Estimating the Volume Delay Functions in the Mashhad's Streets

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Abstract

This study analyzes the estimation of volume delay function in the city of Mashhad, IRAN. The regression and the least square methods are used to obtain the estimated volume delay functions of 20 links in the city. These functions are observed to be different from the standard volume delay functions.

(Volume Delay Function, Traffic Assignment, Regression, Least Square)

1. Introduction.

An important factor in traffic assignment and transportation analysis is the volume delay function. This function represents the variation of delay time with respect to traffic volume as an element of the transportation system, for example, in a link. In the traffic assignment, this function determines the delay time of trip as an index of trip cost for various traffic volumes as an element of transportation system in a link.

This study deals with the qualities of volume delay function and the methods of utilizing these functions for a comprehensive study of the Mashhad's transprotation.

The paper unfolds as follows. Section 2 introduces the volume delay function. In section 3, the strategy for data collection is represented. The main results, estimated functions, are provided in section 4.

2. The Volume Delay Function.

This study considers the volume delay function only for the links in the city transportation network. An important step in traffic assignment is how to choose a path between the origins and the destinations for the users of the transportation system.

Choosing the best path can be stated with the different criterion, for example, the pleasant path, the coldest path, the safest path, the

An important criterion for choosing the best path is the travel time, thus, this study considers the criterion for the shortest time path.

The travel time changes with various factors, for example, the time of travel, the day of travel, the month of travel, the season of travel, and so on. These factors can be summarized by the traffic volume, thus, this study searches for the relation of the time of travel and the traffic volume.

Therefore, the volume delay function represents the relation of the flow or the traffic volume and the travel time. It is necessary to consider the homogeneous traffic assumption, i.e. the flow is formed by only one means of transportation.

The general form of this function is shown in figure 1. This general form is used by almost all the traffic assignment models. However, the parameters of this function are based on some circumstances, for example, the facilities of the link, the users' treatment.

The traffic volume affects weakly the travel time when the traffic volume approaches zero, and as the traffic volume increases, the travel time increases sharply, and approaches infinity.

Indeed, when the traffic volume is increased by the specific volume, the critical volume, the travel time increases as the traffic volume decreases.

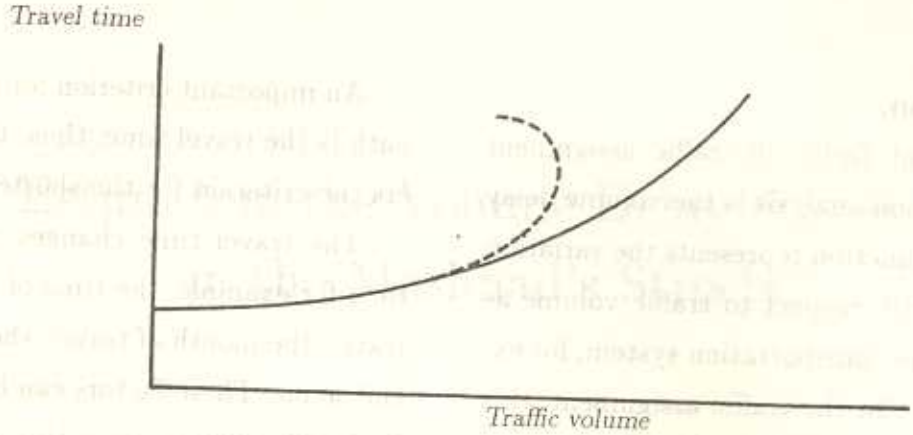

Figure 1. The general form of volume delay function.

$$t = t_0 + aV^n;\ V < C$$

where t is the average travel time on link, t_0 is the travel time on link at free flow, V is the flow on link, C is the capacity of the link, a, and n are the parameters of the model.

But one of usual models, the standard function, which is used can be stated as follows:

$$t = t_0\ (1 + \beta\ (\frac{x}{q^l}\ )^n\ )$$

where t is the average travel time in term of minute for the distance of one kilometer, x is the traffic volume in term of the number of means of transportation in an hour, t_0 is the average free travel time, i.e. travel time in the traffic volume equals to zero in term of minute, q^l is the practical volume of the link in the level of service of l in term of the number of means of transportation in an hour, β, and n are the parameters of the model.

tained as follows: if $x = q^l$,

$$t = t_0\ (1 + \beta\ (\frac{x}{q^l}\ )^n\ ) = t_0(1 + \beta\ )$$

i.e. when the traffic volume, x, is increased the practical volume, q^l, the travel time, t, w be increased 100β percent in comparsion to t free travel time, t_0.

The q^l is a quantity that represents the cha acteristics of the link in the level of service of ($l = a,\ b,\ c,\ d,\ e,\ f$) that are various quant ties, for example, level of service c for the street and b for the roads are used in [6].

The difficulty for estimating the volume de lay function is defining a unit for the traffic vol ume. Consequently, the homogeneous assump tion for this definition is necessary.

There are various means of transportation in a link. This difficulty can be reduced by introducing various coefficients known as passenger car equivalent (pce) for various means of transportation. For example, the [illegible]

Bicycle	Motor cycle	Car	Taxi	Mini bus	Bus	City bus	Truck	Tanker	Others
0.5	0.5	1.0	2.0	2.5	2.0	3.0	2.5	2.5	1.2

Table 1. Passenger Car Equivalent (pce).

3. Data Collection.

For estimating the volume delay function of a link, the observations of the traffic flow and the travel time were needed. Therefore, the samples of the traffic flows and the travel times were collected for 20 links of Mashhad's streets. The selection of the strategies for this data collection were exactly in agreement with the sample theory.

In the estimation of this function, the effects of the length and width of the streets must be considered. The effect of the length can be reduced by estimating the function for one kilometer of the street, and the effect of the width can be reduced by considering the volume delay function as follows:

$$t = t_0 \left(1 + \beta \left(\frac{x}{wq^l}\right)^n\right)$$

where w is the width of the street.

The physical conditions, the traffic characteristics, the data collection methods, and the selection of the data analysis approaches were exactly in agreement with the statistical th

The samples for every link were collected for two variables, t and x, where t is the travel time for one kilometer in term of minute, and x is the traffic volume scaled by one meter of the width of the link in term of the number of means of transportation.

4. Estimated Functions, The Main Results.

As it was mentioned, the standard form of the volume delay function can be stated as follows:

$$t = t_0 \left(1 + \beta \left(\frac{x}{q^l}\right)^n\right).$$

In table 2, are represented amount t_0 for various links.

For q^l is stated $\max(x_i)$, that is the best estimation. Indeed, $n = 4$ is considered. Therefore, only β is stimated. R^2 or determination coefficient is correlation coefficient square between x and t. The results are represented in table 3.

By T-test, with confidence more than 95%, the hypothesis β=0 is reject for every 20 links

Highway	Road	Boulevard	Street	Alley
0.54	0.75	1.00	1.20	2.00

Table 2. Average free travel time (t_0)

Normal distribution of Residuals. By tests Durbin-Watson, Kolmogorov-Smirnov and etc. above assumptions are valid for every 20 estimated function. The computations were executed by MATLAB and SPSS softwares.

Acknowledgment. The authors thank Dr. S. M. Moshiri for his valuable suggestions for this study.

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Link	The Estimated Function (before delete outlier observations)	R^2	The Estimated Function (after delete outlier observations)	R^2
1	$t = 1.20(1 + 1.02(\frac{x}{192})^4)$	.390	$t = 1.20(1 + 0.92(\frac{x}{192})^4)$	.501
2	$t = 1.20(1 + 2.45(\frac{x}{344})^4)$	.501	$t = 1.20(1 + 2.48(\frac{x}{344})^4)$	.543
3	$t = 1.00(1 + 2.08(\frac{x}{279})^4)$	.346	$t = 1.00(1 + 2.52(\frac{x}{279})^4)$	.498
4	$t = 1.20(1 + 1.28(\frac{x}{439})^4)$	.081	$t = 1.20(1 + 5.96(\frac{x}{439})^4)$	.437
5	$t = 1.20(1 + 1.50(\frac{x}{308})^4)$	.334	$t = 1.20(1 + 1.33(\frac{x}{308})^4)$	.434
6	$t = 1.20(1 + 0.81(\frac{x}{481})^4)$	.320	$t = 1.20(1 + 0.77(\frac{x}{481})^4)$	.346
7	$t = 1.00(1 + 0.66(\frac{x}{442})^4)$	.287	$t = 1.00(1 + 0.64(\frac{x}{442})^4)$	.290
8	$t = 1.00(1 + 1.24(\frac{x}{193})^4)$	.545	$t = 1.00(1 + 1.18(\frac{x}{193})^4)$	.634
9	$t = 1.20(1 + 0.29(\frac{x}{489})^4)$	.047	$t = 1.20(1 + 0.29(\frac{x}{489})^4)$	.073
10	$t = 1.20(1 - 0.12(\frac{x}{496})^4)$	.010	$t = 1.20(1 - 0.12(\frac{x}{496})^4)$	.011
11	$t = 1.00(1 + 1.51(\frac{x}{141})^4)$	.385	$t = 1.00(1 + 1.42(\frac{x}{141})^4)$	.532
12	$t = 1.00(1 + 0.49(\frac{x}{206})^4)$	.190	$t = 1.00(1 + 0.23(\frac{x}{206})^4)$	.227
13	$t = 1.20(1 + 0.80(\frac{x}{138})^4)$	.274	$t = 1.20(1 + 0.61(\frac{x}{138})^4)$	.369
14	$t = 1.00(1 + 0.22(\frac{x}{243})^4)$	.073	$t = 1.00(1 + 0.17(\frac{x}{243})^4)$	.059
15	$t = 1.20(1 + 0.62(\frac{x}{226})^4)$	.355	$t = 1.20(1 + 0.58(\frac{x}{226})^4)$	.459
16	$t = 1.20(1 + 0.15(\frac{x}{234})^4)$	.028	$t = 1.20(1 + 0.07(\frac{x}{234})^4)$	.017
17	$t = 1.00(1 - 0.25(\frac{x}{406})^4)$	.085	$t = 1.00(1 - 0.26(\frac{x}{406})^4)$	.094
18	$t = 0.54(1 + 0.84(\frac{x}{210})^4)$	.315	$t = 0.54(1 + 0.80(\frac{x}{210})^4)$	.378
19	$t = 0.75(1 + 1.05(\frac{x}{228})^4)$	.282	$t = 0.75(1 + 1.04(\frac{x}{228})^4)$	.306
20	$t = 2.00(1 + 0.25(\frac{x}{73})^4)$	.108	$t = 2.00(1 + 0.12(\frac{x}{73})^4)$	.006

Table 3. Estimated Functions
(befor and after delete outlier observation)