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The Application of the Combined Model of Gravity-Multinomial Logit and the Assignment of Equilibrium Trip in Simple Network

Rahayu Sulistyorini[1)] *and Ofyar Z. Tamin*[2)]

ABSTRACT

Transportation problems generally require Origin-Destination Matrix (ODM) as their main input that represents travel pattern on a planning area. One method used to obtain the ODM is the ODM estimation method based on traffic data that belong to the category of sufficiently effective and economic, unconventional method. Model developed in this research combine the stages of movement distribution, the assignment of modes and trips, so that this model would be able to simultaneously estimate the ODM for different transportation modes. Some previous researches still advocate "All of Nothing" mode that was unrealistic for some road networks in urban areas for their ignorance of the effects of congestion and perceptional diversities in considering trips options. This research adopts gravity movement dispersion model, multinomial logit mode assignments model and balanced route assignment model. The estimation model developed to calibrate these models using traffic data are as follows: least square (LS). The developed model would be subsequently tested using simple dummy data. Results suggest that the model was successfully run through C++ Language program. It is expected that the application on the real road networks un Bandung City will use EMME/2 software.

Keywords: Combination model of movement dispersion and Mode Selection, Equilibrium Assignment, Gravity, Multinomial Logit, nonlinear least square

I. INTRODUCTION

The majority of techniques and methods to solve transportation problems require ODM information as base line information to plot transportation needs levels (Tamin, 2000), that could be obtained through conventional method and unconventional method. The main constraint in using conventional method is that it is lengthy and requires significant costs with high error and disturbance rates on the part of the traveling actors. To cope this constrain, we need inexpensive method in terms of data and time so that "unconventional methods" were formulated. This method is inexpensive in term that it only requires traffic flow data.

The Four-Stage Transportation Planning model is gradual processes from several separated and sequential sub-models. This model could be simplified to meet transportation planning needs in areas with limited times and financial resources. Currently, combined models are increasingly developed. These combined model are essentially the aggregate sum of some stages of the sub-models, either partially or simultaneously. Some previous researches are still in an "All of Nothing" state that was unrealistic for some road networks in urban areas for their ignorance of the effects of congestion and perceptional diversities in considering routes options. Model developed in this research combine the stage of movement dispersion, modes assignment and route assignments. Movement dispersion model adopted is the gravity model; whereas the mode assignment model adopted is the multinomial logit (ML) model, and the route assignment model adopted is equilibrium route assignment model.

Cascetta and Russo (1997) classified Origin-Destination Matrix (ODM) into 2 (two) categories, i.e., the estimation resulting in Direct Origin-Destination Matrix and the estimation of parameters of transportation need model. In estimating the parameters of transportation need model, in addition to the ODM, other resulted output is parameters of transportation needs model (α and β).

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II. PREVIOUS RESEARCH ON THE ESTIMATION OF TRAFFIC CURRENT BASED ODM

Some previous researches investigated the degree of accuracy of the ODM based on unconventional method (see **Figure 1**).

According to Yang et. all. (1992), the estimation of the ODM based on the information of traffic current has been performed by many researchers. The methods adopted are as follows: Maximum-Entropy (Van Zuylen and Willumsen, 1980), 1980), Maximum-Similarity (Spiess, 1987), General-Least-Square (Cascett, 1984) and Bayesian Inferential Estimation(Maher, 1983, in Tamin, 2000). In general, these models are aimed at minimizing the differences between the traffic currents and the ODM in terms of observational results and the estimation outputs. In this case, the trip assignment mode is used as a function linking the estimation output's traffic currents and the estimation output's ODM.

Van Zuylen and Willumsen (1981) generated the ODM estimation model of traffic current through the use of the Maximum-Entropy approach. Cascetta (1984) developed the General-Least-Square (GLS) estimation model aimed at estimating the ODM by using the combination of the model estimation and traffic flow data. In the meanwhile, Maher (1983) cited by Tamin (2000) as having developed the ODM estimation method of traffic flow through Bayesian statistical approach.

Tamin (1988) conducted studies to estimate the parameters of transportation needs model using information of traffic flow. Under his study, the p_{id}^{l} value for each l columns is assumed to be constant and independent of the changes on the estimated ODM. The trip assignment methods adopted is all-or-nothing (see **Figure 2**).

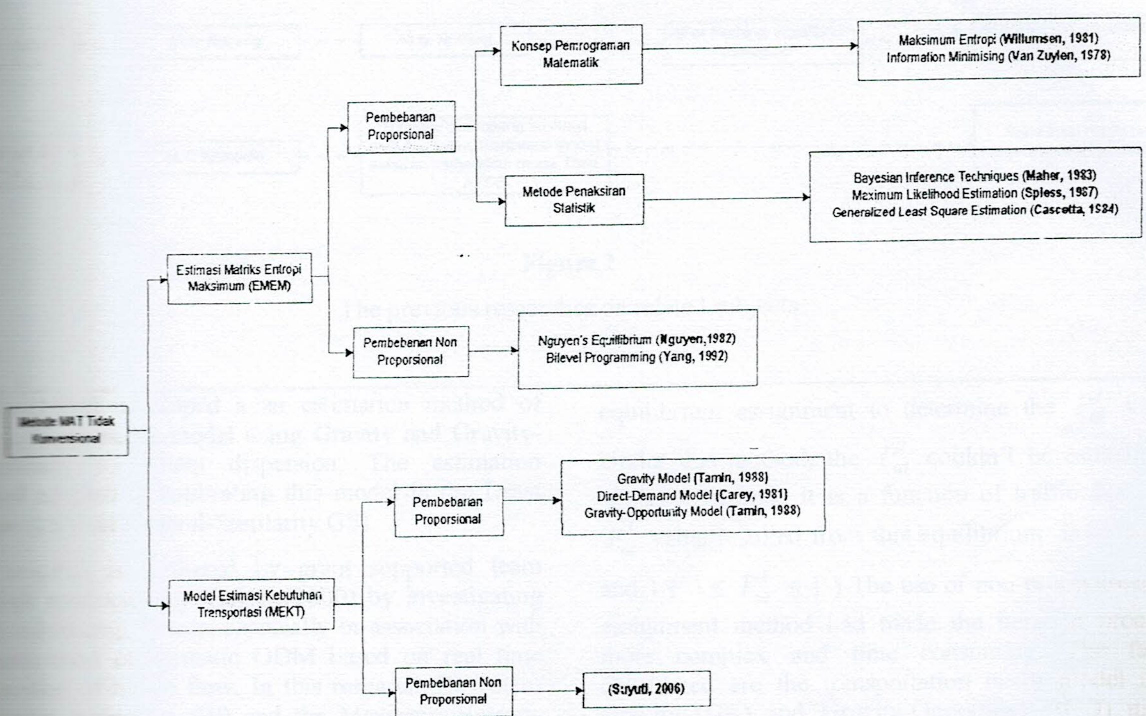


Figure 1

Transportation model based on Traffic Floe Data
(Source: Suyuti, 2006, adapted from Tamin, et al., 2002)

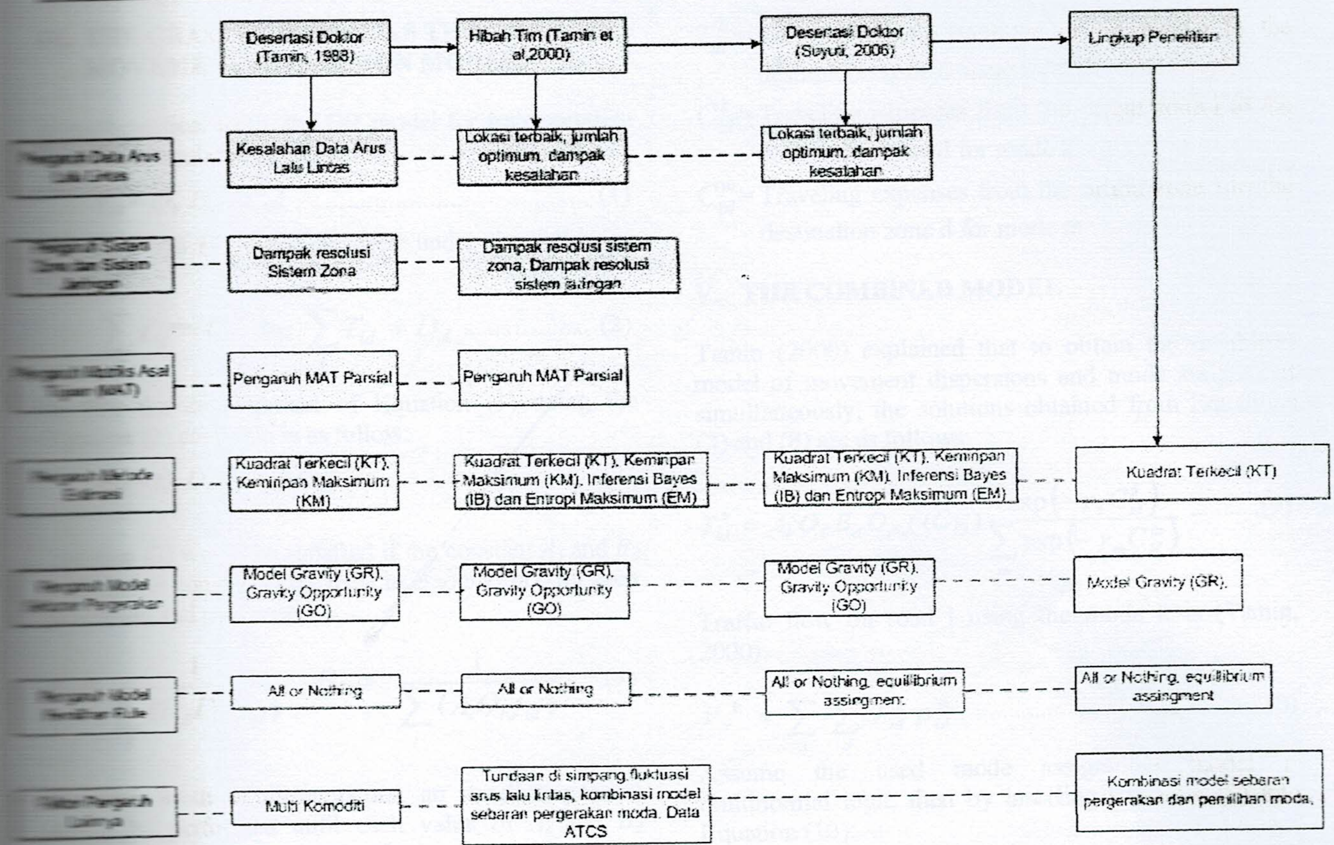


Figure 2

The previous researches on related subjects

Tamin (1988) developed a an estimation method of transportation needs model using Gravity and Gravity-Opportunity movement dispersion, The estimation method adopted in calibrating this model is the Least Square (LS) and General-Similarity GS).

The research is furthered by grant supported team research conducted by Tamin (2000) by investigating other influencing factors, especially in association with the estimation of dynamic ODM based on real time information of traffic flow, In this research, Bayesian-Inferential estimation (BI) and the Maximum-Entropy are introduced. In addition, other factors addressed are: the best location if traffic flow data, the impact of delay on the junctions, the impacts of traffic flow fluctuations and the combination of the models of mode assignment movement dispersion.

Based on these conditions, Suyuti (2006) developed the non-proportional trip assignment technique such as equilibrium assignment to determine the P_{id}^{l} values. Under this method, the P_{id}^{l} couldn't be estimated in advance, because it is a function of traffic flow. The P_{id}^{l} value resulted from this equilibrium is between 0 and 1 ($0 \leq P_{id}^{l} \leq 1$) The use of non-proportional trip assignment method had made the iteration processes more complex and time consuming. The factors considered are the transportation needs model under Gravity (GR) and Gravity-Opportunity (GO) model, with least-square (LS), maximum-similarity (MS), Bayesian Inferential (BI) and the Maximum Entropy (ME) estimation methods. The trip assignment methods adopted are all-or-nothing and equilibrium assignment and the impacts of traffic flow data (location, the size of data and the error level of traffic flow data).

III. THE GRAVITY MODEL AS THE MOVEMENT DISPERSION MODEL

In mathematical form, the GR model for transportation could be formulated as:

$$T_{id} = O_i . D_d . f(C_{id}) \quad \text{.. (1)}$$

The Equation (1) could be used under the following constrains:

$$\sum_d T_{id} = O_i \quad \text{dan} \quad \sum_i T_{id} = D_d \quad \text{.................. (2)}$$

So that the development of Equation (1) using the Equation (2) constrain is as follow:

$$T_{id} = O_i D_d A_i B_d f(C_{id}) \quad \text{.................................... (3)}$$

Equation (3) would be satisfied if the constant A_i and B_d (or balancer constants) are used in association with each generation and pull zone.

$$A_i = \frac{1}{\sum_d (B_d D_d f_{id})} \qquad B_d = \frac{1}{\sum_i (A_i O_i f_{id})} \quad \text{... (4)}$$

To obtain both of these values, an iteration process should be performed until each value of A_i and B_d generate certain (convergent) value.

Hyman (1969) in Tamin (2000) said that there are three types of additional functions that we could use in the Gravity Model, namely:

- quadratic function: $f(C_{id}) = C_{id}^{-\alpha}$ .... (5)
- exponential function: $f(C_{id}) = e^{-\beta C_{id}}$ .... (6)
- Tanner Function: $f(C_{id}) = C_{id}^{\alpha} . e^{-\beta C_{id}}$ .... (7)

IV. THE MODEL OF MULTINOMIAL LIOGIT AS MODE ASSIGNMENT MODEL

The mode assignment model is aimed at knowing the proportion of peoples who will use each mode. We could formulate the multinomial logit as follow:

$$T_{id}^k = T_{id} \frac{\exp(-\beta C_{id}^k)}{\sum_m \exp(-\beta C_{id}^m)} \quad \text{................................... (9)}$$

T_{id} = the total movements from the origin zone i to the destination zone d.

T_{id}^k = total movement from the origin zone i to the destination zone d using mode k

C_{id}^k = Traveling expenses from the origin zone i to the destination zone d for mode k

C_{id}^m = Traveling expenses from the origin zone i to the destination zone d for mode m

V. THE COMBINED MODEL

Tamin (2000) explained that to obtain the combined model of movement dispersions and mode assignment simultaneously, the solutions obtained from Equations (3) and (8) are as follows:

$$T_{id}^k = A_i O_i B_d D_d f(C_{id}) \frac{\exp(-\gamma_k C_{id}^k)}{\sum_m \exp(-\gamma_m C_{id}^m)} \quad \text{..........(9)}$$

Traffic flow on road l using the mode k is (Tamin, 2000):

$$V_l^k = \sum_i \sum_d T_{id}^k p_{id}^{lk} \quad \text{.......................................(10)}$$

Assume the used mode assignment model is multinomial logit, then by inserting Equation (8) Into Equation (10):

$$V_l^k = \sum_i \sum_d T_{id} \frac{\exp(-\gamma_k C_{id}^k)}{\sum_m \exp(-\gamma_m C_{id}^m)} p_{id}^{lk} \quad \text{..............(11)}$$

Assume that inter-zone movements could be represented by a single model of transportation needs (e.g., gravity) then we would obtain the estimation basic equation of the combined transportation model using traffic flow data as follows:

$$V_l^k = \sum_i \sum_d (O_i A_i B_d D_d f(C_{id})) \frac{\exp(-\gamma_k C_{id}^k)}{\sum_m \exp(-\gamma_m C_{id}^m)} p_{id}^{lk} \cdots (12)$$

Equation (12) is an equation system with L simultaneous equations having unknown β and γ_m parameters. To estimate the values of these parameters, certain estimation method is needed.

VI. THE METHOD OF NEWTON-RAPHSON CALIBRATION AND GAUSS JOURDAN ELIMINATION METHOD

Systematically, the calibration process is illustrated in **Figure 3**.

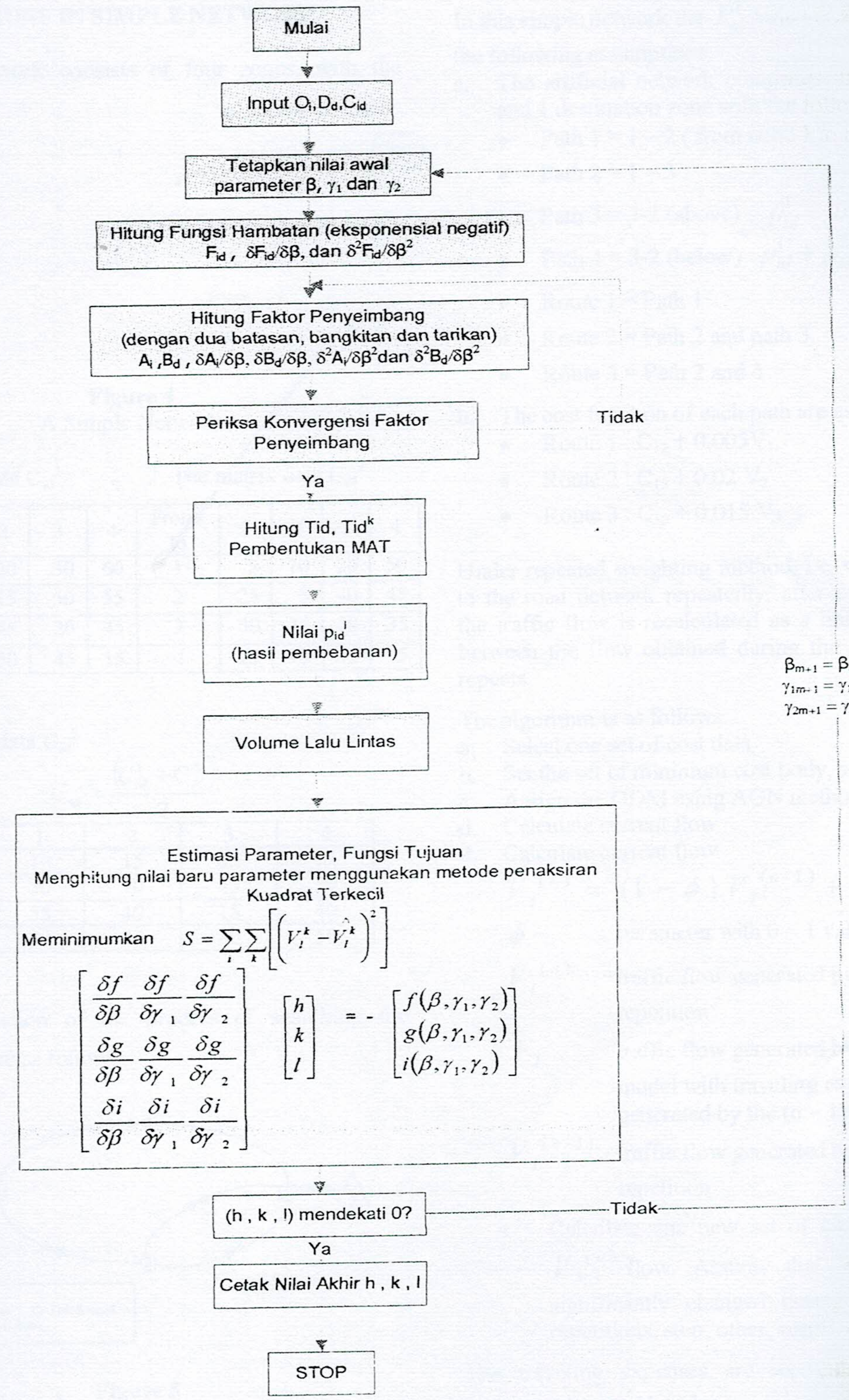


Figure 3

Flow Chart of calibration process for three unknown parameters

VII. TRIAL RUNS IN SIMPLE NETWORK

A simple network consists of four zones, with the following data:

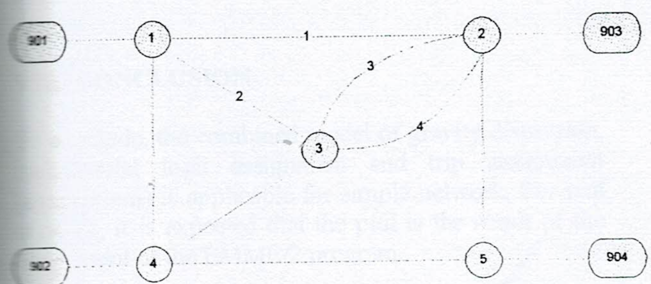


Figure 4
A Simple Network

1. The matrix data C_{id}^1

From/ to	1	2	3	4
1	15	20	30	60
2	35	15	50	55
3	60	45	20	45
4	35	50	45	15

2. The matrix data C_{id}^2

From/ to	1	2	3	4
1	5	10	20	50
2	25	5	40	45
3	50	35	10	35
4	25	40	35	5

3. The matrix data C_{id}^3

$$C_{id} = \frac{\left(C_{id}^1 + C_{id}^2\right)}{2}$$

From/to	1	2	3	4
1	10	15	25	55
2	30	10	45	50
3	55	40	15	40
4	30	45	40	10

The simplification of the process of searching the values p_{id}^l are as follows:

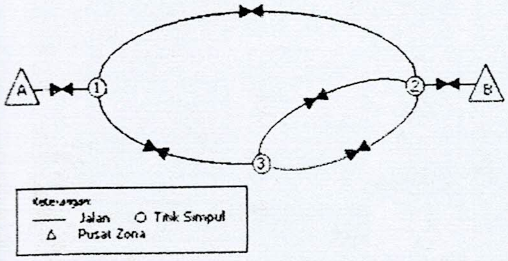


Figure 5
The simplification of Network to obtain P_{id}^l values

In this simple network the P_{id}^l value is searched under the following assumptions:

a. The artificial network comprises of 1 origin zone and 1 destination zone with the following paths:
   - Path 1 = 1 – 2 (from node 1 to node 2)
   - Path 2 = 1 – 3
   - Path 3 = 3-2 (above) $p_{id}^1 + p_{id}^2 = 1$
   - Path 4 = 3-2 (below) $p_{id}^1 + p_{id}^3 + p_{id}^4 = 1$
   - Route 1 = Path 1
   - Route 2 = Path 2 and path 3
   - Route 3 = Path 2 and 4

b. The cost function of each path are as follows:
   - Route 1 : $C_{12} + 0{,}005V_1$
   - Route 2 : $C_{12} + 0{,}02\ V_2$
   - Route 3 : $C_{12} + 0{,}015\ V_3$

Under repeated weighting method, i.e, weighting ODM to the road network repeatedly, after each assignment, the traffic flow is recalculated as a linear combination between the flow obtained during the nth and (n-1)th repeats.

The algorithm is as follows:

a. Select one set of cost data
b. Set the set of minimum cost body, set n = n + 1
c. Assign the ODM using AON method to generate F_l
d. Calculate current flow
d. Calculate current flow

$$V_l^{(n)} = (1-\phi).V_l^{(n-1)} + \phi.F_l$$

ϕ : parameter with 0 – 1 value

$V_l^{(n)}$: traffic flow generated by the n[th] repetition

F_l : traffic flow generated by the AON model with traveling expenses generated by the (n – 1) repetition

$V_l^{(n-1)}$: traffic flow generated by the (n – 1)[th] repetition

e. Calculate one new set of cost, based on the $V_l^{(n)}$ flow. Assume that this flow is not significantly changed during two sequential repetitions, stop; other, continue to stage (2)

The traveling expenses are recalculated after each combination of $V_l^{(n)}$ flow has been assigned. This process should be performed repeatedly until the convergence limit has been achieved.

The Φ value = the inverse of the repetition numbers = 1/n

VIII. CONCLUSION

To conclude, the combined model of gravity dispersion, multinomial logit assignment and trip assignment (equilibrium) is applicable for simple network. For real network, it is expected that the pidl is the result of the assignment of the EMME/2 program.

REFERENCES

Purwanti, O., 2002, "Estimasi Model Kombinasi Sebaran Pergerakan dan Pemilihan Moda Berdasarkan Informasi Arus Lalulintas", *Tesis Magister*, Sekolah Pascasarjana Institut Teknologi Bandung

Suyuti, R. dan Tamin, O.Z., 2006, "Estimasi Parameter Model Kebutuhan Transportasi Berdasarkan Informasi Data Arus Lalu Lintas Pada Kondisi Pemilihan Rute Keseimbangan", *Disertasi*, Sekolah Pascasarjana, Institut Teknologi Bandung

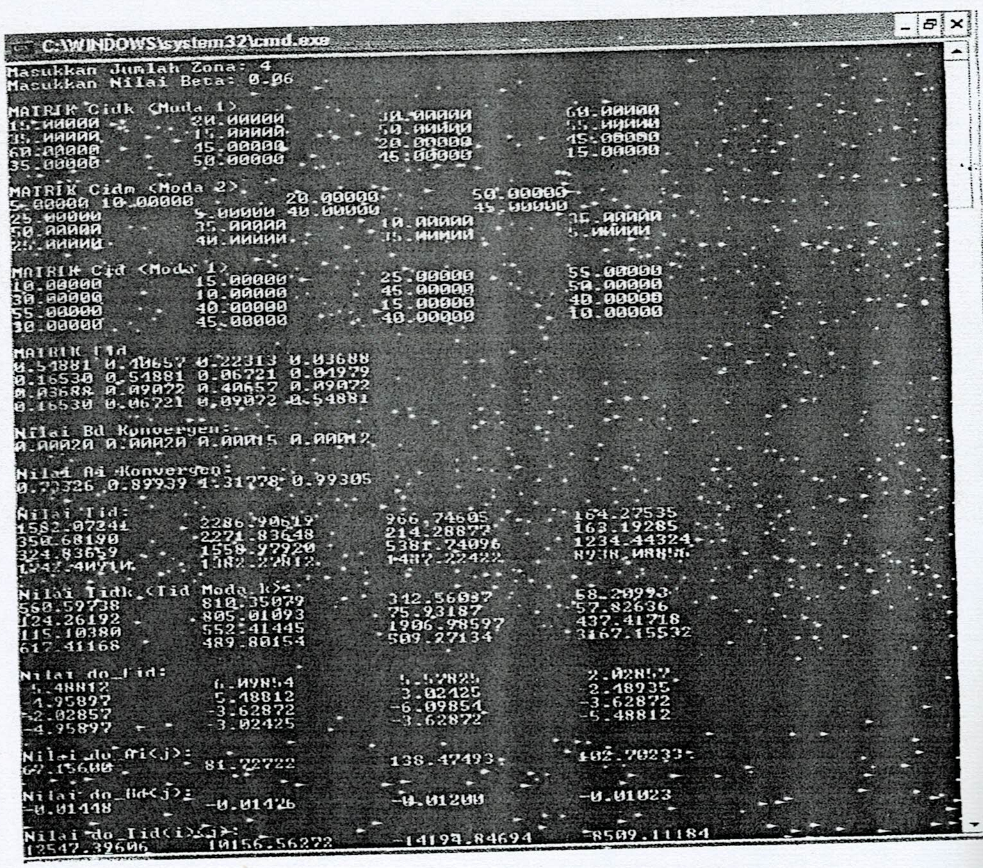
Tamin, O.Z., 1985, "The Estimation of Matrices for Freight Movement From Traffic Counts Using a Non-Linear Regression Approach", *Thesis*, University of London, Imperial College and University College London.

Tamin, O.Z., 1988, "The Estimation of Transport Demand Model From Traffic Counts", *Dissertation*, University of London, University College London.

Tamin, O.Z., 2000, *Perencanaan dan Pemodelan Transportasi, Edisi II*, Penerbit ITB, Bandung.

Tamin, O.Z., et al., 2001, *Dynamic Origin-Destination (O-D) Matrices Estimation From Real Time Traffic Count Information*, Graduate Team Research, University Research for Graduate Education (URGE) Project.

ATTACEHMENT



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Nilai do_Tid(i)(j):
12547.39606     10156.56272     -14194.84694    -8509.11184
-4483.37376     19822.82320     -7585.57306     -7753.87638
-7657.21105     -11009.99172    47431.39722     -28764.19445
-406.81126      -18969.39425    -25650.97727    45027.18277

Nilai do_Tidk(i)(j):
826.55833       -1633.16701     -7241.61711     -3390.98623
-2390.96014     1826.48855      -3178.15890     -3120.89672
-3456.45938     -7468.01986     4494.44131      -13016.62251
-4130.50842     -9884.11974     -12377.40454    -4493.83976

Nilai do_do_Ai(j):
16439.94037     111369.08216    156664.49943    134830.16451

Nilai do_do_Bd(j):
2.13278 2.12942 1.95125 1.80759

Nilai do_do_Tid(i)(j):
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36974122.44935  176317099.62314 616345906.86580 143439447.14966
227389594.79386 180347316.91534 189715139.39188 1188005571.26704

Nilai do do Tidk(i)(j):
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92338255.71888  87267713.81963  336982925.17437 108739728.99439
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Arus akhir pada rute 1: 502.41749

Arus akhir pada rute 2: 129.65613

Arus akhir pada rute 3: 162.07016

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Nilai f: -41030965620.56481

Nilai h: 0.00008
Nilai Beta baru adalah (Beta(n-1)+h): 0.06008
Press any key to continue
```