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The Development of The Combined Model (Trip Distribution-Mode Choice-Route Choice) Based On Traffic Volumes

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Abstract

Research development about combination modeling has the important role in transport modeling for use in effective and efficient transport system planning. The previous research still in a burden condition of "All or Nothing" which was assumption that driver who select a route try to minimize its expense, not depend on traffic flow level, so all driver will select the same route. This method is not realistic for some congested road network in urban area cause it never consider to the traffic jam effect and various perception in considering of route selection. Referring to the previous research, the main objective of this research is the development of a combined trip distribution-mode choice-route choice model estimated from traffic count. Three of the stages of this process (four steps model), trip distribution, modal split and traffic assignment, combine to estimate expected 0-D demands, and as such, are of relevance to this research. Iterative solution algorithms, that are modifications of the Newton Raphson and Elimination Gauss-Jourdan techniques, are proposed to solve each of the model formulations. The methods proposed in this research are based on the least-squares (LS) estimation technique. It is found that by having the information of passenger flows using bus, we can obtain the 0-D matrices for private and bus. Even so, more detailed model testing and implementation studies remain to be accomplished before this model can be regarded as ready for use in practice.

Keywords: BPR formula, combined model, least-squares, newton-raphson, traffic count.

1. Introduction

As usual, the traffic (passenger) counts are expressed as a function of the TDMC model.In this case, the TDMC model is represented by a function of a model form and relevant parameters. The parameters of the postulated model are then estimated, so that the errors between the estimated and observed traffic (passenger) counts are minimized.

The standard approach of transport demand modelling is well known as the sequential model consisting of trip generation, trip distribution, modal split and trip assignment. The models are analyzed sequentially.

Research development about combination modeling has the important role in transport modeling for use in effective and efficient transport system planning. Route Choice is a major element which has to be considered carefully by travelers as an attempt to minimize their travel time. The main objective of the route choice model is to predict the correct throughput of traffic on each road (flow distribution). The previous research still in a burden condition “All or Nothing" which was assumption that driver who select a route try to minimize its expense, not depend on traffic flow level, so all driver will select the same route. This method is not realistic for some congested road network in urban area because it never consider to the traffic jam effect and various perception in considering of route selection.

Referring to the previous research, the main objective of the research development is developed combined trip distribution-mode choice-route choice model estimated from traffic count.

2. Model Formulation

2.1. Proportion of Trip Interchanges on a Particular Link

One can interpret link flows (or traffic counts) as resulting from a combination of two elements: an 0-D matrix and the route choice pattern selected by drivers on the network. These two elements may be linearly related to traffic counts, see equation (1), the total volume of flow in that particular link l (V_l) can be expressed as follows:

$$V_l = \sum_i \sum_d T_{id} \cdot p^l_{id} \qquad (1)$$

In this research, the value of p^l_{id} obtained is between 0-1 .

2.2. Trip Distribution-Mode Choice Model

Suppose now there are M modes travelling between zones, the modified Gravity Model (Doubly-Constrained Gravity Model) can then be expressed as:

$$T_{id} = \sum_m \left(O_i^m . D_d^m . A_i^m . B_d^m . f_{id}^m\right) \qquad (2)$$

where: A_i^m and B_d^m = the balancing factors expressed as:

$$A_i^m = \left[\sum_d \left(B_d^m . D_d^m . f_{id}^m\right)\right]^{-1} \text{ and } B_d^m = \left[\sum_i \left(A_i^m . O_i^m . f_{id}^m\right)\right]^{-1} \qquad (3)$$

This process is repeated until the values of A_i^m and B_d^m is converge to certain unique values.

2.3. Multi Nomial-Logit model (MNL) as a Mode Choice Model

The most general and simplest mode choice model (Multi-Nomial Logit Model) was in this study. It can be expressed as:

$$T_{id}^k = T_{id} \cdot \frac{\exp\left(-\gamma_k . C_{id}^k\right)}{\sum_m \exp\left(-\gamma_m . C_{id}^m\right)} \qquad (4)$$

By substituting equations (2)-(5) to equation (1), then 'the fundamental equation' for the estimation of a combined transport demand model from traffic counts is:

$$V_l^k = \sum_d \sum_i \left[O_i^k . D_d^k . A_i^k . B_d^k . f_{id}^k . p_{id}^{lk} \frac{\exp(-\gamma_k . C_{id}^k)}{\sum_m \exp(-\gamma_m . C_{id}^m)} \right] \quad (5)$$

2.4. Estimation Method

The main idea of this method is to estimate the unknown parameter which is minimizing the sum of' the squared differences between the estimated and observed traffic counts. The problem now is:

$$\text{to minimize} \quad S = \sum_l \left[V_l^{+k} - V_l^k \right]^2 \quad (6)$$

V^k_l = observed traffic flows for mode k V^{+k}_l = estimated traffic flows for mode k

Having substituted (5) to (6), the following set of equation is required in order to find a set of unknown parameter beta and gamma which minimize equation (7) and (8):

$$\frac{\delta S}{\delta \beta} = \sum_l \left[\left(2 \sum_i \sum_d T_{id}^k . p_{id}^{lk} - V_l^k \right) \left(\frac{\sum_i \sum_d \delta T_{id}^k}{\delta \beta . p_{id}^{lk}} \right) \right] = 0 \quad (7)$$

$$\frac{\partial S}{\partial \gamma} = \sum_l \sum_k \left[\frac{2}{\dot{V}_l^k} \left(\sum_i \sum_d T_{id}^k p_{id}^{lk} - \hat{V}_l^k \right) \left(\sum_i \sum_d \frac{\partial T_{id}^k}{\partial \gamma} p_{id}^{lk} \right) \right] = 0 \quad (8)$$

3. Methods

Newton-Raphson method is an efficient algorithm for finding approximations to the zeros (or roots) of a real-valued function. As such, it is an example of a root-finding algorithm.

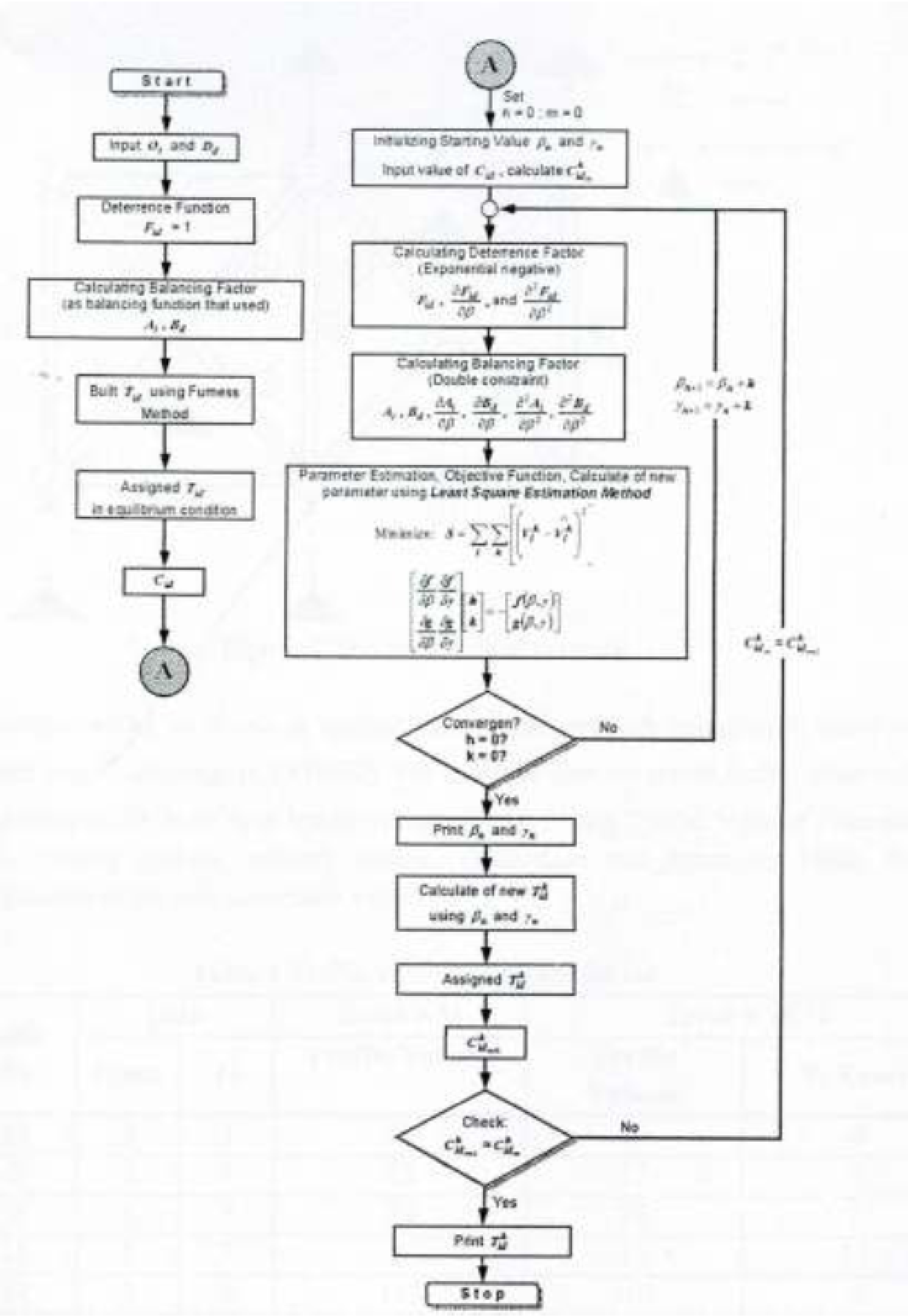

Figure 1 Newton-raphson's combine with the gauss-jourdan

4. Application in Artificial Network

Model has been tested in artificial network consisting of four zones and 42 links esenting the road network. The data as input for estimation process are: O_i, D_d, and Network system.

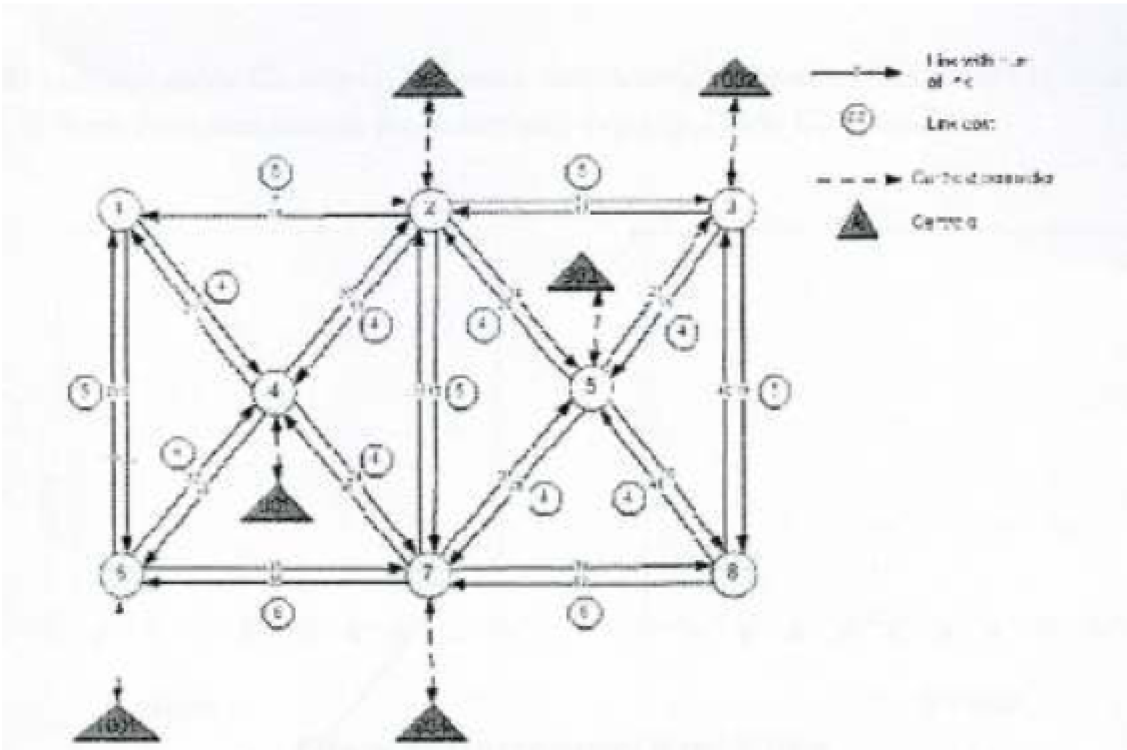

Figure 2 The hypothetical network

The mathematic model as above is applied in artificial network using write some coding program with macro language in EMME/3. For artificial data we create traffic observed $(\hat{V}_l)$ with giving error factor± 10 % in traffic volume above. Using Traffic Volume observed and others data (zoning system, network system, Generation and Attraction Data) we run estimation process to get new parameter value.

Table 1 Traffic volume observed for car

No	Link No	Link		Error 0 %	Error ± 10 %	
		From	To	Traffic Volume	Traffic Volume	% Error
1	13	2	3	53	50	-6
2	2	2	4	72	77	7
3	9	2	5	70	75	7
4	11	2	7	9	10	11
5	14	3	2	110	103	-6
6	20	3	5	325	318	-2
7	1	4	2	3	3	0
8	5	4	6	4	4	0
9	3	4	7	19	18	-5
10	10	5	2	184	202	10
11	19	5	3	220	239	9
12	17	5	7	38	40	5
13	6	6	4	7	7	0
14	24	6	7	242	244	1
15	12	7	2	12	11	-8
16	4	7	4	19	17	-11
17	18	7	5	31	28	-10
18	23	7	6	262	260	-1

We built matrices using Gravity (GR) model with double constraint. This matrix is used to get Traffic Volume from assignment procedure and to get (p_{id}^{l}) and C_{id} value.

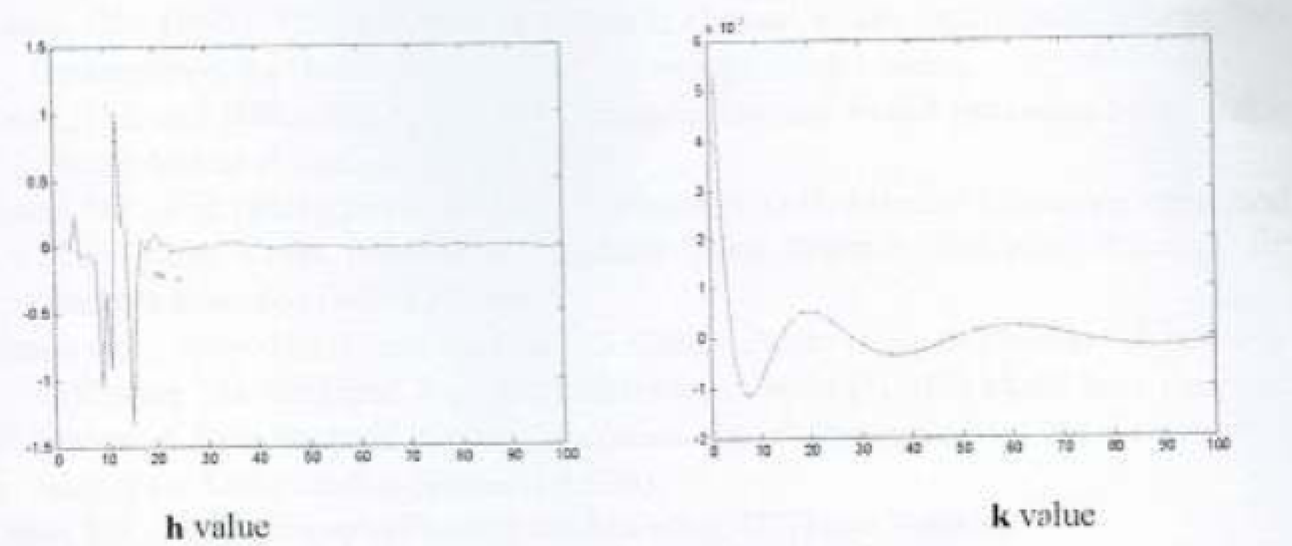

Figure 3 Convergence of h and k value

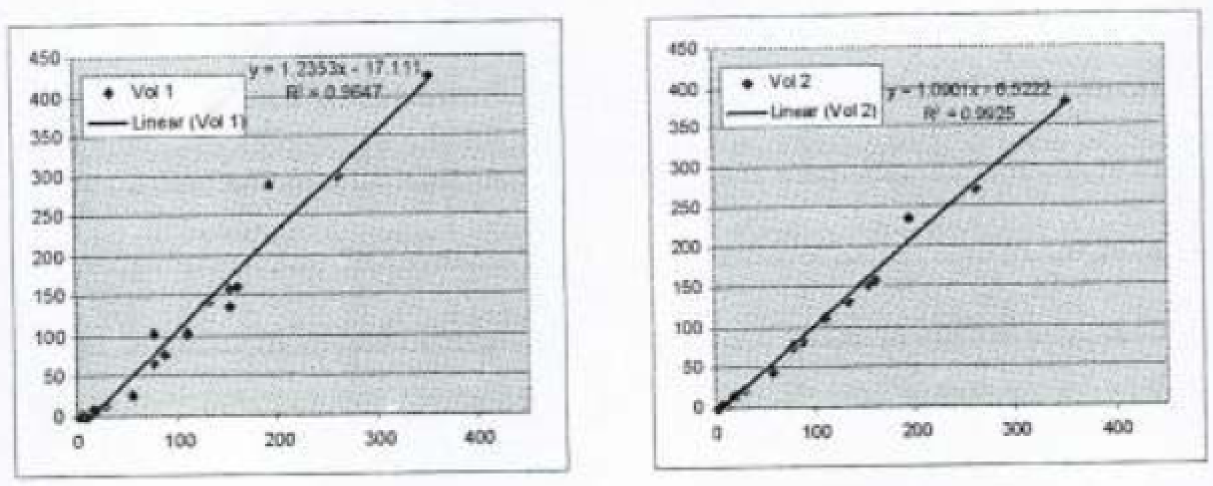

Figure 4 Statistical value of traffic volume observed Vs model

The figure that above is show that the squared deviations between the observed and estimated link flows as the error function that is to be minimized.

5. Conclusion

5.1 The output program from experiment results and it analysis it can be resumed as the mathematical formula of TDMC Model Development can be applied in artificial network.

5.2 The number of observed passenger counts required are at least as many as the number of parameters. The more link flows you have, the faster the estimation method will converge and also the more accurate the estimated 0-D matrix we have.

5.3 It is found that by having the information of passenger flows using transit, we can obtainthe 0-D matrices for private and transit.

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