Establishment of Influence Area using Select Link Analysis for Highway Investment Projects

Hochan KWAK  
Ph. D. Candidate  
Department of Civil and Environmental Engineering  
Seoul National University  
Gwanak-ro 599, Gwanak-gu, Seoul 151-742  
Republic of Korea  
Fax: +82-2-889-0032  
E-mail: firstcolony1@hanmail.net

Youjin Sul  
Ph. D. Candidate  
Department of Civil and Environmental Engineering  
Seoul National University  
Gwanak-ro 599, Gwanak-gu, Seoul 151-742  
Republic of Korea  
Fax: +82-2-889-0032  
E-mail: seol7035@snu.ac.kr

Seungyoung Kho  
Professor  
Department of Civil and Environmental Engineering  
Seoul National University  
Gwanak-ro 599, Gwanak-gu, Seoul 151-742  
Republic of Korea  
Fax: +82-2-889-0032  
E-mail: sykho@snu.ac.kr

Sungmo Rhee  
Professor  
Department of Civil and Environmental Engineering  
Seoul National University  
Gwanak-ro 599, Gwanak-gu, Seoul 151-742  
Republic of Korea  
Fax: +82-2-889-0032  
E-mail: rheesm@snu.ac.kr

Abstract: Influence area means the spatial range that the change of traffic flow pattern is remarkable after the construction of highway facilities. The influence area would be a significant criterion for economic analysis because it has an effect on the benefit estimation. However, existing methods for establishing influence area (such as the O/D method, the method using variation of traffic volume, and the method using variation rate of traffic volume) have no standard criteria. In this paper, problems which existing methods have are analyzed and a new method using select link analysis is proposed. Influence area could be established as the set of zones having 70 percentile cumulative trips out of OD pairs using selected link. In addition, the value of standard criteria for establishing influence area is suggested and it is validated via case study.

Key Words: Influence Area, Select Link Analysis, Standard Criteria

1. INTRODUCTION

1.1 Background and Objectives
An Influence area means the spatial range that the change of traffic flow pattern is remarkable after the construction of road facilities. An influence area would be a significant criterion because it has great effects on the benefit estimation and generally divided to direct influence area and indirect influence area. When estimating benefit of road project, both influences are considered.

Representative methodologies which establish influence area in feasibility study are divided into former one- accumulation ratio of O/D based traffic volume- and later one – variation volume of like traffic and variation ratio of traffic. However, there have not been studied yet which methodology is better. Also, in guides of traffic demand analysis in manual of many Korea related organization, since clear methodology is absent, results of an influence area could be different by each analyst.
In this study, investigate merits and demerits of many methodologies and propose new methodology using select link analysis which establishes a standard for consistent methodology.

1.2 Scope and Contents
It is the first thing to establish an influence area in analyzing traffic demand of road and rail project, it could be applied to every analysis using O/D and network. In this study, basic data for an influence area are O/D and network offered by national traffic date base center and traffic package is traffic computer software Emme/2.

2. LITERATURE REVIEW
Song et al. (1999) used a method to establish an influence area as range of cell which caused reduction of total travel time using stochastic model to estimate an influence of highway. As a result, variations of total travel time estimated using entire network and sub-network were estimated equally, while variations of total travel time estimated using entire network and free choice network were estimated differently, which showed proposed method derive confident result. Although this method could be applied to free choice network based on definition of an influence area, it derives lots of results which are not converged exactly in real network. Therefore, this method is theoretically great but not adequate when applying to real network.

Yang et al. (2003) proposed a method which estimates effects of large-scale public investment project to national and region economic. Yang expressed influence of specific road facilities of a region rating from zero introducing a concept of IZMI (Impact Zone Measurement Index) and variations of those IZMI are consisted of distance from specific IC of administrative district, automobile possession per person of specific administrative district and dummy variations of existence and nonexistence of specific facilities. In this study, process is described below. The definition of variations at each points (DI, CAR, DOR, Z and so on) → Arrangement of relative rank of influence index established as linear function of each variation → Assumption of influence index at each point → Deduction of influence index at each point. Although results of proposed method are values showing differences of relative influences, which could applied to decision of the order of priority of investment and decision of relative investment scale, it is not adequate to estimate absolute range of influence area which is needed in this study.

Kim et al. (2005) developed a model about definition of an influence area for private investment using model of influence area index proposed by yang et al. (2003). This model rated relative influencing power of specific road facilities in related region from zero. Main objective of Kim’s study is to show difference of an influenced area when road facilities are built up by public investment or private investment.

Kim et al. (2005) analyzed problems in existing method for defining an influenced area and introduced a new method using total travel time. They proposed that influence area could be established as the area where the vehicles reach from starting traffic zone to ending zone to which 95 percentile vehicles want to travel. They also proposed the value of standard criteria for defining influence area. This study have great significant to make up for the weak point of existing methodology and to minimize possibility of occurring errors depending on decision of analyst by proposing standard criteria. However their model have some problems which an
influence area are tend to estimated greater than actual are.

3. THEORETICAL REVIEW

3.1 Existing Method to Establish Influence Area

A number of methods have been put forward over the years to estimate influence area. Korea development Institute (2004) proposed method of estimating influence, there are three method proposed by a standard guide study for feasibility such as the O/D method, the method using traffic volume variation and the method using rate of traffic volume variation.

- The O/D method

\[
P V_{ij} = \frac{V_{ij}}{\sum_{j=1}^{n} V_{ij}} \times 100
\]

- The method using variation of traffic volume

\[
DV^k = |V_{Do-Action}^k - V_{do-Nothing}^k |
\]

- The method using variation rate of traffic volume

\[
RV^k = \frac{|V_{Do-Action}^k - V_{do-Nothing}^k|}{V_{do-Nothing}^k} \times 100
\]

where,

- \( PV_{ij} \) = The ratio of arrival trip of zone j out of production trip of zone i
- \( DV^k \) = The variation of traffic volume of link k when doing action
- \( RV^k \) = The variation rate of traffic volume of link k when doing action
- \( V_{Do-Action}^k \) = The traffic volume of link k when doing action
- \( V_{do-Nothing}^k \) = The traffic volume of link k when doing nothing

The O/D method is which could be applied before traffic assignment, defining influence area by absolute trip arrival from project region. This method has a merit which could establish rough influence area before constructing network, but also has a demerit which could not reflect characteristics of route change.

The method using traffic volume variation and rate of traffic volume variation are which establish influence area by traffic variance volume and traffic variance ratio when doing action. These methods are the most direct methodology to find ‘the area that the traffic flow pattern is changed remarkably’, thus correspond with original purpose of defining an influence area. However these methods have limits which could be different by judgment and ability of
analyst because it is achieved by trial and error which adjust size of influence area when processing traffic assignment using computer software emme/2 and also standard of estimating influence area could be changed depends on traffic volume.

3.2 Select Link Analysis
The conventional form of select link analysis reports the OD flow matrix for a single direction on a single link. That is, select link analysis is to estimate how many traffic use selected link after traffic assignment for road network. This analysis could be processed in additional module of computer software of traffic demand estimation, and derive traffic volume using selected link, pairs of OD. Select link analysis is quite adequate method for establishing influence area which is defined as ‘the area that the traffic flow pattern is changed remarkably’.

The figure 1 illustrates select link analysis. There are four zones for a possible 12 interzonal OD pairs. Two of the OD pairs (AB and AC) send trips along paths that use the selected link. These OD pairs and their associated volumes are listed in a select link analysis. In this case, the AB flow is 60 trips and the AC flow is 40 trips. In a large network with many zones, huge amount of data are be generated by a select link analysis. To achieve an understanding of the results, it is usually necessary to restrain the number of selected links and to filter out OD flows that are trivially small. A select link analysis, properly executed, will tell the analyst which zones and OD pairs contribute most to a link volume.

![Figure 1 An example network of select link analysis](image)

4. ESTABLISHMENT OF INFLUENCE AREA USING SELECT LINK ANALYSIS

4.1 A Method to Establish Influence Area using Select Link Analysis
As mentioned earlier, influence area has significant meaning in traffic demand analysis in road project, because a result whether doing project or not could be changed by results of influence area causing benefits of the project. Also exact definition of influence area has significant meaning in that it could raise confidence of traffic assignment results using computer software correcting error of network calculation not happen in actual network.

In this study, a new method is proposed of establishing influence area using select link analysis which has not been considered before. Every existing method has merits and
demerits and its results are derived from trial and error depends on decision of analysis without clear standard criterion. A new method proposed in this study is expected to solve existing problem and to establish influence area more objectively and reasonably. A new method is processed like below flow chart.

The first step of establishing influence area is to add links to entire network. According to road attributes such as new construction or expansion, link is to be added or corrected, this process is additional process, when estimating influence area, and process such as sub-zone division and sub-link addition are omitted.

The next step is to estimate trip interchange going through project region after trip assignment using select link analysis. Emme/2 (software for traffic demand forecasting) offers function to achieve select link analysis as process of traffic assignment; as a result, traffic pattern for analysis link could be understood.

To establish influence area using trip interchange, it is necessary to make up standard criteria for achieved data. In this study, influence area is setting up to OD pair which cumulative ratio of trip interchange is up to 70%, and validation for this standard criteria is going to be processed in case study.

![Figure 2 Processes to establish influence area in this study](image)

### 4.2 Case Study
In order to validate feasibility of proposed method in this study, case study is applied to a national road located on gyeonju-city, gyeongsangbuk-do in korea. The first step is to set up link of national road as selected link and selected link set up is described in Fig3. The basic year of network and OD is 2016 when the national road is expected to open.
The next step is to process traffic assignment using select link analysis and estimate trip interchange using the national road. After cumulating traffic volume from OD pair, influence area is established as the set of zones having 70 percentile cumulative trips out of OD pairs.

Table 1 The result of Select link analysis

<table>
<thead>
<tr>
<th>Origin</th>
<th>Destination</th>
<th>Trip Rate(pcu/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>70</td>
<td>0.49</td>
</tr>
<tr>
<td>1</td>
<td>72</td>
<td>0.43</td>
</tr>
<tr>
<td>1</td>
<td>73</td>
<td>0.71</td>
</tr>
<tr>
<td>2</td>
<td>70</td>
<td>0.49</td>
</tr>
<tr>
<td>2</td>
<td>72</td>
<td>0.50</td>
</tr>
<tr>
<td>2</td>
<td>73</td>
<td>0.81</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>203</td>
<td>911.90</td>
</tr>
<tr>
<td>71</td>
<td>205</td>
<td>196.90</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>249</td>
<td>70</td>
<td>1.53</td>
</tr>
<tr>
<td>249</td>
<td>72</td>
<td>3.53</td>
</tr>
<tr>
<td>249</td>
<td>73</td>
<td>6.43</td>
</tr>
</tbody>
</table>
Table 2 The OD pairs which cumulative rate of inter-zonal trip rate is up to 70%

<table>
<thead>
<tr>
<th>Origin</th>
<th>Destination</th>
<th>Trip Rate (pcu/day)</th>
<th>Rate (%)</th>
<th>Cumulative Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>203</td>
<td>71</td>
<td>1,408</td>
<td>7.1%</td>
<td>7.1%</td>
</tr>
<tr>
<td>203</td>
<td>73</td>
<td>1,174</td>
<td>5.9%</td>
<td>12.9%</td>
</tr>
<tr>
<td>205</td>
<td>73</td>
<td>997</td>
<td>5.0%</td>
<td>17.9%</td>
</tr>
<tr>
<td>71</td>
<td>203</td>
<td>912</td>
<td>4.6%</td>
<td>22.5%</td>
</tr>
<tr>
<td>72</td>
<td>203</td>
<td>725</td>
<td>3.6%</td>
<td>26.1%</td>
</tr>
<tr>
<td>73</td>
<td>203</td>
<td>693</td>
<td>3.5%</td>
<td>29.6%</td>
</tr>
<tr>
<td>203</td>
<td>72</td>
<td>598</td>
<td>3.0%</td>
<td>32.6%</td>
</tr>
<tr>
<td>205</td>
<td>71</td>
<td>560</td>
<td>2.8%</td>
<td>35.4%</td>
</tr>
<tr>
<td>73</td>
<td>205</td>
<td>554</td>
<td>2.8%</td>
<td>38.2%</td>
</tr>
<tr>
<td>72</td>
<td>205</td>
<td>541</td>
<td>2.7%</td>
<td>40.9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>203</td>
<td>108</td>
<td>0.5%</td>
<td>68.6%</td>
</tr>
<tr>
<td>213</td>
<td>73</td>
<td>105</td>
<td>0.5%</td>
<td>69.1%</td>
</tr>
<tr>
<td>72</td>
<td>43</td>
<td>93</td>
<td>0.5%</td>
<td>69.6%</td>
</tr>
<tr>
<td>48</td>
<td>73</td>
<td>90</td>
<td>0.4%</td>
<td>70.0%</td>
</tr>
<tr>
<td>204</td>
<td>72</td>
<td>88</td>
<td>0.4%</td>
<td>70.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In this case study, it is estimated that there are 27 zones having more 70 percentile cumulative trips out of OD pairs and all of those set of zones are located on gyeongsang-do, southeast province in Korea.

Table 3 Established influence Area

<table>
<thead>
<tr>
<th>Region</th>
<th>Zone Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pusan-city</td>
<td>26~41</td>
</tr>
<tr>
<td>Ulsan-city</td>
<td>70~74</td>
</tr>
<tr>
<td>Pohang-city and Gyeonju-city</td>
<td>203~205</td>
</tr>
<tr>
<td>Gyeongsang-do(province)</td>
<td>227, 233, 236</td>
</tr>
</tbody>
</table>
4.2 Validation of Standard Criteria

In this study, in order to validate standard criteria, 70 percentile cumulative trips out of OD pairs, as the index of variation of traffic pattern, variation of total travel time within OD is proposed. That is, among variations of total travel time for entire network before establishing influence area, alternatives are divided to three which is each 70%, 80%, 90% of cumulative traffic volume and influence area are established by each alternative. The reason which the lowest bound of accumulation traffic volume is 70% that trip is increased remarkably by 70% and stands firmly after that percentile. With this reason, validation test is achieved by every 10% from 70% to 90%.
Results of influence area for each alternative are described in figure 6 ~ figure 8.

As a result, after analyzing entire network without establishing influence area, variation of total travel time within OD was 33,005 minutes. After establishing influence area, each variation of total travel time was 30,582 minutes, 31,625 minutes, 32,352 minutes which means the alternative of 70% was about 93% matched with variance of total travel time when not estimating influence. That is, the alternative establishing influence area as the set of zones having 70 percentile cumulative trips out of OD pairs could reflect most of variance of traffic pattern by existence and nonexistence of road. Although alternatives of 80% and 90% reflected variance more, it could cause lots of simulation errors because an influence area is established extensively. With this reason, it is judged that the alternative of 70% is most efficient among all alternatives.

5. CONCLUSION

Establishing influence area in traffic demand analysis is to find the spatial range that the change of traffic flow pattern is remarkable by road project. That is, it could be examined whether a variance of traffic pattern is caused by road project or not. Therefore estimating influence area has great effects on the benefit estimation when analyzing traffic demand analysis. In many countries, A number of methods have been put forward over the years to estimate influence area. In Korea, Korea development Institute (2004) proposed methods of estimating influence and representative method is the one using traffic variance volume. However these methods have limits which could be different by judgment and ability of analyst because it is achieved by trial and error which adjusts size of influence area when processing traffic assignment using computer software emme/2 and also standard of estimating influence area could be changed depends on traffic volume.

In this research, a new method is proposed of establishing influence area using select link analysis which has not been considered before. And in order to validate feasibility of proposed method in this study, case study is applied to a national road located on gyeongju-city, gyeongsangbuk-do in Korea. As a result, the alternative which estimating an influence area by 70% of cumulated traffic volume is most efficient among all alternatives.
This study proposed a new method which make up for limits of existing method and this new method is expected to apply to initial step in traffic demand analysis to estimate an influence area as relatively simple procedure. Also it has significant meaning which minimizes possibility of occurring errors by judgment and ability of analyst. In the future, it is necessary to make up standard criterion of establishing influence area for road rank and validate standard criterion.

ACKNOWLEDGEMENTS

This research is funded by Engineering Research Institute and BK21 Safe and Sustainable Infrastructure Research Group in Seoul National University.

REFERENCES

Federal Highway Administration (1999) Guidebook on Statewide Travel Forecasting. 