Veitch Lister Consulting Pty Ltd

Zenith Model Framework Papers - Version 3.0.1

Paper E - Destination Choice Model

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Draft Report

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Executive Summary

This Technical Note is one of a series of papers that collectively describe the Zenith Transport Model. Zenith is a four step transport model, implemented in the OmniTRANS software package for a range of Australian cities and regions.

This Technical Note details the Destination Choice Model implemented within Zenith. The Destination Choice Model forms an integral part of the overall Zenith Model as it directly determines the number of trips predicted to be made between different areas of the modelled region.

The Destination Choice Model works by predicting, for each trip, the probability that the trip maker will choose to travel to each possible location in the modelled region. In Zenith, destination choice is modelled using a multinomial logit model (equivalent to a Gravity Model), which takes account of:

- **The reason (purpose) for the trip**. For example, a trip made for shopping will likely have a different destination to a trip made for education,
- **The spatial distribution of businesses, shops, other services, housing, schools, universities, parks, etc.** Different trips will be attracted to different types of land uses. For example, shopping trips will generally be attracted to shopping centres, while education trips will be attracted to educational institutions,
- **The structure of the transport network, and the ease with which it facilitates travel to different locations.** Trip makers will generally choose destinations that are easily reached.
- **The cost of travel.** Travel costs such as petrol, tolls or public transport fares can affect the attractiveness of particular destinations.
- **Access to a car.** Inability to access a car can make certain locations less accessible.

The model parameters required by Zenith Destination Choice Models are typically estimated using the data contained in local household travel surveys.

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1 Introduction

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This Technical Note details the Destination Choice Model implemented within Zenith. The Destination Choice Model forms an integral part of the overall Zenith Model as it directly determines the number of trips predicted to be made between different areas of the modelled region.

This document focuses on the methodology of the Destination Choice Model, and does not include parameter estimates or model validation for specific regions. Information about parameter estimates and model validation can be found in the region specific technical notes relating to the Destination Choice Model.

For further information, please contact our research and development team at zenith@veitchlister.com.au.

2 Methodology

2.1 Background

One of the key decisions made by every trip maker is where to travel to. The choices made by trip makers may depend on a wide range of factors, some of which can be included in a strategic travel model such as Zenith, and some which cannot.

Factors which *have* been included in the Zenith Model are:

- **The reason (purpose) for the trip**. For example, a trip made for shopping will likely have a different destination to a trip made for education,
- **The spatial distribution of businesses, shops, other services, housing, schools, universities, parks, etc.** Different trips will be attracted to different types of land uses. For example, shopping trips will generally be attracted to shopping centres, while education trips will be attracted to educational institutions,
- **The structure of the transport network, and the ease with which it facilitates travel to different locations.** Trip makers will generally choose destinations that are easily reached.
- **The cost of travel.** Travel costs such as petrol, tolls or public transport fares can affect the attractiveness of particular destinations.
- **Access to a car.** Inability to access a car can make certain locations less accessible.

By taking these factors into consideration, the model is able to test the sensitivity of destination choices to changes in these factors, and to measure the resulting impact on network patronage and performance.

2.2 Model Form

The Zenith Destination Choice model employs a "*Gravity Model*". The "*Gravity Model*" owes its name to Newton's Law of Gravity, which states that the Gravitational force of attraction towards an object is proportional to that object's mass, and inversely proportional to the square of the distance to that object.

In other words, the pull of gravity is stronger towards larger (heavier) objects, and also stronger towards objects that are close.

This concept is easily translated to destination choice. For a given activity, such as shopping, one is more likely to travel to destinations which provide many opportunities to undertake that activity (large masses such as shopping centres), and one is more likely to travel to destinations which are close.

The mathematical form of the Zenith Gravity Model is:

$$P_d = \frac{F_d}{\sum_k F_k}$$

where P_d is the probability of choosing destination d and F_d is the "*force of attraction*" to destination d. The force of attraction, F_d, is given by:

$$F_d = \frac{A_d}{{C_{od}}^{\alpha}\ e^{\beta C_{od} + U_d}}$$

where $\boldsymbol{A_d}$ is the attractiveness of destination d, in terms of the opportunities provided to participate in a particular activity; $\boldsymbol{C_{od}}$ is the cost of travel from origin, o, to destination d, including travel time and other costs; $\boldsymbol{U_d}$ is a destination specific constant which increases or decreases the likelihood of travel to that destination, and α and β are calibration parameters which control the rate at which attraction decreases as the cost of travel C_{od} increases.

2.3 Segmentation

Separate destination choice models are estimated for each combination of trip purpose and household car ownership level. This means that there exists a unique set of model parameters (α, β and U_d) for each combination of trip purpose and household car ownership level.

The model is also separately applied for each combination of departure time and return time. For example, a trip from home to work in the AM peak followed by the return leg from work to home in the PM peak would have a departure / return time combination of (AM Peak, PM peak).

Destination choice is applied separately for each outward / return time period combination because travel costs vary by time of day (reflecting variations in traffic congestion, service frequency, overcrowding, etc.).

2.4 Model Estimation

The Zenith Destination Choice Model is typically estimated using local household travel surveys.

The estimation is performed by recognising that the gravity model can be equivalently expressed as a multinomial logit model, with alternatives given by the set of possible destinations.

Expressed as a logit model, the observed component of the utility for each destination is:

$$V_d = \beta C_{od} + U_d + \ln(A_d) \ + \ \alpha \ln(C_{od})$$

Expressed as a logit model, we can estimate the parameters α, β and U_d by using "*maximum likelihood*" optimisation.

The following sub-sections describe the construction of each variable which features in the utility function.

2.4.1 Travel Costs

Travel Costs for each origin / destination pair (C_{od}) are a key input to the Destination Choice Model. Separate travel costs are computed for each:

- Trip purpose
- Level of household car ownership
- Journey departure time
- Intended return time

Importantly, the travel cost is not separately defined per mode. Rather, the travel costs for the various modes are combined into a single measure of travel cost, which represents the expected perceived travel cost, assuming that each traveller chooses his or her preferred travel mode. The motivation for combining the by-mode travel costs is that (in Zenith) Destination Choice is undertaken before the choice of mode; hence, the choice of destination must be made based on the costs of all the available modes.

The combined cost of travel for all modes is calculated by determining the "*inclusive value*" of utility resulting from the nested logit model used in mode choice. The inclusive value is calculated using the well-known "*logsum*" calculation.

2.4.2 Trip Attractions

A key input to the Zenith Destination Choice model is the "*attractiveness*" of each destination (A_d).

The attractiveness of a destination depends on the purpose for which the trip is made; a university is not a very attractive destination for primary school or shopping trips. Because of this, a separate measure of the "*attractiveness*" of each destination is calculated for each trip purpose.

For each trip purpose, the attractiveness of a destination is modelled as a linear function of the set of modelled land use variables. The land use variables included in the model are:

- Number of households
- Number of full time equivalent *white collar* jobs
- Number of full time equivalent *blue collar* jobs
- Number of jobs by 13 ANZSIC categories

    - Agriculture
    - Manufacturing
    - Mining
    - Electricity, gas and water
    - Construction
    - Communications
    - Wholesaling
    - Retailing
    - Transport and storage
    - Finance & business
    - Public administration
    - Community services
    - Recreation and personal services
- Number of (equivalent full time) enrolments in:
    - Primary schools
    - Secondary schools
    - Tertiary institutions

2.4.3 Destination Specific Constants

Destination specific constants are parameters which increase or decrease the relative attractiveness of certain destinations. Destination specific constants are necessary in order to capture the atypical attractiveness of certain destinations for certain trip purposes.

Typically, only a few destination specific constants are included in the Zenith Model to represent:

- Destinations in the CBD
- Destinations in the CBD fringe
- Destinations in the CBD frame
- Destinations in the CBD outer frame

The above grouping of destinations is generally identical to the groupings used within the Mode Choice Model.