Analytical Study of Headway Time Distribution on Congested Arterial: A Case Study Palestine Road in Baghdad City

Zainab Ahmed Alkaissi[(✉)]

Highway and Transportation Department,
AlMustansiriyah University, Baghdad, Iraq
zainablkaisi77@googlegmail.com

Abstract. The time headway is important parameter in traffic flow theory and broadly applied in different branches in transportation engineering. In this research the one of the major arterial street in Baghdad city is Palestine arterial street that have been selected as a case study to investigate the distribution of time headway under heavy flow conditions. Collected field data for tow links; Link (1) from Al-Mawal intersection to Bab AlMutham intersection 1.03 km length and link (2) from Zayona intersection to Mayslone intersection is obtained at two different time periods to conform the variation of time headway under congestion periods. The variation in time headway for Link (1) is reduced and more constant state is obtained due heavy flow conditions at congestion peak periods. The situation is not the same on Link (2), the fluctuation in time headway is still observed at higher flow rate. This demonstrated the effect of land use characteristics on time headway distribution and vehicle arrivals. Both Shape for the distribution of probability density function is skewed to the right and the peak rises for link (1) and its higher than for link (2). This illustrated that the peak value for probability density function is higher on link (1) which implies high flow rate at congestion periods. The Logostic probability distribution function is used to probably describe the time headway at congested Palestine arterial street for link (1) and (2). The fitted field data of time headway for different range of scale parameter from 1.5 to 0.85 are obtained. Goodness of fit using Chi Square non- parametric test is applied in this research to explore how the theoretical Logostic distribution fits the empirical data for time headway distribution.

Keywords: Time headway · Statistical analysis · Urban arterial
Congested arterial

1 Introduction

In traffic engineering applications the time headway properties of vehicles are very important task in the studies of highway capacity, level of service, unsignalized intersection and roundabouts. Also the traffic simulation is depend on the modeling of vehicle time headway since its represents an important characteristics in microscopic flow theory that influence on the driver behavior and road safety.

Many studies based on the modeling of headway time distribution, Al-Ghambi (2001), Al-Ghambi (1999) investigated time headway under low, medium and high flow rates and he concluded that at arterial street the time headway follows Gamma distribution and Erlang distribution especially on high flow rates. Abtahi et al. (2011) notified that there was different time headway distribution for passing and middle lanes in urban highways for heavy traffic conditions and suggest that the lognormal and Gamma distribution are best fit with shifting parameter of 0.24 s and 0.69 s for passing and middle lanes respectively. Edigbe et al. (2014) reported that the overtaking induces minimal headways and the Pearson type III and Erlang distribution are fit the headway distribution frequency.

Sara (2014) stated that an appropriate models are selected for headway distribution for heavy vehicles and passenger cars at different flow rates using Chi-Square test. It was conformed that the variation of time headway distribution for heavy vehicles and passenger cars is attributed to the different behavior of drivers under congestion in the vicinity of heavy vehicles and passenger cars.

Another earlier researchers have proposed the distribution models for time headway, such as, Buckley (1968) semi-Poisson model, Cowan (1975) M3 distribution model, the log-normal distribution (Mei and Bullen 1999) and the double displaced negative exponential distribution (Sullivan and Troutbeck 1994). Zhang and Wang (2013) reported that Cowan's M3 model is widely applied due to its simplicity and easy approximations for describing longer headways.

2   Study Area and Data Collected

One of the major arterial street in Baghdad city is Palestine arterial street that have been selected for this research. Its majority evolved from the mix land use characteristics; commercial, residential and educational surrounding area and the location in the east of Baghdad running parallel to the west of Army Cannal between Al-Mustansiriyah Square through Beirut square to the end of it at Maysalone square. Palestine arterial street consists of 6 divided lane carriageway 3-lane in each direction. Figures 1and 2 present the study area of Palestine arterial street with the region of selected links.

Two links parts of major Palestine arterial street in Baghdad city were chosen in this research Link (1) from Al-Mawal intersection to Bab AlMutham intersection 1.03 km length and link (2) from Zayona intersection to Mayslone intersection as mention in previous section. Three days take up for field data collection on 23 Monday, 24 Tuesday and 25 Wednesday 2016 which have been considered in this research. To conform the variation of time headway two time periods during the evening peak hour 6:00–6:30 pm to 6:30–7:00 pm are investigated. Relies on these time period, the time headway data are classified depending upon the flow rate conditions. A four set of field data is collected of 100 data point each with totally 400 data point. The weather conditions during field data collection is of good visibility and sunny with adequate and appropriate distance from the adjacent traffic signalized intersections.

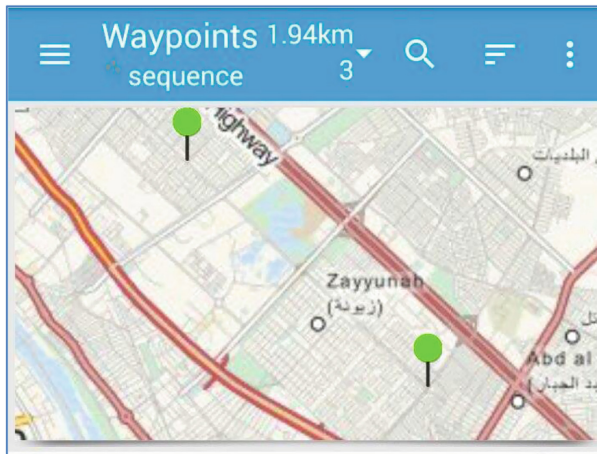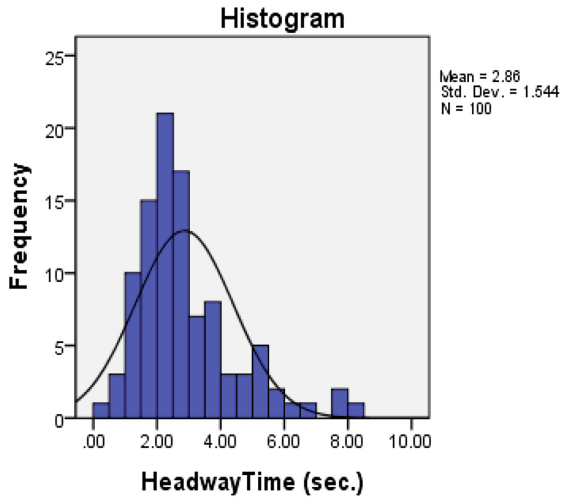**Fig. 1.** Study area of Palestine arterial street.

Fig. 2. Palestine arterial street with selected two links region.

3   Results and Discussions

3.1   Headway Time Distribution

Based on the collected data is for two links of Palestine arterial street; Link (1) from Al-Mawal intersection to Bab AlMutham intersection and link (2) from Zayona intersection to Mayslone Intersection; at two different time periods 6:00–6:30 pm with flow rate 1042 vph and 6:30–7:00 pm with flow rate 1308 vph for link (1) and for link (2) a flow rate of 1104 vph at time period 6–6:30 pm and 1164 vph at 6:30–7:00 pm as explained in Table 1. The two selected links were chosen in this research to compromise the effect of commercial and residential region on vehicle arrival. The frequency distributions for

time headway with normal curve are estimated using SPSS (SPSS ver.21 statistical software) as shown in Figs. 3 and 4 respectively. The statistical variation in mean, medial, mode and variance also presented in Table 1. For links (1) and (2) at different flow rates for different time periods at peak hour.

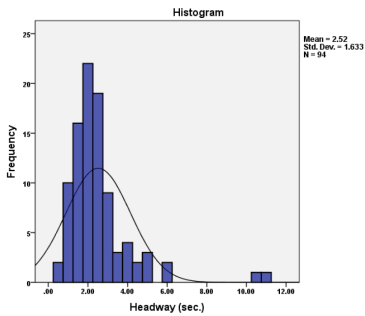(a) Time Period 6:00-6:30 pm at 1042 vph flow rate.
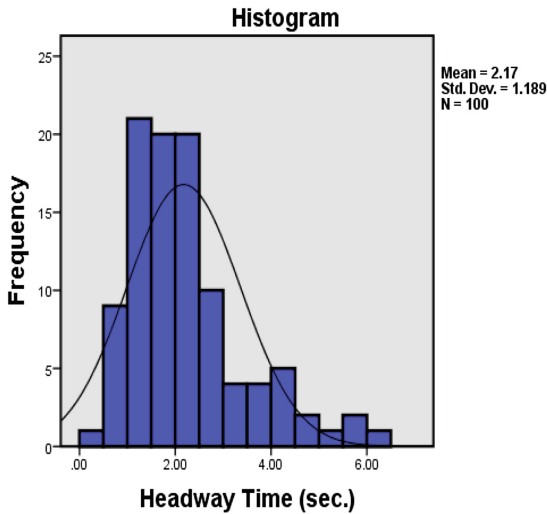
(b) Time Period 6:30-7:00 pm at 1308 vph flow rate.
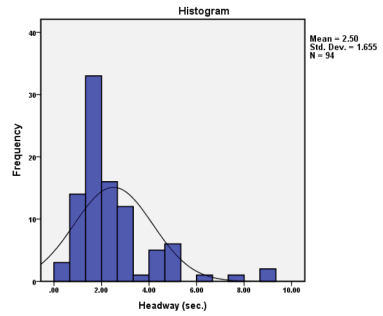
Fig. 3. Time headway distribution for link (1).

Link (1) which represents commercial urban area at Palestine arterial street in Baghdad city attained a mean value of headway time about 2.86 s and standard deviation of 1.544 s at flow rate 1042 vph, and decreased to 2.17 s of mean time headway and 1.189 s of standard deviation at flow rate 1308 vph.

Table 1. Descriptive statistics and flow rate at different time periods for link (1) and link (2).

	Link (1)		Link (2)	
	6:30–7:00 pm	6:00–6:30 pm	6:30–7:00 pm	6:00–6:30 pm
Flow rate (vph)	1042	1308	1104	1164
Mean	2.86	2.17	2.52	2.5
Median	2.45	2.106	2.1	2
Mode	1.9	1.48	2.1	2
Standard deviations	1.544	1.189	1.633	1.655
Variance	2.384	2.191	2.668	2.738
Sample size	100	100	100	100

(a) Time Period 6:00-6:30 pm at 1104 vph flow rate.

(b) Time Period 6:30-7:00 pm at 1164 vph flow rate.

Fig. 4. Time headway distribution for link (2).

This is predictable since the variation in time headway is reduced and more constant state is obtained due heavy flow conditions at congestion peak periods which appears in Fig. 3b, the more uniform shape of frequency distribution. The situation is not the same on Link (2), the fluctuation in time headway is still observed at higher flow rate and this can referred to the residential region as seen in Fig. 4a and b. This demonstrated the effect of land use characteristics on time headway distribution and vehicle arrivals.

3.2 Probability Density Distribution

The Probability density function is estimated for both link (1) and (2) as shown in Figs. 5 and 6 respectively. Both Shape for the distribution of probability density function is skewed to the right and the peak rises for link (1) and its higher than for link (2). This illustrated that the peak value for probability density function is higher on link (1) which implies high flow rate at congestion periods.
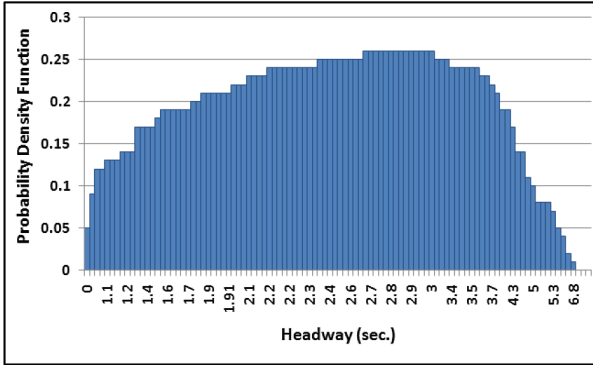

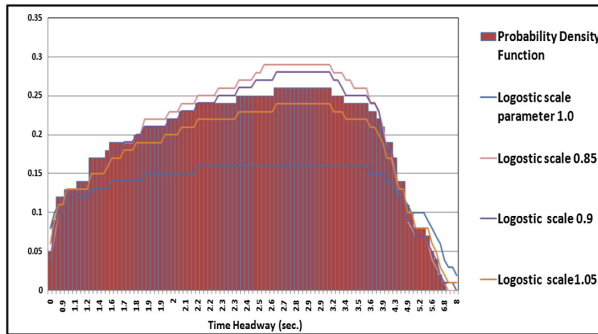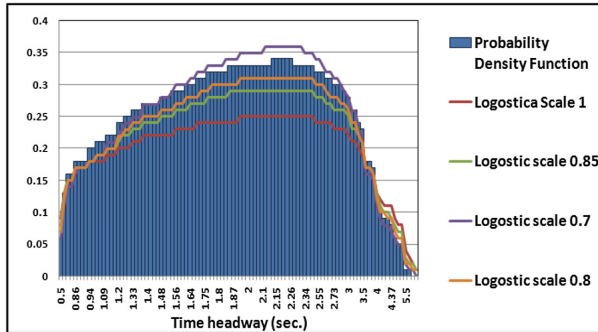**Fig. 5.** Probability density function for link (1).
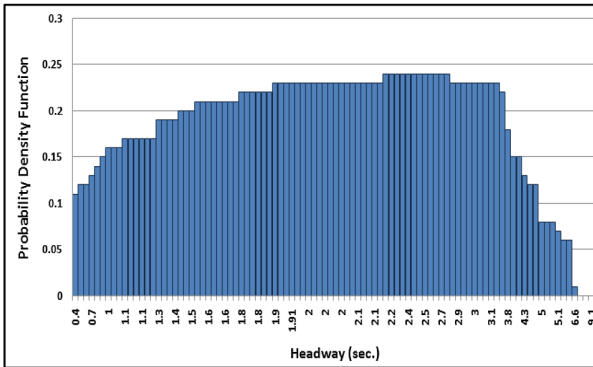
Fig. 6. Probability density function for link (2).

3.3 Time Headway Statistical Modeling

The Probability density function is estimated for both link (1) and (2) as shown in Figs. 7 and 8 respectively. Both Shape for the distribution of probability density function is skewed to the right and the peak rises for link (1) and its higher than for link (2). This illustrated that the peak value for probability density function is higher on link (1) which implies high flow rate at congestion periods.
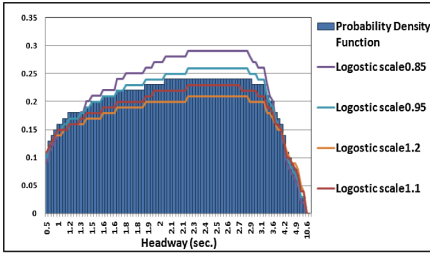

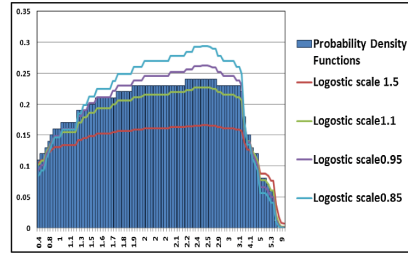(a) Time headway Distribution 6:00- 6:30pm.

(b) Time headway Distribution 6:30- 7:00pm.

Fig. 7. Probability density function of time headway distribution for link (1) at different scale parameter.

Table 2 presents the best fit for time headway distribution with probability density function of Logostic distributions with scale parameter of 0.85 and 1.05 for link (1) at time periods 6:00–6:30 pm and 6:30–7:00 pm and scale parameter of 1.1 for link (2) at both time periods respectively; which illustrated the significant level of p -value greater than 0.05.

(a) Time headway Distribution 6:00- 6:30pm.

(b) Time headway Distribution 6:30- 7:00pm.

Fig. 8. Probability density function of time headway distribution for link (2) at different scale parameter.

For the validation of the Logostic probability distribution function of time headway additional filed data for time headway were collected. A comparison between the observed field data and theoretical time headway are shown in Figs. 9 and 10 for link (1) and link (2) respectively.

Table 2. Test statistics of the estimated scale parameter for logostic density function distribution for link (1) and link (2).

|			Kolmogorov-Smirnov[a]			Shapiro-Wilk		
			Sig.	df	Statistic	Sig.	df	Statistic
Link (1)	Time headway distribution 6:00– 6:30 pm	Logostic distribution scale parameter 0.85	.000	99	.181	.000	99	.852
	Time headway Distribution 6:30– 7:00 pm	Logostic distribution scale parameter 1.05	.000	99	.175	.000	99	.848
Link (2)	Time headway distribution 6:00– 6:30 pm	Logostic distribution scale parameter 1.1	.000	99	.170	.000	99	.839
	Time headway distribution 6:30– 7:00 pm	Logostic distribution scale parameter 1.1	.000	99	.212	.000	99	.804

A good fit is obtained for link (1) and (2) as shown in Figs. 11 and 12 respectively.

Goodness of fit using Chi Square non- parametric test is applied in this research to explore how the theoretical Logostic distribution fits the empirical distribution for time headway. An additional field data is obtained and divided into different time periods 6:00–6:30 pm and 6:30–7:00 pm. As shown in Table 3 the Chi-Square goodness of fit test is less than the table value then the null hypothesis is accepted and enhanced that there is no significant difference between the observed and theoretical value for time headway.
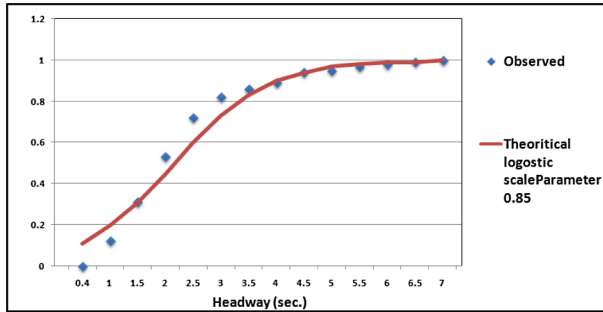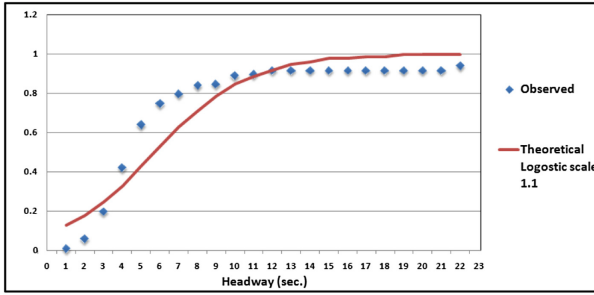

(a) Cumulative Probability of Time headway
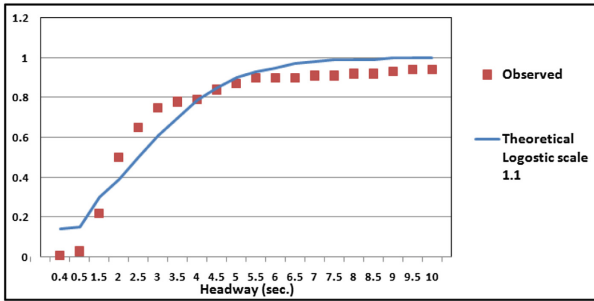Distribution 6:00- 6:30pm.
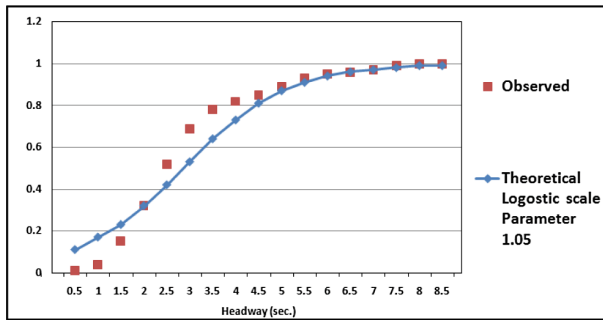
(b) Cumulative Probability of Time headway
Distribution 6:30- 7:00pm.

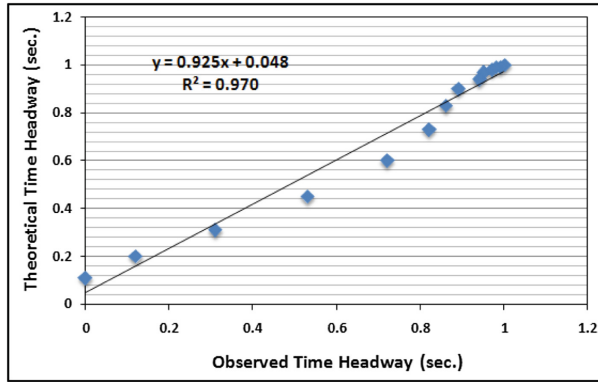**Fig. 9.** Observed and theoretical time headway data for link (1).

(a) Cumulative Probability of Time headway
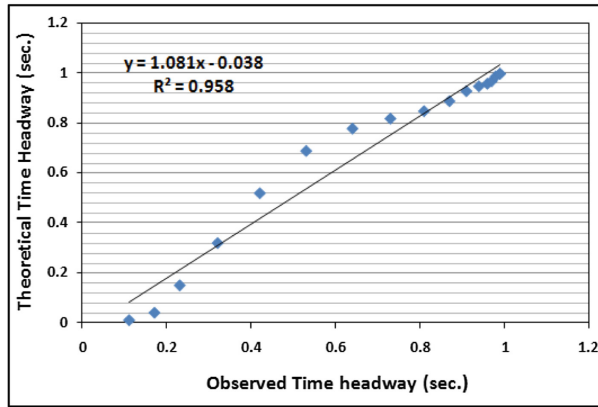Distribution 6:00- 6:30pm.

(b) Cumulative Probability of Time headway
Distribution 6:30- 7:00pm.

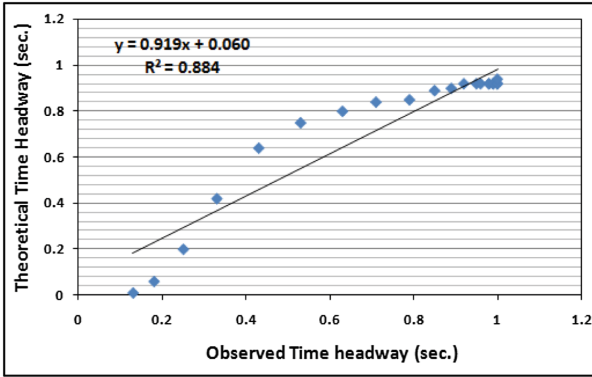**Fig. 10.**   Observed and theoretical time headway data for link (2).

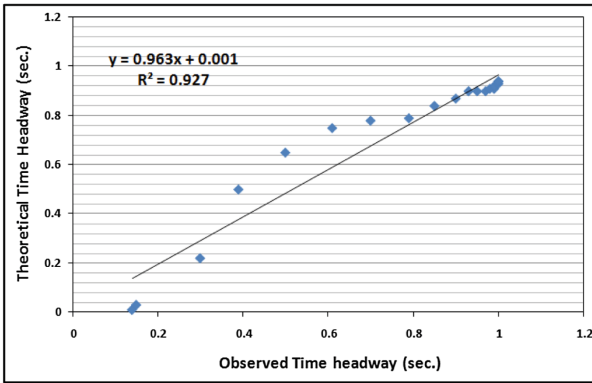(a) At Time Period 6:00- 6:30pm.

(b) At Time Period 6:30- 7:00pm.

Fig. 11.   Theoretical versus observed time headway for link (1).

(a) At Time Period 6:00- 6:30pm.

(b) At Time Period 6:30- 7:00pm.

Fig. 12. Theoretical versus observed time headway for link (2).

Table 3. Chi Square goodness of fit for link (1) and link (2) at different time periods at significant level $\alpha = 0.05$.

	Time period	N	df	χ^2	$\chi_{critical}$
Link (1)	6:00–6:30	17	16	0.335	26.296
	6:30–7:00	15	14	0.193	23.685
Link (2)	6:00–6:30	20	19	0.538	30.144
	6:30–7:00	20	19	0.399	31.41

4   Conclusions

This research displayed the analysis of time headway distribution for selected urban arterials in Baghdad city. The following remarks points are drawn:

1. A mean value of headway time about 2.86 s and standard deviation of 1.544 s at flow rate 1042 vph is obtained for link (1) and decreased to 2.17 s of mean time headway and 1.189 s of standard deviation at flow rate 1308 vph due the variation in time headway is reduced and more constant state is obtained due heavy flow conditions at congestion peak periods. On the other hands the situation is not the same on Link (2), the fluctuation in time headway is still observed at higher flow rate and this can referred to the residential region. This demonstrated the effect of land use characteristics on time headway distribution and vehicle arrivals.
2. The Shape of probability density distribution function is skewed to the right for link (1) and link (2) but the peak for link (1) is higher than for link (2) which implies high flow rate at congestion periods.
3. The Logostic probability distribution function is used to probably describe the time headway at congested Palestine arterial street at link (1) and (2) for scale parameter range from 1.5 to 0.85 for link (1) at time periods 6:00–6:30 pm and 6:30–7:00 pm and scale parameter of 1.1 for link (2) at both time periods respectively.
4. There is no significant difference between the observed and theoretical value for time headway using the Logostic distribution model. Chi Square non- parametric test goodness of fit is applied in this research to explore how the theoretical Logostic distribution fits the empirical data of time headway distribution.

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