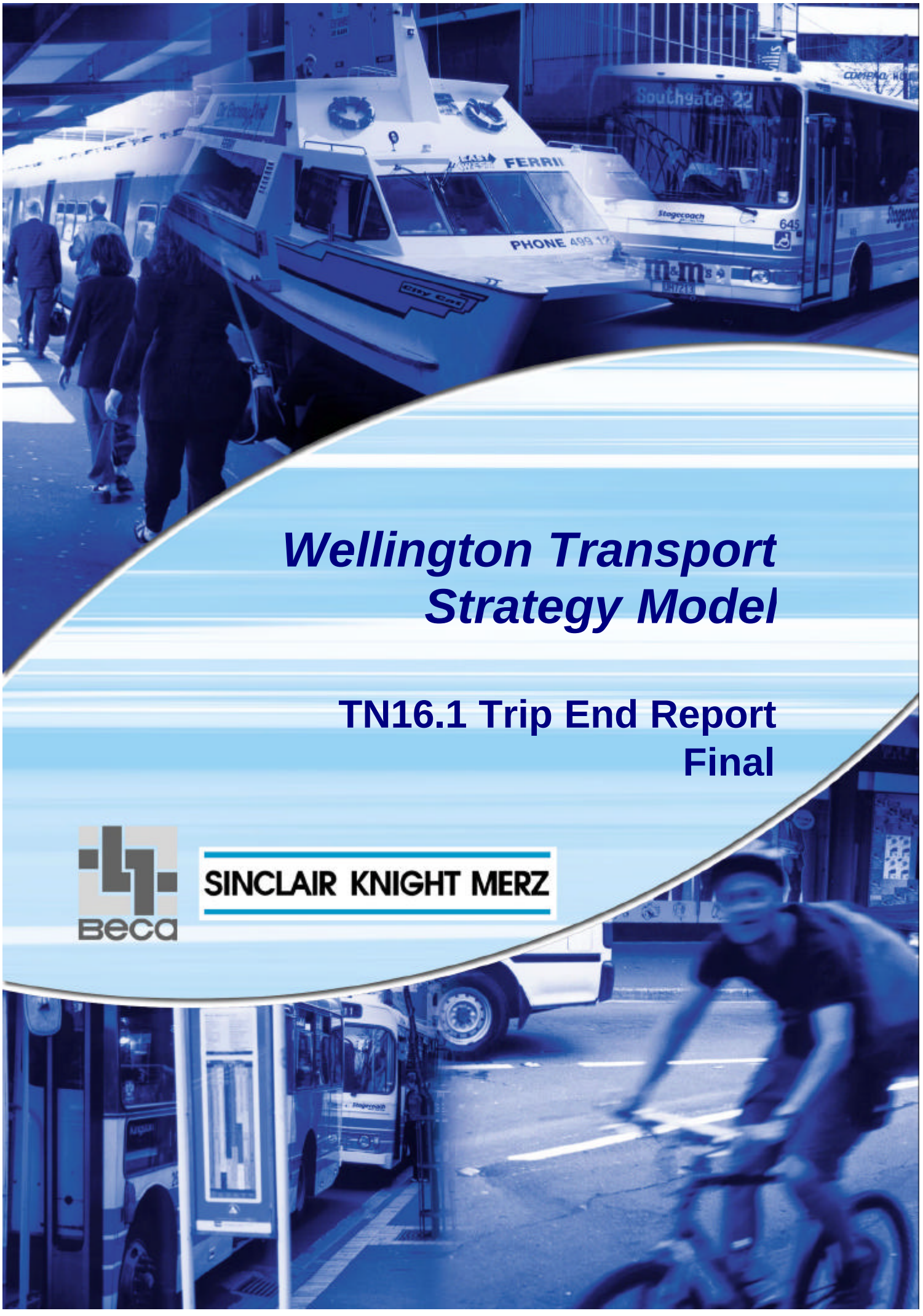

Wellington Transport Strategy Model

TN16.1 Trip End Report
Final

Beca

SINCLAIR KNIGHT MERZ

Wellington Transport Strategy Model

TN16.1 Trip End Report

Final

July 2003

prepared for

Greater Wellington – The Regional Council

By

Beca Carter Hollings & Ferner Ltd

And

Sinclair Knight Merz

Section A – Trip Production Report

Section B – Trip Attraction Report

Section C – Family Structure Model Report

Section D – Miscellaneous Trip End Model Report

Wellington Transport Strategy Model

TN16.2 Trip Productions Report

Final

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Contents

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1. Introduction

This paper describes the calibration of the trip end models (productions and attractions) for the purposes:

- Home Based Work (HBW)
- Home Based Education (HBEd)
- Home Based Shopping (HBSh) - including personal business
- Home Based Other (HBO) – combined Home Based Other and Home Based Social
- Non-Home Based Other (NHBO)
- Business Trips (BU) – combining Home Based and Non Home Based Employers' Business.

2. Trip Production Model Data Analysis File

2.1 Introduction

The development process included the creation of a trip production analysis file (including the recoding of several variables), initial statistical analysis and model calibration.

The analysis file was extracted from three household survey files (household, person and trip). The structure of the produced file can be seen in Table 2-1 (for complete descriptions of each field see Appendix A). Those fields in the table in *italics* have been generated, and those not in italics have been taken directly from one of the 3 household survey files.

Each record represents one person, as the trip production models are person based, only for those respondents aged 5 or over. The survey processing report describes the trip linking and definition of each trip (Section 3.3).

Table 2-1 Revised Trip Production File

Field Number	Field Name	Description
1	HID	Questionnaire No.
2	PID	Person number
		Household Information
3	*HholdType*	*Household Classified into a Group (by adult size/employment)*
4	HholdNum	No. of members living permanently in the H'Hold
5	*HnumAdults*	*No. of adults living permanently in the H'Hold*
6	HvehNum	No. of Vehicles used/owned by H'Hold
7	*CarAvailability*	*Ratio between Vehicles and Adults*
8	Hzone	Zone H'Hold is contained in
9	*HholdLocation*	*H'Hold classed into a geographic region*
10	TLA	TLA H'Hold is contained in
		Person Information
11	*PersonType*	*Person Classified into a Group (by age/employment)*
12	Pbirth	Year of Birth
13	*Pwork*	*Employment Status*
14	*Peducation*	*Education Status*
15	*PworkArrangments*	*Req'd work-time of employment*
16	*PemploymentType*	*Position of employment*
17	Poccupation	Occupation (as per Processing Spec. Report)
18	Pindustry	Industry (as per Processing Spec. Report)
		Recoded Trip Purposes
19	*HBW*	*No. of Home Based Work Trips*
20	*HBEd*	*No. of Home Based Education Trips*
21	*HBEd (Escort) Primary*	*No. of Home Based Escort To Primary School Trips*
22	*HBEd (Escort) Secondary*	*No. of Home Based Escort To Intermediate/ Sec. Sch. Trips*
23	*HBEd (Escort) Tertiary*	*No. of Home Based Escort To Tertiary Education Trips*
24	*HBSh*	*No. of Home Based Shopping Trips*
25	*HBSo+HBO*	*No. of Home Based Social and Home Based Other Trips*
26	*NHBO*	*No. of Non Home Based Other Trips*
27	*BU*	*No. of Business Trips*
		Additional Information
33	*Children*	*Does the H'Hold contain children*
34	*Jobs*	*Does the H'Hold contain an employed person*

2.2 Selection of Relevant Person and Trip Data

The trip production models generated are for weekday travel only and thus not all person or trip data are relevant.

Data Recodes

Before selecting any data, the trip production file was altered, with trip purposes being reassigned. The following reassignments occurred:

- All taxi driver trips were reassigned the purpose of BU
- All trips with mode truck were reassigned to purpose CV
- All trips with vehicle body truck were reassigned to purpose CV
- All CV Purpose trips with vehicle body van/ute were reassigned the purpose of BU

Person Data

Of the 6953 people from the person file, 922 incomplete or irrelevant records were omitted. The three reasons for omission of persons in the analysis were:

- persons were infants (less than 5 years). Infants were not required to complete trip diaries, but some were completed on their behalf - Check 1;
- no trip diary was completed (those that completed a diary and made no trips were included) - Check 2;
- trip diary was only completed for the weekend survey day – Check 2.

Table 2-2 Data Acceptance Check – Person File

Num	Acceptance Check	Field	Criteria	Action	Number Omitted
1	Infant	Pbirth	1997-2001	Omit Person	544
2	Weekday Only	Pday1, Pday2	Neither 1,2,3,4 or 5	Omit Person	378

Trip Data

A number of irrelevant trips have also been specifically excluded from the analysis. These have been omitted for the following reasons:

- the survey day of the trip was a weekend day – Check 3;
- the trip main mode was either truck driver, truck passenger, cable car, charter bus or other (generally plane); in the case of truck trips, these will be included as part of the commercial vehicle model as discussed in the Preliminary Studies report; in the case of plane, as discussed in the Survey Processing Report, the actual air leg was not linked with the access leg, instead the air leg was removed and the access leg flagged and treated separately in the airport model; other minor modes are insignificant. – Check 4,
- the vehicle used was a truck. See description in point above – Check 5;
- the trip was a wholly external trip, i.e. from the ferry terminal to the south island, or Kapiti Island – Check 6;
- the trip maker was an infant – Check 7.

In total 27,137 trips were retained from the original 35,919 trips in the trip file. The table below details the numbers omitted for both persons and trips from the above checks. Note that 274 trips were omitted for failing multiple checks.

■ **Table 2-3 Data Acceptance Check – Trip File**

Num	Acceptance Check	Field	Criteria	Action	Number Omitted
3	Weekday Trips Only	Day	6, 7	Omit Trips	8021
4	Main Mode	Mode	8, 9, 14, 15, 16	Omit Trips	718
5	Truck Vehicles	HvehBody	4	Omit Trips	271
6	External Only Trips	OriginZone, DestinationZone	0	Omit Trips	33
7	Infant	Pbirth	1997-2001	Omit Trips	13

3. Production Model Statistical Approach

3.1 Statistical Tests

The trip production models have been calibrated using linear regression software, and evaluated using model fit statistics such as t-statistics, standard errors, r-squared values and sum of residual values. The fit statistics have then been used to compare alternative models and parameter values. In summary these tests are:

- a higher r-squared value indicates a model explains more of the sample variance than another model - as these models are person based, we would expect the r-squared values to be lower than that for a household based model with a higher degree of aggregation and hence less variation;
- we generally would aim for t-statistics greater than 2 to indicate that a particular variable is significant;
- the standard error can be used to determine if two parameters are statistically different;
- to compare the explanatory power of two models we can calculate an F-statistic as:
  - {(Residual Sum of Squares[1] – Residual Sum of Squares[2])/Q} / {Residual Sum of Squares[2] / (N-Q+1)}
    - where Q is the number of additional parameters and N is the sample size
    - with degrees of freedom Q,N-Q+1.

These tests have generally been applied to each model. However in the final selection of a model, behavioural sensibility may override the choice of model when the statistics are either ambiguous (i.e. r-squared and residual sum of squares suggest alternative models), or the statistical tests indicate only a marginal improvement in performance.

3.2 Presentation of Results

We need to give a brief introduction to one aspect of the presentation of the models. Most models simply comprise different trip rates for different types of person, simplistically for example men, women and children. To calibrate the trip rates for these 3 person types, we identify one as the base segment, say, men. The 'constant' in the model is then the trip rate for men, the base category – say this takes the value 2.0.

The coefficients for the other 2 categories, women and children, measure the difference in their trip rates from the base category, men. Suppose the coefficients for women and children are +0.5 and –1.0 respectively, then we obtain the trip rates for these person types by adding them to the constant (2.0) – so the trip rate for women is 2.5 and that for children 1.0.

If the statistical test on the coefficient for women (0.5) suggests that it is insignificant, then this means that the trip rates for men and women are similar and need not be distinguished in the model.

In some more complex models, other segments dimensions may be added. Suppose for example, we include household car ownership with categories 0, 1 & 2+. The base

category must then be re-defined to be a specific sub-category, for example men in 0 car households. We can then test whether men in 1 and 2+ car households have higher trip rates by calibrating coefficients for these sub-categories, relative to the base category (men in 0 car households). In the subsequent tables where such a sub-category applies it is indicated by nomenclature such as [men, 0car].

4. Home Based Work Productions

4.1 Employee Segmentation

The home based work model (HBW), as specified in the technical specification, is expected to be sensitive to the work arrangements and employer type characteristics of each full time and part time worker. The nomenclature for these categories is shown below. Where aggregations occur, such as employer types 2 and 4, the code would then be ET(2,4).

■ **Table 4-1 Work Arrangement and Employer Type Nomenclature**

Work Arrangement	Nomenclature
Fixed hours	WA(1)
Flexible hours	WA(2)
Rostered shifts	WA(3)
Works from home	WA(4)
Employment Type	**Nomenclature**
Paid employee	ET(1)
Self employed – no others employed	ET(2)
Self employed and employer of people	ET(3)
Family business	ET(4)

An initial analysis of sample size (Tables 4-2 & 4-3) led to some aggregation across employment type. Samples for the 'family business' category ET(4) and, for part-time workers, the self-employed category ET(3) were small. Additionally, virtually all employees on 'rostered shifts' were 'paid employees', and most part time employees working 'fixed hours' were also 'paid employees'. We therefore amalgamated segments to give sufficient samples for statistical analysis, as illustrated in Tables 4-4 & 4-5.

■ **Table 4-2 Full-Time Sample Size**

WA\ET	Paid Employee	Self Employed	Family Business	Employer of Others
Fixed Hours	1436	43	1	53
Flexible Hours	332	181	3	96
Rostered Shifts	171	3	0	0
Works from Home	29	50	0	23

■ **Table 4-3 Part-Time Sample Size**

WA\ET	Paid Employee	Self Employed	Family Business	Employer of Others
Fixed Hours	310	2	1	1
Flexible Hours	326	73	0	9
Rostered Shifts	104	1	0	1
Works from Home	19	44	1	4

■ **Table 4-4 Full-Time Sample Size after Aggregation**

WA\ET	Paid Employee	Self Employed and Family Business	Employer of Others
Fixed Hours	1436	44	53
Flexible Hours	332	184	96
Rostered Shifts	174		
Works from Home	29	50	23

■ **Table 4-5 Part-Time Sample Size after Aggregation**

WA\ET	Paid Employee	Self Employed, Family Business and Employer of Others
Fixed Hours	314	
Flexible Hours	326	82
Rostered Shifts	106	
Works from Home	19	49

A segmentation into blue and white collar workers was considered, but the subsequent reduction in sample size for each segment in the distribution and mode split models was prohibitive to such an approach which, in any case, we have found not to be of great significance in other models (such as London). In forecasting the proportion of workers in each aggregated category is held constant, however the split between full-time and part-time workers is provided in the forecast planning data.

4.2 Calibration

Table 410 details the statistical results from the five most relevant models. As unemployed people usually do not make commuting trips, these are excluded from the statistical analyses until the final model.

Model 1: The full cross classified model of trip rates

The constant in the model refers to part time employees [category WA(1) ET(1,2,3,4)]. For other categories, this constant value is added to the coefficient to determine the trip rate for that category. Thus the trip rate for the equivalent full time category is 1.518 (0.742+0.776); that is, as would be expected, full time employee trip rates are substantially higher generally than their part time equivalent.

The full cross-classification model, has statistically significant coefficients for most of the full time variables, but this is less true of the part time categories. The results suggest that for all employment types, the trip rates reduce in shifting from work arrangement category WA(1) to WA(2), WA(3) and WA(4). Thus, in the full time categories, 'fixed hours' coefficients [WA(1)] are 0.5-0.8, whereas 'working from home' coefficients [WA(4)] are –0.1 to –0.3. Similarly, the trip rate differences between employment types seemed similar for each work arrangement category.

Model 2: The separate effects of employer type and work arrangement, for part time and full time workers.

We therefore simplified the model structure to investigate these common effects. The new model differentiated the incremental effects of employment type and work arrangements for part time and full time workers. In this and all subsequent models the constant refers to full time employees with work arrangement and employer type

category WA(1)ET(1). While the r-squared dropped marginally for this model, the significance of the coefficients (t-stats) improved.

Further analysis of this model indicated that, having allowed for the average difference between full time and part time employee trip rates, the employer type and work arrangement coefficients for part time and full time workers were generally not statistically different. For example, the largest coefficients for full and part time workers apply to 'working from home' (0.794 and 0.692) and these are not in statistical terms significantly different.

Model 3: The separate effects of employer type and work arrangement, *not* differentiated between part time and full time workers.

In consequence, the coefficients relating to working arrangement and employment type for full and part time workers were not distinguished, with the results shown in the third model. These new variables were very significant but, as in the previous analysis, some increments were not significantly different from each other and were subsequently merged in Model 4.

The merged increments shown in model 4 are highly significant. The r-squared value for this model is as good as that for the original full cross-classified model.

The final model 5 introduced the non-workers into the statistical analysis, with their implied trip rate being close to zero. The introduction of this additional sample into the dataset has greatly increased the explanatory power of the model as shown by the much higher r-squared value.

A number of additional variables were tested but were found to be insignificant. These were:

- household size;
- household location (eg rural/urban);
- number of household vehicles.

The Final Model

These model results imply the final trip rates by employer type and work arrangement as shown in the following two tables.

Table 4-6 Full-Time Trip Rates

WA\ET	Paid Employee	Self Employed, Family Business and Employer of Others
Fixed Hours	1.51	1.30
Flexible Hours and Rostered Shifts	1.27	1.06
Works from Home	0.78	0.58

Table 4-7 Part-Time Trip Rates

WA\ET	Paid Employee	Self Employed, Family Business and Employer of Others
Fixed Hours	0.97	0.76
Flexible Hours and Rostered Shifts	0.73	0.52
Works from Home	0.24	0.03

■ **Table 4-8 HBW Models**

Model	Model 1		Model 2		Model 3		Model 4		Model 5	
Variable	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat
CONSTANT [PT, WA(1),ET(1,2,3,4)]	0.742	13.861								
CONSTANT [FT,WA(1),ET(1)]			1.524	60.942	1.507	63.277	1.507	63.475	1.507	82.802
FT-WA(1)ET(1)	0.776	13.077								
FT-WA(1)ET(2,4)	0.849	5.464								
FT-WA(1)ET(3)	0.484	3.38								
FT-WA(2)ET(1)	0.538	7.133								
FT-WA(2)ET(2,4)	0.214	2.402								
FT-WA(2)ET(3)	0.341	3.037								
FT-WA(3)ET(1,2,3,4)	0.493	5.434								
FT-WA(4)ET(1)	-0.087	-0.465								
FT-WA(4)ET(2,4)	-0.162	-1.105								
FT-WA(4)ET(3)	-0.264	-1.266								
PT-WA(2)ET(1)	0.143	1.871								
PT-WA(2)ET(2,3,4)	-0.181	-1.518								
PT-WA(3)ET(1,2,3,4)	0.086	0.795								
PT-WA(4)ET(1)	-0.532	-2.33								
PT-WA(4)ET(2,3,4)	-0.579	-3.909								
PT			-0.637	-10.609	-0.543	-13.669	-0.542	-13.73	-0.542	-17.911
FT – WA(2)			-0.275	-5.294						
FT – WA(3)			-0.284	-3.672						
FT – WA(4)			-0.794	-7.463						
FT – ET(2,4)			-0.209	-2.972						
FT – ET(3)			-0.218	-2.674						
PT – WA(2)			-0.177	-2.353						
PT – WA(3)			-0.064	-0.593						
PT – WA(4)			-0.692	-4.698						
PT – ET(2,4)			-0.017	-0.156						
PT – ET(3)			-0.125	-0.49						
WA(2)					-0.247	-5.833				
WA(3)					-0.22	-3.515				
WA(4)					-0.732	-8.54	-0.726	-8.556	-0.726	-11.161
ET(2,4)					-0.192	-3.272				
ET(3)					-0.219	-2.855				
WA(2,3)							-0.239	-6.256	-0.239	-8.161
ET(2,3,4)							-0.206	-4.186	-0.206	-5.461
Non Workers									-1.473	-63.75
R^2	0.118		0.117		0.117		0.118		0.422	

Notes: The first 4 models only include Workers (Sample size = 3319), the last run includes those who do not work (Sample size = 6031), which accounts for the large difference in R^2.

The overall result of the analysis is to confirm that work trip rates are sensibly different by full and part-time employee, work arrangement and employment type. Key results are:

- full time trip rates are 0.54 trips per day higher than the corresponding part time trip rate;
- employees who are either on rostered shifts or flexible hours have trip rates that are 0.24 trips per day lower than those on fixed hours;

- employees who work from home have trip rates that are 0.73 trips per day lower than those on fixed hours;
- employees who are self employed or work for a family business have trip rates that are 0.21 trips per day lower than those who are a paid employee, and
- non-workers have a trip rate of 0.03 home based work trips per day.

5. Home Based Education Productions

5.1 Segmentation and Escort Trip Allocation

The home based education model (HBEd) trip rates are based on the age of the trip maker. All persons have been categorised into 4 age groups:

- Primary school age (5-10 years),
- Secondary school age (11-16 years),
- Young Adult (17-25 years), or
- Adult (26+ years).

Three approaches have been tested for the allocation of education escort trips. A model has been calibrated for each of these alternatives. They are:

1) Base Model – Escort education trips are allocated to the person who actually makes the trip (e.g. the parent escorting a child to school).
2) Reallocated Escorts – Escort education trips are allocated to the person who actually generates the trip (e.g. the child will generate two trips is escorted by a parent).
3) No Escorts – No escort trips are included in the model.

5.2 Calibration

Table 5-1 details the model calibration results for these three models, in which age group 1 (5-10 year olds) is the base, to which the constant applies. Table 5-2 details the final implied trip rates for the three models by the age categories.

The Base Model

All parameters in the base model have high significance. As expected the trip rates decrease with age, particularly for post school age young adults and adults. The constant in this model refers to primary age children. To obtain the trip rate for other age groups the parameters should be added to this constant.

It was supposed that the trip rate for adults, while low at 0.17 trips per day, was due to escort trips. This has been tested in model 2.

Reallocated Escort Model

The model parameters for model 2 showed even higher significance after the reallocation of escort trips. As expected the trip rate for adults (calculated by the subtraction 2.269 – 2.255) of 0.014 trips per day has reduced substantially when compared to the base model. The primary trip rate has increased from 1.54 to 2.27 trips per day, and the secondary trip rate from 1.39 to 1.75, confirming the significance of escort trips for the school age categories.

This reallocation has also resulted in a higher r-squared value, indicating a better overall match to the data for this model.

No Escort Model

A third model was tested removing the escort trips altogether. Again all coefficients were extremely significant. The removal of all escort trips reduced the trip rates for the primary and secondary students by 0.8 and 0.4 trips per person respectively. The tertiary student trip rate only dropped marginally (because, as might be expected, few are escorted), while as expected the adult trip rate remained constant as generally adults will not be escorted.

■ **Table 5-1 HBEd Models**

Model	Base Model		ReallocatedEscort		NoEscort		
Variable	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat	Description
CONSTANT	1.544	55.784	2.269	77.832	1.493	80.857	AgeGroup1: 5-10 years old
AGEGR2	-0.155	-4.004	-0.521	-12.769	-0.155	-5.981	AgeGroup2: 11-16 years old
AGEGR3	-1.207	-32.132	-1.932	-48.837	-1.189	-47.435	AgeGroup3: 17-25 years old
AGEGR4	-1.37	-46.286	-2.255	-72.293	-1.479	-74.855	AgeGroup1: 26+ years old
R^2	0.365		0.555		0.602		

■ **Table 5-2 Implied Trip Rates**

Age Group	Base Model	Reallocated Escort	No Escort
5-10 Years	1.544	2.269	1.493
11-16 years	1.389	1.748	1.338
17-25 Year	0.337	0.337	0.304
26+ Years	0.174	0.014	0.014

The reallocated escort model appears to give the best overall result, as it includes all of the trips we are interested in (ie includes escorts). This model suggests a trip rate of 2.27 trips per primary school age child (including generated escort trips). Secondary school students have a trip rate some 0.52 trips per person lower than primary school aged children, while young adults have a trip rate a further 1.41 trips per day lower. The final adult trip rate as expected is nearly zero at 0.014 trips per day.

A number of additional variables were tested but were found to be insignificant. These were:

- household location (eg rural/urban);
- number of household vehicles.

6. Home Based Shopping Productions

6.1 Person Segmentation

The primary explanatory variable tested for the home based shopping model was person type, with separate trip rate calibrations tested for each person type category. These person type categories are shown below, together with their sample size.

Table 6-1 Person Categorisation Sample Sizes

PersonType	Description	Sample Size
2	Age 5-10	594
3	Age 11-16	620
4	Age 17-25 Full-Time Employed	294
5	Age 17-25 Part-Time Employed	196
6	Age 17-25 Other	216
7	Age 26-65 Full-Time Employed	2103
8	Age 26-65 Part-Time Employed	597
9	Age 26-65 Other	717
10	Age 65+ Full-Time Employed	21
11	Age 65+ Part-Time Employed	39
12	Age 65+ Other	634

In the model result tables these person types are referred to as PType(1), Ptype(2) etc. Where these categories have been aggregated for analysis they are noted as PType(2,3) for example.

6.2 Calibration

Table 6-3 details the results from the statistical analysis of the five key stages in the development of the model. Infants, or person type 1, have of course been excluded from the model as they were not required to complete a trip diary and hence no trips are attributable to them in the final calibration database.

Model 1: The Basic Person Type Model

This model is based on the person type categorisation only, with no aggregations across categories. Person type 2 (age 5-10 years) is the base, to which the constant applies. The initial basic model indicated reasonable significance for most of the coefficients of the person categories excepting secondary school age children (Person Type 3) and full time employed young adults (Person Type 4).

It appeared that the parameters for the "part time employed" and "other" categories were not significantly different within each age band (see, for example, Ptype(5) and Ptype(6)). Aggregations of these parameters were tested in model 3.

Model 2: The Full Household Effects Model

A number of additional household based effects were tested, including, vehicle ownership, household size and household location (urban, rural etc). None of these parameters proved significant (all t-statistics were less than 2), and overall this model

did not add significant explanatory power to the model (the r-squared value increased by 0.001).

Model 3: Aggregated Person Types and Vehicle Effects Model

Following the results of model 1, the part time workers and "other" person categories within each age band have been aggregated to create a simpler person type categorisation. This model was then tested with the addition of a vehicle ownership parameter.

While the person category coefficients were highly significant (with the exception of full time employed young adults), the vehicle parameter remained insignificant.

Models 4 and 5: Aggregated Person Types Model Without/With Income

The aggregated person type model was then tested with and without an income parameter. All person category parameters remained significant in each case (excepting full time employed young adults). The household income parameter remained insignificant.

The Final Model

The table below illustrates the final trip rates suggested by the adopted model 4.

Table 6-2 Final Home Based Shopping Trip Rates

Heading	Full Time Employed	Other
Children (6-16 Years)		0.35
Young Adults (17-25 Years)	0.41	0.74
Adults (26-65 Years)	0.54	1.22
Older Adults (66+ Years)	0.81	1.29

The key observations of these rates are:

- persons who are either part-time employed or not employed have a higher trip rate than the corresponding full time employed persons (0.33 higher for young adults, 0.68 for adults and 0.48 for older adults).
- trip rates increase with age.

In addition the effect of the presence of children on person trip rates was tested, and found to be insignificant.

■ **Table 6-3 HBSh Models**

Model	Model 1		Model 2		Model 3		Model 4		Model 5	
Variable	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**
CONSTANT [Ptype(2)]	0.322	7.185								
CONSTANT [Ptype(2,3),Vehicles(0)]					0.318	5.23				
CONSTANT [Ptype(2,3)]							0.352	11.233	0.368	9.692
CONSTANT [Ptype(6),Hsize(1), Vehicles(0), Loc(WCBD)]			0.763	7.601						
Ptype (2)			-0.434	-4.965						
Ptype (3)	0.059	0.944	-0.38	-4.381						
Ptype (4)	0.083	1.07	-0.396	-4.02	0.052	0.733	0.053	0.748	0.058	0.818
Ptype (5)	0.388	4.314	-0.071	-0.66						
Ptype (6)	0.452	5.211								
Ptype(5,6)					0.392	6.301	0.391	6.285	0.391	6.287
Ptype (7)	0.218	4.305	-0.251	-3.178	0.186	4.729	0.188	4.78	0.193	4.839
Ptype (8)	0.868	13.728	0.404	4.64						
Ptype (9)	0.931	15.383	0.472	5.544						
Ptype (8,9)					0.873	20.087	0.872	20.078	0.869	19.949
Ptype (10)	0.488	2.015	-0.013	-0.053	0.455	1.895	0.458	1.906	0.461	1.919
Ptype (11)	1.345	7.461	0.852	4.443						
Ptype (12)	0.943	15.148	0.46	5.105						
Ptype (11,12)					0.939	17.852	0.937	17.862	0.928	17.335
Hsize(2)			0.056	0.984						
Hsize(3)			-0.047	-0.72						
Hsize(4)			-0.029	-0.445						
Hsize(5+)			-0.011	-0.167						
Vehicles(1)			0.036	0.611						
Vehicles(2)			0.016	0.252						
Vehicles(3+)			0.123	1.749						
Vehicles(1,2,3+)					0.036	0.652				
Loc(WCCUrban)			0.01	0.118						
Loc(Porirua)			-0.064	-1.333						
Loc(UpperHutt)			0.08	1.288						
Loc(LowerHutt)			-0.08	-1.274						
Loc(Other)			-0.018	-0.517						
Household Income									0	-0.755
R^2	0.101		0.102		0.101		0.101		0.101	

WCBD: the Wellington CBD

WCCUrban: WCC urban areas that are not in the CBD.

7. Home Based Other Productions

7.1 Person Segmentation

The person segmentation in Table 6-1 for the home based shopping models is also the starting point for the HBO trip rates.

7.2 Calibration

As for Home Based Shopping, this model is based primarily on person type categories, but household income, household size, number of children in the household and household vehicle ownership have also been tested. Table 7-1 details the calibration results for the five key stages of model development.

Model 1: The Basic Person Type Model

This model includes all person types and vehicle ownership. The coefficients for person types 3, 4, 7, 10 & 11 are not significant, generally only the trip rates for the part time and 'other' categories being significantly higher than the base person type (children). Vehicle ownership is highly significant.

Model 2: Aggregation of Person Types and the Effects of Children

Given the results of model 1, we combined:

- children with teenagers,
- young and other full time employed adults,
- part time workers and 'other' persons.

Initial analysis of variance had suggested that the presence of children in a household had a significant impact on person trip rates, particularly for adults. This model therefore also tested the effect of differing numbers of children in the household.

All parameters in this model are highly significant, including all three children coefficients. The r-squared value has also increased from 0.036 to 0.043 indicating an improvement to the explanatory power of the model.

Model 3: Other Household Characteristics

This model additionally tested the effects of household income and household size. For simplicity, we also combined the three 'presence of children' categories (2 of the 3 coefficients were not significantly different) and the vehicle ownership categories (into a 1 or more vehicles category). Income proved to be significant but not household size, and the r-squared value increased further to 0.045.

Model 4: Preferred Model

Following further analyses of the interactions between the presence of children and household size, we defined 2 new variables:

- a modified household children variable (ChildTest) applying to young adults and adults where there are children in the household (but not applying to retired persons), and
- we distinguished persons living alone from other households.

In addition the vehicle ownership coefficient has been modified to distinguish single and multiple car owning households.

The majority of parameters in this model were highly significant, particularly the ChildTest parameter. This model shows the most explanatory power with an r squared of 0.050.

Model 5: Alternative Model without Children

A fifth model was tested that modified model 4 by removing the children parameter. This was tested to check the effects of the children parameter independently. The results clearly indicate that the performance of the model has decreased.

The Final Model

Model 4 has been adopted as the preferred model for the reasons outlined above. The key results from this model indicate:

- the highest trip rates belong to adults not employed full time, who own 2 or more vehicles, with children, at 1.82 trips per day before the effect of household income; older adults who work full time have the lowest trip rates;
- full time worker trip rates are lower than part time and non working persons;
- trip rates increase with household income,
- the trip rate per person is 0.20 trips per day lower for single person households compared to households with more than one person,
- trips rates are higher in single and multi-car owning households.

The final trip rates are shown in the table below.

Table 7-1 Final Home Based Other Trip Rates

Person Type	With No Children		With 1 Child		With 2+ Children	
	Full Time Employed	Other	Full Time Employed	Other	Full Time Employed	Other
Children (6-16 Years)		0.57		0.57		0.57
Young Adults (17-25 Years)	0.361	0.726	0.595	0.96	0.829	1.194
Adults (26-65 Years)		0.975		1.209		1.443
Older Adults (66+ Years)	0.207	0.748	0.207	0.748	0.207	0.748
Additional Parameters (adjustments to trip rates above)						
With 1 Vehicle	+0.304					
With 2+ Vehicles	+0.411					
Household Size 2+	-0.198					
Household Income (000's)	+0.001 by income					

■ **Table 7-2 HBO Models**

Model	Model 1		Model 2		Model 3		Model 4		Model 5	
Variable	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**
CONSTANT - Ptype(2)+Veh(0)	0.468	5.493								
CONSTANT – Ptype(8,9) + Child(0)			1.208	28.063						
CONSTANT – Ptype(8,9) + Child(0) + Vehicles(0)					0.921	11.064	0.975	12.2	1.134	14.4
Ptype(3)	0.005	0.069								
Ptype(2,3)			-0.784	-13.34	-0.76	-13.12	-0.405	-7.01	-0.605	-11.172
Ptype(4)	0.066	0.674								
Ptype(7)	-0.048	-0.764								
Ptype(4,7)			-0.56	-12.02	-0.617	-12.818	-0.614	-12.77	-0.658	-13.646
Ptype(5)	0.427	3.817								
Ptype(6)	0.214	1.983								
Ptype(5,6)			-0.258	-3.372	-0.287	-3.711	-0.249	-3.263	-0.287	-3.741
Ptype(8)	0.522	6.637								
Ptype(9)	0.668	8.862								
Ptype(10)	-0.367	-1.218	-0.732	-2.457	-0.792	-2.661	-0.768	-2.586	-0.974	-3.266
Ptype(11)	0.007	0.029								
Ptype(12)	0.199	2.537								
Ptype(11,12)			-0.29	-4.339	-0.269	-3.969	-0.227	-3.325	-0.42	-6.401
+Child(1)			0.228	4.307						
+Child(2)			0.432	8.102						
+Child(3+)			0.411	7.121						
+Child(1,2,3+)					0.348	6.319				
+ChildTest*							0.234	9.553		
+Household Income					0.001	2.224	0.001	2.386	0.001	1.885
+Household Size					-0.007	-0.318				
+Household Size (2,3,4,5+)							-0.198	-3.4	-0.151	-2.573
+Vehicles(1)	0.293	4.041								
+Vehicles(2)	0.429	5.849								
+Vehicles(3)	0.339	4.067								
+Vehicles(1,2,3+)					0.29	4.068	0.304	4.106	0.312	4.196
+Vehicles(2,3+)							0.107	2.632	0.117	2.86
R^2	0.036		0.043		0.045		0.050		0.036	

Notes:

- * ChildTest – 0 for child/teenager, over 65's and all members of h'holds who have no children, 1 for Adults (inclusive of young adults) with 1 child in h'hold, 2 for Adults with 2+ children.

8. Non-Home Based Other Productions

8.1 Segmentation

The non home based other model person segmentation is that used in both the home based shopping and the home based other models.

8.2 Calibration

Table 8-1 details the model calibration results for five key stages in the non home based trip production model development. The primary explanatory variables used were person types, although household effects have also been tested, including vehicle ownership, household location, household size, the presence of children and household income.

Model 1: The Basic Person Type and Household Effects Model

This model tested the effect of all person type categories on the trip rate and in addition tested vehicle ownership levels, household location (WCC CBD, WCC Urban, Porirua Urban, Upper Hutt Urban, Lower Hutt Urban, Other). Most coefficients are significant.

Model 2: Aggregated Person Types and Household Effects Model

In this model, we have combined person types with statistically similar trip rates:

- all full time employed persons (Young Adults, Adults and Older Adults),
- part time employed young adults and adults,
- 'other' young adults and adults,
- part time and 'other older adults.

These variables were tested with parameters for each level of vehicle ownership, and the aggregation of household location suggested from the model 1 results (distinguishing Porirua and Lower and Upper Hutts).

All coefficients in this model proved highly significant. The vehicle parameters were not significantly different from each other, suggesting an aggregation across ownership levels.

Model 3: Aggregated Vehicle Ownership

This model aggregated the vehicle ownership categories into a single 1+ car owning group. It also distinguished rural area trip rates. All variables were significant in this model except the rural location parameter.

Model 4: The Final Model

In the final model, Wellington City trip rates were distinguished from other urban areas.

In summary, the main variations in the trip rates for this model are:

- the lowest trip rates are for children and retired people, while young adults and adults employed part-time have the highest trip rates;

- households that own a vehicle have a trip rate 0.31 higher than those without a vehicle;
- households in WCC have trip rates 0.14 trips per day higher than those outside WCC.

The final trip rates are shown in the table below.

Table 8-1 Final Non Home Based Other Trip Rates

Person Type	Full Time Employed	Part Time Employed	Other
Children (6-16 Years)			0.612
Young Adults (17-25 Years)	1.18	1.578	1.138
Adults (26-65 Years)			
Older Adults (66+ Years)		0.81	
Additional Parameters (adjustments to trip rates above)			
Locations not in Wellington City		-0.138	
With 1 or more vehicles		+0.309	

A number of additional variables were tested but were found to be insignificant. These were:

- the presence of children;
- household income.

■ Table 8-2 NHBO Models

Model	Model 1		Model 2		Model 3		Model 4	
Variable	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**
CONSTANT – Ptype(2) + Loc(WCBD) + Veh(0)	0.62	5.263	0.578	5.723	0.626	5.954	0.612	5.826
Ptype(3)	0.008	0.074						
Ptype(4)	0.635	4.957						
Ptype(7)	0.553	6.659						
Ptype(10)	0.645	1.632						
Ptype(4,7,10)			0.572	9.105	0.568	9.04	0.568	9.031
Ptype(5)	0.774	5.258						
Ptype(8)	1.017	9.848						
Ptype(5,8)			0.962	11.819	0.958	11.781	0.966	11.878
Ptype(6)	0.431	3.04						
Ptype(9)	0.559	5.653						
Ptype(6,9)			0.532	6.84	0.525	6.772	0.526	6.806
Ptype(11)	0.272	0.926						
Ptype(12)	0.2	1.941						
Ptype(11,12)			0.195	2.235	0.183	2.136	0.198	2.102
Loc(WCCUrban)	-0.01	-0.073						
Loc(Porirua)	-0.222	-2.864						
Loc(UpperHutt)	-0.128	-1.265						
Loc(LowerHutt)	-0.399	-3.891						
Loc(Porirua,Hutts)			-0.185	-3.543	-0.236	-3.797		
Loc(Rural)	-0.09	-1.572			-0.08	-1.457		
Loc(Non WCCUrban)							-0.138	-3.576
Vehicle(1)	0.277	2.901	0.263	2.765				
Vehicle(2)	0.321	3.327	0.305	3.178				
Vehicle(3)	0.345	3.132	0.319	2.923				
Vehicle(1,2,3)					0.296	3.228	0.309	3.134
R^2	0.032		0.032		0.032		0.032	

9. Business Trip Productions

9.1 Segmentation

The person segmentation for the business trips model is based on the employment category segmentation developed for the Home Based Work model (Table 4-1, detailing the work arrangement and employer type categories).

9.2 Calibration

Table 9-1 details the model calibration results for a number of models tested. The major effects tested were employment categories, while additionally various effects of vehicle ownership have been tested.

Model 1: Employment Effects Model

The effect of each employment category was tested in this model, with the significance of the coefficients ranging from insignificant (e.g. fulltime paid employees who work from home –FT WA[4]ET[1]) to highly significant (e.g. fulltime paid employees on fixed hours – FT WA[1]ET[1]).

Model 2: Employment and Vehicle Ownership Level Effects Model

The effect of the presence of a household vehicle on trip rates has been tested in this model. This vehicle parameter was not significant.

Model 3: Aggregated Part Time Employment Effects Model

The trip rates predicted for the part time employee categories were not significantly different and therefore were combined. This coefficient was significant, part time workers having a lower business trip rate.

Model 4: The Final Model: Aggregated Employment and Vehicle Effects Model

Further aggregations were made across the full time employed categories where coefficient values were not statistically different. Most work arrangements were combined across employee types (e.g. self employed or family business or employer of others) and those on rostered shifts were aggregated with part time employees.

Following tests of different levels of vehicle ownership, the number of vehicles was determined to be the best explanatory variable and is tested in this model (applied to employed persons). Each parameter in this model was significant.

The final trip rates are presented in the two tables below.

- **Table 9-1 Full-Time Worker Employers Business Trip Rates**

	Paid Employee	Self Employed, Family Business and Employer of Others
Fixed Hours	0.277	1.779
Flexible Hours	0.704	1.722
Rostered Shifts	0.094	
Works from Home	1.093	

■ **Table 9-2 Part-Time Worker Employers Business Trip Rates**

	All Workers
Part Time Workers	0.094

Additionally these trip rates are increased as vehicle ownership increases with an extra 0.158 trips per day for employees whose household has 1 car, and an extra 0.316 trips per day for households with 2 or more cars.

In summary the final model trip rates suggest:

- the lowest trip rate is for non workers with no vehicles at 0.005 trips per day (arises because of the inclusion of employers business escort trips, where the escorting person may not themselves be employed)
- part time or shift workers are next lowest with a trip rate of 0.09 trips per day for those without household vehicles,
- the highest trip rates are those employees with fixed hours that are either self employed or employers of others at 1.78 trips per day plus vehicle ownership effects,
- of full time employed persons, paid employees generally have lower trip rates than those who are self employed or employers.

A number of additional variables were tested but were found to be insignificant. These were:

- household location (eg urban/rural);
- household income.

■ **Table 9-3 BU Models**

Model	Model 1		Model 2		Model 3		Model 4	
Variable	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**
CONSTANT – FT-WA(1)ET(1)	0.565	11.724			0.566	11.736		
CONSTANT – FT-WA(1)ET(1) + Vehicles(0)							0.277	3.419
CONSTANT – Non Workers + Vehicles(0)			-0.106	-1.168				
FT-WA(1)ET(1)			0.551	9.147				
FT-WA(1)ET(2,4)	1.321	4.72	1.867	6.714	1.32	4.719		
FT-WA(1)ET(3)	1.68	6.568	2.226	8.77	1.679	6.567		
FT-WA(1)ET(2,3,4)							1.502	7.844
FT-WA(2)ET(1)	0.432	3.876	0.981	9.203	0.431	3.87	0.427	3.842
FT-WA(2)ET(2,4)	1.63	11.386	2.181	15.631	1.629	11.384		
FT-WA(2)ET(3)	1.205	6.253	1.753	9.219	1.205	6.251		
FT-WA(2)ET(2,3,4)							1.445	12.089
FT-WA(3)ET(1,2,3,4)	-0.221	-1.503	0.331	2.315	-0.221	-1.508		
FT-WA(4)ET(1)	0.469	1.368	1.015	2.973	0.468	1.366		
FT-WA(4)ET(2,4)	1.075	4.085	1.621	6.206	1.074	4.083		
FT-WA(4)ET(3)	0.782	2.036	1.329	3.469	0.782	2.034		
FT-WA(4)ET(1,2,3,4)							0.816	4.364
PT-WA(1)ET(1)	-0.148	-1.301	0.407	3.733				
PT-WA(2)ET(1)	-0.203	-1.813	0.35	3.266				
PT-WA(2)ET(2,3,4)	-0.102	-0.491	0.446	2.173				
PT-WA(3)ET(1,2,3,4)	-0.292	-1.585	0.257	1.417				
PT-WA(4)ET(1)	-0.25	-0.591	0.303	0.72				
PT-WA(4)ET(2,3,4)	-0.198	-0.745	0.353	1.34				
Part Time Workers					-0.188	-2.411		
Part Time Workers + FT-WA(3)ET(1,2,3,4)							-0.183	-2.478
Non Workers	-0.56	-9.391			-0.561	-9.403	-0.272	-3.08
+Vehicles(1,2,3)			0.125	1.329				
+VehiclesNumber							0.158	4.428
R^2	0.077		0.077		0.078		0.081	

Appendix A Trip Production Code Book

Trip Production Data

Field	Description	Value	Meaning of Value (Where applicable)
HID	Household Questionnaire Number	0001-9999	-
PID	Person in Household is assigned Number (Oldest To Youngest)	1-10	Person ID Number, only those who completed trips on a weekday
HHoldType	Household is classified by the number of adults and employment	1 2 3 4 5	1 Adult, Full or Part-Time Employed 1 Adult, Other 2 Adults, One or more Full or Part-Time Employed 2 Adults, Other 3+ Adults
HHoldNum	Number of People who usually live in the Household	1-9	Number Residents
HNumAdults	Number of Adults who usually live in the Household	1-9	Note: Adult born before 1985
HVehNum	Number of Vehicles the Household Usually Uses (Parked at/near the House overnight)	0-10	Note: Vehicles only Car/Stationwagon, 4-Wheel Drive, and Van/Ute
CarAvailability	Ratio of: (No. of Vehciles)/ (No. of Adults)	0 1 2	Captive - Ratio=0 Competition - Ratio between 0 and 1 Choice - Ratio >= 1
HZone	Zone Number Household is in	0-227	-
HHoldLocation	Determine where the household is in relation to Urban, Rural, and City	1 2 3 4 5 6	WCC CBD Inner WCC Urban Outer Porirua Urban Upper Hutt Urban Lower Hutt Urban Other
TLA	TLA Number Household is in	43-50	-
PersonType		1 2 3 4 5 6 7 8 9 10 11 12	Infant, age<5 Child, age 5-10 (primary sch. age) Child, 11-16 Young Adult, age 17-25, Full-Time Employed Young Adult, age 17-25, Part-Time Employed Young Adult, age 17-25, Other Adult, age 26-65, Full-Time Employed Adult, age 26-65, Part-Time Employed Adult, age 26-65, Other Other Adult, age >65, Full-Time Employed Other Adult, age >65, Part-Time Employed Other Adult, age >65, Other
PBirth	Year of Birth	1905-2001	Note must be born before 1997
PWork	Type of Worker, note: take smallest value for multiple selections	1 2 0	Full-Time Worker Part-Time Worker or Casual Worker Not Currently Working
PEducation	Education Status of Person	1 2 4 5 6 7 0	Primary Student Intermediate, Secondary Student Uni Full-Time Student Uni Part-Time Student Education Other Full-Time Student Education Other Part-Time Student Not Currently Studying

Field	Description	Value	Meaning of Value (Where applicable)
PWorkArrangements	Work Arrangements, note: if multiple arrangements, if 4 is possible, then selected, else smallest value selected	4 1 2 3 0	Work from Home Work Fixed Hours Work Flexible Hours Works Rostered Shifts Not Currently Working
PEmploymentType	Employment Type, note: if multiple arrangements, smallest value selected	1 2 3 4 0	Paid Employee Self-Employed Is an Employer Works for Family Bus. Not Currently Working
POccupation	Occupation of the Person	1-97 -1 99	See Lists for details Did not Need To Ans. Refused to Answer
PIndustry	Industry of the Person	11-96 -1 99	See Lists for details Did not Need To Ans. Refused to Answer
HBW	Home Based Work Trips	0-….	Number of Trip of that Purpose (Includes Escort)
HBEd	Home Based Education Trips	0-….	Number of Trip of that Purpose
HBEd(E)Primary	Home Based Escort Education Trips (Primary Based)	0-….	Number of Trip of that Purpose
HBEd(E)Secondary	Home Based Escort Education Trips (Secondary Based)	0-….	Number of Trip of that Purpose
HBEd(E)Tertiary	Home Based Escort Education Trips (Tertiary Based)	0-….	Number of Trip of that Purpose
HBSh	Home Based Shopping Trips	0-….	Number of Trip of that Purpose (Includes Escort)
HBSo+HBO	Home Based Social and Home Based Other Trips	0-….	Number of Trip of that Purpose (Includes Escort)
NHBO	Non-Home Based Other Trips	0-….	Number of Trip of that Purpose (Includes Escort)
BU	Business Trips (HB and NHB)	0-….	Number of Trip of that Purpose (Includes Escort)

Wellington Transport Strategy Model

TN16.3 Trip Attractions Report

Final

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prepared for

Greater Wellington – The Regional Council

By

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1. Data Analysis File and Sector System

1.1 Introduction

The data analysis file is based on trip attractions by purpose at a zonal level and information pertaining to that zone (such as the number of residents in the zone). The trip attraction file was constructed from the same survey data used in the trip production analysis file, that is data from the Wellington Regional Council (such as major attractors) and land use data from MERA.

To increase the statistical reliability of the estimates of travel (i.e. the sample size in each calibration area), zones were aggregated on a geographic basis into sectors for model calibration. Care was taken to ensure aggregated zones were compatible in terms of land use and/or their level of accessibility. A number of zones were not aggregated, such as the airport zone. The sector system is further detailed in section 1.4.

The structure of the Trip Attraction file produced can be seen in Table 1-1 below. This structure is identical at either the zonal or sector level.

Table 1-1 Trip Attraction File (Zonal/Sector level)

Field Number	Field Name	Description
1	Zone/Sector	All internal zones – Zone File Only Zones Aggregated in groups of (2-5) – Sector file only
	Survey Data	
2	HBW	All Home-Based Work trips attracted to that zone/sector
3	HBEd	All Home-Based Education trips attracted to that zone/sector
4	HBSh	All Home-Based Shopping trips attracted to that zone/sector
5	HBO	All Home-Based Other trips attracted to that zone/sector
6	NHBO	All Non Home-Based Other trips attracted to that zone/sector
7	BU	All Business trips attracted to that zone/sector – HBEB/NHBEB
	MERA/WRC Data	
8	Leisure_Entertainment	Zone/Sector contains a Leisure/Entertainment place (Value= 0 or 1)
9	Parks_Reserves	Zone/Sector contains a Park/Reserve (Value= 0 or 1)
10	Public_Services	Zone/Sector contains a Public Service place (Value= 0 or 1)
11	Sports_Grounds	Zone/Sector contains Sports Grounds (Value= 0 or 1)
12	Shopping_Places	Zone/Sector contains Shopping Places (Value= 0 or 1)
13	INFNTS	No. of Infants in the zone/sector
14	CHLD5_10	No. of 5-10 year old Children in the zone/sector
15	CHLD11_16	No. of 11-16 year old Children in the zone/sector
16	YGAD_FTE	No. of Young Adults Full-Time Employed in the zone/sector
17	YGAD_PTE	No. of Young Adults Part-Time Employed in the zone/sector
18	YGAD_OTH	No. of Young Adults Other in the zone/sector
19	ADLT_FTE	No. of Adults Full-Time Employed in the zone/sector
20	ADLT_PTE	No. of Adults Part-Time Employed in the zone/sector
21	ADLT_OTH	No. of Adults Other in the zone/sector
22	OAP_FTE	No. of Older Adults Full-Time Employed in the zone/sector
23	OAP_PTE	No. of Older Adults Part-Time Employed in the zone/sector
24	OAP_OTH	No. of Older Adults Other in the zone/sector
25	PSN_PD_TOTAL	Total No. of people in the Zone/Sector
26	ADLT1_EMP	1 Adult household with at least one employed Adult
27	ADLT1_OTH	1 Adult household with no employed Adults
28	ADLT2_EMP	2 Adults household with at least one employed Adult
29	ADLT2_OTH	2 Adults household with no employed Adults
30	ADLTS3	3+ Adults household
31	HHTOTAL	Total No. of households in the Zone/Sector
32	Other	Other employment in the zone/sector (see Table 1-2)
33	Manufac	Manufacturing employment in the zone/sector (see Table 1-2)
34	Retail	Retail employment in the zone/sector (see Table 1-2)
35	TransCom	Transport and Communications employment in the zone/sector (see Table 1-2)

Field Number	Field Name	Description
36	Services	Services employment in the zone/sector (see Table 1-2)
37	EmployTotal	Total Employment in the zone/sector
38	AREA	Area of the zone/sector (Square metres)
39	Location	Location of the zone/sector (6 – regions, see Production table for regions)
40	PrimarySch	No. of Children enrolled in Primary Schools in the zone/sector
41	SecondarySch	No. of Children enrolled in Secondary Schools in the zone/sector
42	TertiarySch	No. of Children enrolled in Tertiary Institutes in the zone/sector

1.2 Survey Data

The same trip data used in the Trip Productions modelling was used to produce the trip attraction file with each trip allocated by purpose to the attraction zone of that particular trip. Data from three other surveys was appended to the trip production data. The following data was added:

1) screenline survey trip attractions at sites 1 and 3 (expanded) for all purposes replaced the household survey external trips, - site 2 was not used as it is an internal site and duplicated data collected in the household survey (see Roadside Interview Survey Report),
2) HBW and HBEd (expanded) trips from the rail survey replaced the corresponding trips from the household survey, and
3) all bus trips (expanded) from the school survey were combined[1] with the household survey HBEd trips.

1.3 Planning Data

Planning and land use data were sourced from both the Wellington Regional Council and MERA.

Fields 8-12 in Table 1-1 were generated using data from WRC at the meshblock level. The remaining planning data in the trip attraction file was obtained from MERA. Employment was aggregated to just 5 categories, as can be seen in Table 1-2. “Not Legible” was combined with “Others” (the most general employment category).

Table 1-2 Employment Categories

Industry	Employment Category	Total Employed
Agriculture Forestry Hunting Fishing	Other	5579
Mining	Maufacturing	130
Manufacturing	Maufacturing	17799
Utilities	Maufacturing	709
Building and Construction	Maufacturing	9328
Wholesale Retail Restaurants Hotels	Retail	41664
Transport and Communications	Transport and Communications	10868
Finance Real Estate and Business Services	Services	46196
Government Community Social Personal Services	Services	76395
Not Legible	Other	355

[1] The data sources by combined using weighs based on the relative sampling rates.

1.4 Sector System

The Wellington region contains 225 zones. As detailed in Section 1.1, a sector system was established to ensure greater statistical reliability in the calibration area trip totals. Depending on the trip purpose, the average number of sampled trips per zone from the household survey is 10-30 trips. Although we have increased this by also using the intercept surveys, the zonal attraction confidence intervals are wide. By merging zones we have tripled the average number of sampled trips per calibration area to a level which we judged appropriate and thus increased the reliability of the individual observations on which the attraction model is based.

The sector system was created by manually looking at each region and joining adjacent, like zones together. Some specific zones (the airport zone and the wharf zone surrounding the CBD) were not aggregated due to their unique characteristics. The maximum number of zones joined was five. This resulted in seventy-four sectors. The zonal aggregation to sectors can be seen in Table 1-3.

Table 1-3 General Sector System

Sector	Zones contained in sector					Trips	Sector	Zones contained in sector					Trips
1	1	2	3			20805	38	112	113				2420
2	4	5	6			11387	39	114	115	116			12466
3	7					5234	40	117	119	120	121		75238
4	8	9	14	20		78748	41	118	122	123			18015
5	10	11	12			10333	42	124	125	126			30477
6	13	19	21	22		33448	43	127	128	130			2228
7	15	16	17			15480	44	129	131				20797
8	18	23	24			6502	45	132	149				1748
9	25	26	27	55		25444	46	133	134	135	136	137	11495
10	28	29	34	35		18849	47	138	140	141			50912
11	30	31	32	33		36432	48	139	144				6142
12	36	37	61			15077	49	142	143				11759
13	38	39				27330	50	145	151	152	153		15915
14	40	41	42			16859	51	146	147	148	150		21802
15	43	44	45			17313	52	154	159				5265
16	46	51				17940	53	155	156	161	162		14265
17	47	48				53761	54	157	158	160			16349
18	49	59				42077	55	163	166				6806
19	50	52	53			58163	56	164	165	167	168		30562
20	54	56	57			27961	57	169	192				7106
21	58	63				22027	58	170	171	172			21070
22	60	62				38861	59	173	203	204			12341
23	64					9247	60	174	198	199	202		15892
24	65	66				37479	61	175	176	187			14372
25	67	68	69	70	81	15086	62	177	178	181			41772
26	71	72	73	74	76	27782	63	179	180	182	183		29129
27	75	77	82	83		43748	64	184	185	186			30933
28	78	79	80	84	85	19726	65	188	189	197			19846
29	86	87				9568	66	190	191	195	196		49537
30	88	89	90	91		24570	67	193	194				5406
31	92	93	97			56260	68	200	201	205			15010
32	94	95	96			12461	69	206	213	224			4698
33	98	99	100			10533	70	207	208	218			11250
34	101	102				9225	71	209	217	222	225		19830
35	103	104	105			11599	72	210	211	212			108313
36	106	107	108			14917	73	214	215	216	220		9292
37	109	110	111			14161	74	219	221	223			2914

A second zonal aggregation (seen in Table 1-4) was required for home based shopping as shopping centres were required to remain separated from other zones. This resulted in 88 calibration sectors. These shopping centre zones were distinguished through a two-fold process; firstly a number of zones were attracting a disproportionate amount

of trips, inspection of the Wellington Street map confirmed these were major shopping centres. Secondly the other major shopping centres that were referenced on the Wellington Street map were also flagged. These corresponded to the zones indicated as containing shopping places as discussed in Table 1-1. The shopping centres flagged were major retail centres rather than the local suburban shopping strips.

■ **Table 1-4 HBSh Sector System**

Sector	Zones contained in sector					HBSh Trips	Sector	Zones contained in sector					HBSh Trips
1	1	2	3			3896	45	114	115	116			1332
2	4	5	6			2115	46	117	120	121			7675
3	7					161	47	118	122	123			1259
4	8	20				1596	48	119					14169
5	9					11368	49	124	126				1361
6	14					6321	50	125					6261
7	10	11	12			523	51	127	128	130			194
8	13	19	21	22		6141	52	129	131				4425
9	15	16	17			3517	53	132	149				0
10	18	23	24			948	54	133	134	135	136	137	1443
11	25	26	27	55		3448	55	138	141				1496
12	28	29	34	35		4865	56	139	144				203
13	30					6658	57	140					17113
14	31	32	33			1905	58	142	143				1117
15	36	37	61			919	59	145	151	152	153		1404
16	38	39				3643	60	146	147	148	150		2508
17	40	41	42			1676	61	154	159				322
18	43	44	45			1280	62	155	156	161	162		3149
19	46	51				1929	63	157	158	160			1396
20	47					2656	64	163	166				1556
21	48					7034	65	164	165	167	168		7553
22	49	59				1856	66	169	192				165
23	50	52	53			6841	67	170	171	172			3331
24	54	56	57			2156	68	173	203	204			2668
25	58	63				1489	69	174	198	199	202		4290
26	60	62				1680	70	175	176	187			1018
27	64					131	71	177	178				744
28	65	66				2536	72	179					4829
29	67	68	69	70	81	1280	73	180	182	183			2537
30	71	72	73	74	76	4268	74	181					12753
31	75	82	83			2164	75	184	185	186			2502
32	77					14183	76	188	189	197			1689
33	78	79	80	84	85	1407	77	190	191	196			2092
34	86	87				725	78	193	194				153
35	88	89	90	91		3886	79	195					7264
36	92	93				4264	80	200	201	205			3376
37	94	95	96			1803	81	206	213	224			1113
38	97					12078	82	207	208	218			2499
39	98	99	100			1826	83	209	217	222	225		2889
40	101	102				1614	84	210					1673
41	103	104	105			1880	85	211					8184
42	106	107	108			3414	86	212					11833
43	109	110	111			2731	87	214	215	216	220		565
44	112	113				481	88	219	221	223			235

2. Attraction Model Statistical Approach

2.1 Calibration Statistics

As with the trip productions, the trip attraction models have been calibrated using linear regression software. The trip attraction models were calibrated at a sector level. When calibrating the models, t-statistics, r-squared values, standard errors and residual sum of squares values have been used to help us determine the best model. This data alone is not enough to determine the model, as the statistics produced can be misleading, and so careful manual consideration of the model fit is required as well. This generally has involved inspecting plots of predicted and observed attractions identifying and analysing outliers.

The tests involved to compare and find the best model are:

- a higher r-squared value indicates a model explains more of the sample variance than another model;
- we generally would aim for T-statistics greater than 2 to indicate that a particular variable is significant;
- the standard error can be used to determine if two parameters are statistically different;
- manual inspection of outliers and other points of significance.

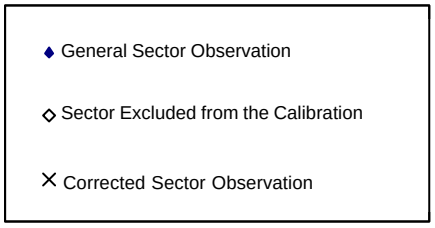
2.2 Outliers

All outliers have been considered individually. Only outliers falling outside the confidence intervals[2] for the observed data have been investigated. For these true outliers, if the over or under prediction of the model is balanced by surrounding sectors it has been ignored. If the error is more generally systematic (i.e. all CBD sectors under predicting a particular purpose), either a correction factor for the sectors in question, or a segregation of one or more of the explanatory variables (to separate out the effect of the problem area) has been adopted. If the misfit is of a local nature only, and not balanced by the surrounding zones, the predictions for these sectors have been factored to better match the observed data ("corrected" sectors). The final calibration, may or may not include those outliers, depending on their leverage (i.e. whether they bias the calibration results). Plots of the predicted versus observed attractions identify those outliers which have been factored or excluded from the model calibrations as indicated in Figure 3-2.

We have paid particular attention to those outliers that have a high number of observed trips, while for those observations with extremely low observed trips we have usually refrained from introducing outlier corrections or particular model adjustments.

[2] The 95% confidence intervals are based on the significance of the raw sample of observations. That is they take into account the sampling rate of each observation. The confidence intervals decrease in percentage terms as the size of the observation increases.

■ **Figure 2-1 Legend For all Predicted Vs Observed Graphs**



2.3 TLA Factors

Finally, the fit of the model to Territorial Local Authorities (TLA) totals has been checked, and insignificant under- or over-prediction corrected by incorporating additional TLA factors. To ensure adequate sample size for this TLA correction, the TLA's of Masterton, Carterton and South Wairarapa were combined. This aggregation will be denoted as *MasCatSthWai*.

2.4 Constants in the Models

Regression models can have intercept or (constant) terms. For models which are to be applied at varying levels of geographical disaggregation, constant terms are inconvenient because they are not transferable between levels – and thus models calibrated at a sector level could not be applied to zones. Thus, the final models reported here are all origin-forced to exclude the intercepts, in most cases because it is statistically insignificant. The regression statistics of the origin-forced models are provided, but should be interpreted with caution.

2.5 Signs of Model Coefficients

Negative coefficient values make no logical sense and can lead to unacceptable forecasts of negative numbers of attractions in individual zones with unusual distributions of population and employment. Consequently where negative values were encountered during model calibration, we have sought to re-specify the model to eliminate the negative coefficient while still representing the observed differences in attractions.

3. Home Based Work Attractions

3.1 Calibration

Table 3-2 contains the calibration results for 5 models. The main variables of influence are the five employment categories. Other variables such as the number of households in the sector, number of persons, location of the zone (eg rural/urban) were tested, but did not improve the model.

Model 1 was calibrated on the preliminary planning data. All other models were calibrated on the final MERA planning data.

Model 1: Basic Employment Model using all categories (Initial Data)

The trip rates generated all were significant (t-stats greater then two). Transport and Communications had a much higher trip rate than other categories. The constant is negative, but only marginally significant. The r-squared value for this model is very high at 0.955.

Model 2: Basic Model with Other/Manufacturing Aggregated

Other Employment, having a barely significant trip rate, was combined with Manufacturing Employment, the trip rates being not statistically different. The number of trips to Masterton (Sector 72) was extremely high and could not be explained by any explanatory variable or on a geographic basis. Thus it was considered an outlier and removed from the calibration. All employment variables remain significant (using the updated planning data), and the constant has now become statistically insignificant.

Models 3/4/5: The Final Model

Retail and Services Employment having similar trip rates were combined. On closer inspection of Transport and Communications Employment, it became apparent that two or three sectors were having a significant effect on the trip rate. When these sectors were removed from the calibration, the trip rate decreased to be comparable with that for the Retail and Services Employment categories, and it was possible to aggregate the three together in Model 3 and Model 4 without the intercept. Model 5 excludes the other two outliers.

Figure 3-1 details the model fit. Clearly sector 72 (9803, 13301) falls outside the 95% confidence range and has therefore been corrected in the final model. A correction factor of 1.357 was applied to that sector.

TLA level correction factors were calibrated and are shown in Table 3-1.

Table 3-1 HBW TLA Correction Factors

Kapiti	Porirua	Upper Hutt	Lower Hutt	Wellington	Masterton	Carterton	South Wai
1.011	0.779	1.246	1.001	0.994	0.986	1.292	0.664

Notes:
1) South Wai – refers to South Wairarapa.

Figure 3-2 detailed the model fit after correction, illustrating the improved model fit. The key results are:

- Other and Manufacturing Employment categories have a trip rate approximately half of that for the Retail, Transport, Communications and Services Employment categories;
- Sector 72 has required a correction factor of 1.357;
- there was a residual geographic effect at the TLA level which was incorporated in the model.

Figure 3-1 HBW Observed Trips Vs Predicted Trips Sector Plot

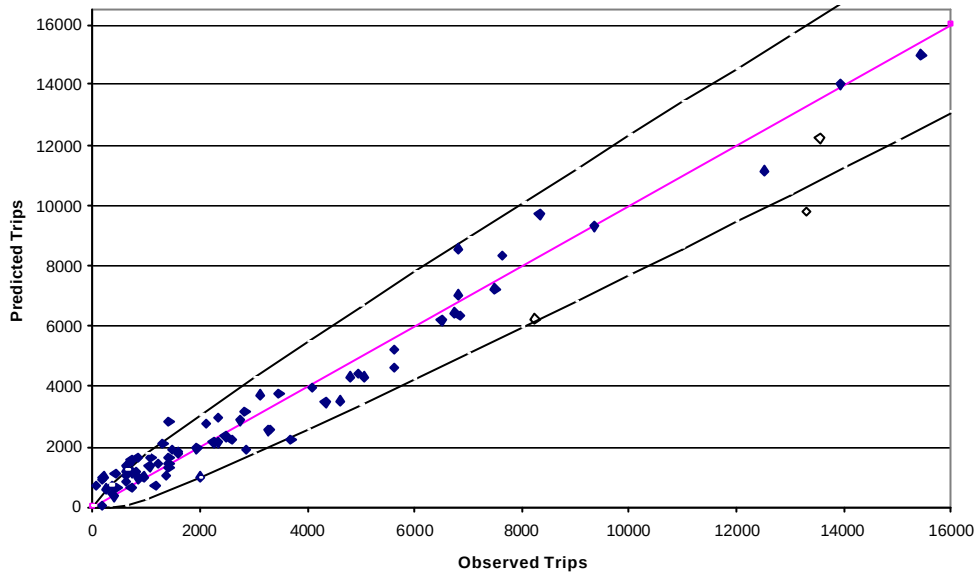
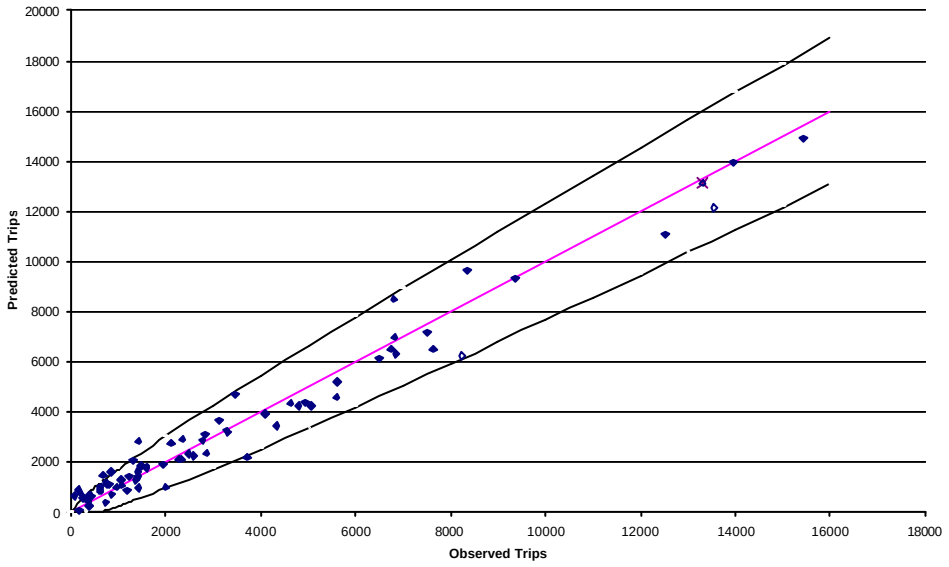


Figure 3-2 HBW Corrected Observed Trips Vs Predicted Trips



■ **Table 3-2 HBW Models**

Model	Model 1		Model 2		Model 3		Model 4		Model 5	
Variable	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat
Constant	-293.785	-2.053	-177.941	-1.486	-246.568	-2.018				
Retail Employment	1.571	5.772	1.249	5.186						
Transport & Communications Employment	2.172	4.015	2.958	5.291						
Services Employment	1.42	20.263	1.276	18.786						
Other Employment	1.383	2.407								
Manufacturing Employment	1.122	4.083								
Other + Manufacturing Employment			0.712	3.47	0.935	5.832	0.786	5.408	0.637	4.074
Retail +Transport & Communications + Services Employment					1.362	41.238	1.328	45.778	1.322	44.569
Total Employment										
R^2	0.955		0.966		0.963		0.98		0.98	
Sample Size	74		73		73		73		71	

Notes:

- Sector 72 (Masterton) was omitted for Models 2 through to 5
- Model 1 was calibrated using preliminary land use data that was replaced for models 2 through 5.
- Sectors 72, 24 (Mornington) and 65 (Petone) were omitted for Model 5

4. Home Based Education Attractions

4.1 Data

The home based education attraction model has been developed with the main explanatory variables being secondary and tertiary enrolments, and the number of households in each sector. As primary trips have been omitted from the data, primary enrolments have not been used in the modelling.

The accuracy of the tertiary data is particularly questionable. As such, any errors in model fit associated with high tertiary enrolments have generally not been corrected, particularly if these errors are balanced by adjacent zones.

4.2 Calibration

The key variables tested for home based education attractions were secondary and tertiary enrolments and also the total number of households. Variations in the definition of these variables have been tested and where used, explained below. Table 4-3 details the results for 5 key trip attraction models.

Model 1: Base Model – Households, Secondary and Tertiary Enrolment Effects

All three variables are significant in this basic model and the constant is insignificant. However, on closer inspection of the actual fit of this model, several sectors containing large tertiary enrolments were poorly predicted. This suggested that a segmentation of both secondary enrolments and total households by whether or not a sector contained tertiary enrolments should be tested to establish whether sectors with high tertiary employment were influencing the model specification.

Model 2: Modified Household and Secondary Enrolment Effects

Two variables (households and secondary enrolments) were added to the model for sectors with zero tertiary enrolments. As the reliability of the tertiary data was less than the school data, the trip rates for sectors with and without tertiary enrolments were calibrated separately to distinguish the effect of the tertiary data on secondary trip rates. Overall the model fit has been improved (r-squared has increased from 0.777 to 0.815), but neither household parameter is significant. This model suggests that the secondary enrolment trip rate is 0.652 higher for those sectors with no tertiary enrolments[3]. The constant has remained significant.

Model 3: Modified Secondary Enrolment Effects

A variation of model 2 was tested, reverting to the original household formulation. The fit of this model remains strong with only a marginal decrease in the r-squared value. All variables are statistically significant and the constant is insignificant. A detailed inspection of the fit of this model shows three sectors (17, 31 and 41) that are poorly predicted.

[3] Note that in this model, the trip rates for sectors with no tertiary enrolments are the sum of the general trip rate and that specific to zones with no tertiary enrolments (eg for secondary enrolments, trip rate = 1.099+0.652).

Model 4/5: Omission of Outliers

The model has been recalibrated omitting these 3 outliers (sectors 17, 31 and 41) from the calibration. It improves the fit of the model greatly. In model 4, the secondary enrolment variable for sectors with tertiary enrolments was reduced by approximately 0.2 trips, while the secondary variable without tertiary enrolments was increased by 0.2. This indicates that the three sectors removed were biasing the predicted trip rates of the secondary enrolments in the model. The constant remains insignificant and the omission of the constant in Model 5 does not significantly modify the calibrated trip rates.

The presence of number of households in this model as a minor parameter is likely to be related to the deficiencies of the tertiary enrolment data and may also reflect the role of escorting/car pooling in education trips.

Model 6: The Final Model

Subsequent to the initial calibrations, in order to be consistent with the trip production and distribution and mode choice models, those escort trips made by non – primary school children who were escorting primary school children were removed from the dataset. The recalibration of this model then reduced the influence of the number of households variable. Model 6 presents the final calibration results with the removal of this variable.

The fit of the model is illustrated in Figure 4-1 with the outlier corrected fit demonstrated in Figure 4-2.

The three outliers have a poor fit:

- concerning sector 17 (in the CBD), approximately 2400 trips travel to this sector, but neither the enrolments nor the number of households were able to explain them; we could find no obvious reason for these trips, in fact most of the trips to this sector were from only one household. We took the view that they may be an aberration in the data and did not include a correction in the model;
- the under-prediction of sector 31 is balanced by an over-prediction in the adjacent sector 32 and has therefore been left uncorrected;
- sector 41 has however been corrected, as no corresponding over-prediction in the geographic vicinity explains its under-prediction. The correction facto is 2.305.

Table 4-1 HBEd Trip Rates

Variables	Sector with Tertiary Enrollments	Sector w ithout Tertiary Enrollments
Secondary School Enrolments	0.726	1.894
Tertiary Enrolments	0.717	0

Notes:

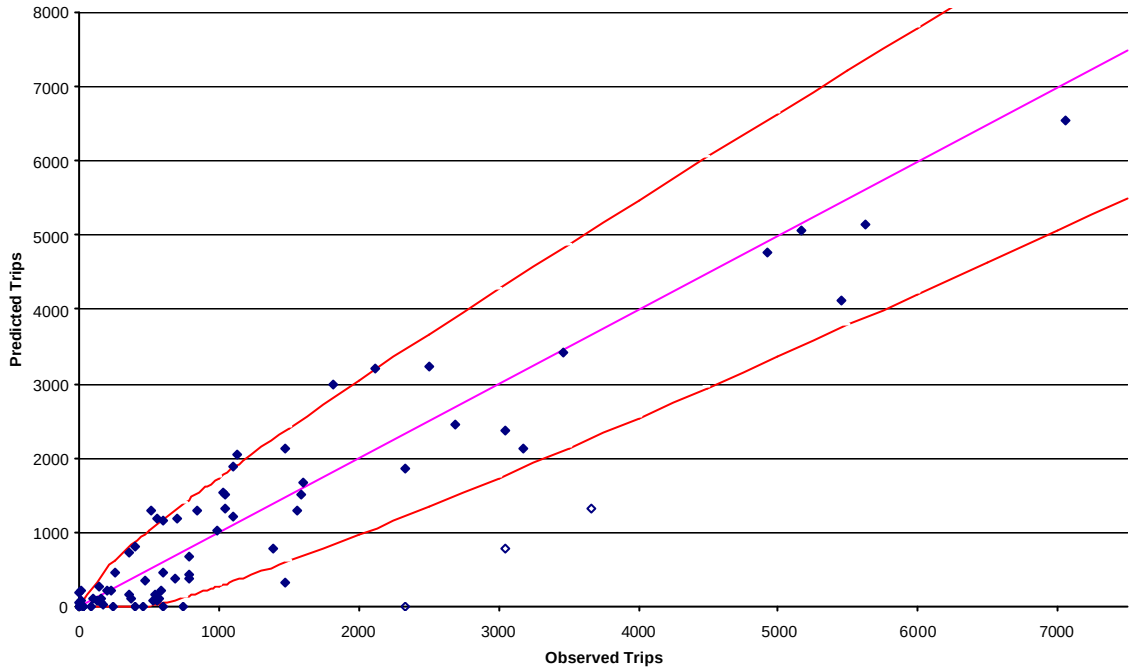
1) For zones in sector 41, coefficients are multiplied by a factor of 2.789

TLA correction factors were found to be significant for this purpose

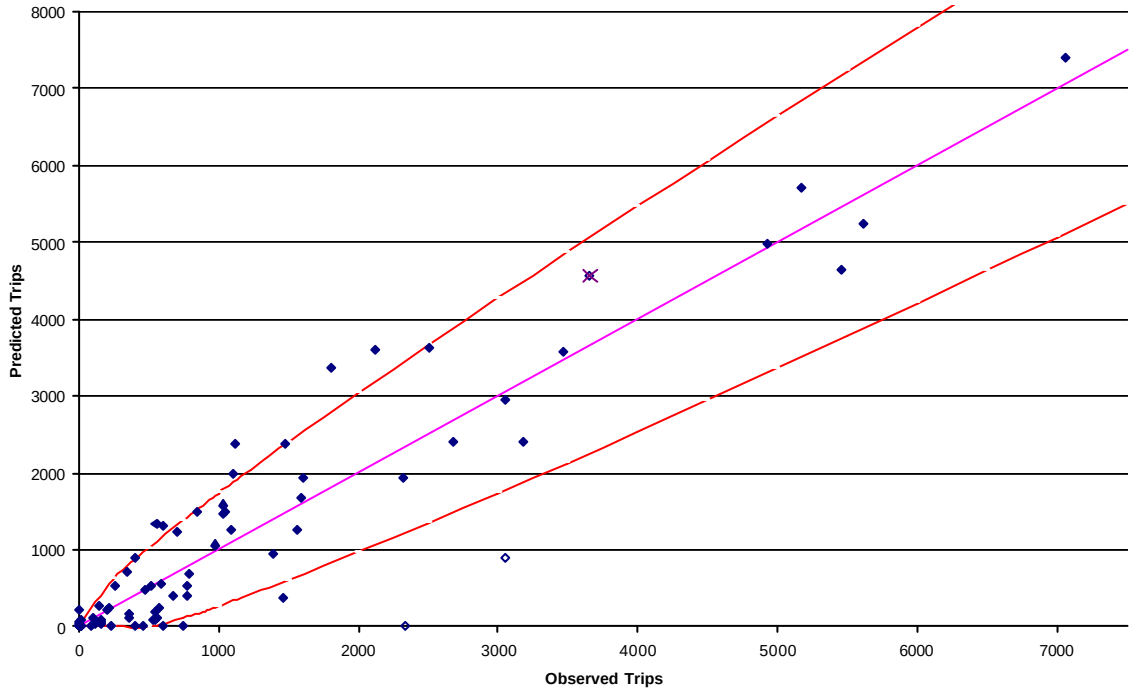
Table 4-2 HBEd TLA Correction Factors

Kapiti	Porirua	Upper Hutt	Lower Hutt	Wellington	Masterton	Carterton	South Wai
1.245	1.154	0.979	1.044	1.127	1.020	1.362	0.417

■ **Figure 4-1 HBEd Observed Trips Vs Predicted Trips Sector Plot**



■ **Figure 4-2 HBEd Corrected Observed Trips Vs Predicted Trips Sector Plot**



■ **Table 4-3 HBEd Models**

Model	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Variable	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**
Constant	118.953	0.721	128.576	0.847	149.864	0.989	-42.131	-0.345				
No. of Households	0.261	3.743	0.073	0.615	0.2	3.028	0.25	4.768	0.237	6.439		
No. of Households with no Tertiary Enrolments			0.161	1.277								
Secondary School Enrolments	1.462	10.363	1.099	5.332	0.974	5.344	0.762	5.136	0.759	5.159	0.726	5.868
Secondary School Enrolments with no Tertiary Enrolments			0.652	2.46	0.839	3.786	1.073	5.995	1.075	6.049	1.167	7.980
Tertiary Enrolments	0.543	7.074	0.705	8.152	0.651	8.577	0.682	11.476	0.68	11.575	0.717	14.655
R^2	0.777		0.815		0.813		0.885		0.94		0.93	
Sample Size	74		74		74		71		71		71	

Notes:

- Sectors 17 (CBD), 31 (Porirua region) and 41 (Paraparaumu) were omitted for Models 4, 5 and 6

5. Home Based Shopping Attractions

5.1 Sector System

As explained in Section 1.4, a different sector system has been used for the shopping attractions to distinguish major shopping attractors.

5.2 Calibration

A selection of four of the most relevant models can be seen in Table 5-4 HBSh Models. The major effects to be tested were all five employment categories and the number of households in each sector.

Model 1: Basic Household and Employment Category Model

Only Services and Retail jobs are statistically significant in this relatively poorly fitting model. Inspection of the model fit showed a consistent bias for the shopping centre sectors and also sectors in the upper CBD (Table 5-1 identifies these sectors).

Model 2: Shopping Centre and CBD Effects

Because there seemed to be a different trip rate for the upper CBD and the shopping centre sectors seemed to have a much higher trip rate than other sectors with similar employment, these areas have been separately treated. Also sectors 21, 79 and 85 have been omitted from the calibration as they are outliers.

■ **Table 5-1 HBSh Sets**

Abbreviation	Description	Sectors
SC	Sector contains a Shopping Centre	5, 6, 13, 32, 38, 48, 50, 57, 72, 74, 86
UCBD	Upper (Northern) Central Business District	22, 24, 25, 26, 28

For shopping centre sectors, only retail employment has been used to explain trip attractions. For the remaining sectors all employment categories have been used. The retail employment rates have been calibrated separately for shopping centre sectors, upper CBD sectors and all other sectors.

The number of households is now highly significant, and the retail and services variables remain significant, while all other variables are insignificant. The overall fit of the model has improved markedly (from an r-squared of 0.318 to 0.869), and the constant is now also insignificant.

Model 3/4: Final Model

The insignificant employment variables have been removed from the model. Close inspection of the model fit suggested retaining the retail trip rate differential for shopping centres. By re-specifying the services employment variable we have been able to eliminate the negative coefficient of upper CBD retail employment. All parameters are significant in this model, while there is a slight increase in the r-squared and the constant remains insignificant. The very high trip rate for the shopping centres is notable. Removal of the insignificant constant has little effect on the predicted trip rates.

Table 5-2 contains the final trip rates. Of the 3 outliers, sector 79 was corrected as the other sectors were balanced by surrounding sectors. The correction factors for sector 79 was 3.076.

Table 5-2 HBSh Trip Rates

Location	CBD	Non CBD	
Variables	Upper CBD	Sectors containing a Shopping Centre	Sectors not containing a Shopping Centre
No. of Households	0.559	0.559	0.559
Retail Employment	1.321	15.922	1.321
Services Employment	0	0	0.623

Notes:

1) For zones in sector 79, coefficients (Non SC, Non CBD) are multiplied by a factor of 3.076

2) Sector's 21, 79, 85 were omitted from the final calibration.

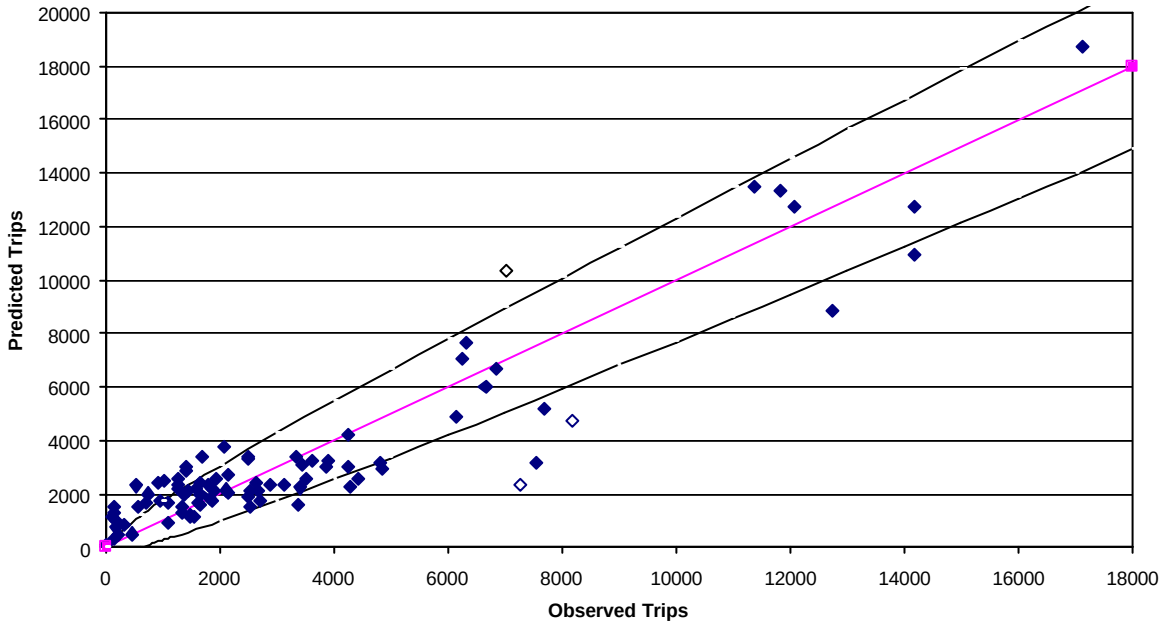
3) Sector 21 was allocated as a sector containing a shopping centre, and Sector's 79 and 85, allocated as Non-CBD Non-Shopping Centre Sectors.

TLA correction factors were found to be significant for this purpose and are presented below.

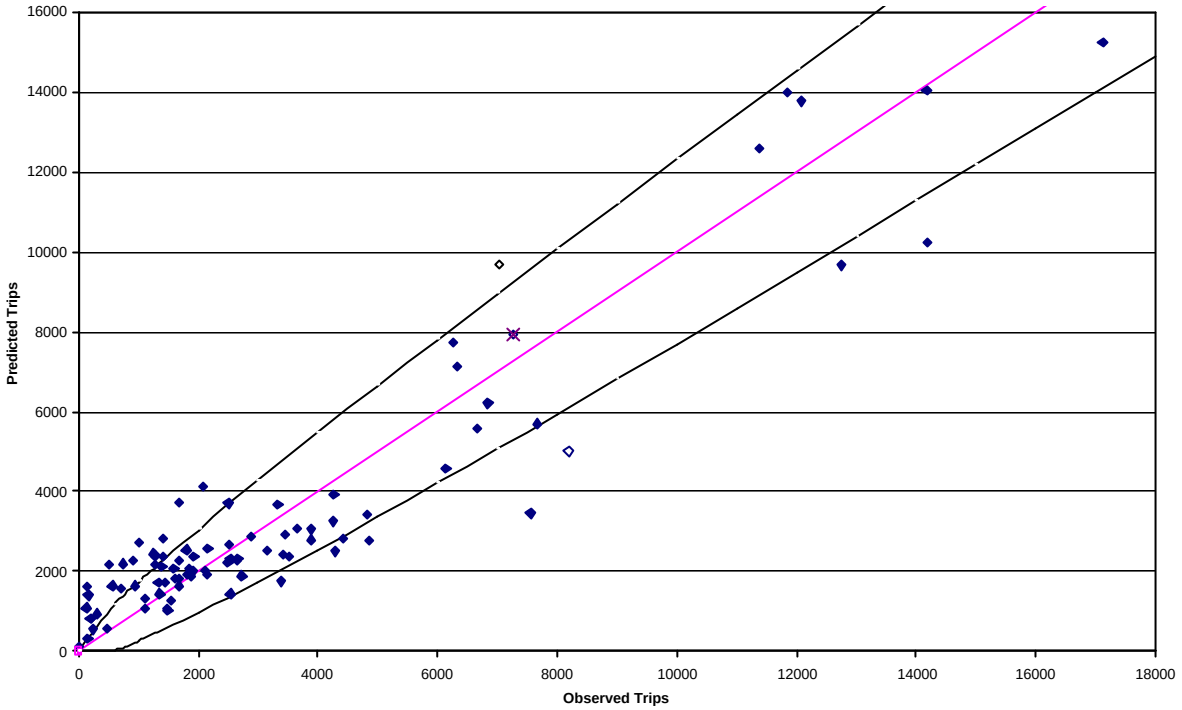
Table 5-3 HBSh TLA Correction Factors

Kapiti	Porirua	Upper Hutt	Lower Hutt	Wellington	Masterton	Carterton	South Wai
1.1002	1.0806	0.8113	1.0901	0.9318	1.0492	1.2219	1.1437

Figure 5-1 HBSh Observed Trips Vs Predicted Trips Sector Plot



■ **Figure 5-2 HBSh Corrected Observed Trips Vs Predicted Trips Sector Plot**



■ **Table 5-4 HBSh Models**

Model	Model 1		Model 2		Model 3		Model 4	
Variable	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat
Constant	2251.66	2.828	-90.84	-0.239	-124.614	-0.356		
No. of Households	0.081	0.286	0.584	4.361	0.594	4.721	0.559	7.003
Other Employment	-1.987	-0.994						
Other Employment in Non SC Sectors			-0.257	-0.291				
Manufacturing Employment	-2.308	-1.875						
Manufacturing Employment in Non SC Sectors			-0.05	-0.085				
Transport & Communications Employment	-2.1	-0.729						
Transport & Communications Employment in Non SC Sectors			-1.625	-1.187				
Retail Employment	8.071	6.412	1.579	2.179	1.391	3.366	1.321	3.652
Retail Employment in SC Sectors			14.438	14.471	14.661	20.983	14.601	21.648
Retail Employment in UCBD Sectors			-3.896	-3.446				
Services Employment	-1.195	-3.84						
Services Employment in Non SC Sec			0.735	2.676				
Services Employment in UCBD Sect.								
Services Employment in Non SC and Non UCDB Sectors					0.631	3.385	0.623	3.385
R^2	0.318		0.869		0.871		0.932	
Sample Size	88		85		85		85	

Notes:

- Sectors 21 (CBD), 79 (near Petone) and 85 (Masterton) were omitted for Models 2 through to 5
- SC - Sector contains a Shopping Centre
- UCBD - Upper (Northern) Central Business District

6. Home Based Other Attractions

6.1 Calibration

As for Home Based Shopping, households and all employment categories were initially tested, to reflect the diversity of possible trips in this purpose. A number of particular areas were grouped together to take into account specific traits of those sectors as detailed in Table 6-1. Table 6-3 contains five of the most important models for the home based other attractions modelling.

Model 1: Household and Employment Categories Effects

The 5 employment categories and total households have been used in this initial model. While manufacturing, services, retail and households are all significant, the negative trip rates for manufacturing and services employment are unacceptable and the coefficients of other employment categories are insignificant.

Model 2: Simple Household and Retail Effects

The simplest model includes the effects of retail employment and households only. The decrease in r-squared is only marginal (0.016) considering the reduction in the number of variables. On closer inspection of the predicted plots generated for this model, a number of local regional effects were evident. The remaining models adjust this base model with a number of additional variables to account for some of these locational effects.

Table 6-1 HBO Sets

Abbreviation	Description	Sectors
Petone	Sectors in the region surrounding Petone	65, 66
LCBD (1)	Lower (Southern) Central Business District Sectors	15, 16, 17, 18, 19, 20
LCBD (2)	Lower (Southern) Central Business District Sectors	19, 23
UCBD	Upper (Northern) Central Business District Sectors	15, 20, 21, 22

Model 3: Lower CBD Effects

This model paid particular attention to the LCBD (1) (see Table 6-1) area which was a large portion of the lower part of the CBD. While the use of the LCBD (1) segregation did improve the basic model (the r-squared increased from 0.867 to 0.874), further analysis of the retail variables (and their standard errors) suggested that the retail variables were not statistically different. There was only a marginal change in the household parameter in this model.

Model 4/5: Final Model

A revised segmentation of the CBD was implemented, including distinguishing both part of the upper CBD and a smaller lower CBD segmentation (see Table 6-1 for LCBD (2) and UCBD). Furthermore the area around Petone (sectors 65 and 66) was singled out as having different trip rates. Segmentation of the household variable was dropped. This model has a much higher r-squared value and on inspection of the final plots, a fairly good fit of predicted vs observed. The constant however, remained significant.

Two sectors were analysed further and it was determined that one zone in each of the sectors was required to be corrected rather than the entire sector. Sector 17 consists of zones 47 and 48, but only 48 was corrected as approximately 86% of the trips to the

sector are to zone 48 rather than 47. In sector 54, zone 160 is under-predicted by approximately 3000 trips, while the other two zones in the sector are approximately on target, hence only zone 160 was corrected.

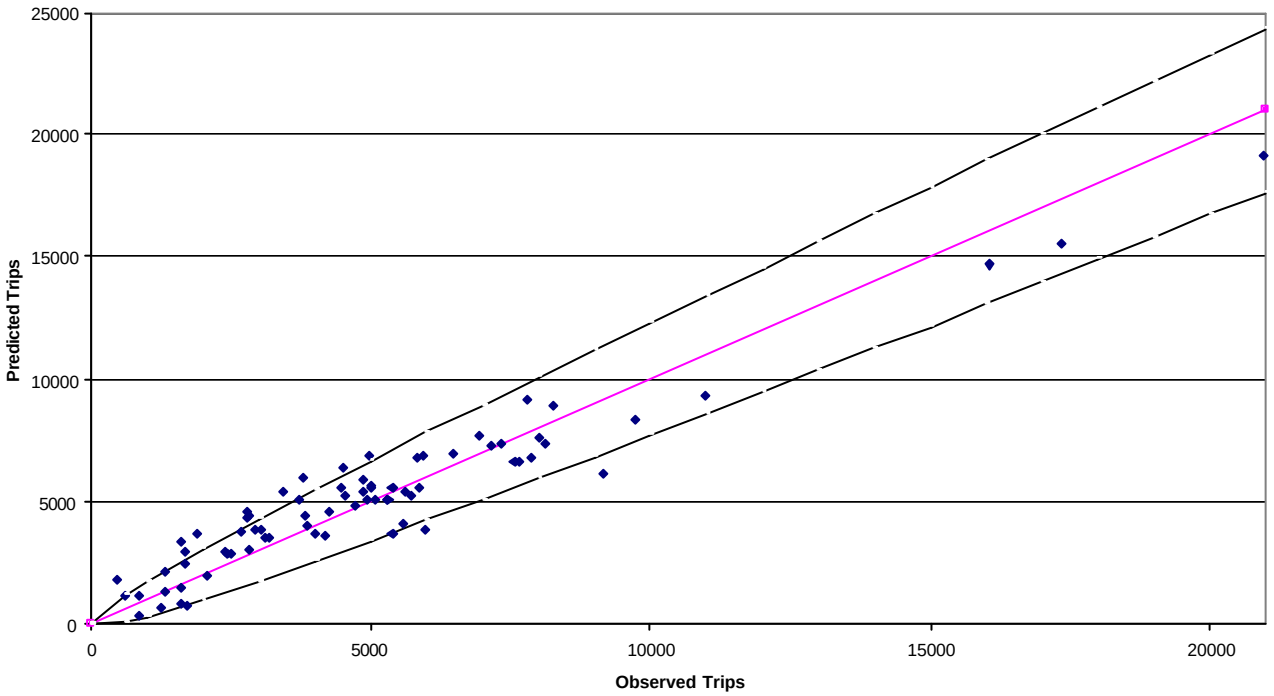
The TLA correction factors, although generally small, were statistically (Table 3-1); the highest value referred to the Kapiti Coast TLA, for which the model was 10% lower than observed.

Table 6-2 HBO TLA Correction Factors

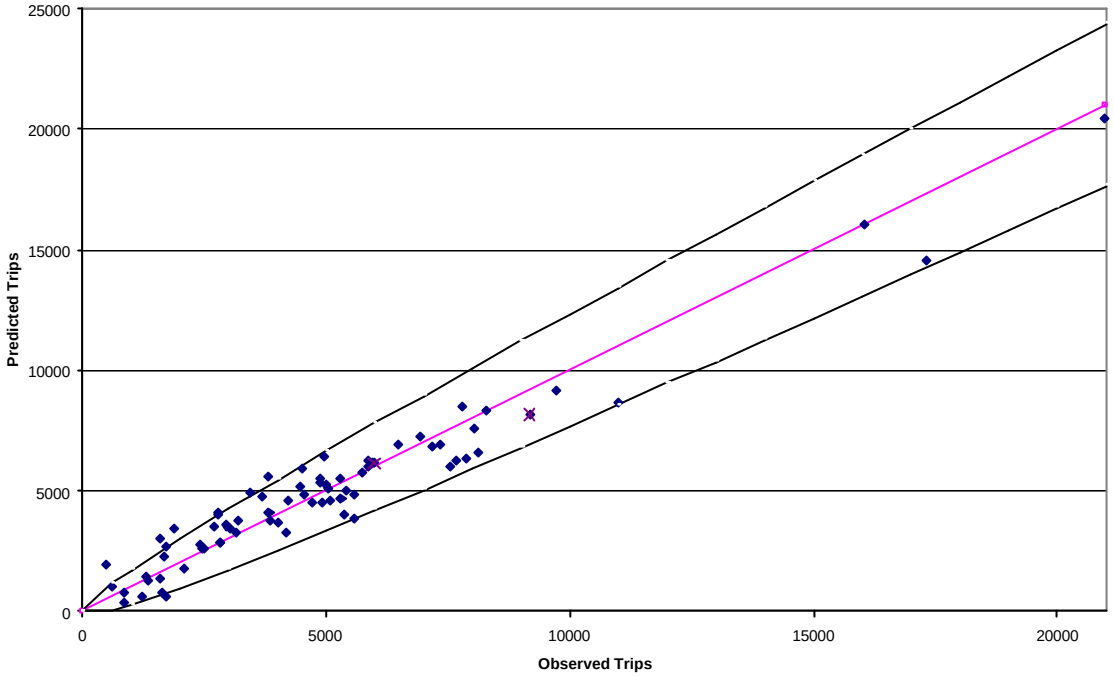
Kapiti	Porirua	Upper Hutt	Lower Hutt	Wellington	Masterton	Carterton	South Wai
1.091	0.941	1.002	0.901	0.933	1.067	1.083	0.648

Figure 6-1 and Figure 6-2 detail the fit of the HBO attraction modelat the sector level, before and after the corrections.

Figure 6-1 HBO Observed Trips Vs Predicted Trips Sector Plot



■ **Figure 6-2 HBO Corrected Observed Trips Vs Predicted Trips Sector Plot**



■ **Table 6-3 HBO Models**

Model	Model 1		Model 2		Model 3		Model 4		Model 5	
Variable	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat
Constant	-538.224	-1.677	-790.08	-2.59	-736.83	-2.49	-724.293	-2.848		
Other Employment	0.408	0.488								
Manufacturing Employment	-1.491	-3.114								
Transport & Communications Employment	0.245	0.218								
Services Employment	-0.31	-2.259								
Retail Employment	4.652	9.842	3.283	12.404			4.045	15.661	3.765	15.008
Retail Employment in LCBD (1)					3.906	9.623				
Retail Employment not in LCBD (1)					3.175	10.608				
Retail Employment n UCBD							-2.574	-4.336	-2.878	-4.694
Retail Employment in Petone							-2.435	-4.993	-2.308	-4.524
Retail Employment in LCBD (2)							-1	-1.958	-1.011	-1.884
No. of Households	1.833	17.7	1.84	17.734			1.733	19.554	1.554	23.738
No. of Households in sector not in LCBD (1)					1.851	17.348				
R^2	0.883		0.867		0.874		0.912		0.967	
Sample Size	74		74		74		74		74	

Notes:

- Petone - Sectors in the region surrounding Petone
- LCBD (1) - Lower (Southern) Central Business District Sectors
- LCBD (2) - Lower (Southern) Central Business District Sectors
- UCBD - Upper (Northern) Central Business District Sectors

7. Non-Home Based Other Attractions

7.1 Calibration

Similar to the other models, households and all employment category effects were initially considered.
Table 7-3 details the most important models.

Model 1: Basic Model – Household and Employment Effects

The initial model considered the 5 employment category effects as well as total households. The Other, Services and Transport & Communications employment parameters were statistically insignificant (t-stats less than 2). These categories have been removed in subsequent models.

Model 2: Revised Basic Model

The three remaining parameters remained highly significant, however the large negative coefficient of manufacturing employment results in negative trips in some sectors and has therefore been removed. Additionally, inspection of predicted observed plots for this model indicated sector 72 (Masterton) was a large outlier. It has been removed from the subsequent calibrations.

Model 3: Household and Retail model

While the r-squared for this model has reduced, the overall fit appears better, and the parameters sensible. The constant is now not significant. The predicted trips for 3 sectors around Petone (see Table 7-1) appear to be lower than all other sectors. Additionally sector 26 now also appears as an outlier on the predicted plots and has been removed from subsequent calibrations.

Model 4/5: Final Model

The inclusion of a Petone retail variable has increased the r-squared value significantly. The Petone area parameter is half that of retail employment in all other sectors. The constant has again become significant. The removal of this constant in the final model has decreased the household parameter from 0.94 to 0.63.

■ **Table 7-1 NHBO Sets**

Abbreviation	Description	Sectors
Petone	Sectors in the region surrounding Petone	64, 65, 66

The outlier sector 72 was corrected after inspection of the predicted value. This correction factor is 1.47. Sector 16 was also corrected (with a correction factor of 0.44), as was zone 74 in sector 26 (with a factor of 0.16). Additionally the calibration of TLA correction factors indicated that they were significant (Table 7-2). These factors range from –7.8% for Porirua to 7.7% for Kapiti Coast.

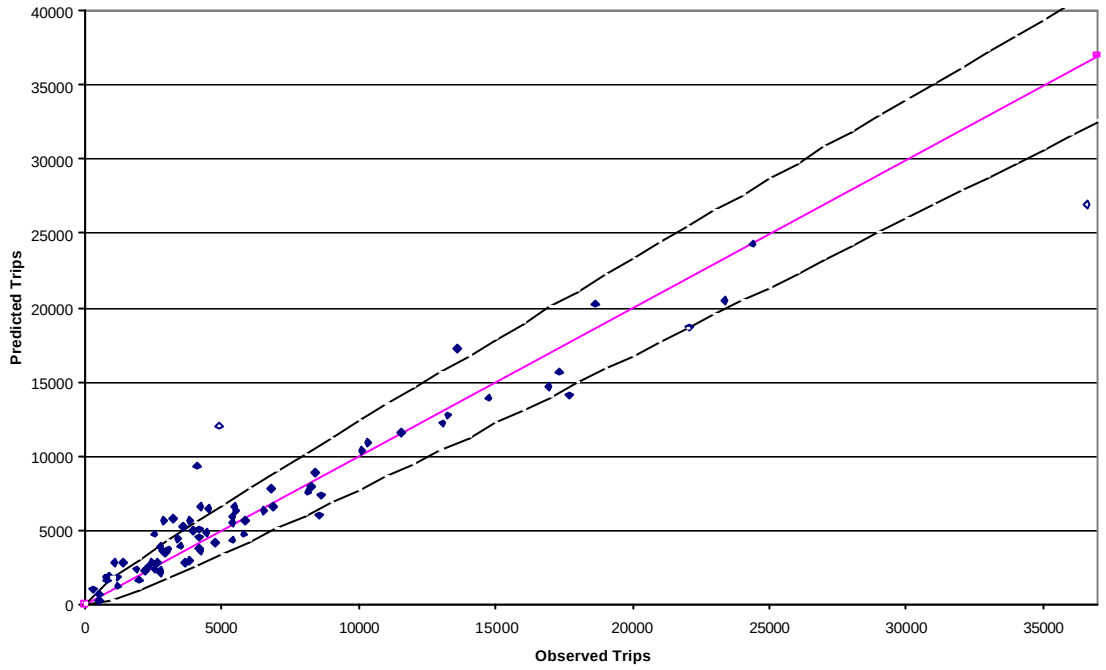
■ **Table 7-2 NHBO TLA Correction Factors**

Kapiti	Porirua	Upper Hutt	Lower Hutt	Wellington	Masterton	Carterton	South Wai
0.993	0.902	0.920	0.951	0.985	0.985	0.993	0.466

The final observed vs predicted trip plots are shown for the uncorrected and corrected models in Figure 7-1 and Figure 7-2. Despite the necessary removal of the significant

intercept and the consequent change to the household parameter, the fit of the model for this trip purpose is remarkably good.

■ **Figure 7-1 NHBO Observed Trips Vs Predicted Trips Sector Plot**



■ **Figure 7-2 NHBO Corrected Observed Trips Vs Predicted Trips (TLA corrected also) Sector Plot**

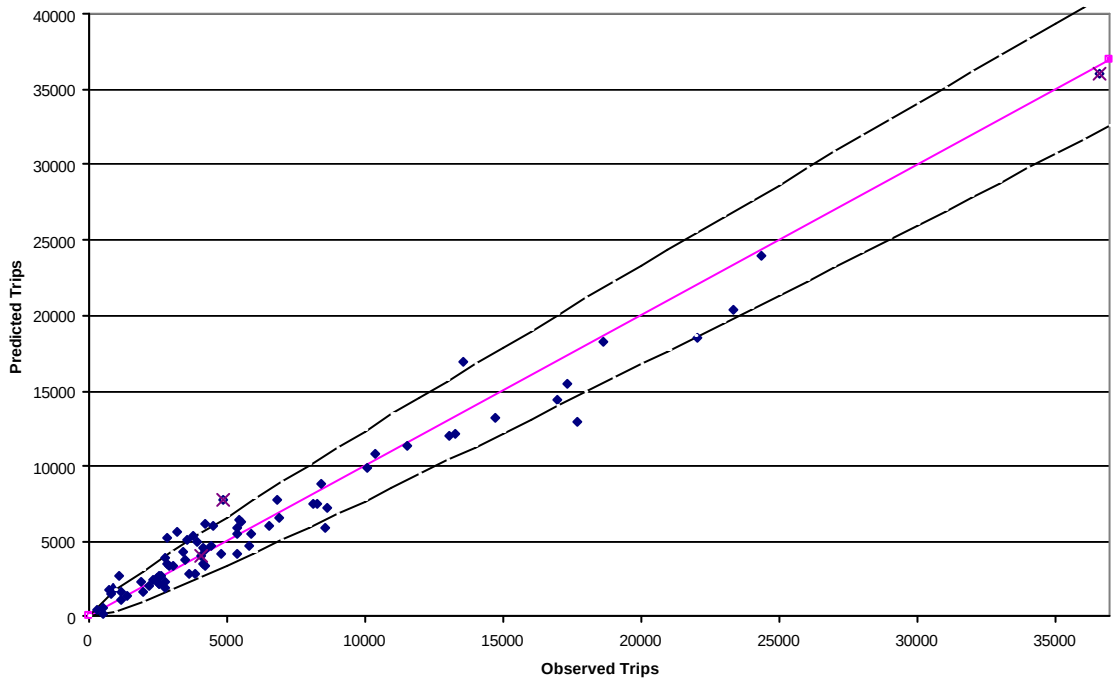


Table 7-3 NHBO Models

Model	Model 1		Model 2		Model 3		Model 4		Model 5	
Variable	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat
Constant	-1740.52	-3.371	-1514.79	-3.318	-583.846	-1.077	-1213.22	-3.422		
No. of Households	1.319	7.918	1.305	8.218	0.794	4.297	0.943	7.849	0.631	7.513
Retail Employment	11.721	15.412	11.903	24.199	9.49	20.557	10.846	33.045	10.218	34.937
Retail Employment in Petone							-5.022	-8.892	-4.72	-7.872
Manufacturing Employment	-3.588	-4.657	-3.628	-5.91						
Other Employment	1.662	1.238								
Transport & Communications Employment	0.037	0.02								
Services Employment	0.088	0.397								
R^2	0.91		0.911		0.855		0.941		0.969	
Sample Size	74		74		73		72		72	

Note:

- Sector 72 (Masterton) was omitted for Models 3, 4 and 5, while sector 26 (in the vicinity of Ngaio/Kaiwharawhara) was omitted for Models 4 and 5
- Petone - Sectors in the region surrounding Petone

8. Business Attractions

8.1 Calibration

The main variables considered were employment by category for each sector and total households in a given sector. This model is expected to be similar to the Home Based Work Model. Detailed below are the 5 most important models.

Model 1: Household and Employment Categories Effects

This model explicitly calculates a separate trip rate for each employment category. Other and Manufacturing parameters are not significant (t-stats less than 2) and have been dropped from further model calibrations, while the rest of the variables were. Inspection of the model fit suggested that a differential trip rate for some cbd sectors may be appropriate.

Model 2: Retail CBD Model

Including an additional segmentation of Retail Employment for LCBD sectors (see Table 8-1) has improved the fit of the model. This new parameter is significant and suggests that the LCBD retail coefficient is 50% higher than for other sectors. Furthermore it can be seen that Transcom and Retail have very similar trip rates. And have been merged in further model calibrations.

Table 8-1 BU Sets

Abbreviation	Description	Sectors
LCBD	Sectors in the Lower (southern) Central Business District Area	14, 15, 16, 17, 18, 19, 20

Model 3: Transcom/Retail Aggregated Model

The aggregation of Transport and Communications Employment with Retail has slightly improved the model's r-squared value. The t-stat for this parameter is significantly improved. There are two outlying points in the model (sectors 17 and 72) and these have been removed for the final model.

Model 4/5: The Final Model

It has been noted in the earlier discussions the observation of differing trip rates on a gepgraphic basis. In the previous models this has been evidenced by the Lower CBD retail segmentation, and the omission of 2 outlier sectors. Additionally it has been noted that both Porirua and Kapiti Coast exhibit trip rates that are consistently lower than other areas in the region.

In an attempt to correct this, a separate retail and transport & communications coefficient has been estimated for these two regions. This segmentation proved highly significant, with the retail/transport trip rate being some 41% lower than for the rest of the region.

With this segmentation the lower cbd trip rate variable is no longer significant and has been dropped. Additionally the removal of the 2 outliers has increased the r-squared value. While the constant has changed sign, it is still statistically insignificant.

The two sectors removed from calibration showed a poor fit to observed data with the application of the final model. These sectors, and also sector 56 were corrected as outliers. All three sectors underpredicted the number of employers business trips (see Figure 8-3), and are shown corrected in Figure 8-4 by the large crosses.

TLA correction factors were calibrated and were found to be statistically insignificant and thus, were not applied to the model. The final trip rates for the Business Attraction Model can be viewed in Table 8-2.

Table 8-2 BU Trip Rates

Variables	Kapiti / Porirua	All other TLA's
Num of H'holds	0.2047	0.2047
Transport and Communications Employment	0.980	1.670
Services Employment	0.279	0.279
Retail Employment	0.980	1.670

Notes:

1) For zones in sector 17, coefficients are multiplied by a factor of 1.714

2) For zones in sector 56, coefficients are multiplied by a factor of 1.937

3) For zones in sector 72, coefficients are multiplied by a factor of 1.443

It might have been expected that a model of employer's business trips would also include parameters for manufacturing, other or total employment as well as those included in the final model. As a further check, the final model was recalibrated, reintroducing these other variables. It was found that these additional parameters were not significant and added further explanation of business trips.

Figure 8-1 BU Observed Trips Vs Predicted Trips Sector Plots

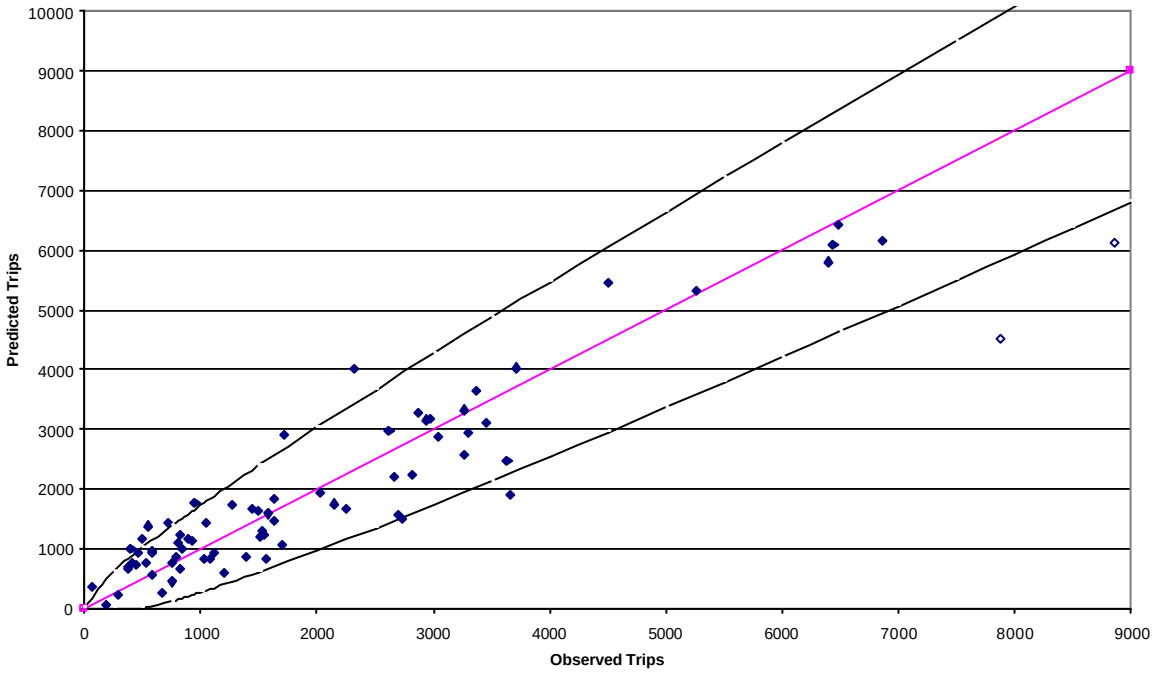


Figure 8-2 BU Corrected Observed Trips Vs Predicted Trips Sector Plots

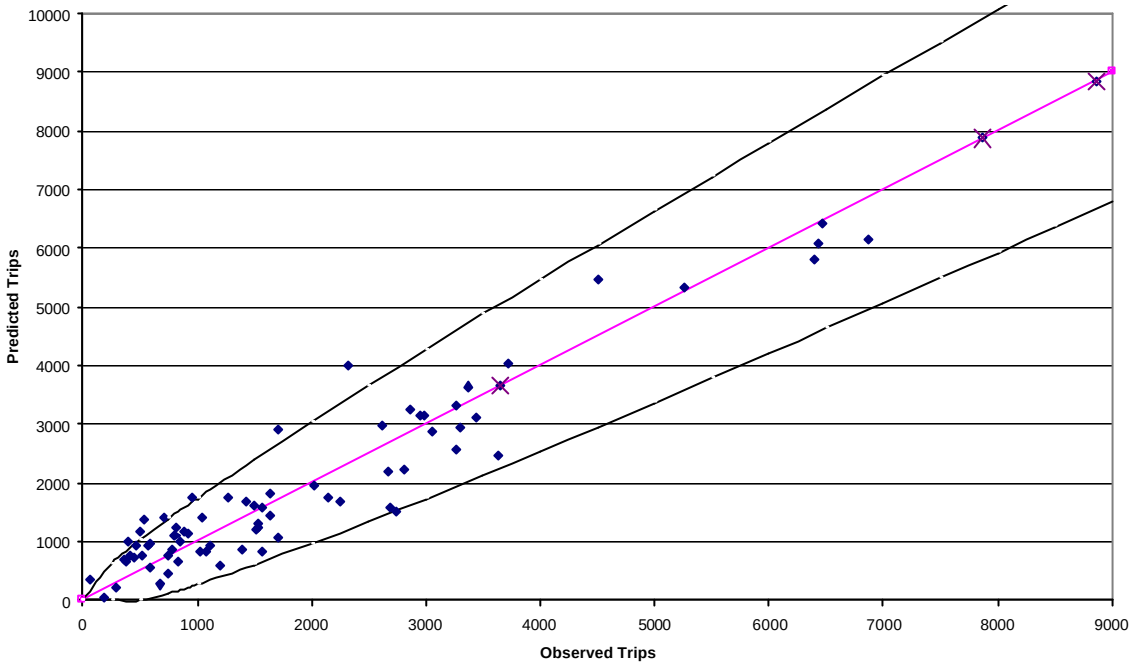


Table 8-3 BU Models

Model	Model 1		Model 2		Model 3		Model 4		Model 5	
Variable	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat
Constant	-48.009	-0.235	-100.372	-0.537	-100.326	-0.541	58.993	0.379		
No. of Households	0.212	3.22	0.257	3.949	0.257	4.026	0.189	3.568	0.205	6.282
Other Employment	0.424	0.798								
Manufacturing Employment	-0.507	-1.664								
Transport & Communications Employment	2.085	2.915	1.658	2.783						
Services Employment	0.209	2.396	0.237	3.27	0.237	3.303	0.2719	4.874	0.279	5.336
Retail Employment	2.144	7.133	1.654	6.698						
Retail Employment in the CBD			0.824	3.072	0.823	3.146				
Retail + Transport & Communications Employment					1.655	9.091				
Retail + Transport & Communications Employment in Porirua and Kapiti District							0.977	4.438	0.980	4.483
Retail + Transport & Communications Employment NOT in Porirua and Kapiti District							1.665	11.153	1.670	11.322
R^2	0.828		0.844		0.847		0.871		0.948	
Sample Size	74		74		74		72		72	

Note:

- Sectors 17 (CBD) and 72 (Masterton) were omitted for Models 4 and 5
- LCBD - Sectors in the Lower (southern) Central Business District Area

Wellington Transport Strategy Model

TN16.4 Family Structure Model Report

Final

July 2003

prepared for

Greater Wellington – The Regional Council

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1. Model Structure

The family structure model is at the interface between the planning data, car ownership model and trip production model.

The planning data will provide for each zone the populations classified by 7 person types (employed adult etc) and the number of households split into 5 types (by size and employment status).

For each of the 5 household types, the car ownership model forecasts will enable a further disaggregation by level of car ownership, giving in all 14 household categories (by size, employment status and car ownership).

For the trip production model, we require the full cross-classification of the population in each zone by the 7 person types and 15 household categories, and this is estimated in the family structure model.

2. Family Structure Model

2.1 The Core Model

The purpose of the family structure model is to develop the cross-classification of zonal population by person type and household category illustrated in Figure 2-1.

The method is as follows.

From the household survey we have established a matrix Nij of the average number of persons of type i in household category j as illustrated in Figure 2-2.

The model we propose for forecasting the cross-classification of the population uses this matrix:

$$P'_{ij} = P'_i * N_{ij} * H'_j / (\Sigma_j N_{ij} * H'_j)$$

Where, for each zone:
P'_{ij} is a future population classified by person type i and household category j
P'_i is the population by type from the planning data
H'_j is the households by category from the planning data and car ownership model

■ Figure 2-1 The Population Proportions in each Person Type and Household Category

Household Category			Person Type							
					young adult		adult			
Adults	Status	Cars	infant	chld	unemployed	employed	unemployed	employed	retired	Total
1 adult	0 employed	0	0.1%	0.5%	0.1%	0.0%	1.0%	0.0%	1.5%	3.2%
		1+	0.3%	0.5%	0.1%	0.0%	1.0%	0.0%	2.3%	4.3%
	1+ employed	0	0.0%	0.2%	0.0%	0.0%	0.0%	0.9%	0.0%	1.2%
		1+	0.2%	1.5%	0.0%	0.2%	0.0%	4.2%	0.1%	6.2%
2 adults	0 employed	0	0.1%	0.1%	0.1%	0.0%	0.2%	0.0%	0.3%	0.8%
		1	0.2%	0.2%	0.2%	0.0%	1.3%	0.0%	3.6%	5.4%
		2+	0.0%	0.1%	0.0%	0.0%	0.9%	0.0%	1.1%	2.0%
	1+ employed	0	0.1%	0.3%	0.1%	0.2%	0.2%	0.6%	0.1%	1.6%
		1	2.0%	3.5%	0.5%	1.1%	1.5%	8.3%	0.5%	17.3%
		2+	3.1%	6.6%	0.1%	0.8%	2.6%	15.0%	0.7%	29.0%
3+ adults		0	0.0%	0.2%	0.3%	0.3%	0.4%	0.2%	0.0%	1.3%
		1	0.2%	1.2%	1.0%	1.1%	1.2%	1.9%	0.4%	7.0%
		2	0.4%	1.8%	1.2%	2.1%	1.0%	4.5%	0.5%	11.7%
		3+	0.3%	1.1%	0.7%	1.8%	0.8%	4.1%	0.2%	8.9%
Total			7.2%	17.7%	4.4%	7.6%	12.0%	39.7%	11.4%	100.0%

Source: 2001 Household Survey Data

■ **Figure 2-2 The Matrix Nij - The Average Number of Persons of Each Type in Each Household Category**

Household Category			Person Type							
					young adult		adult			Average
Adults	Status	Cars	infant	chld	unemployed	employed	unemployed	employed	retired	family size
1 adult	0 employed	0	0.05	0.19	0.05	0.00	0.37	0.00	0.58	1.24
		1+	0.10	0.16	0.02	0.00	0.29	0.00	0.69	1.26
	1+ employed	0	0.03	0.24	0.00	0.01	0.00	0.95	0.04	1.27
		1+	0.04	0.32	0.00	0.05	0.00	0.92	0.03	1.36
2 adults	0 employed	0	0.26	0.47	0.48	0.00	0.61	0.00	0.90	2.72
		1	0.06	0.09	0.06	0.00	0.50	0.00	1.43	2.15
		2+	0.02	0.08	0.00	0.00	0.90	0.00	1.10	2.10
	1+ employed	0	0.20	0.46	0.14	0.36	0.40	1.01	0.09	2.66
		1	0.34	0.58	0.08	0.18	0.26	1.39	0.09	2.92
		2+	0.33	0.68	0.01	0.09	0.27	1.56	0.08	3.01
3+ adults		0	0.06	0.53	0.80	0.85	1.20	0.55	0.00	3.99
		1	0.14	0.69	0.59	0.65	0.72	1.13	0.26	4.18
		2	0.15	0.65	0.44	0.75	0.36	1.61	0.18	4.15
		3+	0.16	0.51	0.33	0.85	0.36	1.90	0.08	4.19

Source: 2001 Household Survey Data

The forecast population distribution using this formula exactly reflects the planning forecast of persons by type and approximates the effects on the population cross-classification of changes in the household category distribution. It is likely to increase the proportion of the population in a person type/household category if either or both of the person type and household category are forecast to form a greater proportion of the future population.

In effect, the process adjusts the matrix Nij in forecasting. Although the forecast matrix would look very similar to the observed Nij, because it is a simplified procedure it does not fully preserve some of the logical constraints on Nij. For example the implicit average household size for 1 and 2 person households may be marginally different from 1 or 2. Given that it is our expectation that the population distribution will not change by a large magnitude in future in a city with slowly-changing population and high car ownership, we are of the view that this approximation is acceptable.

The alternative would be to use quadratic programming algorithms to search to a population distribution for each zone which met these logical household constraints. We are reluctant to adopt such an increase in complexity, particularly as the optimisation approach does not itself provide assurance that the outcomes are correct (only that they are compatible with the constraints).

2.2 Additional Requirements

The calibration of the trip production model has led to a requirement to allow for growth in household income and the effects on adult trip rates of children in the household. As household income has a uniform incremental effect on trip rates for all persons, no special calculations are required.

Concerning the effects of children on adult trip rates, the HBO trip production model indicates that the average HBO trip rate for a zone should be increased for the effects of children by:

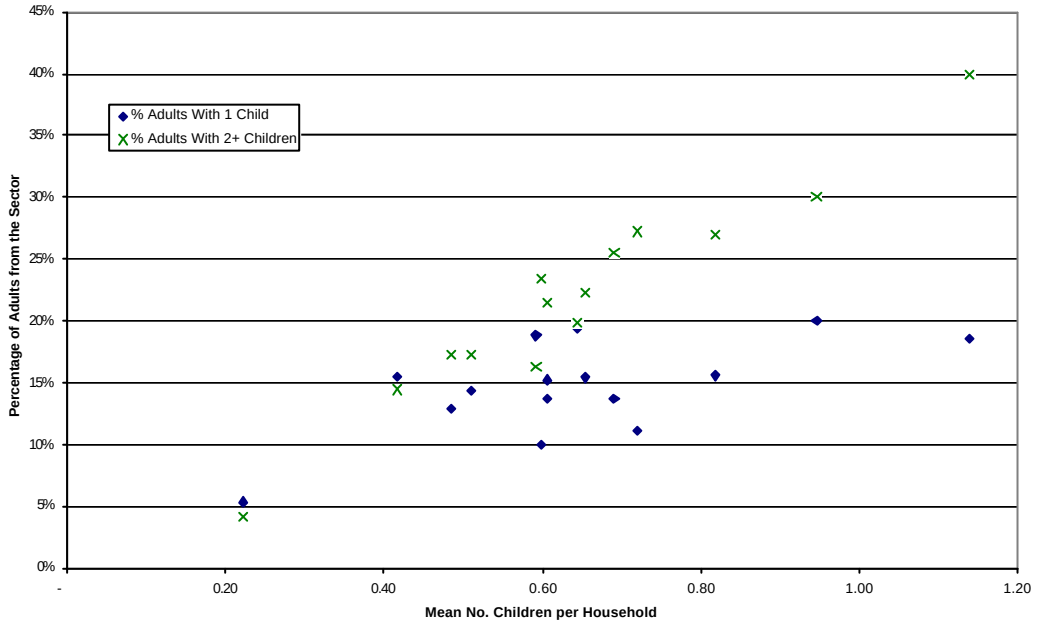
$$\alpha * (P_1 + 2 * P_{2+})$$

where:

α is a the calibrated coefficient for children,
P_1 is the proportion of adults in 1 child households, and
P_{2+} is the proportion of adults in households with 2 or more children.

As illustrated by Figure 2-3, the proportions P_1 & P_{2+} are closely related to the average number of children/household in each zone, and we propose to use a relationship of this kind to estimate the additional adult trips generated by the presence of children in the household.

Figure 2-3 The Variation in the Proportion of Adults with 1 or 2+ Children in their Household with the Average Number of Children per Household (by geographic sector)



3. Calibration and Validation of the Models

3.1 The Core Model

The model described in Section 2-1 uses the study area cross-classification of persons and households and adjusts it for the specific zonal distributions of households and persons. The model exactly reproduces the classification by person types, but is an approximate representation of the distribution of persons within the 14 household categories. To check the extent of the approximation, we have divided the region into 15 sectors and compared the model estimate of this distribution with that indicated by the household survey data. This sectorisation was chosen for the validation because the household sample in most sectors would be sufficient to provide a reasonable indication of the population distribution.

The table below shows the number of persons and households in each of the 15 sectors.

Table 3-1 Sector Sample Size

Sector	Persons	Households
1	70282	27562
2	34437	14547
3	4335	1919
4	38267	14676
5	12038	4541
6	27425	8457
7	17573	6250
8	33572	14020
9	34332	13304
10	47963	16071
11	25579	10400
12	19746	7491
13	8071	3353
14	12612	5515
15	23409	9287

The validation results are given in Table 3-2. This table compares the actual and estimated proportions of people in each household type within each sector. These comparisons are illustrated graphically in Figures 2-1 to 2-14 (plotting the predicted proportions against the observed for each household type). The line on each plot corresponds to predicted = observed.

Additionally Tables 2-3 to 2-16 give the details of a linear regression between the predicted and observed proportions. The ideal result of the regression would have a slope of 1, a y-intercept of 0 and an r-squared of 1. Sector 3, the smallest sector, has been omitted from the estimation of these linear models (due to its small sample size) – but is included in each of the predicted versus observed plots, identified by a hollow marker in contrast with solid markers for other sectors.

Generally the predicted proportions have a close match with the observed and the linear regression statistics are close to the ideal. There is only one segment - single person households, employed, with 1+ cars - where model does not meet the targets.

3.2 Adults with Children

Following an analysis of the data, the approach we have adopted is to predict first the proportion of adults with 1 or more children and then, secondly, the proportion of these who have 2 or more children.

Table 2-17 and Figure 2-15 give the results of the analysis showing the relationships with the average number of children per adult for 15 sectors. The model for 1 or more children is very accurate (an r-squared of 0.97), while there is more scatter in the second relationship but still an acceptable fit.

These proportions will be used in the HBO trip production models to predict the effects of changes in the number of children in the household on trip rates.

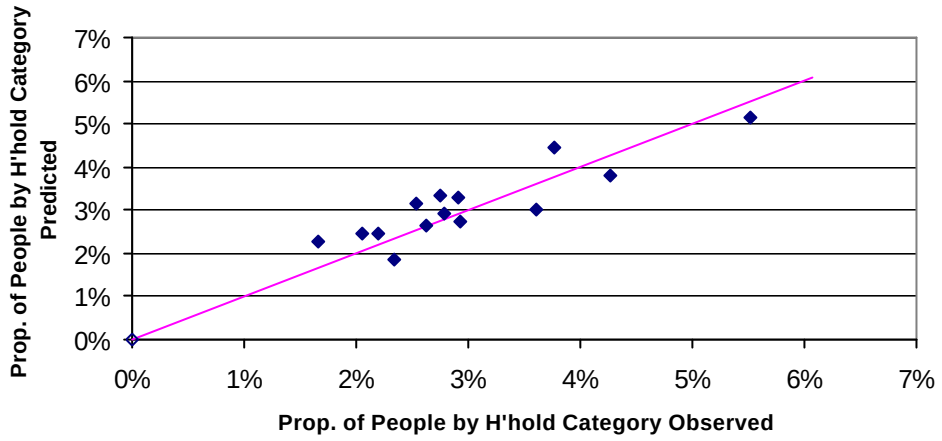
■ Table 3-2 Proportion of People in each Sector by Household Category Type

Num. Adults	1 Adult		1 Adult		2 Adults			2 Adults			3+ Adults			
Adult Employment	None		Employed		Neither Employed			1+ Adults Employed			-			
Num Cars	0	1+	0	1+	0	1	2+	0	1	2+	0	1	2	3+
Sector 1 Predicted	3%	3%	2%	6%	2%	4%	1%	2%	21%	21%	2%	11%	13%	9%
Sector 1 Observed	3%	3%	2%	5%	1%	4%	1%	2%	22%	23%	2%	11%	12%	9%
Sector 2 Predicted	2%	2%	3%	7%	0%	2%	4%	2%	21%	24%	1%	5%	19%	8%
Sector 2 Observed	2%	2%	3%	6%	0%	2%	4%	2%	19%	28%	1%	4%	18%	8%
Sector 3 Predicted	0%	3%	4%	4%	0%	3%	0%	18%	23%	0%	10%	24%	10%	0%
Sector 3 Observed	0%	7%	4%	11%	0%	7%	0%	17%	19%	0%	6%	16%	12%	0%
Sector 4 Predicted	3%	3%	0%	7%	1%	4%	1%	1%	21%	34%	1%	3%	13%	8%
Sector 4 Observed	4%	3%	0%	6%	1%	3%	1%	1%	24%	34%	1%	2%	12%	9%
Sector 5 Predicted	3%	2%	0%	6%	0%	7%	4%	1%	29%	28%	0%	4%	7%	8%
Sector 5 Observed	3%	2%	0%	4%	0%	7%	4%	1%	29%	32%	0%	4%	7%	9%
Sector 6 Predicted	4%	3%	2%	4%	1%	6%	0%	3%	19%	16%	1%	17%	15%	9%
Sector 6 Observed	4%	4%	2%	4%	0%	7%	0%	5%	17%	15%	1%	17%	14%	10%
Sector 7 Predicted	2%	2%	0%	6%	0%	1%	4%	0%	13%	50%	0%	2%	6%	15%
Sector 7 Observed	2%	1%	0%	7%	0%	1%	4%	0%	13%	50%	0%	2%	5%	15%
Sector 8 Predicted	3%	11%	0%	6%	1%	14%	4%	0%	14%	29%	0%	1%	11%	6%
Sector 8 Observed	3%	9%	1%	7%	1%	12%	4%	0%	14%	28%	0%	1%	13%	6%
Sector 9 Predicted	4%	4%	1%	6%	1%	5%	4%	0%	13%	33%	1%	8%	11%	10%
Sector 9 Observed	4%	3%	1%	6%	1%	5%	4%	0%	13%	31%	1%	9%	11%	10%
Sector 10 Predicted	5%	4%	0%	5%	1%	4%	0%	2%	15%	30%	3%	10%	11%	10%
Sector 10 Observed	6%	5%	0%	7%	1%	4%	0%	2%	15%	26%	3%	10%	10%	10%
Sector 11 Predicted	3%	7%	1%	8%	0%	4%	3%	0%	16%	29%	1%	8%	7%	11%
Sector 11 Observed	3%	8%	1%	8%	0%	4%	3%	0%	17%	30%	1%	8%	7%	10%
Sector 12 Predicted	2%	3%	2%	7%	1%	8%	3%	3%	16%	31%	0%	3%	13%	8%
Sector 12 Observed	2%	3%	3%	6%	1%	10%	3%	4%	13%	29%	0%	3%	16%	7%
Sector 13 Predicted	2%	10%	0%	6%	4%	8%	3%	0%	16%	34%	0%	3%	5%	8%
Sector 13 Observed	2%	9%	0%	9%	5%	7%	3%	0%	18%	32%	0%	3%	6%	7%
Sector 14 Predicted	3%	7%	0%	8%	1%	8%	1%	1%	9%	44%	0%	6%	5%	7%
Sector 14 Observed	3%	6%	1%	8%	0%	7%	1%	1%	9%	46%	0%	5%	4%	9%
Sector 15 Predicted	3%	6%	2%	5%	1%	10%	2%	1%	11%	36%	1%	2%	13%	8%
Sector 15 Observed	3%	6%	1%	4%	0%	9%	3%	0%	12%	39%	2%	3%	12%	7%

- **Table 3-3 One Adult Non-Employed 0 Cars**

Slope	Y-Intercept	r-squared
0.781	0.008	0.793

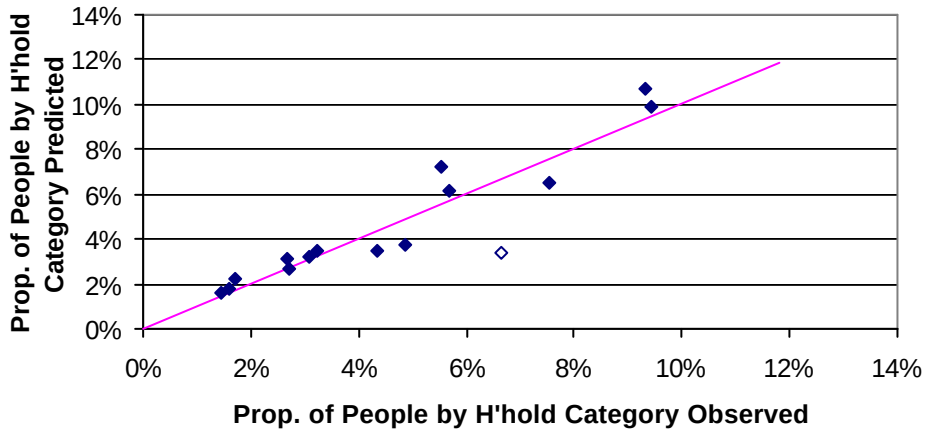
- **Figure 3-1 One Adult Non-Employed 0 Cars**



- **Table 3-4 One Adult Non-Employed 1+ Cars**

Slope	Y-Intercept	r-squared
1.045	0.000	0.927

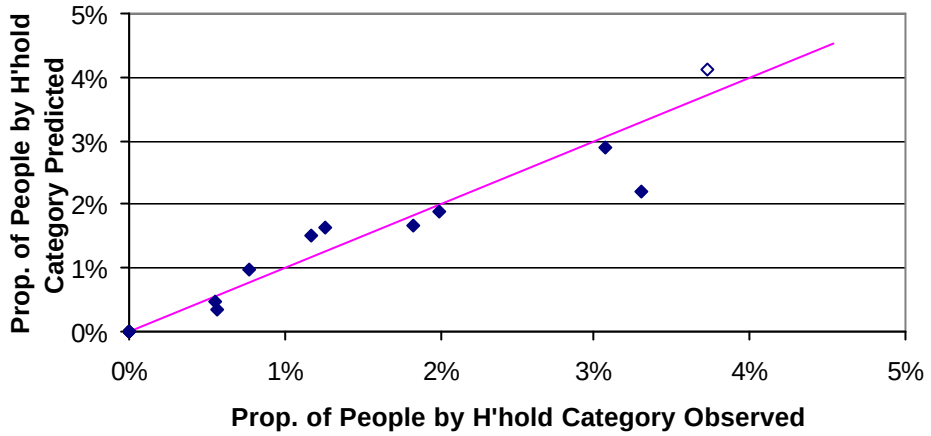
- **Figure 3-2 One Adult Non-Employed 1+ Cars**



■ **Table 3-5 One Adult Employed 0 Cars**

Slope	Y-Intercept	r-squared
0.83	0.001	0.914

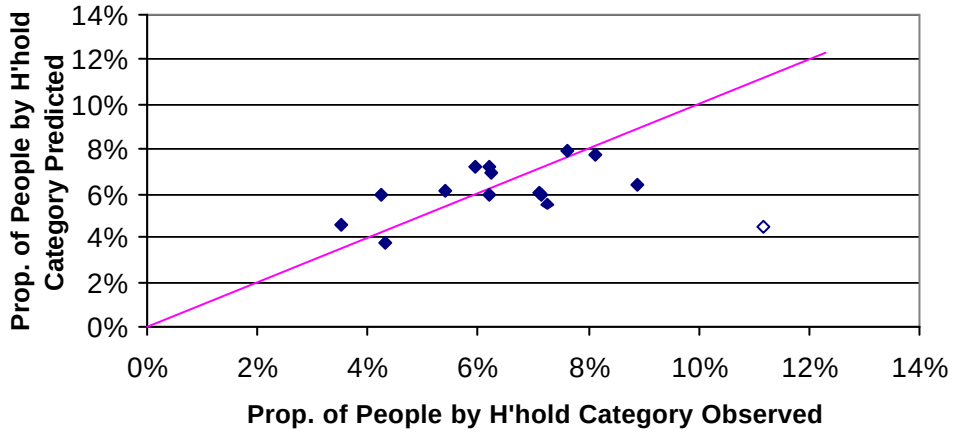
■ **Figure 3-3 One Adult Employed 0 Cars**



■ **Table 3-6 One Adult Employed 1+ Cars**

Slope	Y-Intercept	r-squared
0.467	0.033	0.379

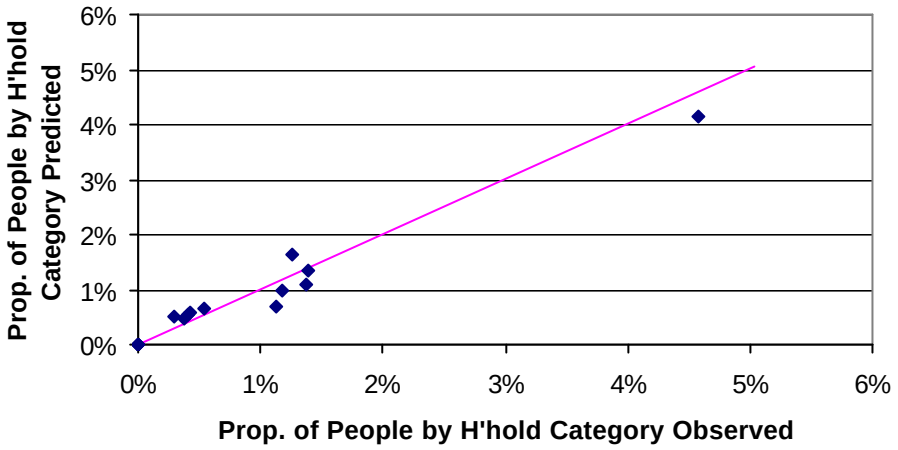
■ **Figure 3-4 One Adult Employed 1+ Cars**



■ **Table 3-7 Two Adults Non-Employed 0 Cars**

Slope	Y-Intercept	r-squared
0.883	0.001	0.967

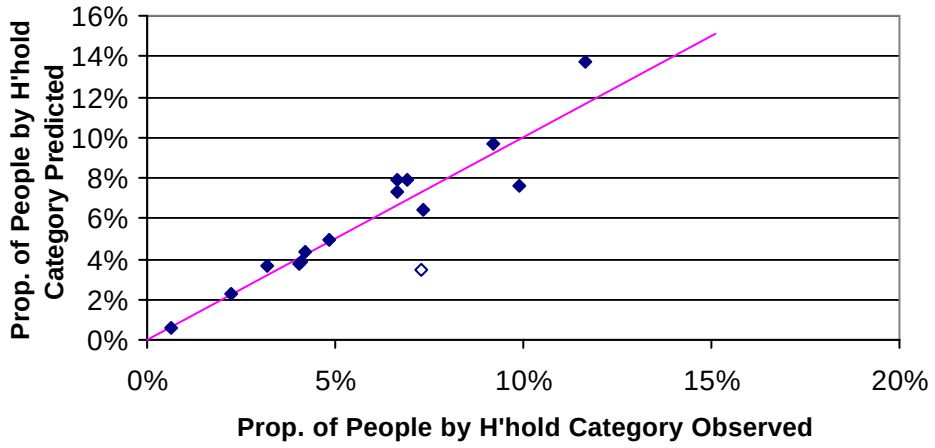
■ **Figure 3-5 Two Adults Non-Employed 0 Cars**



■ **Table 3-8 Two Adults Non-Employed 1 Car**

Slope	Y-Intercept	r-squared
1.044	-0.001	0.909

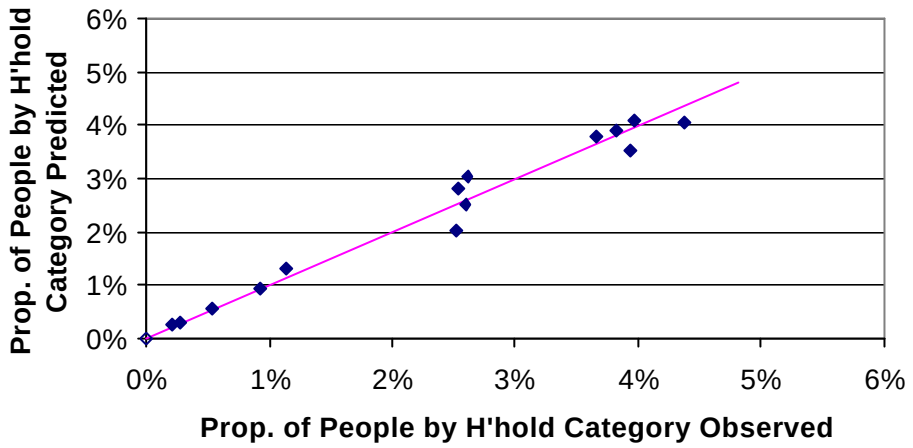
■ **Figure 3-6 Two Adults Non-Employed 1 Car**



- **Table 3-9 Two Adults Non-Employed 2+ Cars**

Slope	Y-Intercept	r-squared
0.960	0.001	0.970

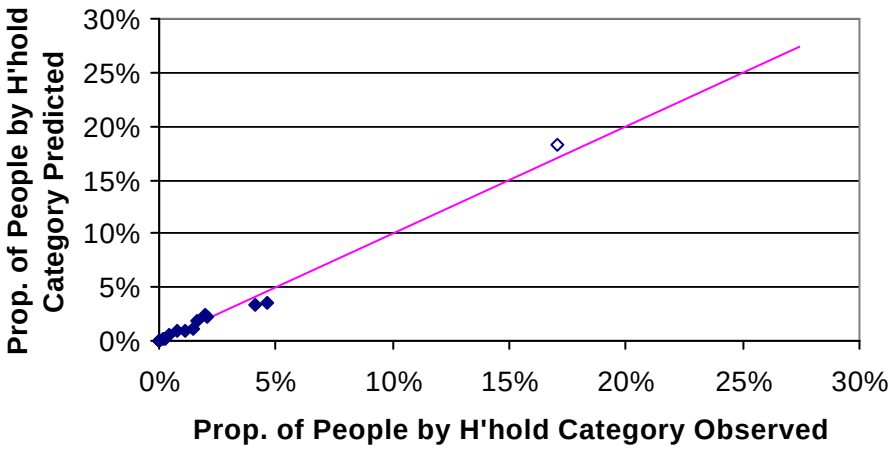
- **Figure 3-7 Two Adults Non-Employed 2+ Cars**



- **Table 3-10 Two Adults 1+ Employed 0 Cars**

Slope	Y-Intercept	r-squared
0.799	0.002	0.931

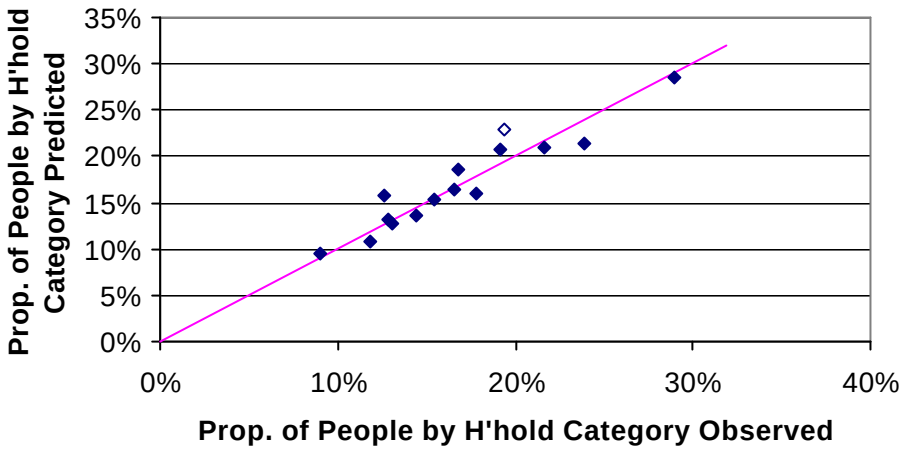
- **Figure 3-8 Two Adults 1+ Employed 0 Cars**



- **Table 3-11 Two Adults 1+ Employed 1 Car**

Slope	Y-Intercept	r-squared
0.908	0.015	0.924

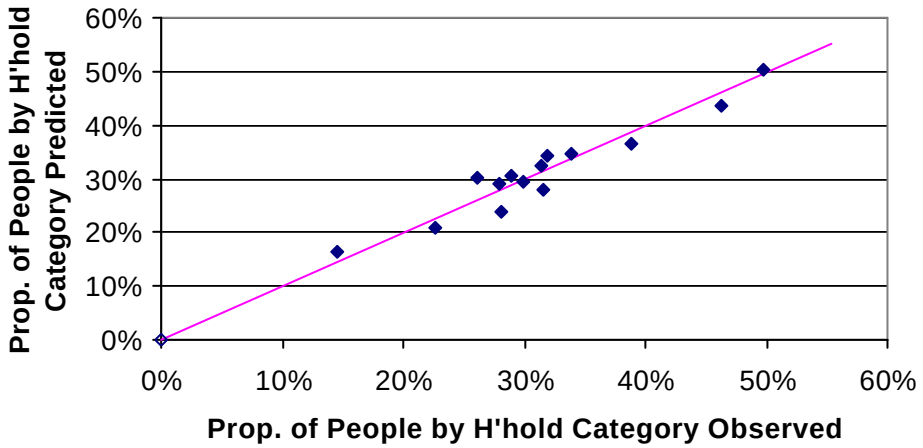
- **Figure 3-9 Two Adults 1+ Employed 1 Car**



- **Table 3-12 Two Adults 1+ Employed 2+ Cars**

Slope	Y-Intercept	r-squared
0.926	0.022	0.927

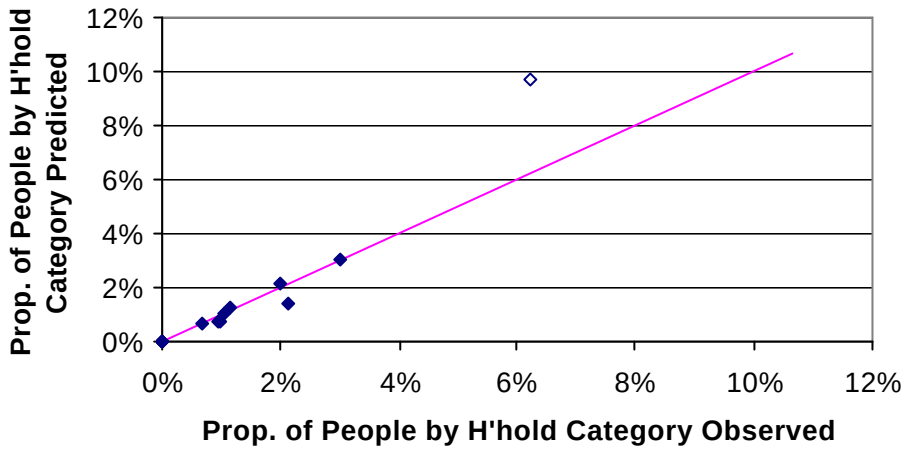
- **Figure 3-10 Two Adults 1+ Employed 2+ Cars**



- **Table 3-13 Three Adults 0 Cars**

Slope	Y-Intercept	r-squared
0.948	0.000	0.944

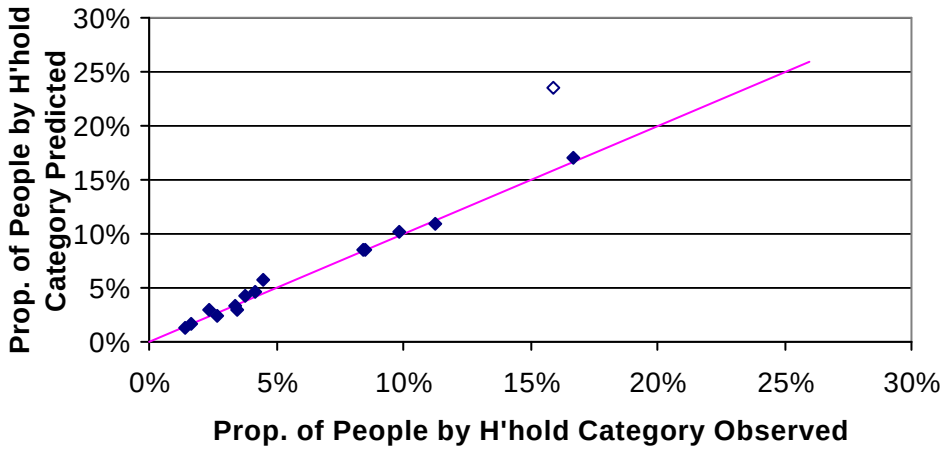
- **Figure 3-11 Three Adults 0 Cars**



- **Table 3-14 Three Adults 1 Car**

Slope	Y-Intercept	r-squared
1.000	0.001	0.989

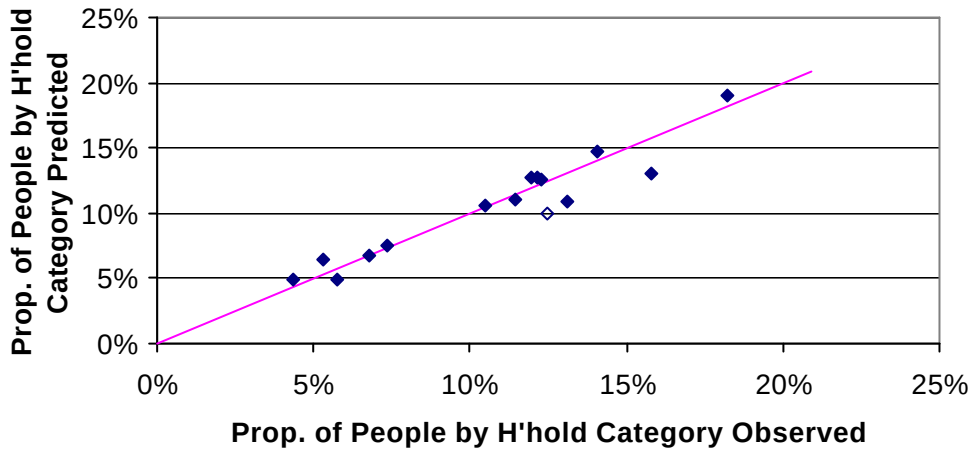
- **Figure 3-12 Three Adults 1 Car**



■ **Table 3-15 Three Adults 2 Cars**

Slope	Y-Intercept	r-squared
0.935	0.006	0.925

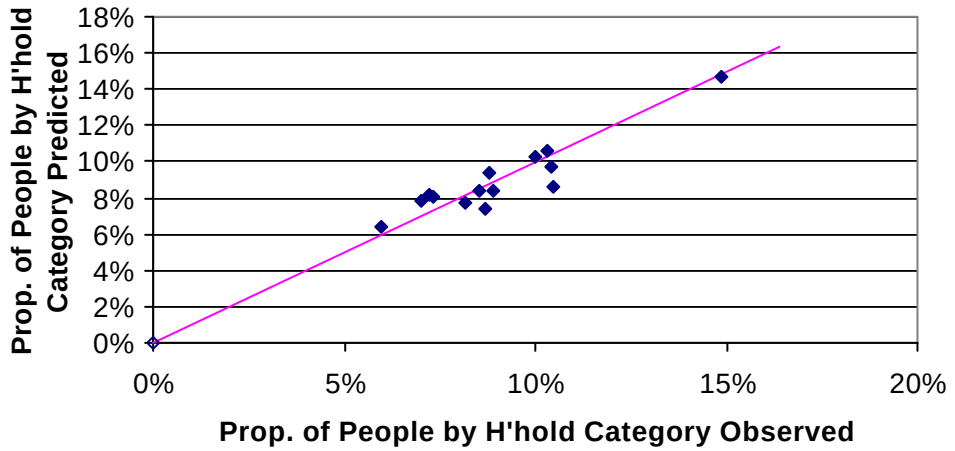
■ **Figure 3-13 Three Adults 2 Cars**



■ **Table 3-16 Three Adults 3+ Cars**

Slope	Y-Intercept	r-squared
0.848	0.013	0.856

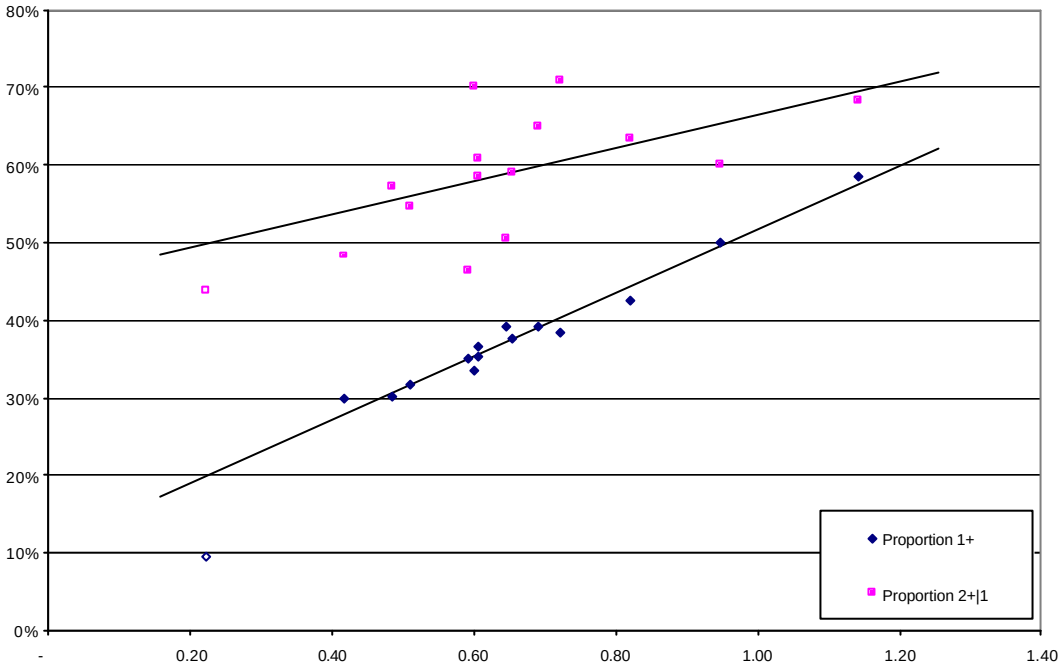
■ **Figure 3-14 Three Adults 3+ Cars**



■ **Table 3-17 The Variation in the Proportion of Adults with 1+ Children and the Proportion of Adults with 2+ Children given 1 Child with the Average Number of Children per Household (by geographic sector)**

Adults with…	Slope	Y-Intercept	r-squared
1+ children	0.406	0.110	0.973
2+ given 1+ children	0.215	0.450	0.279

■ **Figure 3-15 The Variation in the Proportion of Adults with 1+ Children and the Proportion of Adults with 2+ Children given 1 Child with the Average Number of Children per Household (by geographic sector)**



Wellington Transport Strategy Model

TN16.5 Miscellaneous Trip end Model Report

Final

July 2003

prepared for

Greater Wellington – The Regional Council

By

Beca Carter Hollings & Ferner Ltd

And

Sinclair Knight Merz

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1. External Trips

1.1 Introduction

There are three external zones in the WTSM network:

- 226 – SH 1
- 227 – SH 2
- 228 – The inter-island ferry terminal.

External trip data was collected in both the household survey amd the external screenline survey. The latter source of external trips were car driver trips only. Very few public transport external trips have been collected in the household survey, and consequently they were omitted from the calibration process.

1.2 Treatment of External Trips and Costs

Only car driver trips have been included in the modelling process. Thus the mode split model is not applied to external trips. External trips are included with internal trips in the calibration of the distribution models.

As the generalised costs from the network skims for these external trips are only for the internal part of the trip, we would in principle need some incremental cost to be arbitrarily added. However, as, in practice, this extra cost is the same as increasing the external zone balancing factor in the distribution model, this is not required.

Thus the additional requirements for external trip modelling are car productions and attractions by purpose (and car availability) for each of the external zones, and these are documented below.

1.3 Survey Data – Base Year

As stated previously, external trip data has been collected in both the external screenline survey and the household survey. This data has been processed differently for external productions and attractions as described below.

1.3.1 External Production Data

As the household survey was only conducted within the Wellington Region, there are no external productions (ie internal travel generated by non-residents) in the household survey data for all of the home based trip purposes. All external productions therefore come from the external screenline survey.

All trips from the screenline survey have been assumed to be choice, excepting HBW, where 35.5% of trips were assumed to be competition, with the remaining being choice[1]. This factor was calculated from the household survey HBW trips. Table 1-1 contain the final trip productions for the external trips.

[1] The split between choice and competition trips required for HBW modelling was not obtained in the screenline surveys.

■ **Table 1-1 External Car Driver Productions to the Wellington Region**

Zone	Car Availability	HBW	HBEd	HBSh	HBO	NHBO	BU
226	Competition	663	0	0	0	0	0
226	Choice	1205	139	853	1946	611	1983
227	Competition	200	0	0	0	0	0
227	Choice	364	110	476	324	247	424

1.3.2 External Attraction Data

Although external attractions were collected in the household survey, the sample size is much smaller than that in the screenline survey (1.6% compared to 26.6%). Thus the external screenline survey has been used as the sole source of external trip attractions because its survey sampling error is very much smaller.

External trip attractions are car driver trips only. The table below details the external trip attractions by purpose.

■ **Table 1-2 External Car Driver Attractions from the Wellington Region**

Zone	HBW	HBEd	HBSh	HBO	NHBO	BU
226	1338	104	687	1411	655	944
227	375	154	84	299	251	362

1.4 External Trip Growth

Rather than being driven by the internal Wellington region population and land use data, external trip end growth requires a separate growth factor calculation.

The approach to be adopted assumes external car driver trip ends to grow at the same rate as internal car trips. Thus the formulation of future external trip ends are:

$$\mathrm{Pr}\,oduction_{zone}^{ForecastYear} = \mathrm{Pr}\,oduction_{zone}^{2001} \cdot \frac{\mathrm{Pr}\,oductions_{InternalZones}^{ForeecastYear,Car}}{\mathrm{Pr}\,oductions_{InternalZones}^{2001,Car}}$$

$$Attraction_{zone}^{ForecastYear} = Attraction_{zone}^{2001} \cdot \frac{Attractions_{InternalZones}^{ForeecastYear,Car}}{Attractions_{InternalZones}^{2001,Car}}$$

2. Airport Trips

2.1 Background

The household survey data in principle includes the airport access trips of resident air passengers and the commutes of airport employees but, unsurprisingly we appear to have under-sampled residents' air passenger access trips. Additionally the household data does not include the airport access trips of visitors.

Thus we have developed a synthetic approach to developing the airport air passenger access trips. However, there was no reason to distinguish the commuting trips to the airport from any other HBW journeys and these have been included in the trip production and attraction models for HBW.

2.2 Model

The model developed produces a separate base trip matrix of air passenger vehicle trips based on airport passenger numbers and access data. This is projected forward by using growth factors (from air passenger forecasts) and time period factors are applied. These airport based trips are then added to the vehicle trip matrices developed in the main model procedures.

2.2.1 Trip Attractions

In the base year, the number of visiting air passengers and their choice of access mode are known. The model's task therefore is to estimate the car/taxi trip rates. Public transport access trip rates have not been calculated because they are mainly on dedicated bus services, which may not be in the WTSM network.

Figure 2-1 illustrates a model of air passenger and commuter trip rates. Many of the model parameters are unavailable, and are therefore judgements based on reasonable expectation and validated against overall outcomes at Wellington Airport where data is available.

The key drivers of car trip rates are:

1) the split between residents and non residents (non-residents are more reliant on public transport),
2) the split between international and domestic passengers,
3) the split between business and leisure passengers (business travellers rarely use public transport),
4) average group size for each trip type (which determines the number of vehicle trips),
5) the airport access by mode for each trip type.

Where possible we have used airport statistics for these 'drivers' (such as the international domestic split). Otherwise we have made informed judgements.

The final total car trip rate is the summation of the total car trip rate for parked cars, escort cars, taxis and hire cars (the mean vehicle trip rate row). These trip rates are in turn the weighted average of the access proportions and the proportion of each passenger type, scaled by the average group size.

For example, the taxi overall trip rate (0.42) is generated by multiplying the column headed taxi, with the column headed proportion and divided by the column headed group size and then summing over the column. For car escort trips, this calculated trip rate is then multiplied by 2.

The proportion column in the spreadsheet is generated by the passenger type data, items 1,2 and 3 from the above list.

■ **Figure 2-1 Airport Trip Rates – Annual Data**

Passengers									Mode Shares (%)					
Flights		**Residence**		**Purpose**		**Proportion**	**Group size**	**Ratio**	**Parked Car**	**Car Escort**	**Taxi**	**PT**	**Hire car**	**Total**
International	10%	Local residents	50%	Business	30%	1.5%	1.1	0.01	40%	10%	50%	0%	0%	100%
				Leisure	70%	3.5%	1.5	0.02	20%	40%	35%	5%	0%	100%
		Other	50%	Business	30%	1.5%	1.1	0.01	0%	10%	80%	0%	10%	100%
				Leisure	70%	3.5%	1.5	0.02	0%	45%	40%	5%	10%	100%
Domestic	90%	Local residents	50%	Business	30%	13.5%	1.1	0.12	40%	10%	50%	0%	0%	100%
				Leisure	70%	31.5%	1.5	0.21	20%	40%	35%	5%	0%	100%
		Other	50%	Business	30%	13.5%	1.1	0.12	0%	10%	80%	0%	10%	100%
				Leisure	70%	31.5%	1.5	0.21	0%	45%	40%	5%	10%	100%
						100%								
Mean vehicle trip rate									0.10	0.45	0.42	0.00	0.04	**1.01**
Mode Share									13%	33%	46%	4%	5%	100%
2001 pax														3,700,000
														Model
Exited car park										40%				**9,577**
Mean vehicle trip rate by purpose														**Total**
BU									0.05	0.03	0.18	0.00	0.01	**0.27**
HBO									0.05	0.42	0.25	0.00	0.02	**0.74**

Thus we can estimate air passenger trip generation rates for the airport as:

- 1.01 daily car and taxi trips per passenger,
- of which 73% are leisure and 27% business.

While these trip rates could be further segmented by air passenger type, there seems little advantage in this.

We have confirmed that this model broadly reproduces current statistics on car park usage and is consistent with traffic volumes (car and taxi separately) at the airport access roads.

For implementation in WTSM, daily air passenger estimates are required, to which the trip rate of 1.01 car trips / passenger is applied to produce the daily trip attractions to the airport.

Data provided by WIAL show average arrivals and departures on a typical weekday of 11,764 (Data provided 14th August 2002). This represents an annual to weekday factor of 311.9. (3,669,000 annual passenger movements / 11,764).

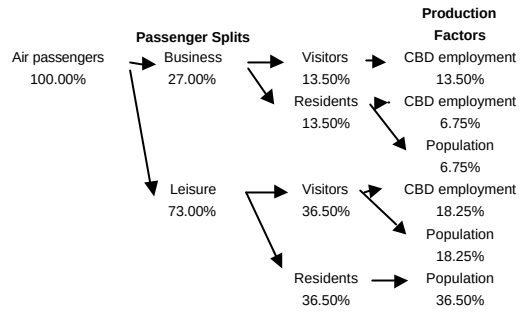
2.2.2 Trip Matrix Distribution

These trip attractions have been distributed across origin zones by considering factors such as:

- the proportion of visitor trips which will start at hotels, primarily in the CBD;
- the proportion of business trips which will start in the CBD, related to service employment and the nature of CBD businesses;
- the population in each zone.

The approach illustrated overleaf has been implemented.

■ **Figure 2-2 Air Travel Distribution Model**



Implied Trip Rates

Category	Air passengers	Planning data	Trip rate
CBD employment	0.385	70000	0.0000055
Population	0.615	410000	0.0000015

This approach divides trip productions into two types, that driven by cbd employment and that driven by population, for each passenger type. Assuming population proportions for each of these types allows a total weighting between cbd employment and population to be calculated as:

- 38.5% for cbd employment, and
- 61.5% for population.

The productions are then scaled to match the total attractions. Thus the final process involves forecasting the trip productions as:

$$Initial\ \mathrm{Pr}oduction_{zone} = 1.01 \cdot (0.385 * CBDEmployment + 0.615 * Population)$$

$$Final\ \mathrm{Pr}oduction_{zone} = Initial\ \mathrm{Pr}oduction_{zone} \cdot \frac{AirportTotalAttractions}{\sum Initial\ \mathrm{Pr}oduction_{zone}}$$

2.2.3 Growth Forecasting

Growth forecasts are obtained for trip attractions by applying air passenger forecasts to the attraction trip rates.

These attractions are then distributed across the region using updated forecasts of population and employment following the same process as for the base year.

This growth forecast has been sourced from a number of sources, namely forecasts done for Wellington Airport by Leigh Fisher Associates in 1997 and reproduced in a 2001 report by WIAL[2]. This report also contains forecasts by Tourism Futures International for international growth rates. The adopted growth is 14% from 2001 to 2011 and 15% growth between 2011 and 2021. This rate increases as the international segment increases it's share of total passenger throughput at Wellington Airport.

2.2.4 Time Period Factors

Time period factors have been developed to factor the daily trip matrix produced above into the three time periods.

Analysis of the arrivals and departures information data provided by WIAL suggests that there is no directionality in the peak periods (that is there are as many vehicles arriving as departing). As a result the air passenger OD matrix can be allocated to the time periods as follows:

- am peak: 13%

[2] WIAL'S Comments on Historic and Forecast Passenger Activity Levels at Wellington Airport, 2001 – Appendix 6(a)

- interpeak: 45%
- pm peak: 15%.

These factors have been calculated from the domestic and international arrivals and departures data provided by WIAL, accounting for the various check-in time requirements for domestic and international flights.

3. Further Production and Attraction TLA Factoring

Subsequent to the analysis provided in the trip production and attraction reports, a series of validation tests was undertaken of the expanded household data and the fully synthetic trip production and attraction totals at a sector and TLA (Territorial Local Authority) level by purpose.

3.1 Attraction Factoring

The significant differences between the observed and modelled trip attractions by purpose and segment were reflected with the TLA correction factors presented in the Attraction Report.

However, as the attraction models have been calibrated against the *observed* trip matrices from the household survey, any underestimate of population in our survey will be reflected with lower observed trip rates. Hence we would expect to underestimate the total observed attractions in proportion to our underestimate of population.

We have therefore adjusted the attraction trip rates by the error in the population for each TLA. Presented below are the final TLA correction factors which incorporate both the correction to the observed trips reported in the Attraction Report, and the factors to correct the underestimate of the population in the household data.

Table 3-1 HBW TLA Implemented Correction Factors

Kapiti	Porirua	Upper Hutt	Lower Hutt	Wellington	Masterton	Carterton	South Wai
1.031	0.813	1.305	1.030	1.024	0.992	1.429	0.759

Table 3-2 HBEd TLA Implemented Correction Factors

Kapiti	Porirua	Upper Hutt	Lower Hutt	Wellington	Masterton	Carterton	South Wai
1.269	1.209	1.030	1.071	1.160	1.025	1.604	0.483

Table 3-3 HBSh TLA Implemented Correction Factors

Kapiti	Porirua	Upper Hutt	Lower Hutt	Wellington	Masterton	Carterton	South Wai
1.1210	1.1303	0.8555	1.1173	0.9581	1.0550	1.3900	1.3017

Table 3-4 HBO TLA Implemented Correction Factors

Kapiti	Porirua	Upper Hutt	Lower Hutt	Wellington	Masterton	Carterton	South Wai
1.112	0.986	1.054	0.923	0.959	1.065	1.257	0.729

Table 3-5 NHBO TLA Implemented Correction Factors

Kapiti	Porirua	Upper Hutt	Lower Hutt	Wellington	Masterton	Carterton	South Wai
1.012	0.942	0.969	0.975	1.012	0.983	1.133	0.520

Table 3-6 BU TLA Implemented Correction Factors

Kapiti	Porirua	Upper Hutt	Lower Hutt	Wellington	Masterton	Carterton	South Wai
1.020	1.042	1.046	1.026	1.028	1.008	1.121	1.118

3.2 Production Factoring

As the production models were calibrated at a disaggregate person level, the person trip rates, applied to the correct population totals will correctly reflect the trip making associated with the census population data.

However, inspection of the final modelled productions at a purpose and sector level revealed an underestimation of Home Based Education trips in sector 2 (the area South and East of the Wellington CBD). While in total the Wellington City TLA error did not warrant a correction factor (it was statistically insignificant), the underestimate in Sector 2 was of a large enough magnitude to require correction. This correction factor is 29%, applied to home based education productions in Sector 2.

4. Production and Attraction Trip Balancing

The distribution models implemented in WTSM undertake a two dimensional balancing process.

For this process to converge, we require the total production and attractions to be balanced for each purpose.

This trip balancing is explained below, separately for the home based and non home based purposes.

4.1 Home Based Purpose Trip Balancing

For home based purposes, the trip attractions are scaled to match the total attractions. The scaled attractions are calculated as shown below:

$$FinalAttraction_{zone}^{purpose} = Attraction_{zone}^{purpose} * \frac{\sum_{zone,segment} Productions_{zone}^{purpose,segment}}{\sum_{zone} Attractions_{zone}^{purpose}}$$

4.2 Non Home Based Purpose Trip Balancing

For the non home based trip purposes, it is assumed that the 24 hour trip productions and attractions should be symmetrical. However the trip production and attraction models do not specifically reproduce this. Hence for these purposes, the total trip productions are used as the control total for the trip attractions, which are then assumed to be the same as the productions. This is expressed mathematically below:

$$FinalAttraction_{zone}^{purpose} = Attraction_{zone}^{purpose} * \frac{\sum_{zone,segment} Productions_{zone}^{purpose,segment}}{\sum_{zone} Attractions_{zone}^{purpose}}$$

$$FinalProduction_{zone}^{purpose} = FinalAttractions_{zone}^{purpose}$$