

Transport Modelling in OmniTRANS

Exercise book

Course and Contact Information

Course:

Exercise book: Transport Modelling in OmniTRANS

Course Description:

This exercise book has been developed to offer a structured set of resources to support the teaching of transport planning and modelling in academic courses. It is established by collaboration between Omnitrans International BV and Delft University of Technology. This document is provided together with the OmniTRANS template project *Omniville*.

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Preface

A transport model is a simplified description of the transport system. Although multiple classifications exist, this exercise book uses the term to express multiple facets of transport planning models. The transport model can have multiple objectives ranging from calculating the optimal signal settings for a signalised junction to the evaluation of several infrastructure schemes.

The main focus in this exercise book is on strategic transport modelling. This type of modelling investigates the interaction of supply (infrastructure) and demand (trips) for the mid and long term. Often this comprises future scenario evaluation, where the transport model is used to determine the 'best' option.

Structure of the book

The exercise book is divided in several sections, each with a specific focus. It is advised to work your way from begin to start, as later chapters expect to know things that are explained in earlier chapters.

Layout

Some gray boxes are used to point out some specific actions.
Exercises are marked by a heavy left border.

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2.6 Trip distribution

The second step of the 4-step transport model approach is the trip distribution.

2.6.1 The doubly-constraint gravity model

Given the trip productions, trip attractions, and the impedances/accessibilities between zones, we are able to estimate the trips between each origin and destination zone. The doubly constraint gravity model will be used to perform the trip distribution:

$$T_{ij} = a_i b_j P_i A_j f(c_{ij}) \quad (2.2)$$

where

- T_{ij} = number of trips from zone i to zone j ,
- a_i, b_j = scaling factors,
- P_i = production of zone i ,
- A_j = attraction of zone j ,
- $f(c_{ij})$ = accessibility from i to j and
- c_{ij} = travel impedance (e.g. distance, travel time) between zones i and j .

Estimation of a gravity model

The quality of the trip distribution depends on the used distribution function $f()$. Also, the travel impedances are of much importance to the quality of the resulting trip matrix. Usually household surveys and/or road-side interviews can be used to estimate both impedance- and distribution functions.

For example the impedance function could be a weighted summation of multiple impedance characteristics such as distance and travel time. The estimation process could determine the weighting factors for these attributes.

Distribution functions

The gravity model has close resemblance with Newton's gravitational law. The general assumption is that the probability that a certain destination is chosen decays with the travel impedance to that destination. The distribution function, sometimes referred to as deterrence function, describes the accessibility of a certain zone, which can be seen as related to the probability that a trip to a certain destination is made.

Multiple types of deterrence functions are known from the literature. Examples are the (top-)exponential function, (top-)lognormal function and discrete distribution functions.

Distribution functions in OmniTRANS

OmniTRANS has several trip distributions built-in:

- Log-Normal $f(c_{ij}) = \alpha \cdot e^{\beta \cdot \ln^2(c_{ij} + 1)}$
- Top-Log-Normal $f(c_{ij}) = \alpha \cdot e^{\beta \cdot \ln^2(c_{ij} / \gamma)}$
- Exponential $f(c_{ij}) = \alpha \cdot e^{-\beta \cdot c_{ij}}$

Furness/Fratar balancing technique

The balancing factors a_i and b_j in the doubly constraint gravity model are interdependent. This means that an iterative technique is required to derive them. To ensure this, a process of balancing is used which in the literature is known as Furness or Fratar. This technique repeatedly calculates and applies row- and column balancing factors until convergence is achieved.

The Furness balancing technique

The Furness balancing technique uses sequential balancing factors on rows and columns to determine contents of a matrix such that summation of row and column values matches constraints.

Example

Consider we have the following matrix

A =

| | | |
|---|---|---|
| 2 | 1 | 3 |
| 3 | 2 | 1 |
| 2 | 3 | 2 |

The objective row totals (given trip productions) are 11, 9, 11 and the objective column totals (given trip attractions) are 13, 9, 9.

We want to alter the matrix in such a way that the row- and column totals will match our objectives, but at the same we want to preserve the internal structure of the matrix.

Balancing row totals

The current row totals are 6, 6 and 7. For each row we can calculate a balance factor to multiply the whole row with. After altering the matrix we obtain A'.

Now the row totals will match the objectives, but the column totals will not. So now column balancing factors are determined and applied to obtain matrix A'' .

$$A' = \begin{bmatrix} 3.7 & 1.8 & 5.5 \\ 4.5 & 3.0 & 1.5 \\ 3.1 & 4.7 & 3.1 \end{bmatrix}$$

Now again the rows do not match. The process of calculating and applying row and column balancing factors can be repeated several times.

$$A'' = \begin{bmatrix} 3.7 & 1.8 & 5.5 \\ 4.5 & 3.0 & 1.5 \\ 3.1 & 4.7 & 3.1 \end{bmatrix}$$

After applying factors 6 times (3 times on rows, 3 times on columns), we obtain matrix A^* , which satisfies all constraints.

$$A^* = \begin{bmatrix} 4.3 & 1.7 & 5.0 \\ 5.0 & 2.8 & 1.3 \\ 3.7 & 4.5 & 2.8 \end{bmatrix}$$

2.6.2 Generating impedance matrices in OmniTRANS

In OmniTRANS, the travel impedances (C_{ij} in formula 2.2) are stored in skim matrices. These matrices can hold different kind of impedance data, such as distance-, travel time or generalised (congested) travel costs. To generate such matrices a job script has to be used that uses the built-in class OtTraffic. This tool will generate shortest paths for all zone-pairs and store the impedance of these paths into a skim matrix.

In one script three skim matrices can be generated simultaneously: for distance, travel time and generalised cost (a weighted combination of distance and time). More information and an example can be found in the OmniTRANS manual under The Job Engine → OmniTRANS Classes → Modelling Classes → OtTraffic → OtTraffic – Examples → Example 5.

Create distance and time skim with OtTraffic:

```
makeSkim = OtTraffic.new()
makeSkim.network = [Mode,Time]
makeSkim.skimMatrix = [Purpose,Mode,Time,User,[0, ResultDistance,ResultTime],
Iteration]
makeSkim.skimFactors = [0,1,0]
makeSkim.execute()
```

2.6.3 Applying the gravity model

Before the gravity model can be applied some input data has to be generated. First, the trip totals must have been calculated. Secondly, an impedance matrix must be present. Finally, the trip distribution function type and its parameters must have been determined.

| Trip distribution | |
|--------------------------|--|
| Input | <ol style="list-style-type: none"> 1) Total trip production and attraction 2) Distance (skim) matrix/matrices 3) Distribution function(s) specification |
| Processing | <p>Function is applied to skim matrix</p> <p>Matrix is balanced using Furness/Fratar process</p> |
| Output | Trip matrix/matrices |

Apply the distribution function

The gravity model is also available in OmniTRANS through a built-in tool, the OtGravity class (read chapter 1.4 for information about classes). Using a job script, the modeller can specify the properties such as dimensions of the skim matrix, the objective travel demand matrix, deterrence functions and balancing options. An example is provided below. For more information see the OmniTRANS manual: The Job Engine → OmniTRANS Classes → Modelling Classes → OtGravity.

Create distance and time skim with OtTraffic:

```
makeOd = OtGravity.new()
makeOd.odMatrix = [Purpose,Mode,Time,User]
makeOd.skimMatrix = [Purpose,Mode,Time,User,Result,Iteration]
makeOd.functionType = FunctionType
makeOd.functionSpec = FunctionSpec
makeOd.balance = PRODUCTIONS or ATTRACTIONS
makeOd.iterations = NumberOfBalances
makeOd.execute()
```

Exercise 2.5

In this exercise you will continue with your 'Omniville Car' project.

Experiment with techniques

1. Open the spreadsheet file '2_5_Furness.xls' from the 'External User Data' folder of your project. Follow the instructions in the spreadsheet to get familiar with the Furness balancing technique.
2. Open the spreadsheet file '2_5_Deterrence functions.xls' from the 'External User Data' folder of your project. Follow the instructions in the spreadsheet to discover some deterrence functions.

Create a distance skim

3. On the 'Jobs' tab in OmniTRANS, investigate the script 'Create distance skim' to see which parameters are used.
4. Define the parameters (parameter list or within the job).
5. Run the job.
6. Investigate the job output window. If necessary, make changes to your network and re-run the job until you are satisfied.

Apply a gravity model

7. Open the script 'Gravity model' and investigate which parameters are needed to run this job.
8. Define the parameters.
9. Run the job to generate an OD-matrix.
10. Check if the O-D matrix is generated. It should be in the matrixcube.

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