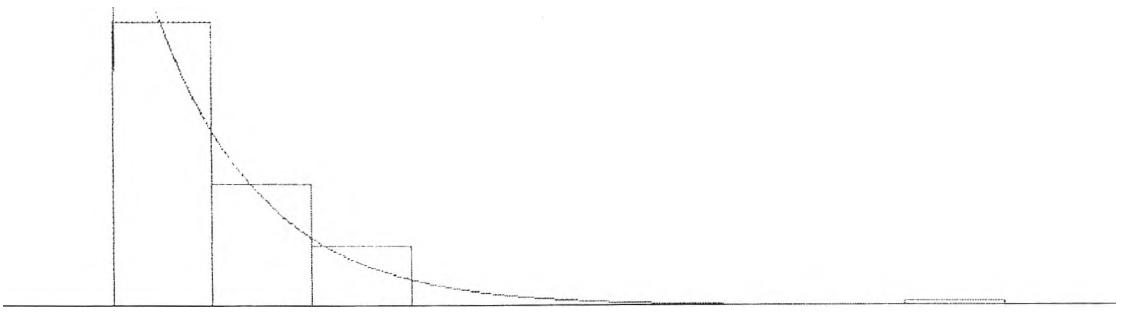
Data Summary

Number of Data Points	= 1124
Min Data Value	= 3
Max Data Value	= 1.4e+003
Sample Mean	= 158
Sample Std Dev	= 119

Histogram Summary

Histogram Range	= 3 to 1.4e+003
Number of Intervals	= 33

Figure 6-10: IVR service time distribution on 29 January, 10:00 to 11:00



Distribution Summary

Distribution: Gamma
Expression: 26 + GAMM(240, 0.982)
Square Error: 0.003453

Chi Square Test
Number of intervals = 3
Degrees of freedom = 0
Test Statistic = 0.235
Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
Test Statistic = 0.0599
Corresponding p-value > 0.15

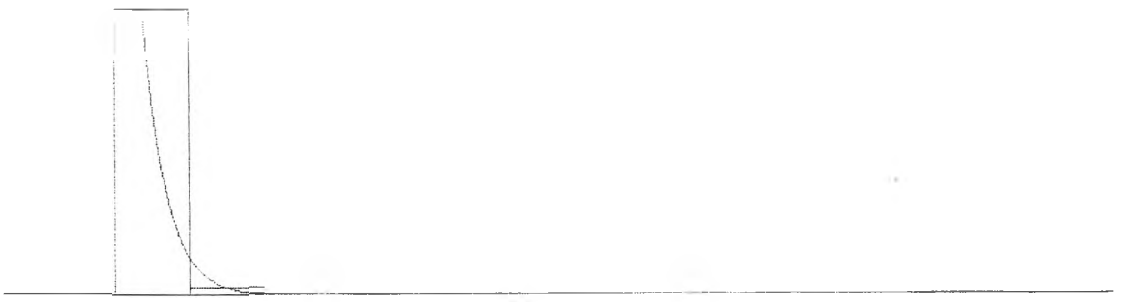
Data Summary

Number of Data Points = 85
Min Data Value = 26
Max Data Value = 2.03e+003
Sample Mean = 261
Sample Std Dev = 258

Histogram Summary

Histogram Range = 26 to 2.03e+003
Number of Intervals = 9

Figure 6-11: Transfer time distribution on 29 January, 10:00 to 11:00



Distribution Summary

Distribution: Exponential
Expression: 8 + EXPO(242)
Square Error: 0.000290

Chi Square Test
Number of intervals = 1
Degrees of freedom = -1
Test Statistic = 0.013

Corresponding p-value	< 0.005

Kolmogorov-Smirnov Test

Test Statistic	= 0.206
Corresponding p-value	< 0.01

Data Summary

Number of Data Points	= 165
Min Data Value	= 8
Max Data Value	= 9.42e+003
Sample Mean	= 250
Sample Std Dev	= 750

Histogram Summary

Histogram Range	= 8 to 9.42e+003
Number of Intervals	= 12

Figure 6-12: Agent service time distribution on 24 January, 10:00 to 11:00

Input for 11:00 to 12:00

The average service times of IVR service time, transfer time, and agent service time of this period are shown as follows:

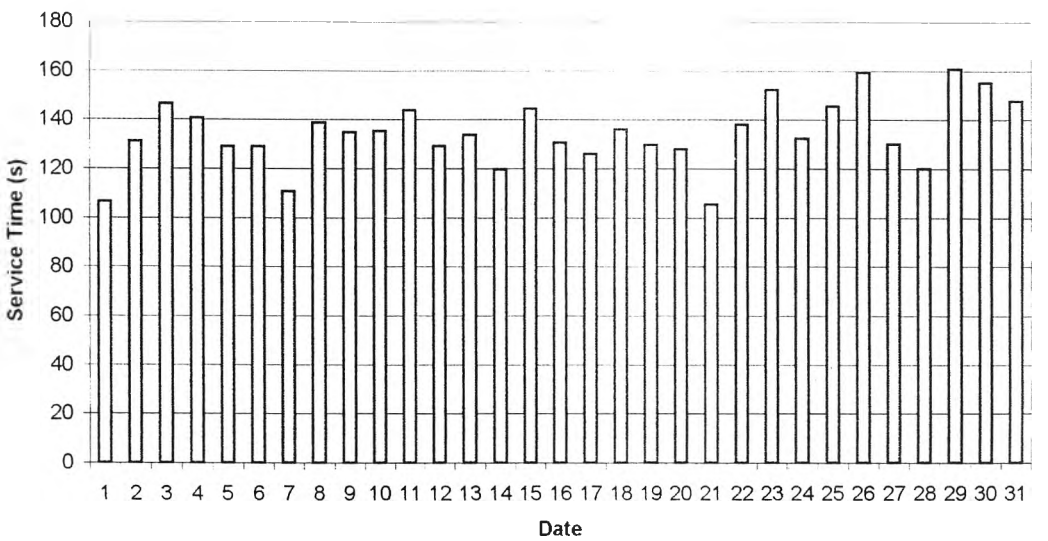


Figure 6-13: Average IVR service time at 11:00 to 12:00

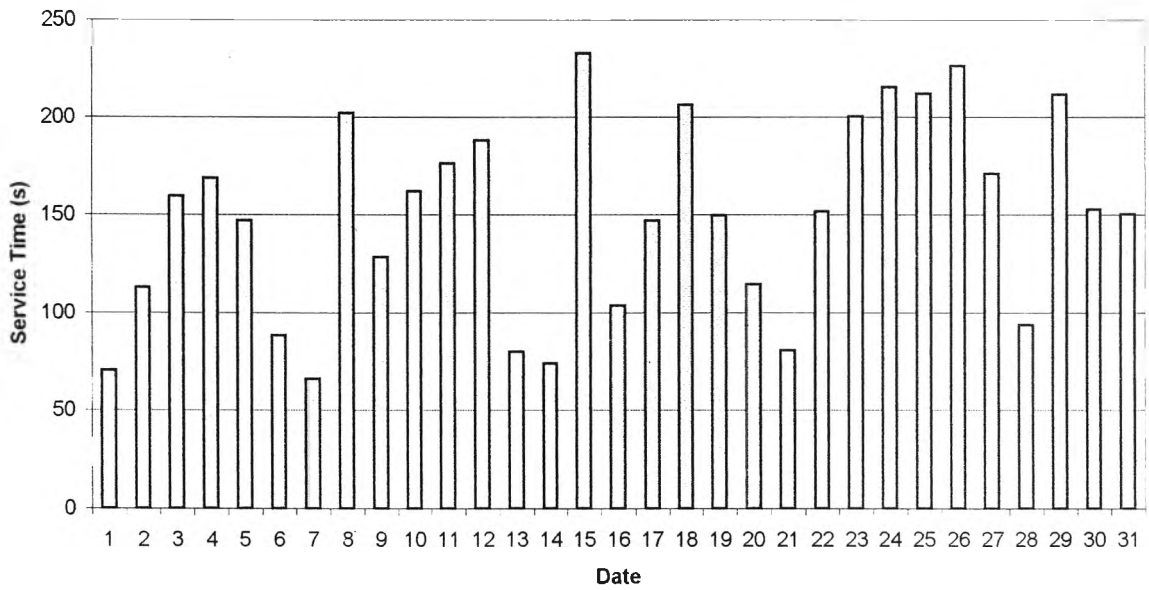


Figure 6-14: Average transfer time at 11:00 to 12:00

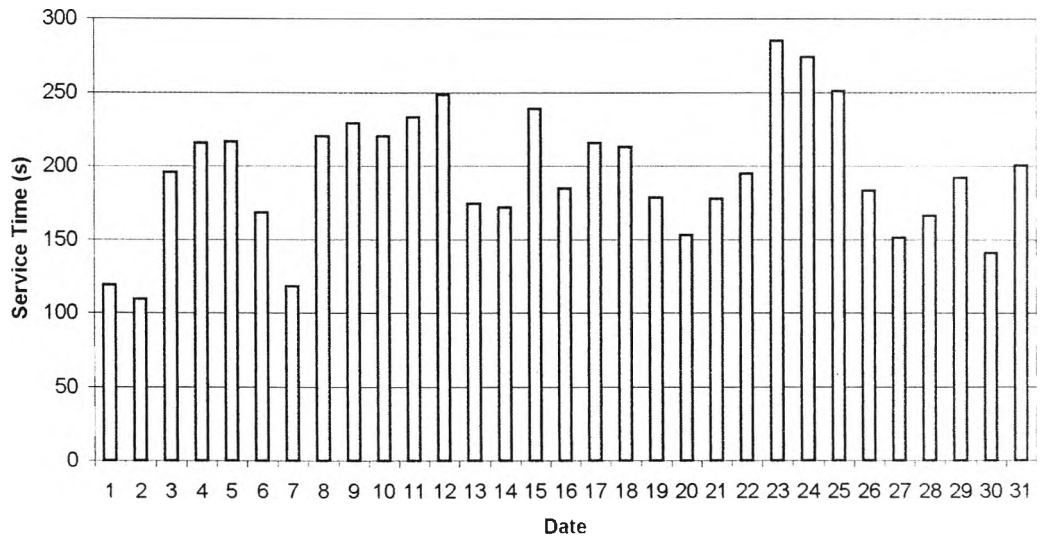
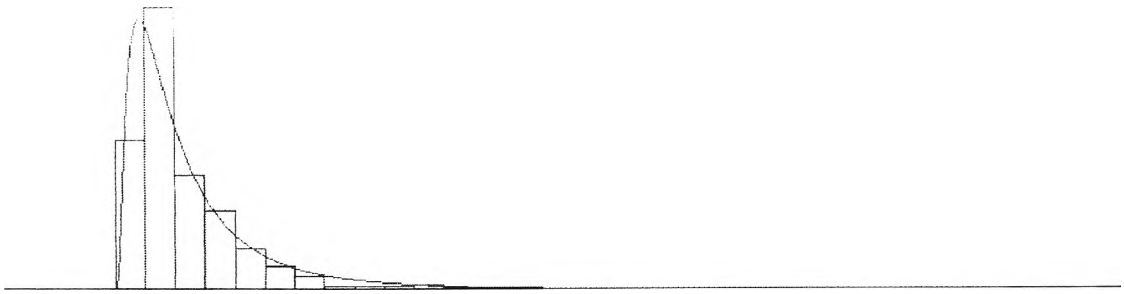


Figure 6-15: Average agent service time at 11:00 to 12:00

From these figure, we choose the IVR service time on day 29, transfer time on day 15, and agent service time on day 23 as inputs for 11:00 to 12:00.

The distribution of these inputs is shown below:



Distribution Summary

Distribution: Lognormal
Expression: 11 + LOGN(163, 178)
Square Error: 0.012614

Chi Square Test
Number of intervals = 11
Degrees of freedom = 8
Test Statistic = 58.7
Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
Test Statistic = 0.109
Corresponding p-value < 0.01

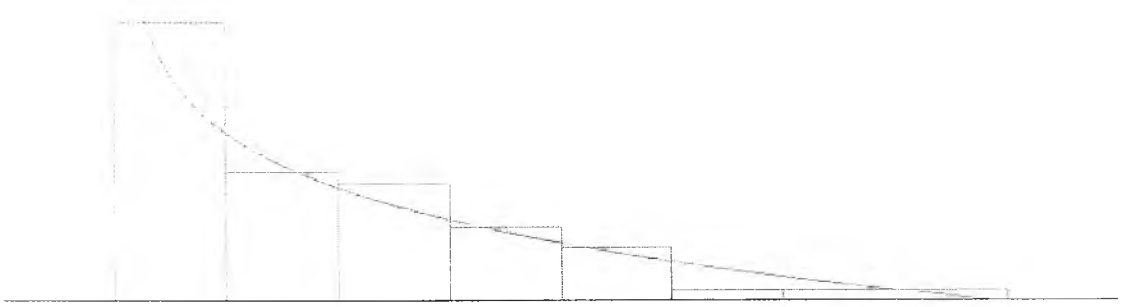
Data Summary

Number of Data Points = 900
Min Data Value = 11
Max Data Value = 1.88e+003
Sample Mean = 161
Sample Std Dev = 138

Histogram Summary

Histogram Range = 11 to 1.88e+003
Number of Intervals = 30

Figure 6-16: IVR service time distribution on 29 January, 11:00 to 12:00



Distribution Summary

Distribution: Beta
Expression: 41 + 782 * BETA(0.676, 2.09)
Square Error: 0.002407

Chi Square Test
Number of intervals = 5
Degrees of freedom = 2
Test Statistic = 1.1
Corresponding p-value = 0.589

Kolmogorov-Smirnov Test
Test Statistic = 0.0594
Corresponding p-value > 0.15

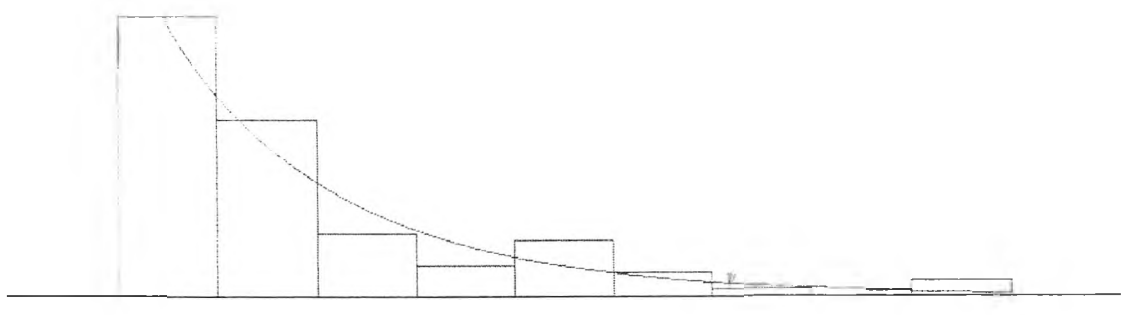
Data Summary

Number of Data Points = 64
Min Data Value = 41
Max Data Value = 823
Sample Mean = 232
Sample Std Dev = 173

Histogram Summary

Histogram Range = 41 to 823
Number of Intervals = 8

Figure 6-17: Transfer time distribution on 15 January, 11:00 to 12:00



Distribution Summary

Distribution: Weibull
Expression: 10 + WEIB(268, 0.941)
Square Error: 0.005630

Chi Square Test
Number of intervals = 4
Degrees of freedom = 1
Test Statistic = 1.45

Corresponding p-value = 0.236

Kolmogorov-Smirnov Test
Test Statistic = 0.0728
Corresponding p-value > 0.15

Data Summary

Number of Data Points = 82
Min Data Value = 10
Max Data Value = 1.33e+003
Sample Mean = 285
Sample Std Dev = 275

Histogram Summary

Histogram Range = 10 to 1.33e+003
Number of Intervals = 9

Figure 6-18: Agent service time distribution on 23 January, 11:00 to 12:00

Input for 12:00 to 13:00

The average service times of IVR service time, transfer time, and agent service time of this period are shown as follows:

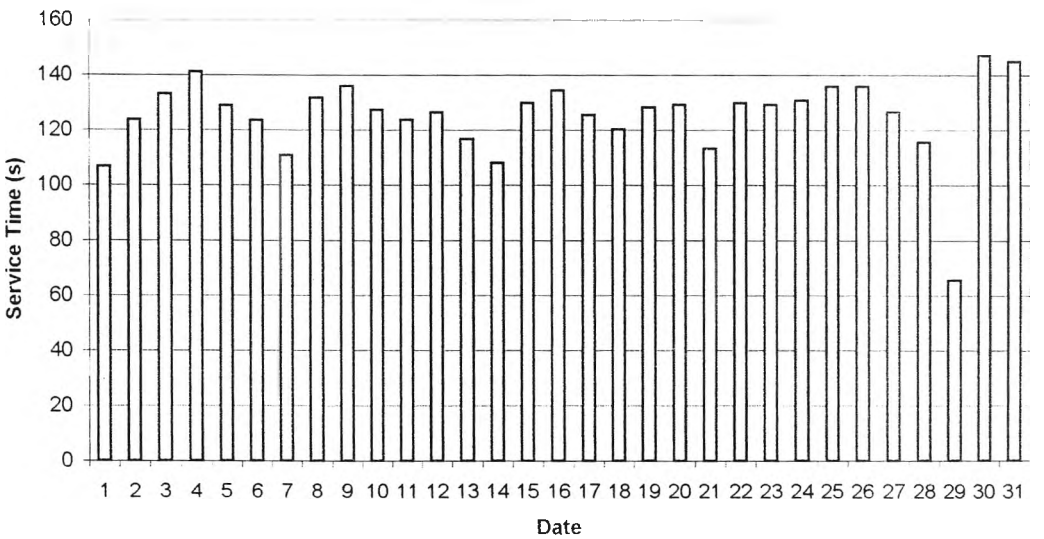


Figure 6-19: Average IVR service time at 12:00 to 13:00

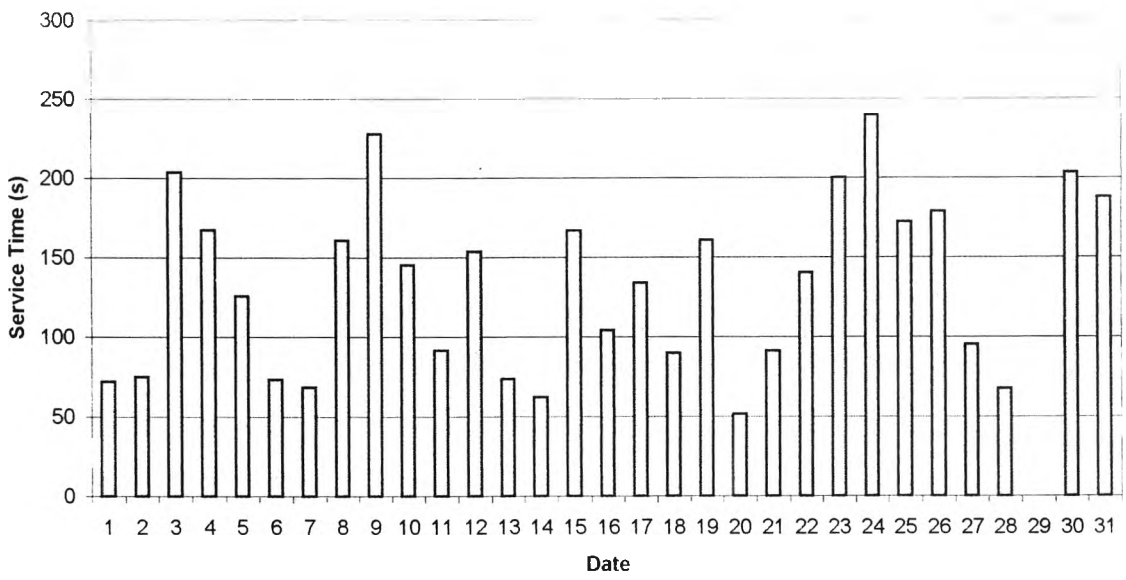


Figure 6-20: Average transfer time at 12:00 and 13:00

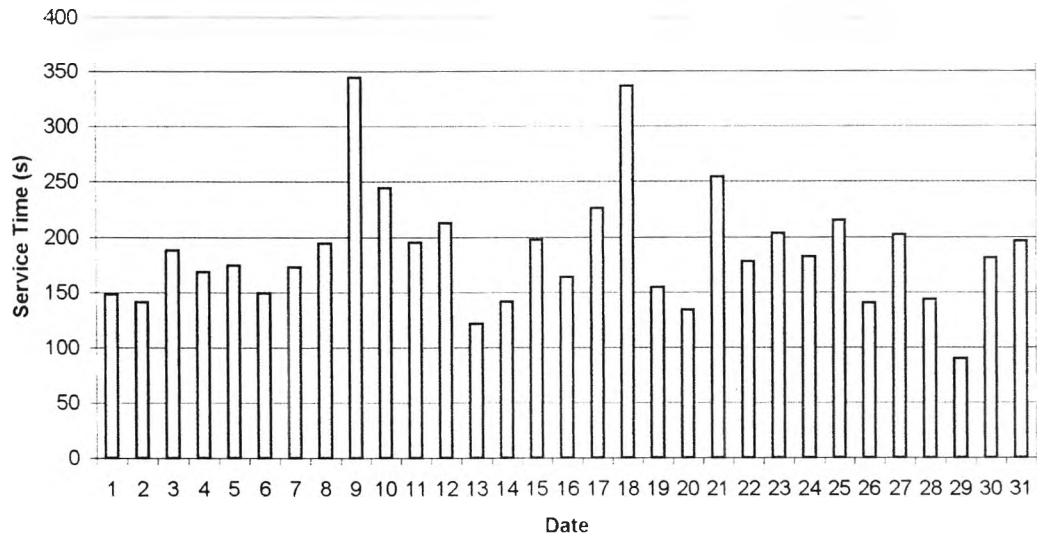
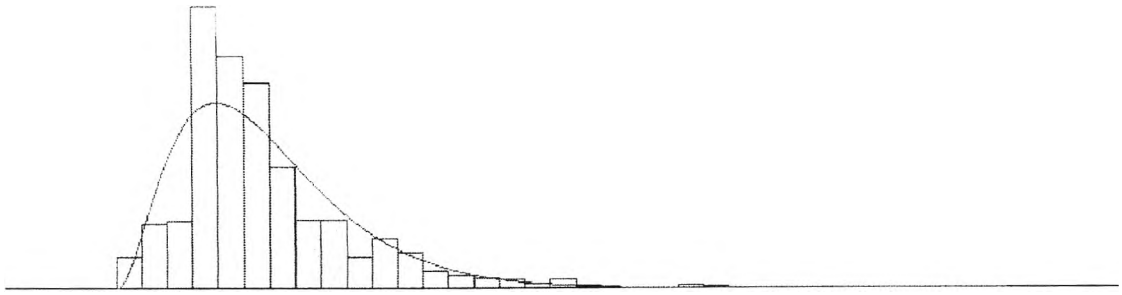


Figure 6-21: Average agent service time at 12:00 and 13:00

From these figure, we choose the IVR service time on day 30, transfer time on day 24, and agent service time on day 9 as inputs for 12:00 to 13:00.

The distribution of these inputs is shown below:



Distribution Summary

Distribution: Erlang
Expression: 0.999 + ERLA(48.7, 3)
Square Error: 0.014820

Chi Square Test

Number of intervals	= 16
Degrees of freedom	= 13
Test Statistic	= 179
Corresponding p-value	< 0.005

Kolmogorov-Smirnov Test

Test Statistic = 0.0948	
Corresponding p-value	< 0.01

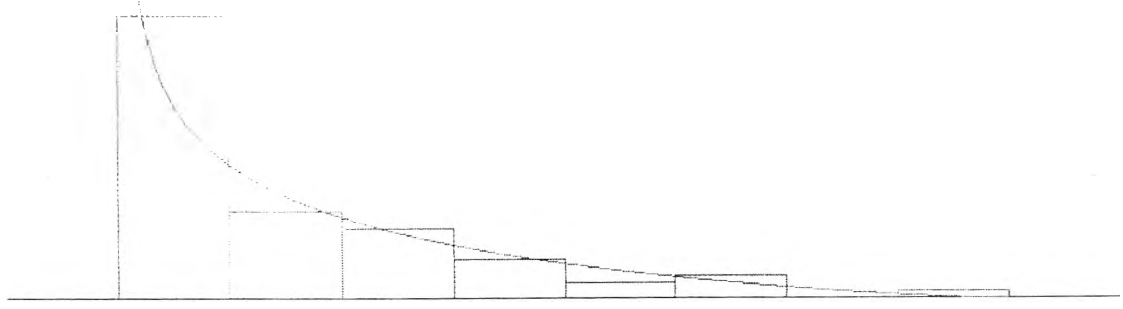
Data Summary

Number of Data Points	= 1241
Min Data Value	= 1
Max Data Value	= 874
Sample Mean	= 147
Sample Std Dev	= 93

Histogram Summary

Histogram Range	= 0.999 to 874
Number of Intervals	= 35

Figure 6-22: IVR service time distribution on 30 Jan, 12:00 to 13:00



Distribution Summary

Distribution: Beta
Expression: 17 + 1.11e+003 * BETA(0.589, 2.35)
Square Error: 0.002426

Chi Square Test
Number of intervals = 4
Degrees of freedom = 1
Test Statistic = 1.09
Corresponding p-value = 0.316

Kolmogorov-Smirnov Test
Test Statistic = 0.125
Corresponding p-value > 0.15

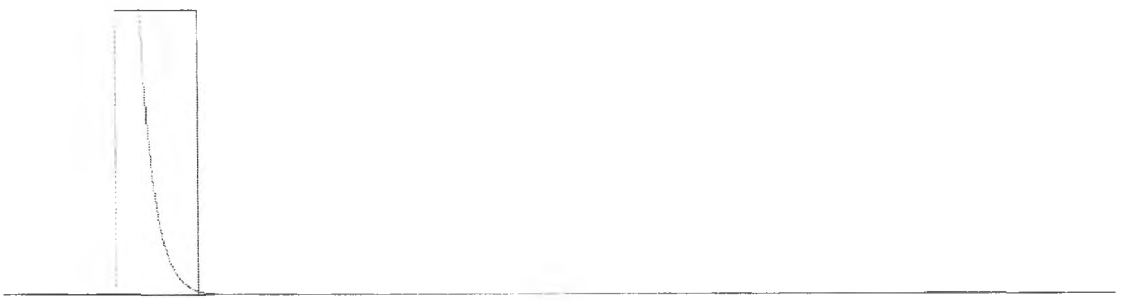
Data Summary

Number of Data Points = 67
Min Data Value = 17
Max Data Value = 1.13e+003
Sample Mean = 240
Sample Std Dev = 224

Histogram Summary

Histogram Range = 17 to 1.13e+003
Number of Intervals = 8

Figure 6-23: Transfer time distribution on 24 January, 12:00 to 13:00



Distribution Summary

Distribution: Exponential
Expression: 8 + EXPO(336)
Square Error: 0.000093

Chi Square Test
Number of intervals = 1
Degrees of freedom = -1
Test Statistic = 0.00336

Corresponding p-value	< 0.005

Kolmogorov-Smirnov Test

Test Statistic	= 0.317
Corresponding p-value	< 0.01

Data Summary

Number of Data Points	= 129
Min Data Value	= 8
Max Data Value	= 2.19e+004
Sample Mean	= 344
Sample Std Dev	= 1.93e+003

Histogram Summary

Histogram Range	= 8 to 2.19e+004
Number of Intervals	= 11

Figure 6-24: Agent service time distribution on 9 January, 12:00 to 13:00

Input for 13:00 to 14:00

The average service times of IVR service time, transfer time, and agent service time of this period are shown as follows:

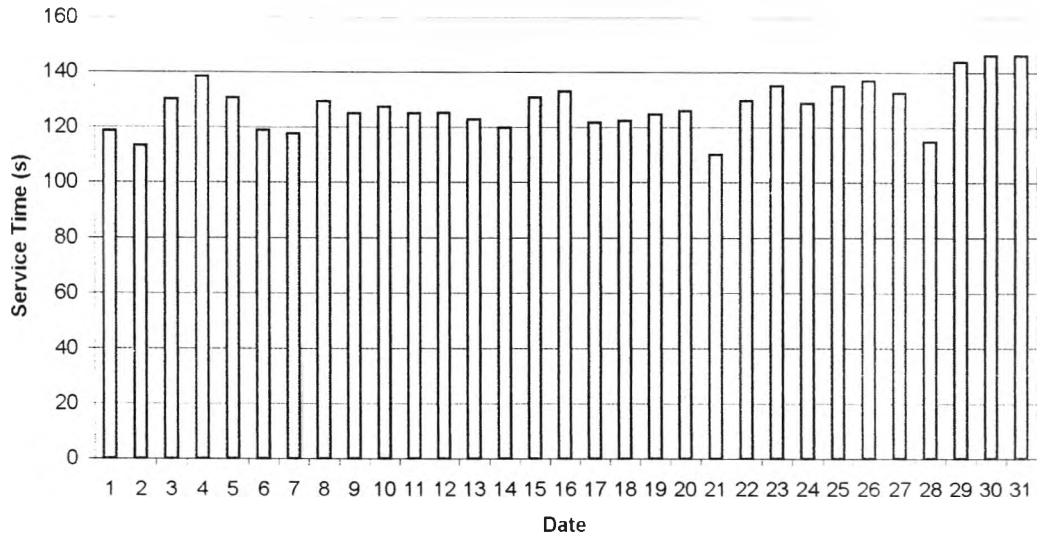


Figure 6-25: Average IVR service time at 13:00 to 14:00

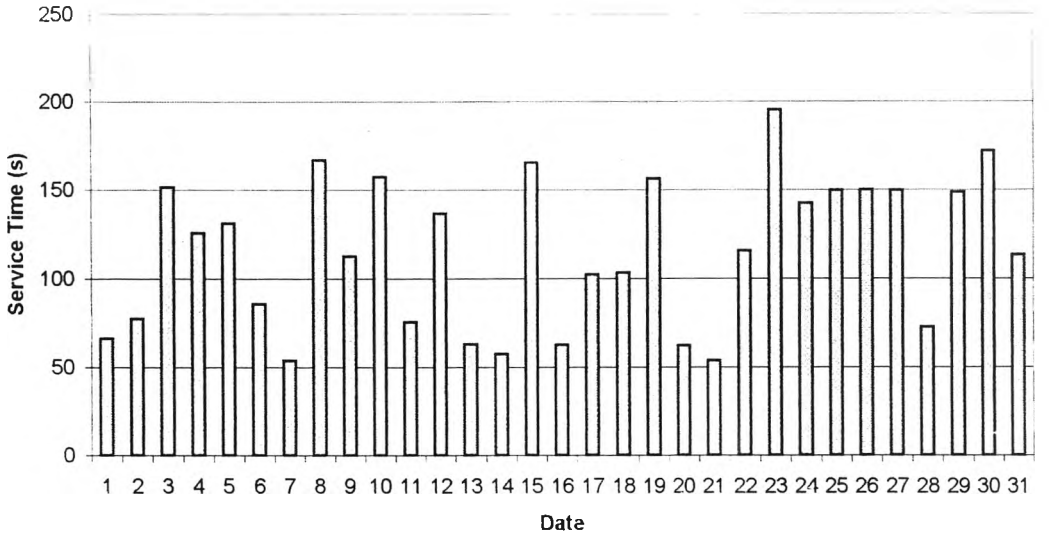


Figure 6-26: Average transfer time at 13:00 to 14:00

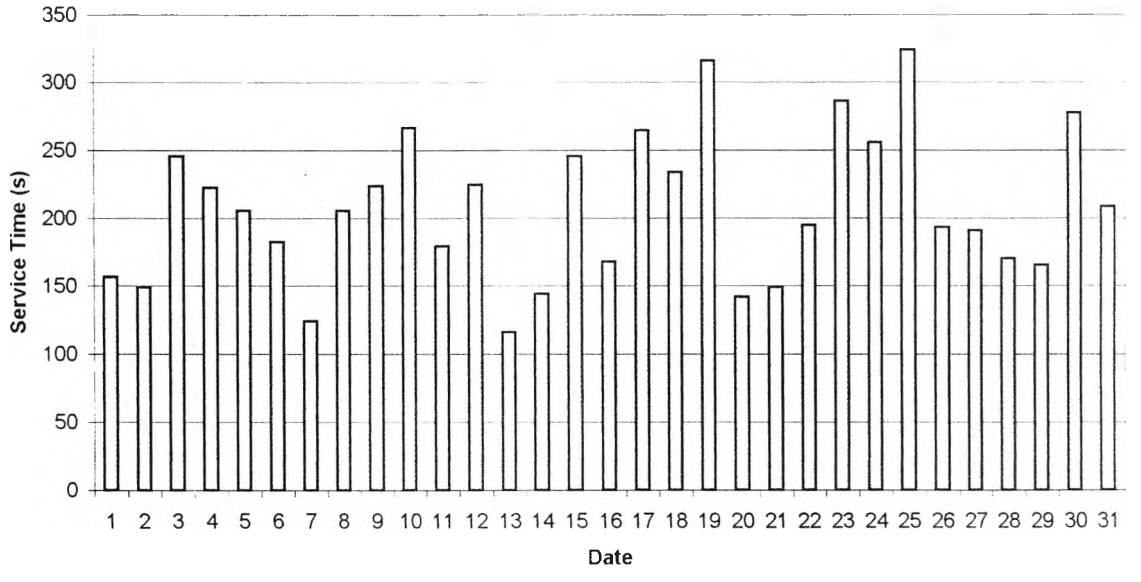
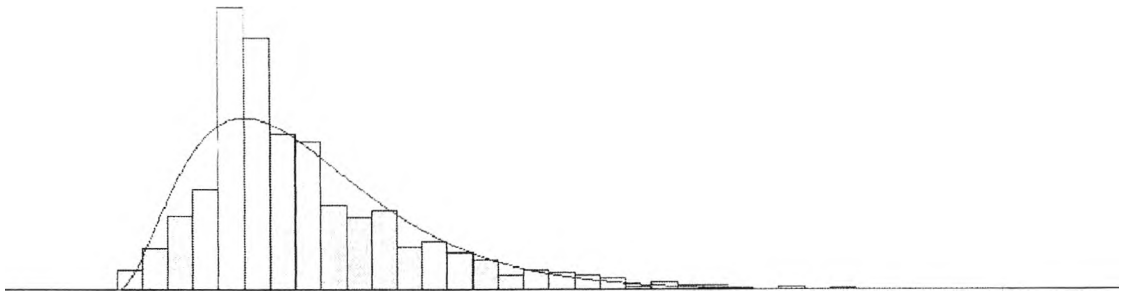


Figure 6-27: Average agent time at 13:00 to 14:00

From these figure, we choose the IVR service time on day 30, transfer time on day 23, and agent service time on day 25 as inputs for 13:00 to 14:00.

The distribution of these inputs is shown below:



Distribution Summary

Distribution: Erlang
Expression: 5 + ERLA(47.1, 3)
Square Error: 0.010960

Chi Square Test

Number of intervals	= 19
Degrees of freedom	= 16
Test Statistic	= 152
Corresponding p-value	< 0.005

Kolmogorov-Smirnov Test

Test Statistic	= 0.0799
Corresponding p-value	< 0.01

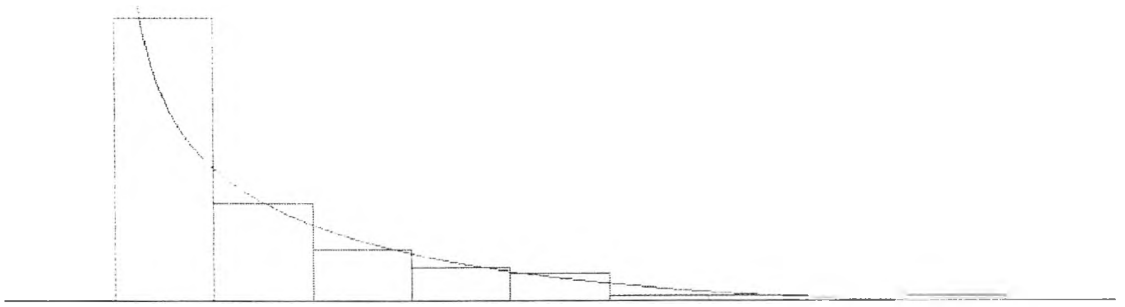
Data Summary

Number of Data Points	= 1230
Min Data Value	= 5
Max Data Value	= 666
Sample Mean	= 146
Sample Std Dev	= 85.7

Histogram Summary

Histogram Range	= 5 to 666
Number of Intervals	= 35

Figure 6-28: IVR service time distribution on 30 January, 13:00 to 14:00



Distribution Summary

Distribution: Beta
Expression: 34 + 982 * BETA(0.558, 2.84)
Square Error: 0.002198

Chi Square Test
Number of intervals = 4
Degrees of freedom = 1
Test Statistic = 0.499
Corresponding p-value = 0.487

Kolmogorov-Smirnov Test
Test Statistic = 0.146
Corresponding p-value = 0.0414

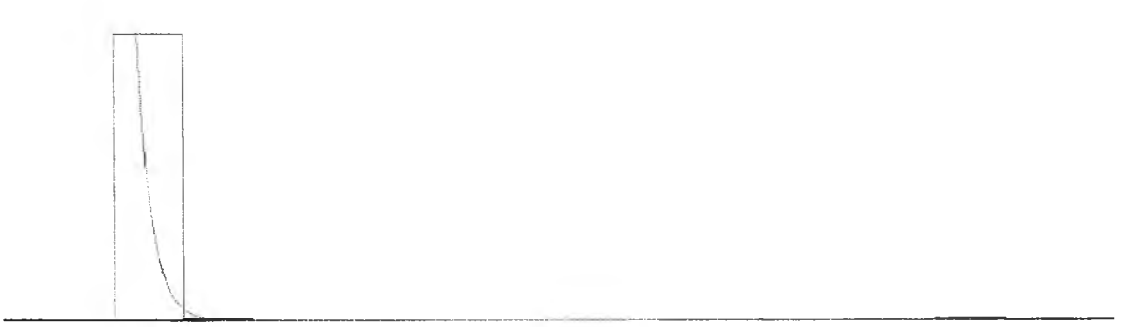
Data Summary

Number of Data Points = 89
Min Data Value = 34
Max Data Value = 1.02e+003
Sample Mean = 195
Sample Std Dev = 174

Histogram Summary

Histogram Range = 34 to 1.02e+003
Number of Intervals = 9

Figure 6-29: Transfer time distribution on 23 January, 13:00 to 14:00



Distribution Summary

Distribution: Exponential
Expression: 9 + EXPO(315)
Square Error: 0.000045

Chi Square Test
Number of intervals = 1
Degrees of freedom = -1

Test Statistic	= 0.00135
Corresponding p-value	< 0.005

Kolmogorov-Smirnov Test

Test Statistic	= 0.255
Corresponding p-value	< 0.01

Data Summary

Number of Data Points	= 181
Min Data Value	= 9
Max Data Value	= 1.96e+004
Sample Mean	= 324
Sample Std Dev	= 1.46e+003

Histogram Summary

Histogram Range	= 9 to 1.96e+004
Number of Intervals	= 13

Figure 6-30: Agent service time distribution on 25 January, 13:00 to 14:00

Input for 14:00 to 15:00

The average service times of IVR service time, transfer time, and agent service time of this period are shown as follows:

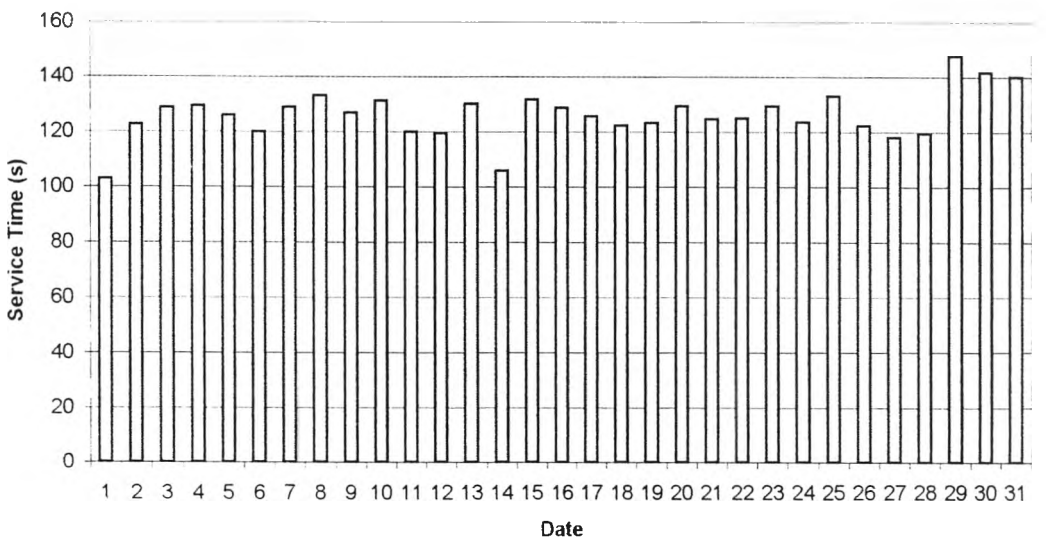


Figure 6-31: Average IVR service time at 14:00 to 15:00

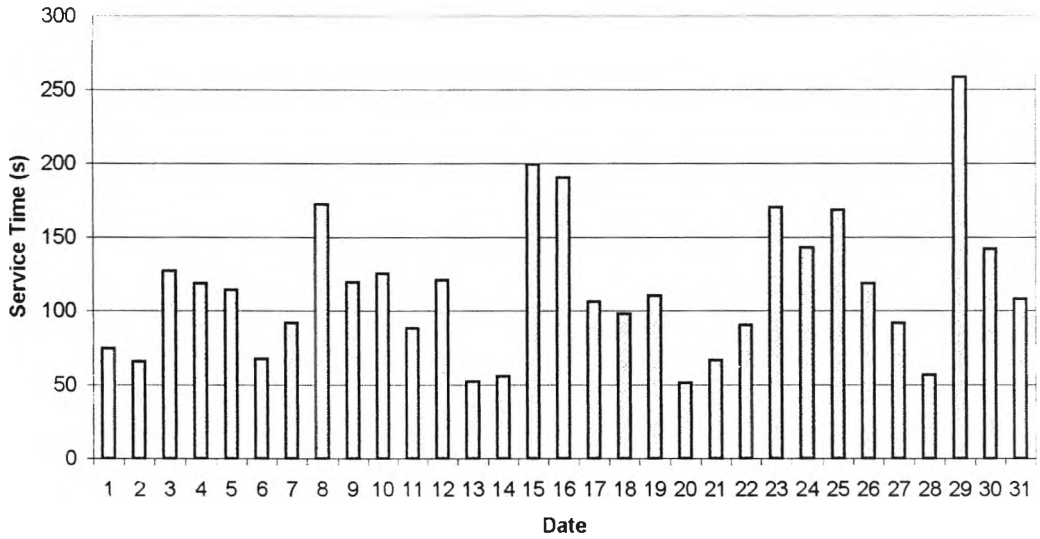


Figure 6-32: Average Transfer time at 14:00 and 15:00

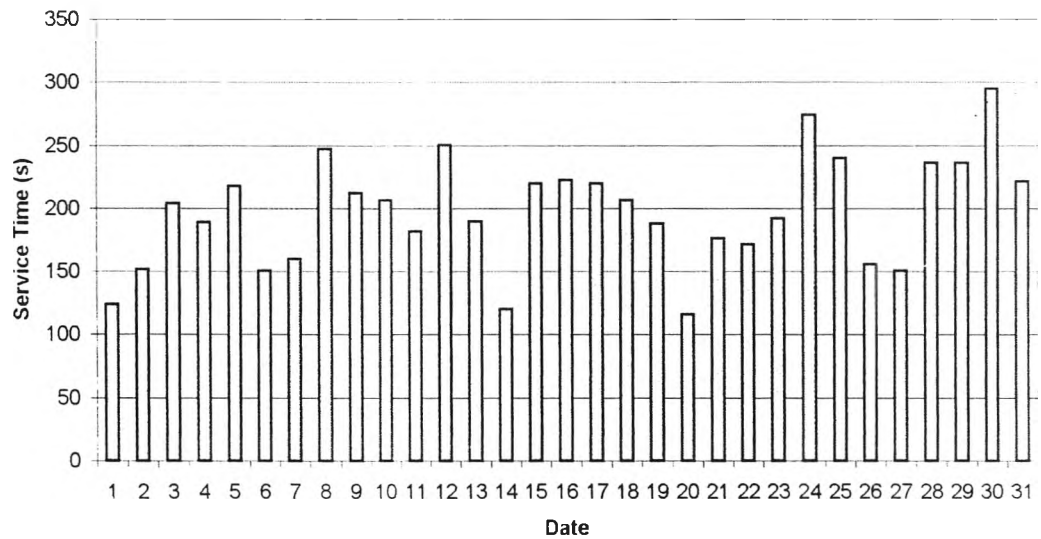


Figure 6-33: Average agent service time at 14:00 and 15:00

From these figure, we choose the IVR service time on day 29, transfer time on day 29, and agent service time on day 30 as inputs for 14:00 to 15:00.

The distribution of these inputs is shown below:

Distribution Summary

Distribution: Gamma
Expression: 6 + GAMM(60.7, 2.33)
Square Error: 0.016975

Chi Square Test
Number of intervals = 14
Degrees of freedom = 11
Test Statistic = 152
Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
Test Statistic = 0.101
Corresponding p-value < 0.01

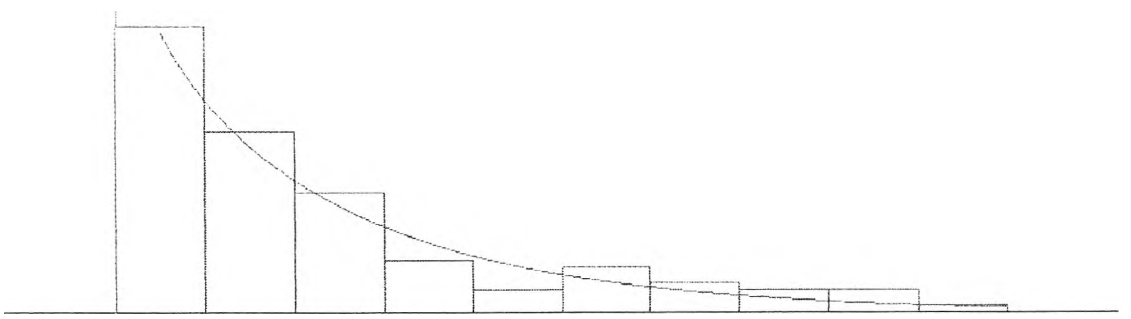
Data Summary

Number of Data Points = 1172
Min Data Value = 6
Max Data Value = 1.05e+003
Sample Mean = 148
Sample Std Dev = 104

Histogram Summary

Histogram Range = 6 to 1.05e+003
Number of Intervals = 34

Figure 6-34: IVR service time distribution on 29 January, 14:00 to 15:00



Distribution Summary

Distribution: Gamma
Expression: 40 + GAMM(258, 0.845)
Square Error: 0.002921

Chi Square Test
Number of intervals = 5
Degrees of freedom = 2
Test Statistic = 8.51

Corresponding p-value = 0.0157

Kolmogorov-Smirnov Test
Test Statistic = 0.0519
Corresponding p-value > 0.15

Data Summary

Number of Data Points = 105
Min Data Value = 40
Max Data Value = 981
Sample Mean = 258
Sample Std Dev = 220

Histogram Summary

Histogram Range = 40 to 981
Number of Intervals = 10

Figure 6-35: Transfer time distribution on 29 January, 14:00 to 15:00

Distribution Summary

Distribution: Exponential
Expression: 13 + EXPO(282)
Square Error: 0.000119

Chi Square Test
Number of intervals = 1
Degrees of freedom = -1
Test Statistic = 0.00335
Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
Test Statistic = 0.174
Corresponding p-value < 0.01

Data Summary

Number of Data Points = 198
Min Data Value = 13

Max Data Value = 1.56e+004
Sample Mean = 295
Sample Std Dev = 1.12e+003

Histogram Summary

Histogram Range = 13 to 1.56e+004
Number of Intervals = 14

Figure 6-36: Agent transfer time on 30 January, 14:00 to 15:00

Input for 15:00 to 16:00

The average service times of IVR service time, transfer time, and agent service time of this period are shown as follows:

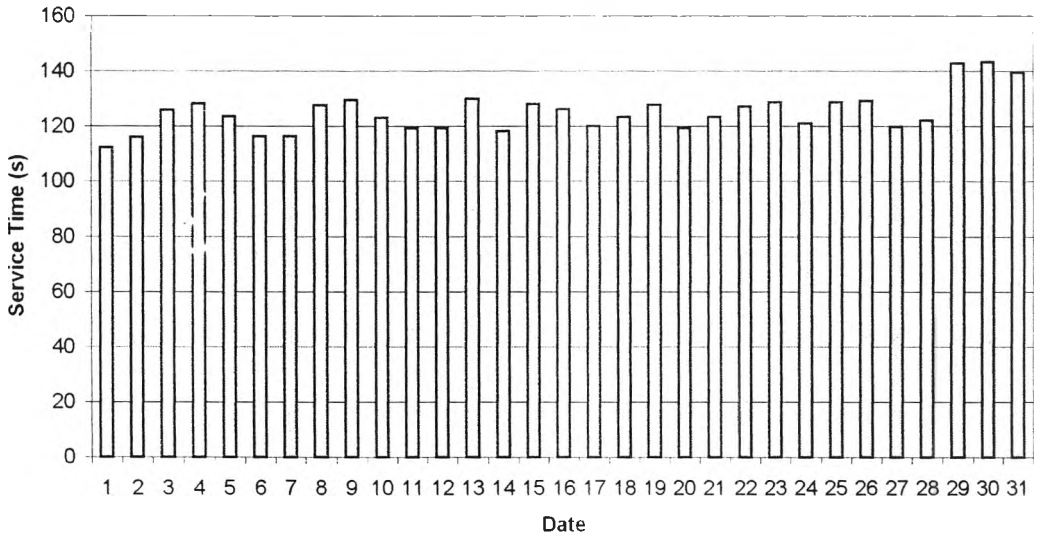


Figure 6-37: Average IVR service time at 15:00 to 16:00

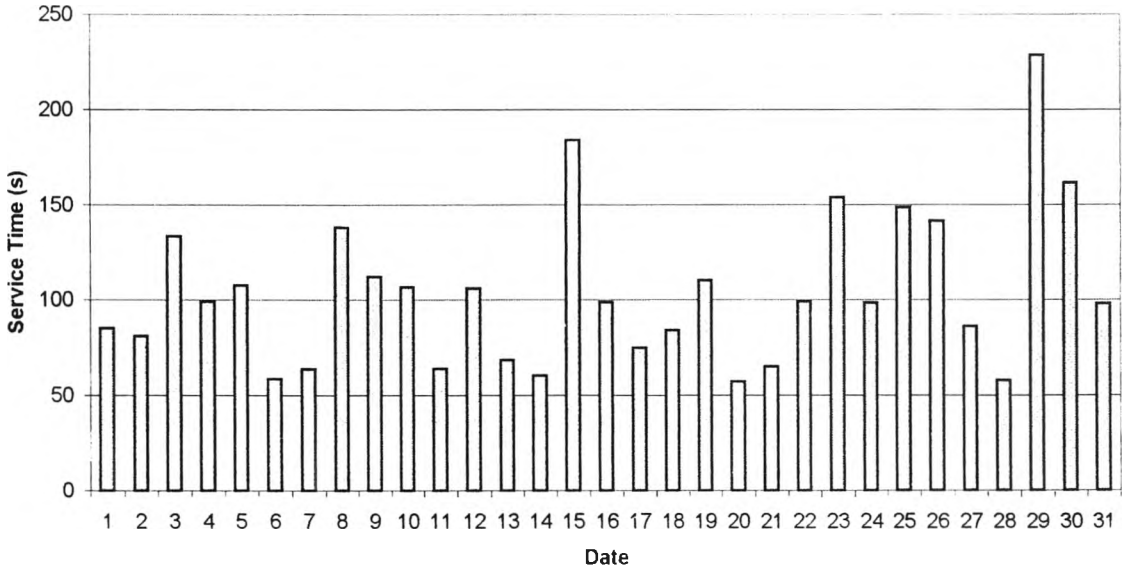


Figure 6-38: Average transfer time at 15:00 to 16:00

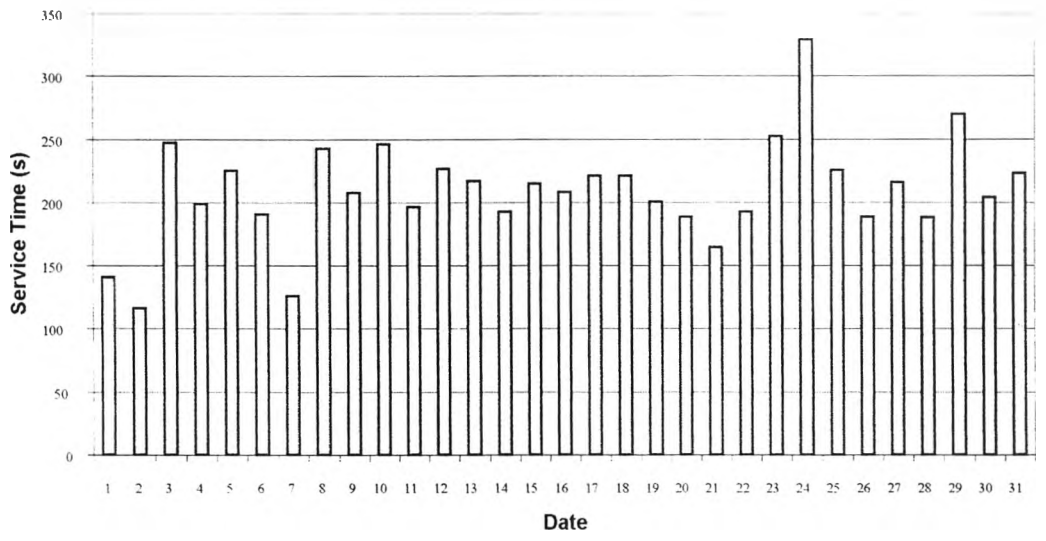
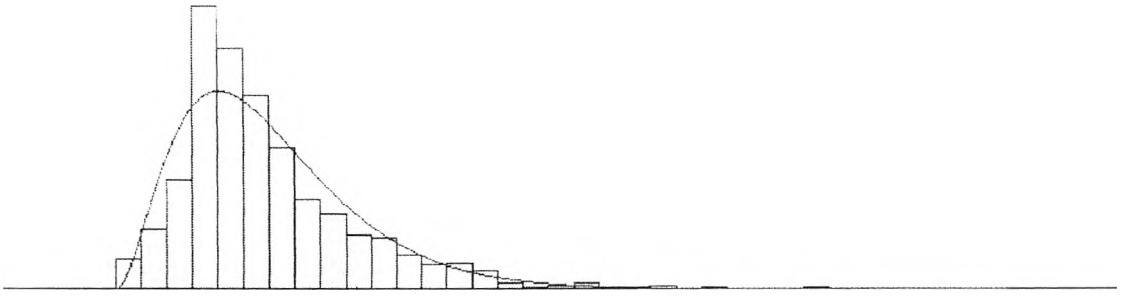


Figure 6-39: Average agent service time at 15:00 to 16:00

From these figure, we choose the IVR service time on day 30, transfer time on day 29, and agent service time on day 24 as inputs for 15:00 to 16:00.

The distribution of these inputs is shown below:



Distribution Summary

Distribution: Erlang
Expression: 5 + ERLA(46.1, 3)
Square Error: 0.007610

Chi Square Test

Number of intervals	= 17
Degrees of freedom	= 14
Test Statistic	= 110
Corresponding p-value	< 0.005

Kolmogorov-Smirnov Test

Test Statistic	= 0.0783
Corresponding p-value	< 0.01

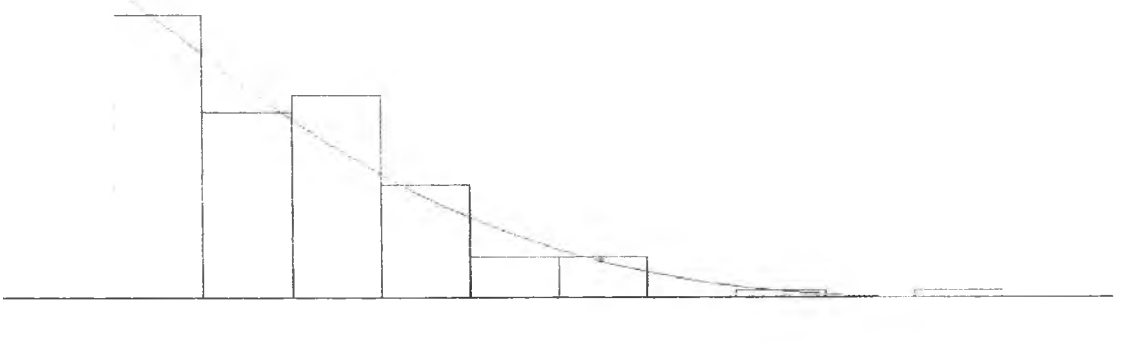
Data Summary

Number of Data Points	= 1241
Min Data Value	= 5
Max Data Value	= 808
Sample Mean	= 143
Sample Std Dev	= 86.8

Histogram Summary

Histogram Range	= 5 to 808
Number of Intervals	= 35

Figure 6-40: IVR service time distribution on 30 January, 15:00 to 16:00



Distribution Summary

Distribution: Beta
Expression: 28 + 945 * BETA(1.02, 3.8)
Square Error: 0.005747

Chi Square Test
Number of intervals = 5
Degrees of freedom = 2
Test Statistic = 4.23
Corresponding p-value = 0.131

Kolmogorov-Smirnov Test
Test Statistic = 0.0866
Corresponding p-value > 0.15

Data Summary

Number of Data Points = 109
Min Data Value = 28
Max Data Value = 973
Sample Mean = 229
Sample Std Dev = 160

Histogram Summary

Histogram Range = 28 to 973
Number of Intervals = 10

Figure 6-41: Transfer time distribution on 29 January, 15:00 to 16:00

Distribution Summary

Distribution: Exponential
Expression: 6 + EXPO(323)
Square Error: 0.000052

Chi Square Test
Number of intervals = 1
Degrees of freedom = -1

Test Statistic	= 0.00546
Corresponding p-value	< 0.005

Kolmogorov-Smirnov Test

Test Statistic	= 0.201
Corresponding p-value	< 0.01

Data Summary

Number of Data Points	= 204
Min Data Value	= 6
Max Data Value	= 1.6e+004
Sample Mean	= 329
Sample Std Dev	= 1.15e+003

Histogram Summary

Histogram Range	= 6 to 1.6e+004
Number of Intervals	= 14

Figure 6-42: Agent service time distribution on 24 January, 15:00 to 16:00

Input for 16:00 to 17:00

The average service times of IVR service time, transfer time, and agent service time of this period are shown as follows:

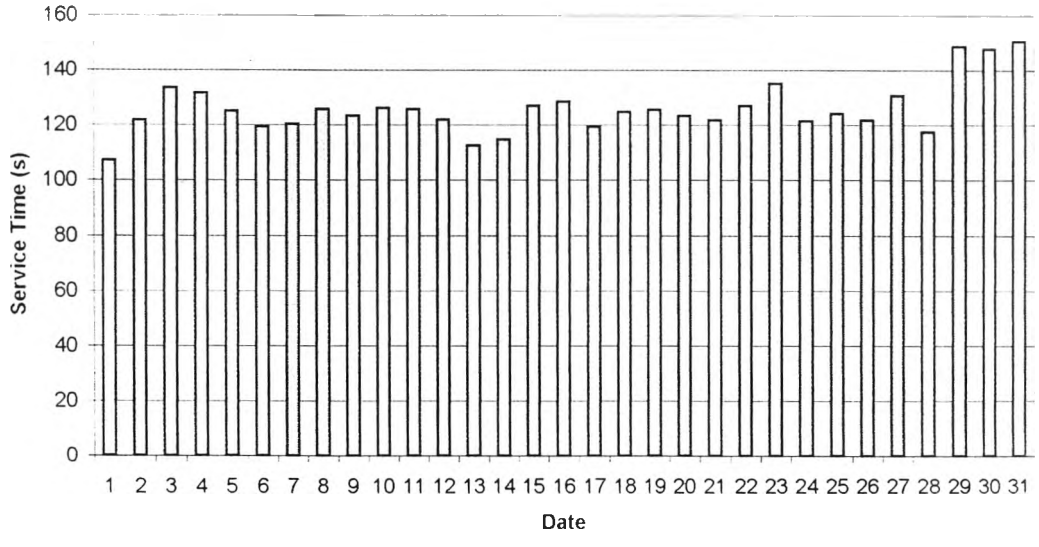


Figure 6-43: Average IVR service time at 16:00 to 17:00

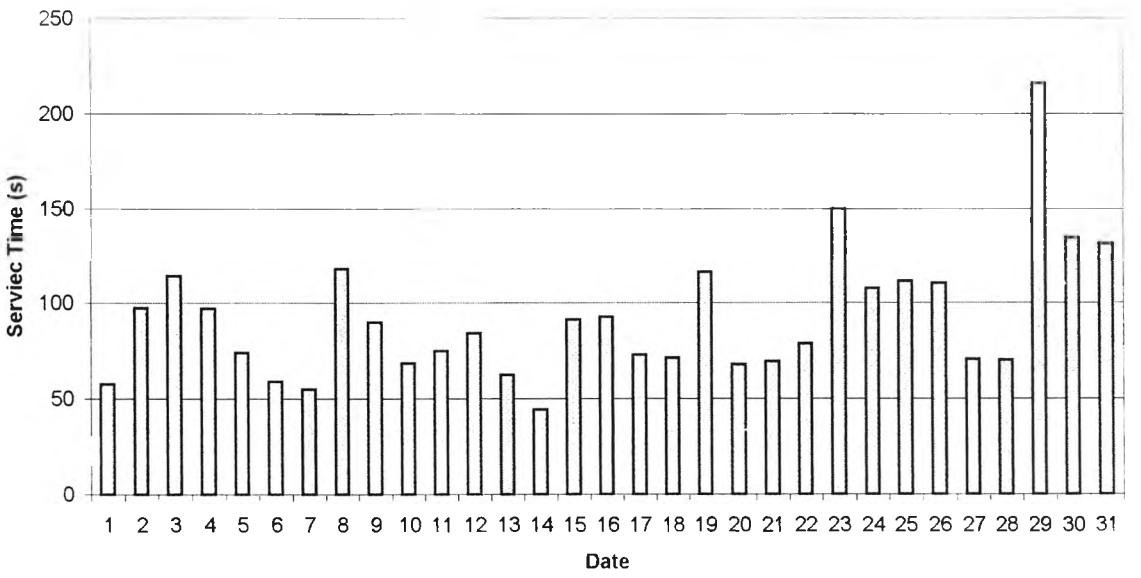


Figure 6-44: Average transfer time at 16:00 to 17:00

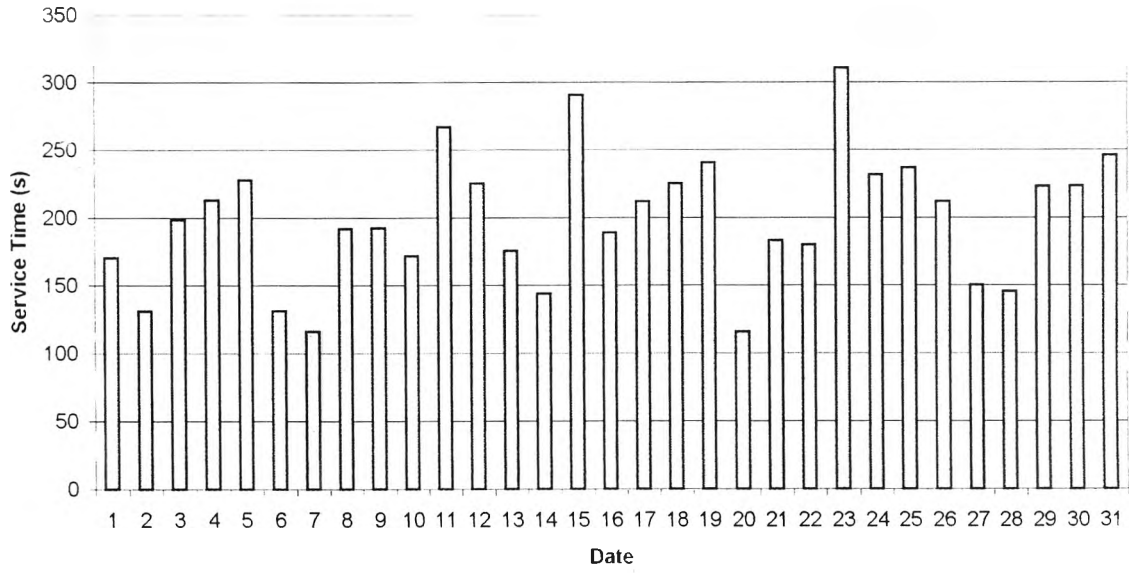


Figure 6-45: Average agent service time at 16:00 to 17:00

From these figure, we choose the IVR service time on day 31, transfer time on day 29, and agent service time on day 23 as inputs for 16:00 to 17:00.

The distribution of these inputs is shown below:

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Distribution Summary

Distribution: Erlang
Expression: 34 + ERLA(182, 1)
Square Error: 0.009681

Chi Square Test
Number of intervals = 4
Degrees of freedom = 1
Test Statistic = 4.67
Corresponding p-value = 0.0325

Kolmogorov-Smirnov Test
Test Statistic = 0.0986
Corresponding p-value > 0.15

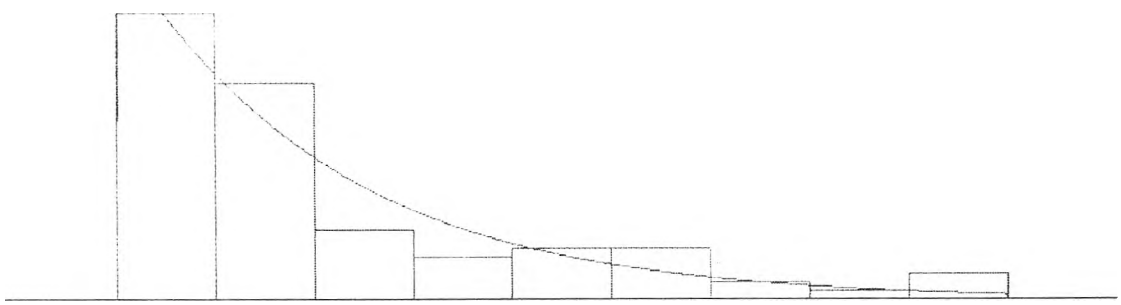
Data Summary

Number of Data Points = 87
Min Data Value = 34
Max Data Value = 1.05e+003
Sample Mean = 216
Sample Std Dev = 194

Histogram Summary

Histogram Range = 34 to 1.05e+003
Number of Intervals = 9

Figure 6-47: Transfer time distribution on 29 January, 16:00 to 17:00



Distribution Summary

Distribution: Erlang
Expression: 13 + ERLA(297, 1)
Square Error: 0.008472

Chi Square Test
Number of intervals = 4
Degrees of freedom = 1
Test Statistic = 3.49

Corresponding p-value = 0.0655

Kolmogorov-Smirnov Test
Test Statistic = 0.0859
Corresponding p-value > 0.15

Data Summary

Number of Data Points = 89
Min Data Value = 13
Max Data Value = 1.25e+003
Sample Mean = 310
Sample Std Dev = 301

Histogram Summary

Histogram Range = 13 to 1.25e+003
Number of Intervals = 9

Figure 6-48: Agent service time distribution on 23 January, 16:00 to 17:00

Input for 17:00 to 18:00

The average service times of IVR service time, transfer time, and agent service time of this period are shown as follows:

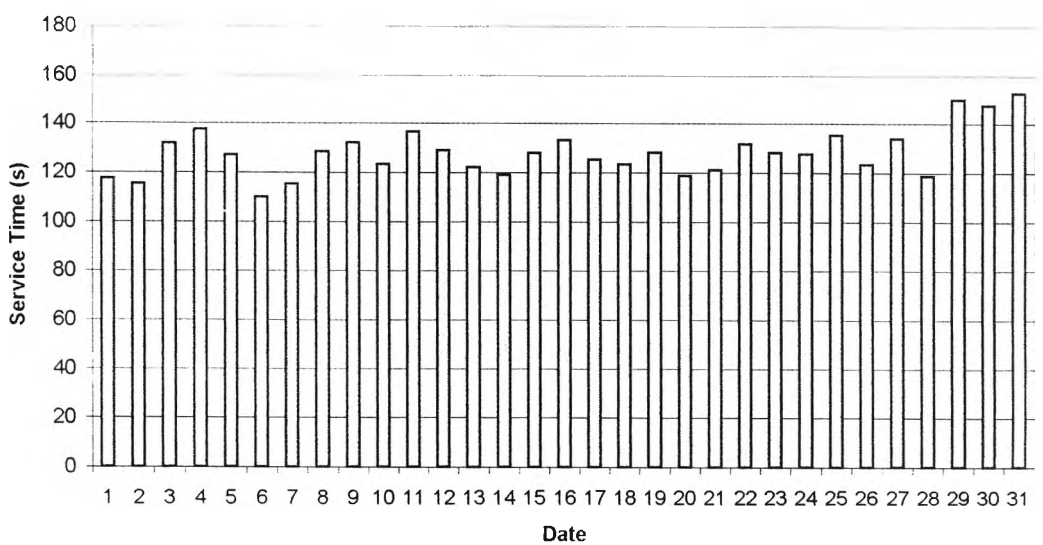


Figure 6-49: Average IVR service time at 17:00 to 18:00

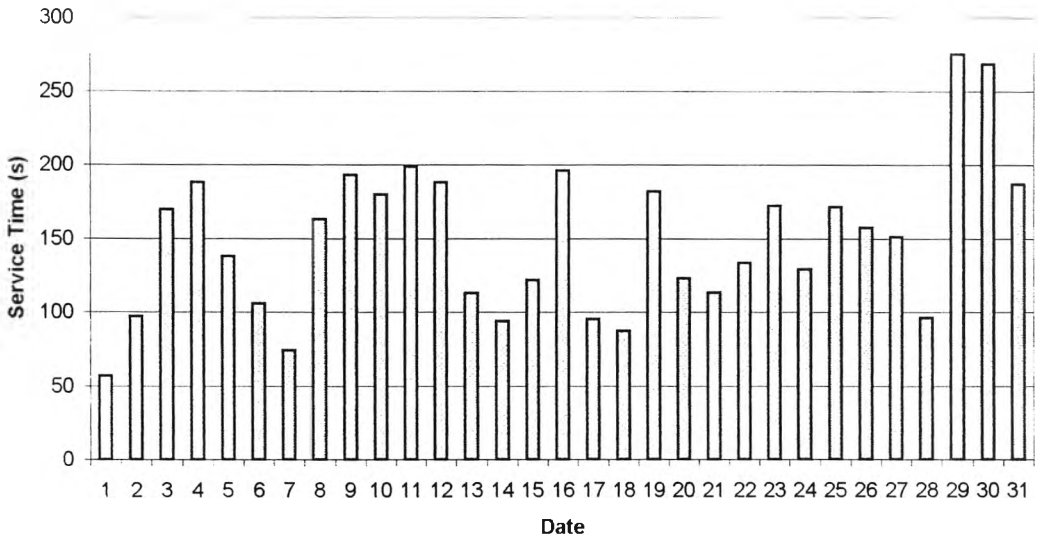


Figure 6-50: Average transfer time at 17:00 tc 18:00

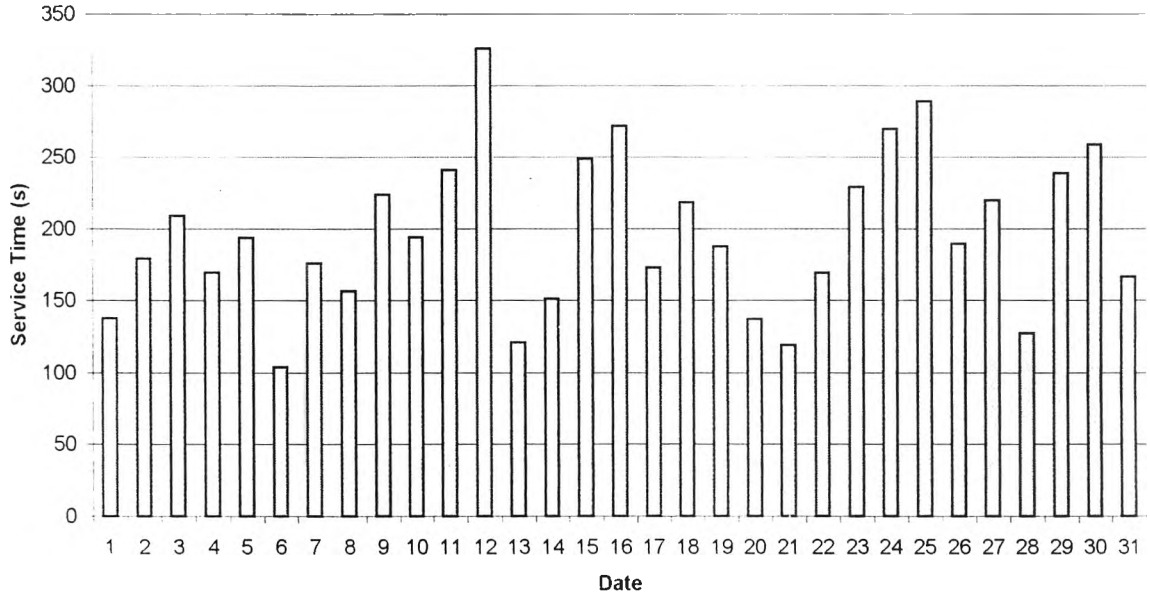
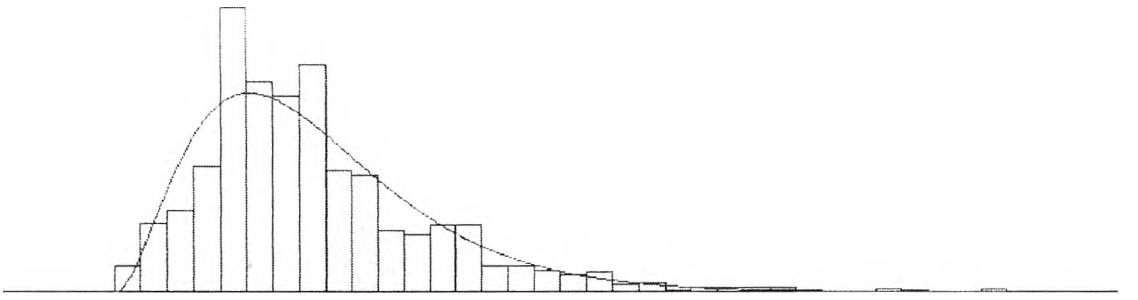


Figure 6-51: Average agent service time at 17:00 to 18:00

From these figure, we choose the IVR service time on day 31, transfer time on day 29, and agent service time on day 11 as inputs for 17:00 to 18:00.

The distribution of these inputs is shown below:



Distribution Summary

Distribution: Erlang
Expression: 0.999 + ERLA(50.5, 3)
Square Error: 0.005707

Chi Square Test

Number of intervals	= 19
Degrees of freedom	= 16
Test Statistic	= 88.6
Corresponding p-value	< 0.005

Kolmogorov-Smirnov Test

Test Statistic	= 0.062
Corresponding p-value	< 0.01

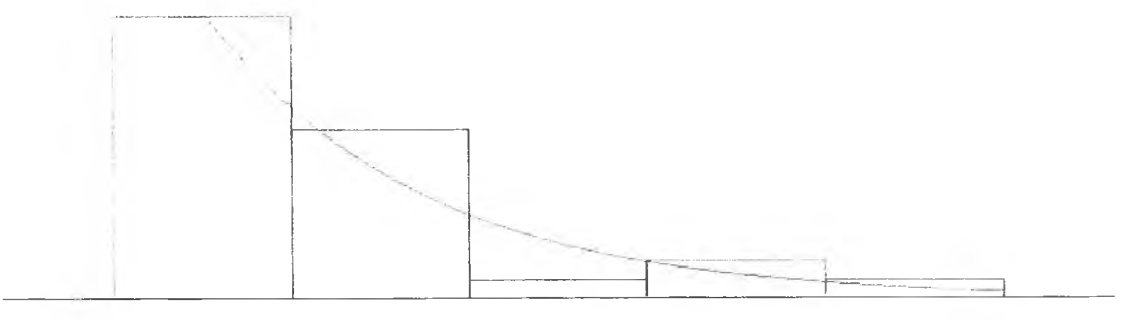
Data Summary

Number of Data Points	= 1190
Min Data Value	= 1
Max Data Value	= 675
Sample Mean	= 152
Sample Std Dev	= 91.7

Histogram Summary

Histogram Range	= 0.999 to 675
Number of Intervals	= 34

Figure 6-52: IVR service time distribution on 31 January, 17:00 to 18:00



Distribution Summary

Distribution: Exponential
Expression: 77 + EXPO(198)
Square Error: 0.012277

Chi Square Test

Number of intervals	= 2
Degrees of freedom	= 0
Test Statistic	= 0.777
Corresponding p-value	< 0.005

Kolmogorov-Smirnov Test

Test Statistic	= 0.0916
Corresponding p-value	> 0.15

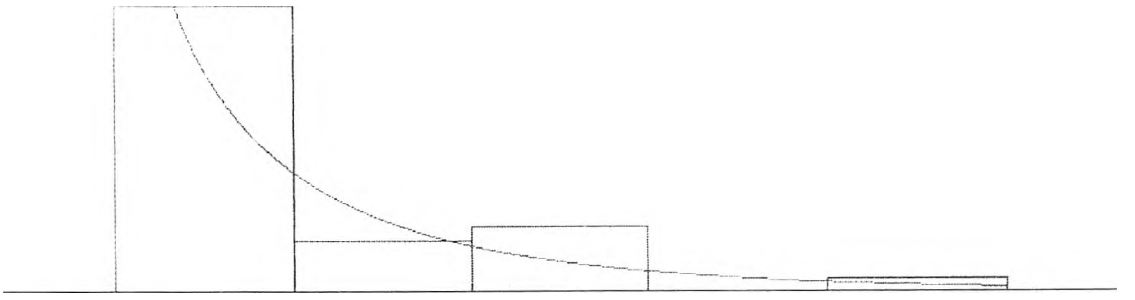
Data Summary

Number of Data Points	= 28
Min Data Value	= 77
Max Data Value	= 888
Sample Mean	= 275
Sample Std Dev	= 195

Histogram Summary

Histogram Range	= 77 to 888
Number of Intervals	= 5

Figure 6-53: Transfer time distribution on 29 January, 17:00 to 18:00



Distribution Summary

Distribution: Weibull
Expression: 11 + WEIB(204, 0.779)
Square Error: 0.011321

Chi Square Test

Number of intervals	= 2
Degrees of freedom	= -1
Test Statistic	= 0.56

Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
Test Statistic = 0.0956
Corresponding p-value > 0.15

Data Summary

Number of Data Points = 32
Min Data Value = 11
Max Data Value = 1.18e+003
Sample Mean = 241
Sample Std Dev = 260

Histogram Summary

Histogram Range = 11 to 1.18e+003
Number of Intervals = 5

Figure 6-54: Agent service time distribution on 11 January, 17:00 to 18:00

The conclusion of these distributions in each time period is illustrated below:

Time	Distribution		
	IVR	Transfer	Agent
9:00 to 10:00	3 + ERLA(52.9, 3)	15 + EXPO(191)	10 + LOGN(341, 908)
10:00 to 11:00	3 + GAMM(69.7, 2.22)	26 + GAMM(240, 0.982)	8 + EXPO(242)
11:00 to 12:00	11 + LOGN(163, 178)	41 + 782 * BETA(0.676, 2.09)	10 + WEIB(268, 0.941)
12:00 to 13:00	0.999 + ERLA(48.7, 3)	17 + 1.11e+003 * BETA(0.589, 2.35)	8 + EXPO(336)
13:00 to 14:00	5 + ERLA(47.1, 3)	34 + 982 * BETA(0.558, 2.84)	9 + EXPO(315)
14:00 to 15:00	6 + GAMM(60.7, 2.33)	40 + GAMM(258, 0.845)	13 + EXPO(282)
15:00 to 16:00	5 + ERLA(46.1, 3)	28 + 945 * BETA(1.02, 3.8)	6 + EXPO(323)
16:00 to 17:00	5 + ERLA(48.5, 3)	34 + ERLA(182, 1)	13 + ERLA(297, 1)
17:00 to 18:00	0.999 + ERLA(50.5, 3)	77 + EXPO(198)	11 + WEIB(204, 0.779)

Figure 6-55: Distribution conclusion of each period

6.2 Input For Determining the Appropriate Dynamic Resource

The dynamic resource in this case is the number of agent because it can be adjusted and scheduled based on time. Thus, we require the agent service time distributions of each period (9:00 to 18:00). These inputs are used for agent model.

Input for 9:00 and 10:00

To merge the sets of observations, it is necessary to recognize whether these data sets are homogeneous. According to Averill M. Law and W. David Kelton (2000, pp.394-395), Kruskal – Wallis statistic is used to test for homogeneity. It is nonparametric test since no assumptions are made about the distributions of the data.

This statistical test is used to find out the service time distribution on workdays. The result of testing is shown below:

Ranks

	DATE	N	Mean Rank
SERVICET	3	156	1677.16
	4	236	1637.03
	5	213	1591.12
	8	153	1656.56
	9	216	1541.13
	10	211	1698.93
	11	193	1653.11
	12	181	1755.10
	15	167	1673.89
	17	189	1680.49
	18	166	1589.46
	19	175	1520.02
	22	215	1492.02
	23	103	1649.37
	25	167	1652.60
	29	165	1579.56
	30	148	1658.65
	31	184	1498.68
	Total	3238	

Test Statistics[a,b]

	SERVICET
Chi-Square	19.680
df	17
Asymp. Sig.	.291

a. Kruskal Wallis Test

b. Grouping Variable: DATE

Figure 6-56: Kruskal – Wallis Test for Agent Service time at 9:00 to 10:00

The agent service time distribution of this period is shown below:

Distribution Summary

Distribution: Lognormal
Expression: 5 + LOGN(221, 336)
Square Error: 0.003793

Chi Square Test
Number of intervals = 21
Degrees of freedom = 18
Test Statistic = 76.1
Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
Test Statistic = 0.0525
Corresponding p-value < 0.01

Data Summary

Number of Data Points = 3238
Min Data Value = 5
Max Data Value = 2.84e+003
Sample Mean = 207
Sample Std Dev = 240

Histogram Summary

Histogram Range = 5 to 2.84e+003
Number of Intervals = 40

Figure 6-57: Agent service time distribution on workdays at 9:00 to 10:00

Input for 10:00 to 11:00

The result of Kruskal – Wallis test for this period is shown below:

Ranks

	DATE	N	Mean Rank
SERVICET	3	235	1617.85
	4	294	1653.38
	5	254	1661.54
	8	200	1582.56
	9	259	1562.28
	10	239	1594.76
	11	268	1565.84
	15	183	1702.66
	17	189	1698.33
	18	211	1573.45
	22	236	1558.95
	23	132	1800.28
	25	180	1724.76
	29	164	1756.66
	31	213	1533.94
	Total	3257	

Test Statistics[a b]

	SERVICET
Chi-Square	19.494
df	14
Asymp. Sig.	.147

a. Kruskal Wallis Test

b. Grouping Variable: DATE

Figure 6-58: Kruskal – Wallis Test for Agent Service time at 10:00 to 11:00

The agent service time distribution of this period is shown below:

Distribution Summary

Distribution: Lognormal
Expression: 4 + LOGN(212, 299)
Square Error: 0.000291

Chi Square Test

Number of intervals	= 10
Degrees of freedom	= 7
Test Statistic	= 25.6
Corresponding p-value	< 0.005

Kolmogorov-Smirnov Test

Test Statistic	= 0.0488
Corresponding p-value	< 0.01

Data Summary

Number of Data Points	= 3257
Min Data Value	= 4
Max Data Value	= 6.75e+003
Sample Mean	= 203
Sample Std Dev	= 270

Histogram Summary

Histogram Range	= 4 to 6.75e+003
Number of Intervals	= 40

Figure 6-59: Agent service time distribution on workdays at 10:00 and 11:00

Input for 11:00 to 12:00

The result of Kruskal – Wallis test for this period is shown below:

Ranks

	DATE	N	Mean Rank
SERVICET	3	191	1413.66
	4	234	1336.13
	5	214	1423.87
	8	152	1539.67
	9	220	1513.01
	10	215	1369.42
	11	215	1439.18
	17	194	1504.30
	18	148	1442.23
	19	190	1350.92
	22	200	1407.87
	25	134	1445.10
	26	159	1291.01
	29	157	1317.22
	31	200	1393.57
	Total	2823	

Test Statistics[a,b]

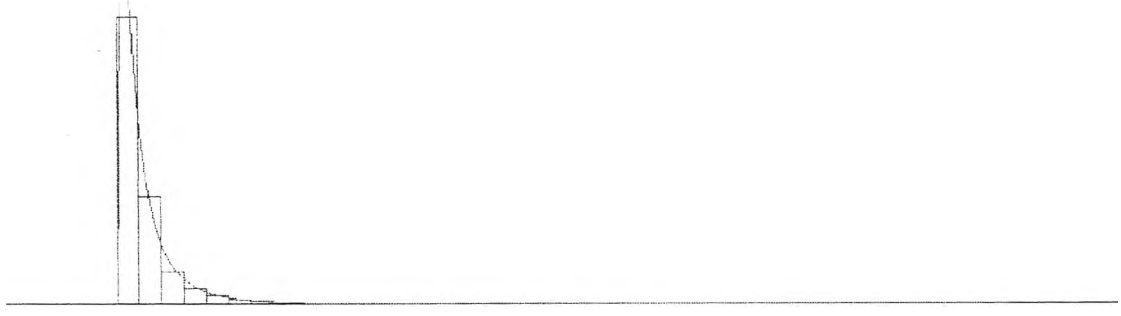
	SERVICET
Chi-Square	19.721
df	14
Asymp. Sig.	.139

a. Kruskal Wallis Test

b. Grouping Variable: DATE

Figure 6-60: Kruskal – Wallis Test for Agent Service time at 11:00 to 12:00

The agent service time distribution of this period is shown below:



Distribution Summary

Distribution: Lognormal
Expression: 3 + LOGN(217, 298)
Square Error: 0.000307

Chi Square Test
Number of intervals = 10
Degrees of freedom = 7
Test Statistic = 17.5
Corresponding p-value = 0.016

Kolmogorov-Smirnov Test
Test Statistic = 0.0426
Corresponding p-value < 0.01

Data Summary

Number of Data Points = 2823
Min Data Value = 3
Max Data Value = 6.76e+003
Sample Mean = 211
Sample Std Dev = 291

Histogram Summary

Histogram Range = 3 to 6.76e+003

Number of Intervals = 40

Figure 6-61: Agent service time distribution on workdays at 11:00 to 12:00

Input for 12:00 to 13:00

The result of Kruskal – Wallis test for this period is shown below:

Ranks

	DATE	N	Mean Rank
SERVICET	3	105	1065.79
	4	154	1005.17
	5	118	1059.15
	8	120	1136.66
	9	129	1071.93
	10	143	1017.36
	11	157	1014.87
	12	84	1205.51
	15	111	1048.52
	16	107	1060.05
	17	118	1194.53
	18	112	1078.67
	19	110	938.06
	22	147	1077.60
	23	84	1188.69
	25	97	1031.41
	30	135	1116.42
	31	115	1108.76
	Total	2146	

Test Statistics[a,b]

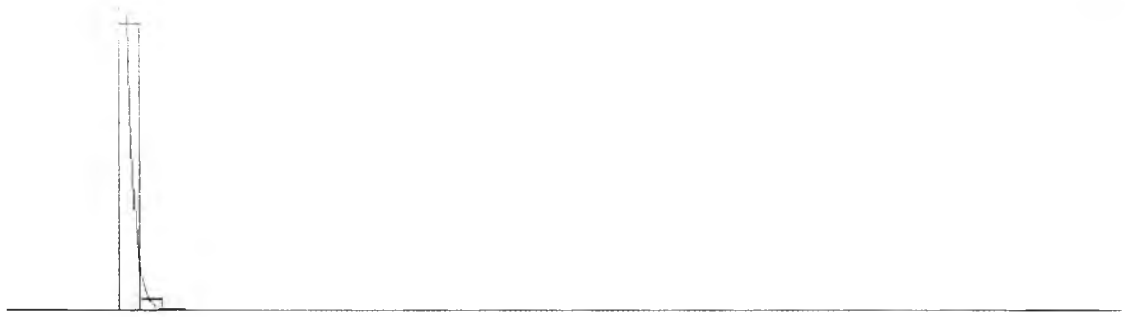
	SERVICET
Chi-Square	23.965
df	17
Asymp. Sig.	.120

a. Kruskal Wallis Test

b. Grouping Variable: DATE

Figure 6-62: Kruskal – Wallis Test for Agent Service time at 12:00 to 13:00

The agent service time distribution of this period is shown below:



Distribution Summary

Distribution: Weibull
Expression: 6 + WEIB(177, 1.04)
Square Error: 0.000201

Chi Square Test

Number of intervals	= 2
Degrees of freedom	= -1
Test Statistic	= 9.27
Corresponding p-value	< 0.005

Kolmogorov-Smirnov Test

Test Statistic	= 0.0649
Corresponding p-value	< 0.01

Data Summary

Number of Data Points	= 2146
Min Data Value	= 6
Max Data Value	= 2.19e+004
Sample Mean	= 209
Sample Std Dev	= 675

Histogram Summary

Histogram Range	= 6 to 2.19e+004
Number of Intervals	= 40

Figure 6-63: Agent service time distribution on workdays at 12:00 to 13:00

Input for 13:00 to 14:00

The result of Kruskal – Wallis test for this period is shown below:

Ranks

	DATE	N	Mean Rank
SERVICET	3	178	1715.06
	4	249	1583.58
	5	222	1618.57
	8	183	1571.93
	9	239	1670.08
	10	152	1758.31
	11	244	1540.94
	12	173	1651.31
	15	173	1702.48
	17	194	1654.44
	18	187	1805.82
	19	151	1666.14
	22	201	1493.64
	25	181	1599.73
	26	186	1514.71
	30	153	1656.21
	31	186	1532.51
	Total	3252	

Test Statistics[a,b]

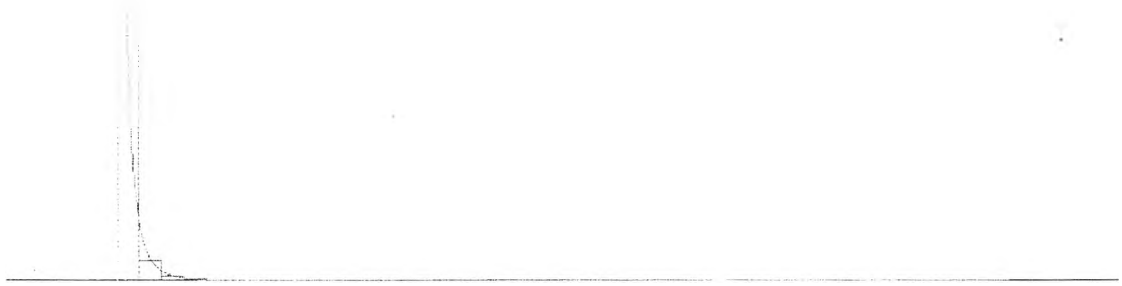
	SERVICET
Chi-Square	25.616
df	16
Asymp. Sig.	.060

a. Kruskal Wallis Test

b. Grouping Variable: DATE

Figure 6-64: Kruskal – Wallis Test for Agent Service time at 13:00 to 14:00

The agent service time distribution of this period is shown below:



Distribution Summary

Distribution: Lognormal

Expression: 3 + LOGN(226, 303)
Square Error: 0.000184

Chi Square Test

Number of intervals	= 5
Degrees of freedom	= 2
Test Statistic	= 8.01
Corresponding p-value	= 0.0198

Kolmogorov-Smirnov Test

Test Statistic	= 0.0448
Corresponding p-value	< 0.01

Data Summary

Number of Data Points	= 3252
Min Data Value	= 3
Max Data Value	= 1.96e+004
Sample Mean	= 233
Sample Std Dev	= 490

Histogram Summary

Histogram Range	= 3 to 1.96e+004
Number of Intervals	= 40

Figure 6-65: Agent service time distribution on workdays at 13:00 to 14:00

Input for 14:00 to 15:00

The result of Kruskal – Wallis test for this period is shown below

Ranks

	DATE	N	Mean Rank
SERVICET	3	209	1972.18
	4	304	1789.04
	5	270	1914.83
	8	207	1984.24
	9	258	1824.73
	10	240	1856.03
	11	266	1813.91
	15	168	1955.27
	16	174	1919.26
	17	222	2017.30
	18	268	1918.73
	19	209	1790.53
	22	239	1729.78
	23	157	1932.23
	29	197	1970.51
	30	198	1990.68
	31	211	2038.58
	Total	3797	

Test Statistics[a,b]

	SERVICET
Chi-Square	25.158
df	16
Asymp. Sig.	.067

a. Kruskal Wallis Test

b. Grouping Variable: DATE

Figure 6-66: Kruskal – Wallis Test for Agent Service time at 14:00 to 15:00

The agent service time distribution of this period is shown below:

Distribution Summary

Distribution: Lognormal
Expression: 3 + LOGN(213, 291)
Square Error: 0.000146

Chi Square Test

Number of intervals	= 6
Degrees of freedom	= 3
Test Statistic	= 6.84
Corresponding p-value	= 0.081

Kolmogorov-Smirnov Test

Test Statistic	= 0.0389
Corresponding p-value	< 0.01

Data Summary

Number of Data Points	= 3797
Min Data Value	= 3
Max Data Value	= 1.56e+004
Sample Mean	= 212
Sample Std Dev	= 357

Histogram Summary

Histogram Range	= 3 to 1.56e+004
Number of Intervals	= 40

Figure 6-67: Agent service time distribution on workdays at 14:00 to 15:00

Input for 15:00 to 16:00

The result of Kruskal – Wallis test for this period is shown below:

Ranks

	DATE	N	Mean Rank
SERVICET	3	216	2068.63
	4	279	2043.05
	5	218	2198.05
	8	190	2089.51
	9	252	1962.10
	10	201	2238.75
	11	223	1952.67
	12	184	2211.60
	15	187	1964.89
	16	241	2088.66
	17	217	2136.98
	18	225	2153.90
	19	189	2000.87
	22	252	1956.77
	25	172	2198.49
	26	240	2008.58
	29	211	2006.31
	30	233	2033.55
	31	215	2162.70
	Total	4145	

Test Statistics[a,b]

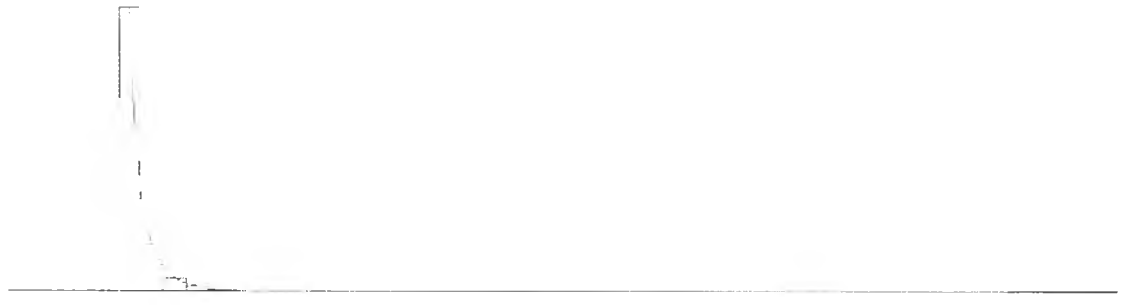
	SERVICET
Chi-Square	24.320
df	18
Asymp. Sig.	.145

a. Kruskal Wallis Test

b. Grouping Variable: DATE

Figure 6-68: Kruskal – Wallis Test for Agent Service time at 15:00 to 16:00

The agent service time distribution of this period is shown below:



Distribution Summary

Distribution: Lognormal
Expression: 4 + LOGN(220, 310)
Square Error: 0.000188

Chi Square Test
Number of intervals = 8
Degrees of freedom = 5
Test Statistic = 9.19
Corresponding p-value = 0.103

Kolmogorov-Smirnov Test
Test Statistic = 0.037
Corresponding p-value < 0.01

Data Summary

Number of Data Points = 4145
Min Data Value = 4
Max Data Value = 1.17e+004
Sample Mean = 218
Sample Std Dev = 365

Histogram Summary

Histogram Range = 4 to 1.17e+004
Number of Intervals = 40

Figure 6-69: Agent service time distribution on workdays at 15:00 to 16:00

Input for 16:00 to 17:00

The result of Kruskal – Wallis test for this period is shown below:

Ranks

	DATE	N	Mean Rank
SERVICET	3	181	1451.45
	4	185	1561.64
	5	173	1573.36
	8	200	1542.45
	9	207	1475.52
	10	172	1472.12
	11	149	1521.44
	12	140	1695.19
	15	144	1648.58
	16	142	1445.71
	17	182	1579.80
	18	163	1560.29
	19	147	1699.12
	22	196	1437.85
	25	134	1697.93
	26	156	1627.10
	29	133	1678.58
	30	167	1599.26
	31	159	1617.96
	Total	3130	

Test Statistics[a,b]

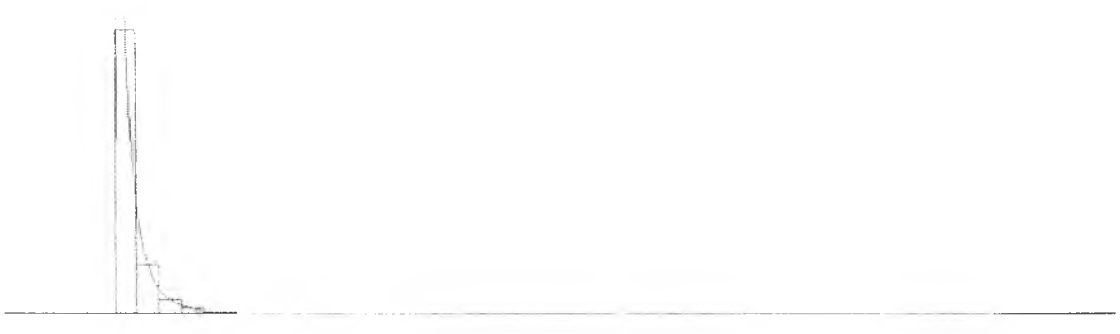
	SERVICET
Chi-Square	27.497
df	18
Asymp. Sig.	.070

a. Kruskal Wallis Test

b. Grouping Variable: DATE

Figure 6-70: Kruskal – Wallis Test for Agent Service time at 16:00 to 17:00

The agent service time distribution of this period is shown below:



Distribution Summary

Distribution: Lognormal
Expression: 4 + LOGN(217, 297)
Square Error: 0.000186

Chi Square Test
Number of intervals = 7
Degrees of freedom = 4
Test Statistic = 7.02
Corresponding p-value = 0.147

Kolmogorov-Smirnov Test
Test Statistic = 0.0318
Corresponding p-value < 0.01

Data Summary

Number of Data Points = 3130
Min Data Value = 4
Max Data Value = 1.13e+004
Sample Mean = 217
Sample Std Dev = 363

Histogram Summary

Histogram Range = 4 to 1.13e+004
Number of Intervals = 40

Figure 6-71: Agent service time distribution on workdays at 16:00 to 17:00

Input for 17:00 to 18:00

The result of Kruskal – Wallis test for this period is shown below:

Ranks

	DATE	N	Mean Rank
SERVICET	3	47	498.91
	4	51	446.29
	5	56	511.37
	8	62	439.03
	9	55	513.62
	10	36	467.06
	11	32	522.00
	12	48	606.45
	15	64	525.13
	16	39	547.63
	17	64	499.04
	18	56	525.52
	19	46	502.78
	22	60	463.41
	23	40	556.39
	25	53	497.23
	26	55	488.71
	29	38	567.70
	30	39	568.06
	31	65	416.89
	Total	1006	

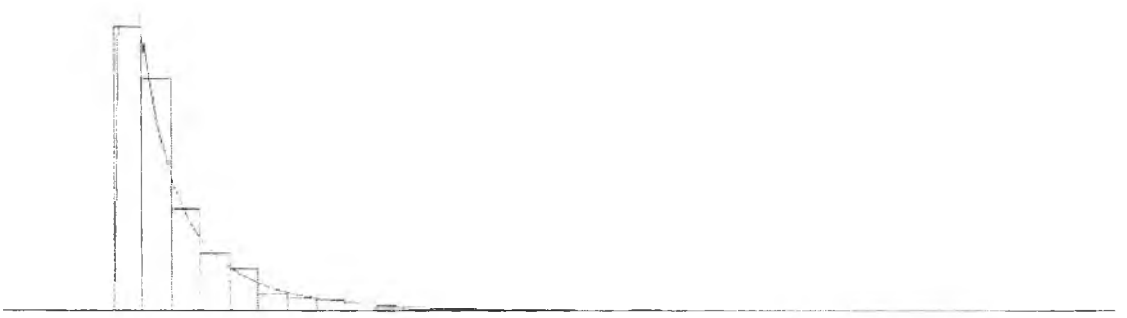
Test Statistics[a,b]

	SERVICET
Chi-Square	25.654
df	19
Asymp. Sig.	.140

a. Kruskal Wallis Test

b. Grouping Variable: DATE

Figure 6-72: Kruskal – Wallis Test for Agent Service time at 17:00 to 18:00



Distribution Summary

Distribution: Lognormal
Expression: 5 + LOGN(229, 346)
Square Error: 0.003582

Chi Square Test
Number of intervals = 12
Degrees of freedom = 9
Test Statistic = 30.1
Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
Test Statistic = 0.0619
Corresponding p-value < 0.01

Data Summary

Number of Data Points = 1006
Min Data Value = 5
Max Data Value = 2.92e+003
Sample Mean = 214
Sample Std Dev = 265

Histogram Summary

Histogram Range = 5 to 2.92e+003
Number of Intervals = 31

Figure 6-73: Agent service time distribution for workdays at 17:00 to 18:00

The conclusion of agent service time distribution of each period is shown below:

Time	Distribution
9:00 to 10:00	5 + LOGN(221, 336)
10:00 to 11:00	4 + LOGN(212, 299)
11:00 to 12:00	3 + LOGN(217, 298)
12:00 to 13:00	6 + WEIB(177, 1.04)
13:00 to 14:00	3 + LOGN(226, 303)
14:00 to 15:00	3 + LOGN(213, 291)
15:00 to 16:00	4 + LOGN(220, 310)
16:00 to 17:00	4 + LOGN(217, 297)
17:00 to 18:00	5 + LOGN(229, 346)

Figure 6-74: Agent Service Time Distribution for each period