Testing the Stability of Estimated Results According to Different Numbers of Inputted Cross-section Locations in the OD Traffic Volume Inverse Estimation Method

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1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) gathers information about OD traffic volumes through the national Road Traffic Census (the Census), which is a sample survey conducted approximately every five years. For this reason, NILIM is developing an OD traffic volume inverse estimation method that estimates the OD traffic volume inversely from the cross-sectional traffic volume for roads, which can be measured easily, with the objective of finding out the probable OD traffic volume for an arbitrary day. This is expected to enable appropriate traffic management that allows for fluctuations in traffic demand according to the season or day of the week. However, previous studies have assumed that all observed cross-sectional traffic volumes from the Census are available. By contrast, to gain information on the OD traffic volume for an arbitrary day, we must confirm whether the OD traffic volume inverse estimation method can estimate the OD traffic volume accurately, even if fewer observation locations for cross-sectional traffic volume can be applied to the method, based on the fact that the observation locations for cross-sectional traffic volume would be limited to locations where traffic counters and the like are installed. This study examined several cases where the number of observed cross-sectional traffic volume locations applied in the OD traffic volume inverse estimation method was reduced, with the results discussed below.

2. Outline of the OD traffic volume inverse estimation method

The model equation for the daily OD traffic volume inverse estimation method is shown in equation (1). The model minimizes the residual sum of squares of the cross-sectional traffic volume and the residual sum of squares of the originating traffic volume and estimates the originating traffic volume in each zone as an unknown variable. The weighting is the inverse of the variance of each, based on error theory. The second weighting is the inverse of the variance assuming a normal distribution, in view of the fact that the survey accuracy of the originating traffic volume in the Census OD survey is supposed to "have a relative error for the originating traffic volume within a relative error rate of 20% at 95% confidence."

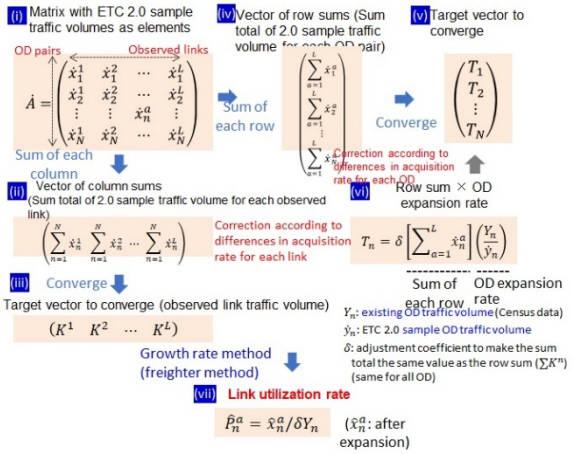
$$\frac{1}{(0.1/1.96)^2\sum_a (v_a^*)^2}\sum_a\sum_i\sum_j\left(\hat{O}_i m_{ij} P_{a,ij} - v_a^*\right)^2 + \frac{1}{(0.2/1.96)^2\sum_i (O_i^*)^2}\sum_i\left(\hat{O}_i - \hat{O}o_i^*\right)^2 \rightarrow Min \quad (1)$$

$$s.t. \quad (1/1.2)O_i^* \le \hat{O}_i \le (1/0.8)O_i^*$$

$P_{a,ij}$: utilization rate of link a for OD traffic volume ij
m_{ij}: destination selectivity between ij
v_a^*: observed cross-sectional traffic volume on link a
$\hat{O}_i$: originating traffic volume (unknown variable)
$\hat{O}$: total originating traffic volume ($\hat{O} = \sum_i \hat{O}_i$)
o_i^*: originating traffic volume proportion from existing data ($= O_i^*/O^*$)
O_i^*: originating traffic volume in existing data
O^*: total originating traffic volume in existing data

This study applies ETC 2.0 probe information to the link utilization rate and employs a method of correcting the link utilization rate with the growth rate method, according to differences in acquisition rate for each OD and link, consisting of the following two steps:

・ Step 1: Correct the ETC 2.0 probe information according to differences in acquisition rate for each OD and link (fig. 1)



・ Step 2: Process to make the sum of the route selectivity rates (the values obtained by dividing the traffic volume in each OD route by the OD traffic volume) 1.0

Fig. 1. Link utilization rate correction method

3. Testing the estimated results according to different numbers of inputted cross-section locations

(1) Test method

The input data for the daily OD traffic volume inverse estimation model is shown (table 1). In a constant observation system, the number of points available for obtaining observed cross-sectional traffic volume is limited to points where traffic counters and the like are installed, and it would therefore be fewer than the number of observation points in the 2015 Census in ordinary roads. Considering this, we set up several cases with different numbers of input points. The link utilization rate is computed by applying the correction method for the link utilization rate described above for case 0 (the basic case), in which all available locations are inputted.

Table 1. Input data

Target area	Originating traffic volume	Destination selection Probability	Link utilization rate	Observed cross-section traffic volume
Kinki region (896 zones)	Computed from OD traffic volumes in 2015 Census	Computed from OD traffic volumes in 2015 Census	Corrected link utilization rate computed from ETC 2.0 route information with the growth rate method	Applied OD traffic volume results in 2015 Census

(2) Test results

(i) Estimated results

The estimated results for cases 0 to 3 over the entire Kinki region are shown in table 2. Cases 1 and 2 remove inputted observation locations at random, while case 3 assumes the use of all constant observation locations that are currently available.

The %RMS of the estimated originating traffic volume in cases 1 and 2 was no more than 3.8% compared to case 0. On the other hand, in case 3, it was 6.4%, representing a slight increase on cases 0 to 2. The %RMS of the cross-sectional traffic flow shows a similar tendency, and although it is slightly larger in case 3 than in cases 0 to 2, the %RMS value was not greatly different and there was not a large difference in the estimate accuracy.

Table 2. Estimated results

Case	Inputted cross-section locations for observed traffic volume	Originating traffic volume		Cross-section traffic volume (Expressway + ordinary)	
		Traffic volume (100,000 vehicles)	%RMS (Compared to case 0)	Traffic volume (100,000 vehicles)	%RMS
Value from Census		147		490	
Case 0 Basic case	Total: 2,264 Ordinary: 1,770 Expressway: 494	145		482	18.1%
Case 1 Ordinary 40% down	Total: 1,556 Ordinary: 1,062 Expressway: 494	144	3.1%	478	18.3%
Case 2 Ordinary 60% down	Total: 1,202 Ordinary: 708 Expressway: 494	143	3.8%	476	18.3%
Case 3 Expressway + ordinary (constant observation)	Total: 510 Ordinary: 32 Expressway: 478	141	6.4%	469	18.9%

(ii) Fluctuation trends in originating traffic volumes

Fluctuation trends in the estimated originating traffic volumes in each zone in case 3 are shown in comparison with case 0, focusing on the areas in the Kinki region (fig. 2). Areas where the originating traffic volume is estimated to be lower were confirmed around suburban zones. The cause is thought to be insufficient correction of the input values for the link utilization rate. For the ETC 2.0 probe information that was applied for the link utilization rate, we collected data using route information collection devices installed on expressways and directly managed national roads. One factor appears to be that, because the network of expressways and directly managed national roads is sparse in these areas, the ETC 2.0 probe information subject to correction is insufficient and the link utilization rate has not been properly corrected.

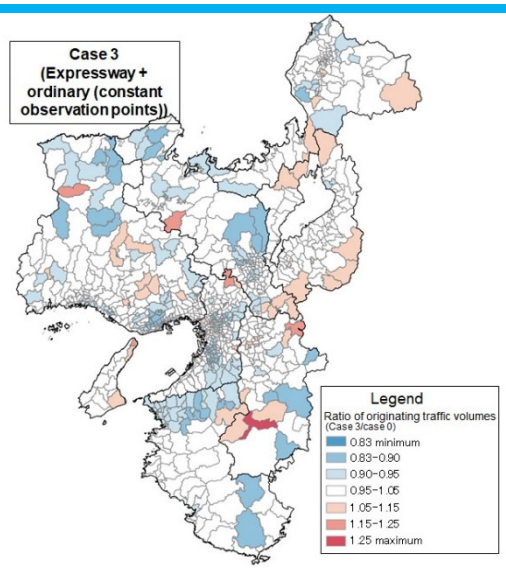


Fig. 2. Comparison of estimated originating traffic volumes between cases 0 and 3

4. Conclusion

This study set up several cases with different numbers of input points and tested the stability of the OD traffic volume inverse estimation results. The estimation accuracy of case 3, which assumed the currently realizable constant observation system, was not found to show large differences compared to the other cases over the entire Kinki region. On the other hand, if we focus on individual areas, some areas have low accuracy and it appears necessary to improve the correction method for the link utilization rate. In addition, some improvements to estimation accuracy can be expected from increased numbers of constant observation locations for traffic volumes in ordinary roads through CCTV camera (AI analysis), where efforts are currently underway.

☞See here for detailed information

1) 64th Proceedings of Infrastructure Planning (Sep. 2021)
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