

# **Trip Generation Model Development for Albany**

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## **Abstract**

This paper discusses two trip generation models: a trip production model and a trip attraction model. The trip production model estimates the number of home based trips to and from zones where trip makers reside. The trip attraction model estimates the number of home based trips to and from each zone at the non-home end of the trip as well as the number of non-home based trips. In this study, these two models are based on the trip rates for individual sample households having the particular characteristics. Households and trips information were retrieved from the Australian Bureau of Statistics Census 2006, the Perth Strategic Transport Evaluation Model (presently calibrated to 2001) and the Perth and Regions Travel Surveys 2001 - 2005, since there were no suitable and available model output and survey data source in Albany. Multiple linear regressions are applied in analysing influential variables in these two models.

**Keywords:** trip production, trip attraction, home based trips, multiple linear regressions.

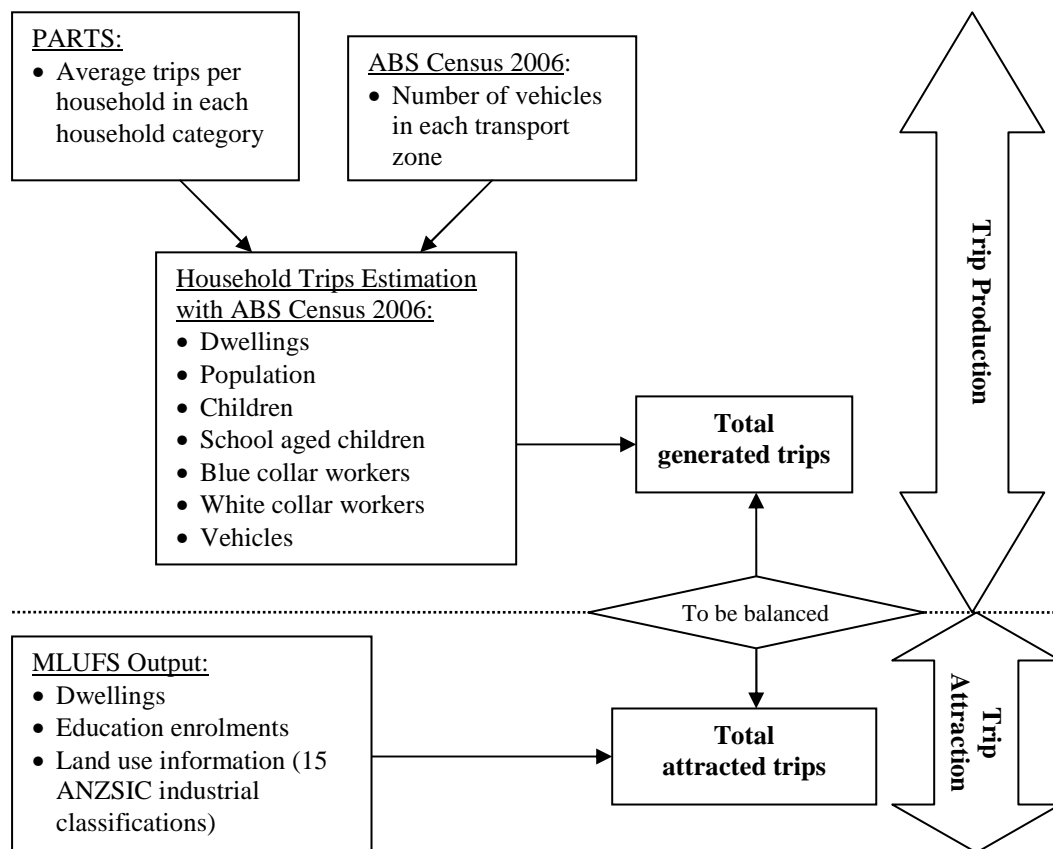
# 1. BACKGROUND TO THE STUDY

## 1.1 Paper Outline

Trip generation models predict how many trips each activity produces and the origins and destinations of such trips. This study discusses two trip generation models using Australian Bureau of Statistics (ABS) Census 2006: a trip production model and a trip attraction model. (ABS 2006) The trip production model estimates the number of home based trips to and from zones where trip makers reside. The trip attraction model estimates the number of home based trips to and from each zone at the non-home end of the trip as well as the non-home based trips.

These two models use factors describing individual sample units (e.g., persons, households or workplaces) for each transport zone. The result is a trip generation model with trip rates for each sample unit having specific characteristics, such as households of one, two, or more family members, owning one, two, or more vehicles. The trip generation model is based on the trip rates for individual sample households having those particular discrete characteristics. (Institute of Transportation Engineers 1999)

This section gives a brief introduction of the Albany transport model; section two mainly discusses the trip production and section three focuses on trip attraction. The final section presents the main conclusions and recommendations derived from this study. Figure 1.1 presents a flow chart of this study with corresponding data source.



**Figure 1.1: Trip Generation Flow Chart**

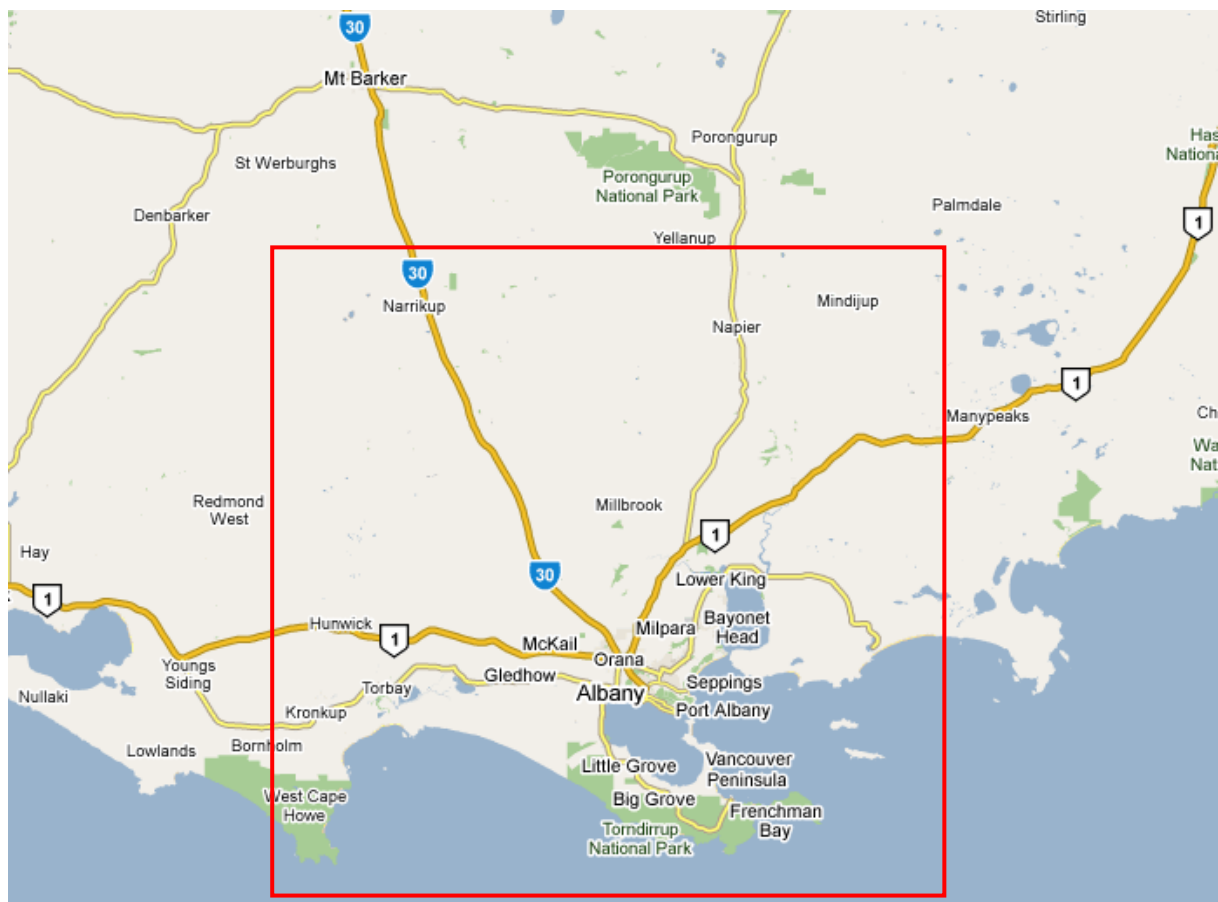
## 1.2 The Study Brief

The Albany Transport Model is being carried out by Department for Planning and Infrastructure (DPI) in conjunction with Main Roads Western Australia (MRWA) and City of Albany. It intends to investigate the impact of future growth of the city and its population, the land use, the transport network, and the performance of a number of highway network options under predicted growth patterns for a selection of design years. It also aims to achieve calibration using the latest land use data and traffic counts provided by the City of Albany.

This model is essentially a conventional four-stage model with a number of additional sub-models. Land use and social economic condition affect trip generation. (Dewberry and Rauenzahn 2008) Land use dictates the location and intensity of the activity, and socio economic factors determine the magnitude and extent of population activity. The two factors are integral components in the development of trip generation models.

## 1.3 Study Area

The study area of this model extends beyond the boundaries of the City of Albany and encompasses approximately 5,000 square kilometres, stretching from Denmark in the west, to Mount Barker in the North and as far as Waychinicup National Park in the east. The model area is reproduced in Figure 1.2.



**Figure 1.2: Albany Transport Model Study Area**

## 1.4 Zone System

Before setting up the Albany Transport model, a strategic transport zones (STZ) system was purposed. The boundaries are based on the 2006 Census collection district (CCD) boundaries to formulate the regression equations with a level of statistical confidence.

The census district level was felt to be too coarse for this model in terms of the local government's future strategic plan (City of Albany 2007). Figure 1.3 is the twenty year strategic plan in Albany. It indicates the development of urban, rural and special residential area, future industrial growth, commercial area's establishments, etc. In accordance with the future plan, some CCDs are disaggregated and a finer zone system was created in those areas where additional detail was needed, particularly in those areas earmarked for major strategic developments throughout the study period.

In addition, geographic information is also important to the transport zone clarification. For example, King River has been used as a new transport zone boundary for its geographic significance. Disaggregation of some census districts creates 88 internal transport zones and 8 external zones in this study. (Figure 1.4)

## 1.5 Road Network

The selection of highway links for inclusion in the base year highway network was undertaken in discussions between DPI, MRWA and City of Albany. It was important for all significant links to be included in the model, but avoiding a level of detail which would lead to excess difficulty in calibration. The model road network is proposed in Figure 1.5. The roads in red are the model centroid connectors; roads in black are all state roads and various important local roads.

## 2. TRIP PRODUCTION

### 2.1 Household Segmentation

The households refer to occupied private dwellings in this study. The purpose of the household segmentation trips analysis is to estimate the number of household trips in each household category in the future years for 88 internal STZs. Modelling for the Perth metropolitan areas including Mandurah and Murray uses the Strategic Transport Evaluation Travel Demand Model (STEM) and divides all households into 12 household categories with the different number of adults, workers, children in each household. These classifications are defined by the market segmentation model. (DPI 2007) With significantly less population and dwellings, the Albany transport model aggregates these household categories to three:

- *unwaged* - Unwaged households
- *waged* - Waged households with no children
- *family* - Waged households with children

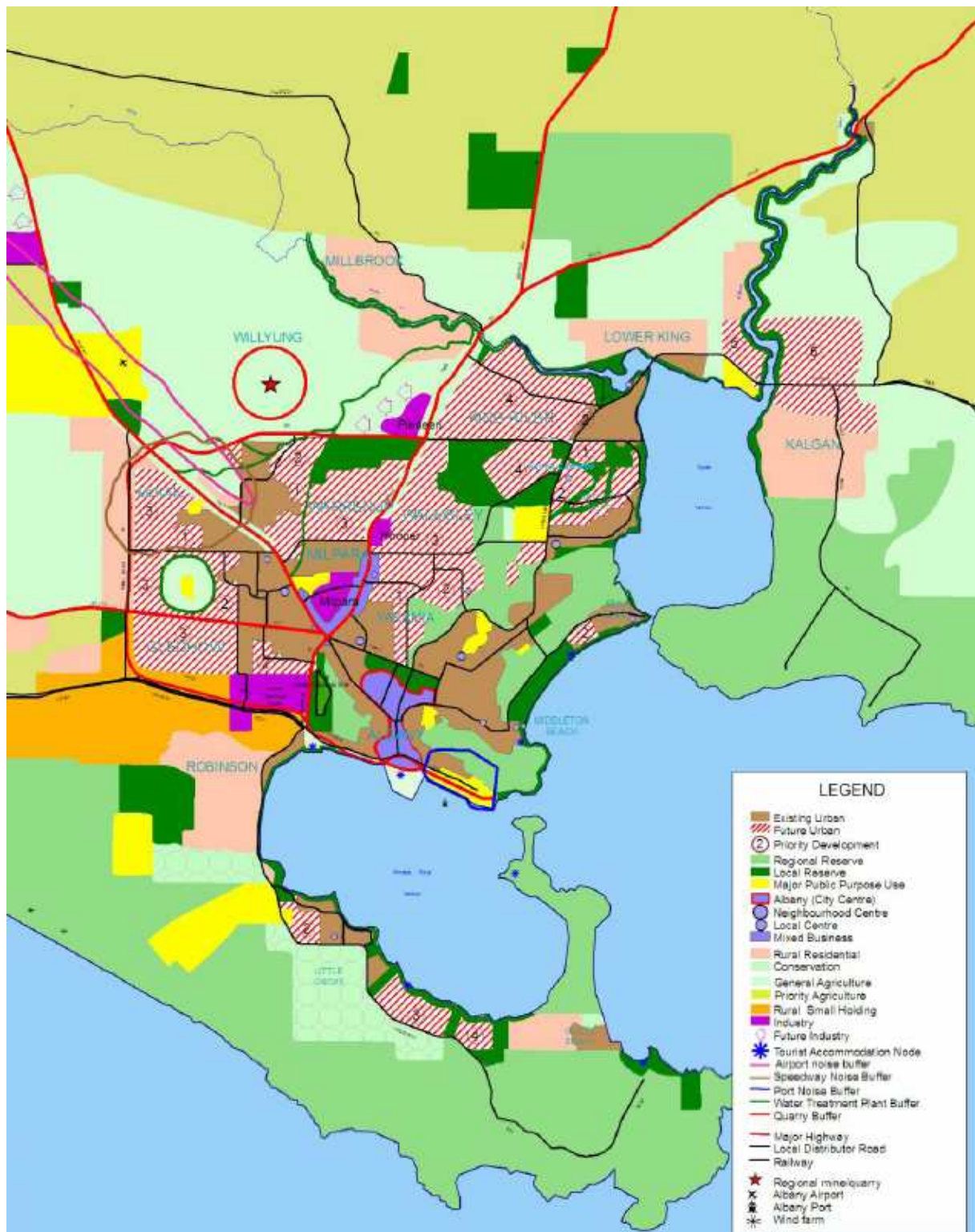
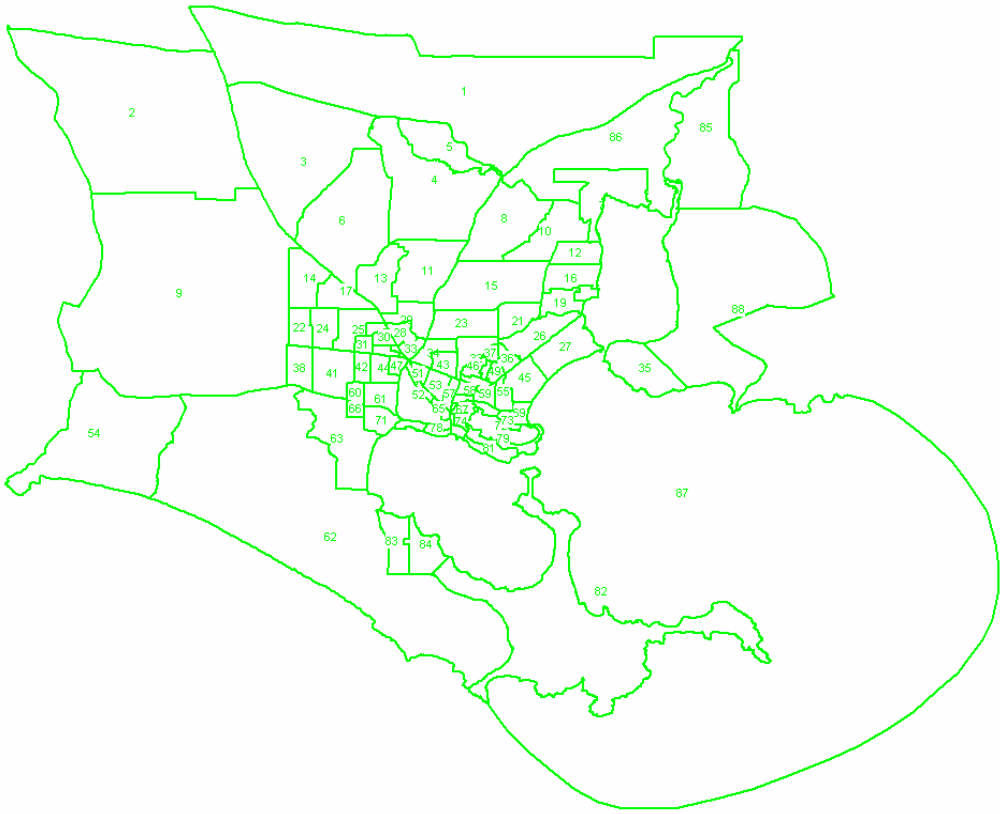


Figure 1.3: Albany Local Planning Strategies (City of Albany 2007)



**Figure 1.4: Albany Transport Model Zone System**



**Figure 1.5: Albany Transport Model Road Network**

The model applies multiple linear regressions where the number of household trips in these household categories is the dependent variable and demographic data from ABS Census 2006 are the potential independent variables.

### 2.2 Demographic Data to Estimated Household Trips

The following descriptive parameters have been retrieved from the ABS Census 2006 and aggregated to the STZ levels for this study:

- number of households
- resident population in private dwellings
- number of children
- number of school aged children
- number of blue collar employed residents
- number of white collar employed residents
- number of vehicles

During the estimation, these variables are applied as independent variables while the dependent variable is the number of household trips in each STZ. Among these variables, households are occupied private dwellings; school aged children are children aged from 5-17 and enrolled on full-time basis. Figure 2.1 shows the distribution of population ages; number of school aged children is relatively large in these age groups, which suggests that the home based education trips will be significant for households with children.

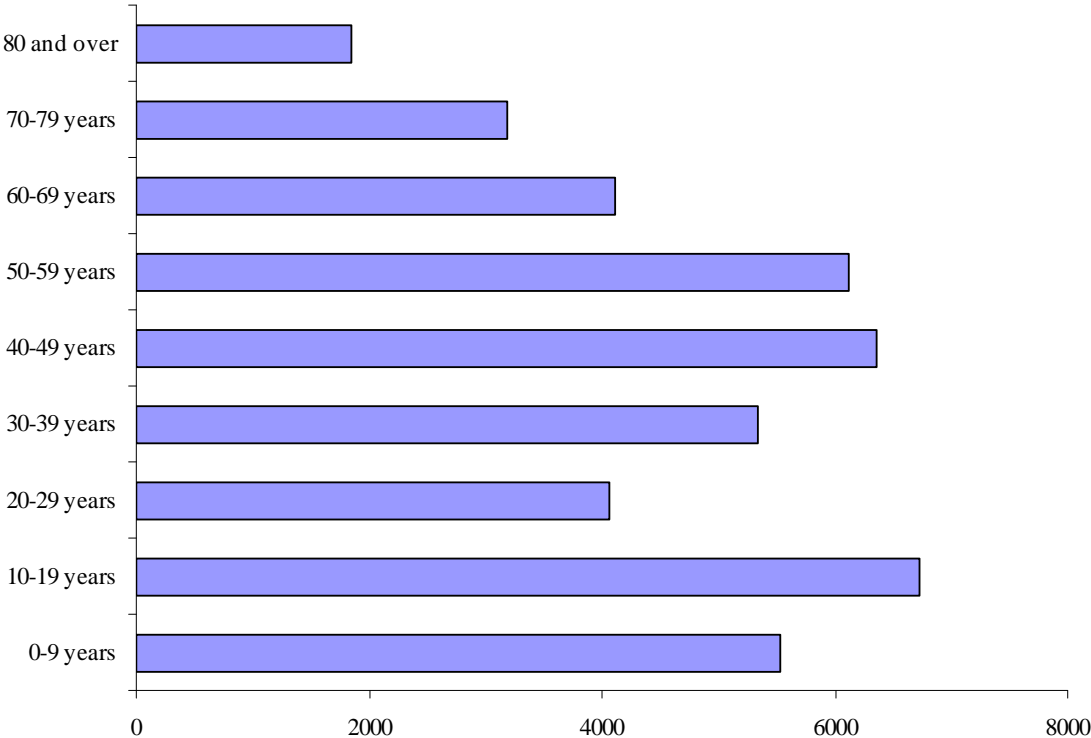


Figure 2.1 Distribution of Population Age in Albany

This study also applied similar employment classifications as STEM: white and blue collar jobs. Table 2.1 shows the detailed industrial classification from the one digit classification of Australian and New Zealand Standard Industrial Classification (ANZSIC) and groups into white and blue collar jobs. (ABS 1993)

**Table 2.1: White and Blue Collar Jobs**

White Collar Jobs	Blue Collar Jobs
G. Retail Trade H. Accommodation, Cafes and Restaurants J. Communication Services K. Finance and Insurance L. Property and Business Services M. Government Administration and Defence N. Education O. Health and Community Services P. Cultural and Recreational Services Q. Personal and Other Services	B. Mining C. Manufacturing E. Construction F. Wholesale Trade I. Transport and Storage Other Industries and Not Stated (contains Fishing, Forest and Agriculture)

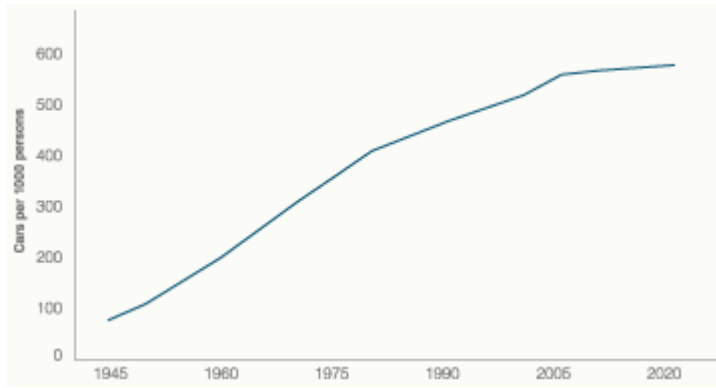
Except for the number of vehicles, future projection of all other listed demographic variables is provided by Spatial Information and Research in DPI. The number of vehicles per household is a potential independent variable in this model and it has been collected in ABS Census 2006. This variable is discussed in the next section.

### 2.3 Vehicle Availability

STEM estimates the vehicle availability using information on jobs accessible to a zone within a given walk time, public transport time and given highway distance from STEM outputs. However, no such information is available in Albany. The vehicle availability in this study is simplified by summarising the number of vehicles in each Albany STZ for each household category and the vehicle availability for future years can be predicted as proportional to the household growth in Albany.

The underlying assumptions in estimating the level of vehicle availability is: the vehicle availability is stable between the calibration and forecast years. It has been reported by Bureau of Infrastructure, Transport and Regional Economics (BTRE) that the vehicle ownership will increase but saturation levels have been almost reached, with nearly one in every two persons in Australia now owning a vehicle (as Figure 2.2). (BTRE 2002)

2006 vehicle ownership information was collected by ABS. This includes number of households with 0 vehicle, 1 vehicle, 2 vehicles, 3 or more vehicles in each transport zone. Equation 2.1 is applied in calculating the total vehicles per household on a STZ level:



**Figure 2.2: Projected Vehicle Ownership in Australia**  
**Source: BTRE Report 107**

$$TotalVEHs = HH0 * 0 + HH1 * 1 + HH2 * 2 + HH3M * a, \quad (2.1)$$

Where, TotalVEHs is the total number of vehicles,

HH0 is the number of households with 0 vehicle,

HH1 is the number of households with 1 vehicle,

HH2 is the number of households with 2 vehicles,

HH3M is the number of households with 3 or more vehicles,

a is the average number of vehicles in households with 3 or more vehicles.

In calculating the average number of vehicles in the households with 3 or more vehicles an average 3.35 vehicles per household (from analysing the ABS Census 2006) is used. The total number of vehicles in each household category in each zone enters the trip production regressions as one of the independents.

## 2.4 Linear Regressions for the Household Trips Production

Trip production models are commonly developed by multiple linear regressions because of their power and simplicity. (Institute of Transportation Engineers 1999) The linear regressions were formulated using LIMDEP software. The observed (from Perth and Regions Travel Surveys (PARTS) data) number of household trips in a zone for a given household category is the dependent variable. (DPI 2006) The demographic parameters for the zone are the independent variables. Using statistical tests, with a measure of commonsense, the significant independent variables were recognized for each of these regressions. (Greene 2007) The final selection of the independent variables was achieved using the manual option of explicitly defining the independent variables to be used.

The values of the independent variable coefficients are given in Table 2.2 and their t-values and the Coefficient of Determination,  $r^2$ , are in Table 2.3.

**Table 2.2: Regression Coefficients of Household Trips Estimation**

Household Category	Dwellings	Population	Children	School Age children	Blue worker	White worker	Vehicles
Unwaged	2.377	0.144	-0.889	1.094	-1.306	-1.704	
Waged	0.624	-0.189		-0.929	1.205	1.253	
Family	-0.524		2.821	-1.088	-0.767	0.515	0.507

**Table 2.3: Regression Coefficient T-Values and the Coefficient of Determination**

Household Category	Dwellings	Population	Children	School Age children	Blue worker	White worker	Vehicles	r <sup>2</sup>
Unwaged	28.553	2.848	-5.794	5.069	-13.060	-24.599		0.993
Waged	6.739	-3.358		-7.486	10.820	16.256		0.989
Family	-5.021		8.622	-2.515	-2.489	3.008	3.576	0.992

Coefficients from Table 2.2 are derived on the basis of 88 transport zones. Where a coefficient is negative, this impacts on the number of household trips through a negative impact on the number of households in the zone. For example, the coefficient for dwellings is negative for family household trips; when all other variables being equal, it implies a fall in the number of high occupancy households, and the number of family households (high occupancy households) decreases. Consequently the number of trips from family households in that zone declines.

The coefficient of determination  $r^2$ , represents the total amount of variance accounted for in the dependent variable by the independent variables. (Miles & Shevin 2001) The high coefficient of determination in Table 2.3,  $r^2$ , indicates that the independent variables fit household trips' estimation model well. There exists correlations between dwellings and population as well as children and school aged children, consequently the number of household trips in each household category depends on the joint effects of these groups.

## 2.5 Total Produced Trips and Projection for Future Years

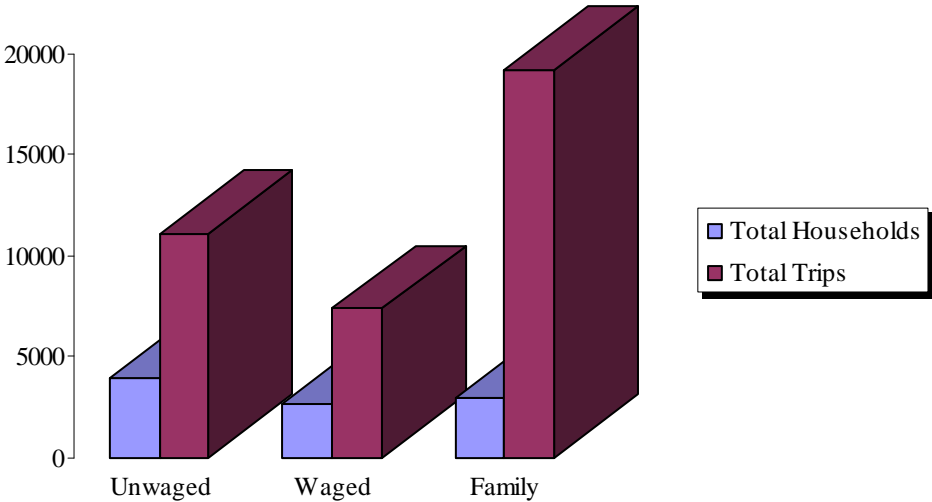
PARTS Year 4 includes 887 households, the average trips per household in each household category is the key input to derive the number of produced trips in this model. Total generated trips in Albany are estimated using Equation 2.2 with the PARTS data and the ABS Census 2006 for Albany.

$$SumTrips_j = \sum_{i=1}^{88} HHs_{ij} \times AT_j \quad (2.2)$$

Where, SumTrips is the total number of trip for each household category,  
 HHs is the number of households for each household category in each STZ,  
 AT is the average trips per household from PARTS,  
 j is one of three household categories,  
 i is STZ zones in Albany, i=1, ... 88.

In the present year, the average number of trips per household is calculated by applying the observed number of trips by households from PARTS to the observed number of households in PARTS; In the future years, the average number of trips per household will be explored by the estimated number of trips by households from the trip production regressions compared to the estimated number of households.

Figure 2.3 shows the comparison of the total number of households and total generated trips for the three household categories.

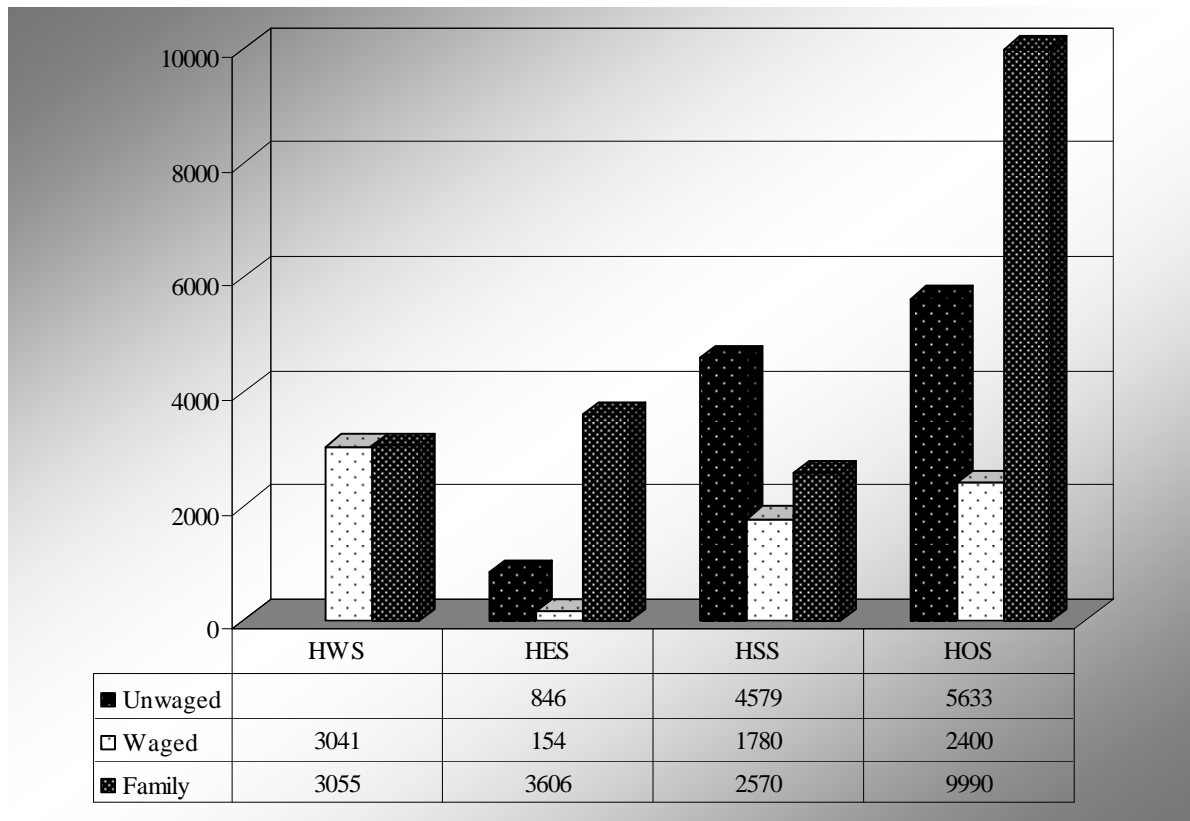


**Figure 2.3: Total Generated Trips vs. Total Households of Each Household Category**

The number of trips for each trip purpose is estimated by applying the proportion of trips for each trip purpose to the total number of trips. Given that there was no available trip information in Albany, the estimation of the number of trips by various trip purposes is calculated using 2008 STEM mode output. Figure 2.4 compares the number of trips with four trip purposes for different household categories.

As indicated in Figure 2.3 and 2.4, there are no work trips in the unwaged households (by definition) and this category also has few education trips since there are a significant number of pensioner households in this category. There are even fewer education trips in waged households as these are households without children.

To estimate the total number of trips for each trip purpose for the future years, this model assumes that the reliable estimates for the significant independent variables are available for the forecast year, and the regressions between the numbers of trips and the independent variables are stable between the calibration and the forecast years. Both the number of produced trip and attracted trips (to be analysed in the next section) will input to the CUBE software to be balanced.



**Figure 2.4: Total Generated Trips by Trip Purposes and Household Categories**

### 3 TRIP ATTRACTION

#### 3.1 Introduction

Similar to trip production model, the multiple linear regressions are used in the trip attraction model. It aims to estimate the number of trips (the dependent variable) attracted to each transport zone based on a linear equation of socio-economic parameters (the independent variables) disaggregated to the STZ level. The trip attraction models have been developed for the following five trip purposes:

- home based work trips (both blue and white collar work trips)
- home based education trips
- home based shopping trips
- home based other trips
- non-home based trips

In this model, the attraction for a work trip is the place of work and the number of work trips attracted to a particular zone. Consequently, it is directly related to the number of job locations in that zone. There was no suitable and available trip data source in Albany, so a trip rate based on Perth metropolitan area job location by ANZSIC industry classification was implemented as the most appropriate model structure. The Metropolitan Land Use Forecasting System (MLUFS) projects job locations by 15 industrial classifications as independent variables to determine the regression equations for, effectively, five trip purposes.

(Ministry for Planning 2001) Except the work trips, it is assumed that the trips attracted to a zone are also related to the number of private dwellings and education enrolments.

The model assumes that reliable estimates for the significant independent variables are available for the forecast year, and the regressions between the numbers of trips and the independent variables are stable between the calibration and the forecast years. Multiple linear regressions apply in LIMDEP software for each trip purpose's investigation. The dependent variable is the observed number of trips attracted to a zone; a set of identified parameters descriptive of the trip attractors in that zone are independent variables, these are listed in the next section.

### **3.2 Trip Attraction Variables**

The trip attraction model in Albany uses MLUFS output for job location by zone in the following fifteen ANZSIC industrial classifications:

- Agriculture
- Mining
- Manufacturing
- Utilities
- Construction
- Retail
- Wholesale
- Transport and storage
- Communications
- Finance, property and business services
- Public administration and defence
- Education
- Health
- Welfare and other community services
- Entertainment and recreation

The number of private dwellings is the standard MLUFS output aggregated to the STZ level. The primary and secondary school enrolments, technical and further education (TAFE) enrolments, and university enrolments are also the independent variables for trip attraction estimation in this model.

### **3.3 Linear Regression for the Trip Attractions from STEM**

For each of the five trip purposes, STEM set up a multiple linear regression for the number of trips attracted to a zone with the significant independent variables being determined using LIMDEP. The values of the significant independent variable coefficients, their t-values (in brackets) and the Coefficient of Determination,  $r^2$ , are given in Table 3.1. (DPI 2007) All coefficients derived from STEM are employed in Albany model to estimate the number of attracted trips.

**Table 3.1: Trip Attraction Independent Variables**

	Blue Collar Work	White Collar Work	Education	Shopping	Other	Non Home Based
Private Dwellings					1.858 (15.4)	0.535 (8.25)
School Enrolments			1.344 (23.8)	0.768 (7.82)	1.505 (7.10)	0.275 (2.45)
University Enrolments			0.678 (11.4)			0.238 (3.90)
TAFE Enrolments			0.245 (3.50)			
Agriculture						
Mining		3.615 (4.08)				
Manufacturing	1.878 (26.0)	1.054 (8.21)		-0.910 (-2.48)		
Utilities	1.233 (2.50)	4.032 (3.91)				8.685 (6.66)
Construction	1.396 (5.07)			2.626 (2.56)		
Retail	0.429 (5.84)	1.387 (8.90)		6.407 (24.1)	2.299 (5.81)	4.880 (24.3)
Wholesale				-1.543 (-2.77)		
Transport and storage	1.511 (8.97)				1.617 (2.33)	
Communications		2.932 (4.72)				
Finance, property and business services		2.173 (16.6)				1.680 (11.3)
Public administration and defence						
Education		1.273 (7.14)	0.772 (3.30)		0.968 (2.16)	
Health		1.161 (7.03)		0.818 (3.19)		1.136 (5.48)
Welfare and other community services		1.505 (2.92)				
Entertainment and recreation					2.372 (4.09)	1.272 (3.89)
r <sup>2</sup>	0.86	0.80	0.63	0.60	0.66	0.77

Source: STEM Technical Report (DPI 2007)

### 3.4 Formulation

Taking account of above coefficients from linear regression for the trip attractions, Equation 3.1 is applied to estimate the total number of attracted trips to a zone in Albany.

$$T = \sum_{i=1}^6 aX_i \quad (3.1)$$

Where, i is number of trip purposes,

T is number of attracted trips in the STZ.

X is identified independent variable,

a is the corresponding coefficient.

Currently, Spatial Information and Research of DPI is working on the land use information retrieval in Albany. The data source will be applied to Equation 3.1 to derive the number of attracted trips on the STZ level. The number of produced trips and the number of attracted trips will be balanced using CUBE software in the later modelling stage.

#### **4. CONCLUSIONS AND RECOMMENDATIONS**

In this study, considerable predictive power and accuracy have been gained by disaggregate analysis of influential variables in the trip generation. The model uses a simplified STEM methodology with modified assumptions and some re-adjustment of trip production and trip attraction required.

Spatial Information and Research of DPI is conducting an employment survey in Albany, which will be applied to the trip attraction model. A travel survey is highly recommended to improve the accuracy and reliability of this model and re-calibration in future years.

The travel demand analysis in this model is a key element of transportation planning, whether for long-range wide area comprehensive plans or for short-range plans for a traffic corridor or specific project. Forecasting travel demand with the elaborate trip generation models depends on the level of detail required for the study.

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