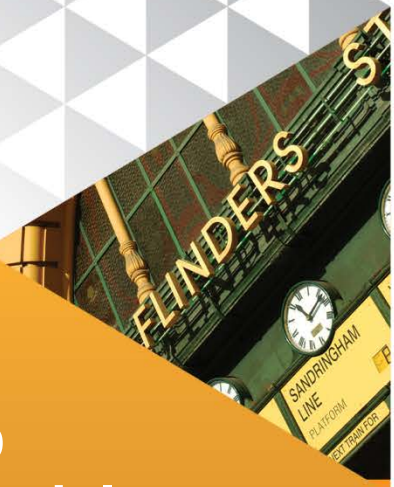
Veitch Lister Consulting Pty Ltd



Zenith Model Framework Papers – Version 3.0.1

Paper C - Trip Production Model

May 2014

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Paper C - Trip Production Model

Draft Report

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16/03/2014	A	TV	JC	TV	Draft Report
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Executive Summary

The Zenith Models are a family of four step transport models, developed by Veitch Lister Consulting (VLC) and implemented in the OmniTRANS software package for a range of Australian cities and regions. This document is one in a series of working papers that collectively describe the model structure and framework of the Zenith Model; in particular, this document describes the Trip Production Model.

The aim of the Trip Production Model is to estimate (for each travel zone) the number of trips that will be produced for a range of trip purposes. These purposes are:

1. Home Based
    a. Home Based Work – White Collar (HWW)
    b. Home Based Work – Blue Collar (HBW)
    c. Home Based Education – Primary (HPR)
    d. Home Based Education – Secondary (HSE)
    e. Home Based Education – Tertiary (HTE)
    f. Home Based Shopping (HBS)
    g. Home Based Recreation (HBR)
    h. Home Based Other (HBO)
2. Non-Home Based
    a. Work Based Work (WBW)
    b. Work Based Shopping (WBS)
    c. Work Based Other (WBO)
    d. Shopping Based Shopping (SBS)
    e. Shopping Based Other (SBO)
    f. Other Non-Home Based (OHNB)

Separate predictive models have been estimated and validated for each of the above trip purposes.

Each predictive model was developed using estimates of the number of trips productions derived from an expanded version of the *Victorian Integrated Survey of Travel and Activity* (VISTA).

The set of models derived for home based purposes is “household based” and has the following variables available for use as predictors:

- Household size;
- Number of white collar workers;
- Number of blue collar workers;
- Number of dependants aged 0-17;
- Number of dependants aged 18-64;
- Number of dependants aged 65+; and
- Number of cars owned.

The zonal variables that were available to predict the amount of non-home based trips produced by a region included:

- Total Employment

- Employment by occupation category (white / blue collar)
- Employment by industry
- Employment by industry x occupation category (white / blue collar)
- Number of households
- Number of educational enrolments (primary, secondary, tertiary)
- Visitor Accommodation and Recreation

The Trip Generation Model is one of the first stages in the model run process and its output feeds all subsequent stages of the model. This output is the estimated number of trips produced by, and attracted to, each travel zone within the modelled region, for each trip purpose. Therefore, the Trip Generation Model is very important as it is wholly responsible for the total amount of travel (i.e. number of trips) predicted to occur throughout the entire model.

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1 Introduction

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 Trip Generation Model implemented within Zenith. The Trip Generation Model forms an integral part of the overall Zenith Model as it directly determines the number of trips produced by each travel zone in the modelled region.

This document focuses on the methodology of the Trip Generation 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 Trip Generation Model.

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

2 The Trip Generation Model

2.1 Background

Trip Generation is the second step in the Zenith model run process, as illustrated in Figure 1 below

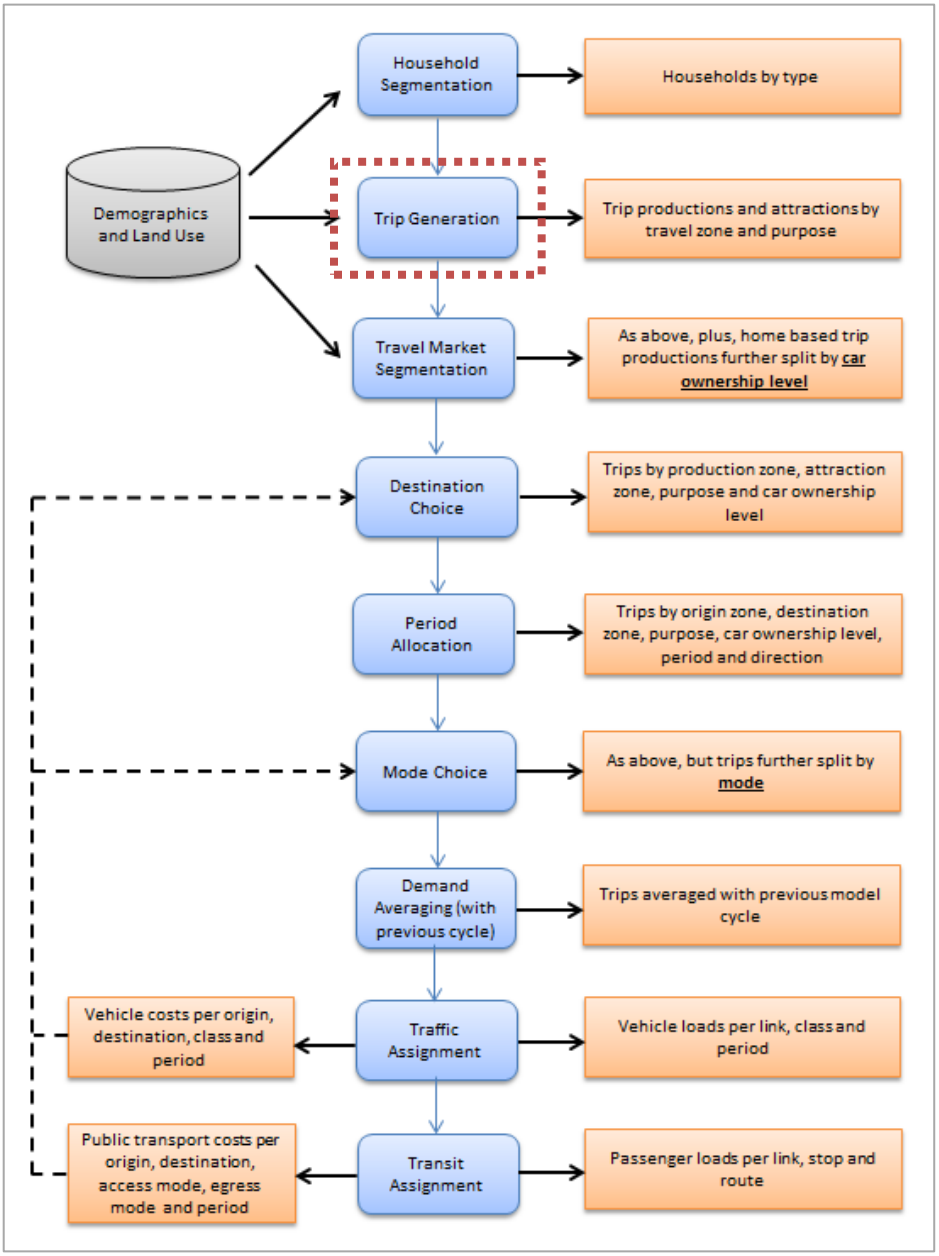

Figure 1 - Standard Zenith Model Run Process

The aim of Trip Generation Model is to estimate the number of trips produced by, and attracted to, each travel zone within the modelled region, for each trip purpose. Therefore, the Trip Generation Model is responsible for the amount of travel (i.e. number of trips) predicted to occur.

Zenith is a “trip based” model (in contrast to “tour based” or “activity based” models). A “trip” can be defined as a single one-way journey by a single person linking spatially separated activities.

For example, the following daily itinerary consists of 5 trips:

Begin at Home	
⇨ Travel to Work	[1 trip]
⇨ Travel to a Work Meeting	[1 trip]
⇨ Travel back to Work	[1 trip]
⇨ Travel to the Shops	[1 trip]
⇨ Travel Home	[1 trip]

In a “trip based” modelling framework, each trip has a “trip purpose”. Each trip purpose defines a unique combination of activities, for example (Home, Work), (Work, Shopping), etc. For each combination of activities, one of the activities is nominated to be the “production activity” and the other activity is nominated to be the “attraction activity”. The “production activity” is determined using the following ranking of activities:

1. Home
2. Work
3. Shopping
4. Recreation
5. Education
6. Other

For any pair of activities, the activity of highest rank (i.e. closest to 1) is nominated to be the “production activity”.

Therefore, a trip from the shops to work would have production activity “Work” (being higher in the ranking) and attraction activity “Shopping”. Note that the production activity can be either the origin or the destination of the trip.

Once the production and attraction activities of a trip are determined, its trip purpose is named as “[*Production Activity*] Based [*Attraction Activity*]”. So, for example, for the trip purpose “home based shopping”, the production activity is “home” and the attraction activity is “shopping”. Any trip made between home and shopping (in either direction) would be the assigned the purpose “home based shopping”.

Therefore, a return journey, made from home, to the shops, and then back, constitutes two home based shopping trips. Both trips have their production activity “Home”, and attraction activity “Shopping”.

The “production zone” is the travel zone where the “production activity” takes place. Therefore, a return journey, made from home to the shops and then back again, will result in two “trip productions” for the “home based shopping” trip purpose, both at the “production zone” – i.e. at the travel zone containing the home. Two “trip attractions” would occur at the travel zone containing the shop.

2.2 Trip Purposes

Trip productions and attractions are calculated for each trip purpose for each travel zone. The trip purposes considered within the Zenith model can be grouped into four categories (and associated sub-categories):

- Resident Travel
  - Home based
    - Home based work - white collar
    - Home based work – blue collar
    - Home based education – primary
    - Home based education – secondary
    - Home based education – tertiary
    - Home based shopping
    - Home based recreation
    - Home based other
  - Non-home based
    - Work based work
    - Work based shopping
    - Work based other
    - Shopping based shopping
    - Shopping based other
    - Other non-home based
- Visitor Travel
  - Visitor accommodation based shopping
  - Visitor accommodation based recreation
  - Visitor accommodation based other
  - Visitor non-accommodation based
- Special Generators
  - Special recreation based home
  - Special recreation based visitor accommodation
  - Airport based home
  - Airport based visitor accommodation
  - Airport based work
  - External travel
- Freight
  - Light commercial vehicles
  - Heavy commercial vehicles
  - Port trucks

The following Sections delve deeper into the way in which Trip Productions and Attractions are calculated for the trip purposes which form each of the above categories.

2.3 Resident Travel

2.3.1 Home Based Travel

Home based trips are trips which have the home at one end (e.g. home to work, shopping to home). The following sub-sections detail the estimation and implementation of the Home Based Trip Production Model and the Home Based Trip Attraction Model.

2.3.1.1 Home Based Trip Productions

Resident home based trip productions are calculated using a "household based" model referred to as the Home Based Trip Production Model. The model employs a stratified dummy variable regression technique, which has the advantage of being linear in the model's parameters, while at the same time using dummy variables to capture non-linear relationships between household attributes and trip making.

Households are assumed to have 7 attributes, the values of which are coded as dummy variables. The seven attributes are listed in Table 1 below.

Variable	Levels
Household size	1, 2, 3, 4, 5, 6+
Number of white collar workers	0, 1, 2, 3+
Number of blue collar workers	0, 1, 2, 3+
Number of dependants aged 0 to 17	0, 1, 2, 3+
Number of dependants aged 18 to 64	0, 1, 2, 3+
Number of dependants aged 65 and over	0, 1, 2+
Number of cars (excludes motor cycles)	0, 1, 2, 3+

Table 1 - Explanatory variables and their discrete levels

Each level of each attribute is assigned a dummy variable. So, for example, the attribute "Number of cars" is represented as four dummy variables, corresponding to the four car ownership levels: 0, 1, 2, 3+. In total across the 7 attributes, this leads to 29 dummy variables. The model is linear, with non-zero parameters estimated for a maximum of 22 (29-7) of the dummy variables (one parameter from each set of attribute levels must be set to zero to ensure identification of the model's parameters).

Example

A family with four members, comprising 1 white collar worker, 0 blue collar workers, 2 dependants aged 0 to 17, 1 dependant 18 to 64, and 0 dependants aged 65 and over, and owning 2 cars would be coded as follows:

	Household size						White Collar Workers				Blue Collar Workers				Dependants (aged 0 to 17)				Dependants (aged 18 to 64)				Dependants (aged 65+)				Cars			
Dummy Variable	1	2	3	4	5	6+	0	1	2	3+	0	1	2	3+	0	1	2	3+	0	1	2	3+	0	1	2+		0	1	2	3+
Household 1	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0		0	0	1	0

The bottom row contains the values of the dummy variables for our example household.

In the Home Based Trip Production Model, each dummy variable can have a parameter associated with it for a given trip purpose. However, in practice, not all parameters are non-zero for all trip purposes. A variable selection process (typically "*leave-one-out cross validation*" is used to filter out variables which do not improve the predictive accuracy of the model. For example, Table 2 lists some example non-zero parameters for the Home Based Work – White Collar trip purpose.

Variable	Level	Parameter
White Collar Workers	1	1.0901
	2	2.0029
	3	3.1713
Dependants 0-17	0	0.1095
Cars	3+	0.1335

Table 2 - Example parameter values for the Home Based Work - White Collar trip purpose

To calculate the predicted Home Based Work – White Collar trips, we multiply (and then sum) the dummy variable parameters by the value of each dummy variable (0 or 1). For the example household described above, we have:

$$Trips = (1.0901 \times \mathbf{1}) + (2.0029 \times 0) + (3.1713 \times 0) + (0.1095 \times 0) + (0.1335 \times 0)$$
$$Trips = 1.0901$$

Table 3 below highlights the parameters which are most commonly significant for each trip purpose.

VARIABLE	Level	HBW White	HBW Blue	HBE PRY	HBE SEC	HBE TER	HBS	HBR	HBO
White Collar Workers	0								
	1								
	2								
	3+								
Blue Collar Workers	0								
	1								
	2								
	3+								
Dependants aged 0-17	0								
	1								
	2								
	3+								
Dependants aged 18-64	0								
	1								
	2								
	3+								
Dependants aged 65+	0								
	1								
	2+								
Cars Owned	0								
	1								
	2								
	3+								
Constant									

Table 3 - Commonly Significant Trip Production Parameters

Some key strengths and weaknesses of the Zenith home based trip production model are as follows:

Strengths

As a predictor of trip making,

- The use of dummy variables means that the model is non-linear in the level of each household variable. For example, there is no requirement for a household with two workers to make twice the number of trips as a household with one worker. This is particularly advantageous in the case of activities which are to

some degree shared across household members, such as shopping, or dropping a household member off,
- Being a household level model, the average interaction between household members can be taken into account. For example, the presence of dependent children in a household can dramatically affect the trip making of the adults in the household (in terms of chauffeuring, etc.).

In application,

- The model does not include interaction terms and as such doesn't require the cross-classification of household variables. This obviates the need for a population synthesis model.

Weaknesses

As a predictor of trip making,

- Certain types of household interactions cannot be explicitly modelled; in particular, interactions that require two person types to be simultaneously present. For example, we cannot consider the combined effect of having a dependent child *and* a dependent adult in the household. We can only consider their effects separately.

2.3.1.2 Home Based Trip Attractions

This sub-section describes the Home Based Trip Attraction Model, which is used to calculate the relative attractiveness of each travel zone for each trip purpose.

The Trip Attraction Model is linear in a range of zonal variables including:

- Total Employment
- Employment by occupation category (white / blue collar)
- Employment by industry
- Employment by industry X occupation category (white / blue collar)
- Number of households
- Number of educational enrolments (primary, secondary, tertiary)

The parameters underpinning the Home Based Trip Attraction Model are estimated simultaneously with the Destination Choice Model through their inclusion in the utility function for each destination (specifically, the inclusion of log(attractions)).

2.3.2 Resident Non-Home Based Travel

Non-home based trips are those trips which have neither end at the home (e.g. work to shopping, shopping to education).

The variables used to predict resident non-home based travel (by purpose) are:

- Total Employment
- Employment by occupation category (white / blue collar)
- Employment by industry
- Employment by industry X occupation category (white / blue collar)
- Number of households

- Number of educational enrolments (primary, secondary, tertiary)

The parameters underpinning non-home based trip productions are estimated through linear regression. An estimate of the actual number of non-home based trips produced by each travel zone is extracted from an expanded version of the local household travel survey, and regressed against.

For trip attractions, the parameters are estimated simultaneously with the destination choice model through their inclusion in the utility function for each destination (specifically, the inclusion of log(attractions)).