

**THE FOUNDATION OF A NEW TRANSPORTATION
PLANNING MODEL FOR THE MANITOBA CAPITAL
REGION**

by

Kean Hoe Lew

A Thesis

Submitted to the Faculty of Graduate Studies

in Partial Fulfillment of the Requirements

for the Degree of

Master of Science

Department of Civil and Geological Engineering

University of Manitoba

Winnipeg, Manitoba

Canada

© Copyright 2000

THE UNIVERSITY OF MANITOBA
FACULTY OF GRADUATE STUDIES

COPYRIGHT PERMISSION PAGE

The Foundation of a New Transportation Planning Model for the Manitoba Capital Region

BY

Kean Hoe Lew

**A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University
of Manitoba in partial fulfillment of the requirements of the degree**

of

Master of Science

KEAN HOE LEW © 2001

Permission has been granted to the Library of The University of Manitoba to lend or sell copies of this thesis/practicum, to the National Library of Canada to microfilm this thesis/practicum and to lend or sell copies of the film, and to Dissertations Abstracts International to publish an abstract of this thesis/practicum.

The author reserves other publication rights, and neither this thesis/practicum nor extensive extracts from it may be printed or otherwise reproduced without the author's written permission.

ABSTRACT

This thesis develops the foundation of a model to predict P.M. peak vehicle trips for the Manitoba Capital Region. This model, called the Manitoba Capital Region Transportation Planning Model (MCRTPM), is built on a Geographical Information System for Transportation (GIS-T) platform. Components of the model were calibrated using the 1996 Statistics Canada Journey-to-Work database and the matrix adjustment algorithm with newly developed traffic data from the City of Winnipeg and Manitoba Department of Highways and Government Services (MHGS).

The foundation developed in this thesis allows further refinement to be made to the MCRTPM in order to develop a complete model. This model facilitates transportation planning in the Manitoba Capital Region.

ACKNOWLEDGEMENTS

I would like to express my sincerest gratitude to Mr. Kenn Rosin and Mr. Doug Hurl for allowing me the opportunity to work with them.

I would also like to thank Mr. Dave Duncan for his support and encouragement.

I would like to extend my appreciation to the City of Winnipeg Public Works Department for their financial assistance in this research. I would also like to thank the people who has helped me in the course of the completion of this thesis:

Mr. Malcolm Brown

Mr. Alan Brownlee

Mr. David Krieger

Mr. Clark Lim

Dr. Ali Mekky

Mr. Alan Taylor

My deepest gratitude goes out to Jeannette Montufar for inspiring me.

I would like to thank C.K. and S.L. for helping me stand up during the times when I faltered.

My deepest gratitude goes out to V.L.M. for giving me a reason to continually strive to be a better person.

I wish to thank my parents, sister and brother-in-law for their love, support, and understanding.

Finally, I would like to thank my advisor, Professor Alan Clayton, for his wisdom, insight, patience, assistance, encouragement and for believing in me.

TABLE OF CONTENTS

1.0	INTRODUCTION.....	1
	<i>This chapter presents the purpose, background, objectives, scope and organization of the thesis</i>	
1.1	PURPOSE	1
1.2	BACKGROUND AND NEED	1
1.3	RESEARCH OBJECTIVES AND SCOPE.....	8
1.3.1	Objectives	8
1.3.2	Scope.....	9
1.4	THESIS ORGANIZATION	11
2.0	TRANSPORTATION PLANNING MODELS.....	13
	<i>This chapter provides an overview of the general transportation planning model structure. Using the structure, transportation planning models from the City of Winnipeg and selected Canadian cities are reviewed, compared and contrasted</i>	
2.1	TRANSPORTATION PLANNING MODEL STRUCTURE.....	13
2.1.1	Subsystem Components and Organization.....	13
2.1.2	Level of Analysis of Each Subsystem	15
2.1.3	Methods Used by Each Subsystem.....	16
2.2	WINNIPEG TRANSPORTATION MODEL.....	16
2.3	TRANSPORTATION MODELS FROM SELECTED CANADIAN CITIES	22
3.0	MODEL FRAMEWORK.....	24
	<i>This chapter develops the framework for the Manitoba Capital Region Transportation Planning Mode</i>	
3.1	THE 1996 JOURNEY-TO-WORK DATABASE.....	24
3.2	PLATFORM	26
3.3	MODEL STRUCTURE	27
4.0	THE MANITOBA CAPITAL REGION TRANSPORTATION ANALYSIS NETWORK..	30
	<i>This chapter discusses the development of the Manitoba Capital Region Transportation Analysis Network (MCRTAN)</i>	
4.1	BACKGROUND.....	30
4.2	NETWORK CONSTRUCTION DETAILS	30
4.3	NETWORK DETAIL AND CENTROID CONNECTORS	31
4.4	STANDARDIZED NETWORK TOPOLOGY	33
4.5	NETWORK ATTRIBUTION.....	35
4.6	TURN RESTRICTIONS	44

4.7	ZONE SYSTEM	45
5.0	COMPONENTS OF THE MCRTPM	46
	<i>This chapter discusses the components of the MCRTPM developed in this research</i>	
5.1	P.M PEAK AUTOMOBILE DRIVER WORK TRIP (PMPADWT) MATRIX	46
5.2	P.M. PEAK VEHICLE OTHER TRIP (PMPVOT) MATRIX	47
5.2.1	P.M. Peak Counts on City of Winnipeg Streets	48
5.2.2	City of Winnipeg Special Interchange Ramp Counts	48
5.2.3	P.M. Peak Counts for the Provincial Highways	49
5.2.4	Results of Matrix Adjustment Algorithm	52
5.3	TRIP GENERATION COMPONENT	61
5.3.1	ADWT Production Equation	62
5.3.2	ADWT Attraction Equation	65
5.4	TRIP DISTRIBUTION COMPONENT	69
5.4.1	PMPADWT and PMPVOT Trip Distribution Equations	72
5.5	TRIP ASSIGNMENT COMPONENT	73
5.5.1	Trip Assignment Component Development	73
6.0	CONCLUSION AND FURTHER WORK	77
	<i>This chapter provides the conclusion of the thesis and proposes further work for the MCRTPM</i>	
6.1	CONCLUSION	77
6.2	DISCUSSION AND FURTHER WORK	77
6.2.1	ADWT Time Distribution	77
6.2.2	PMPVOT Matrix	78
6.2.3	Trip Generation Component	79
6.2.4	Trip Distribution Component	79
6.2.5	Trip Assignment Component	79
6.2.6	Refinement of Centroid Connectors	80
6.2.7	Zone System Improvement	80
	ADDENDUM	81
	REFERENCES	82
	APPENDIX	87
	APPENDIX A	88
	<i>List of Cartographic, Spatial Layer, and Database Files used in the Thesis</i>	
	APPENDIX B	92
	<i>Sample of the MCRTAN in Tabular Form</i>	

APPENDIX C	96
<i>MCRTAN Turn Restriction File in Tabular Form</i>	
APPENDIX D	98
<i>Sample of the Winnipeg Regional Traffic Zone System in Tabular Form</i>	
APPENDIX E.....	100
<i>Links in the MCRTAN which contains Traffic Counts used for the Matrix Adjustment Algorithm</i>	
APPENDIX F.....	112
<i>Trip Production Equations for ADWT</i>	
APPENDIX G	116
<i>Trip Attraction Equations for ADWT</i>	
APPENDIX H.....	122
<i>Trip Production and Attraction Equations for PMPVOT</i>	
APPENDIX I.....	131
<i>Report on Census Place of Work (POW) Seminar (October 2000)</i>	

LIST OF FIGURES

Figure 1: The Manitoba Capital Region	2
Figure 2: Charleswood Bridge and Highway 101 Northeast Extension.....	4
Figure 3: AADT at Station 47.....	6
Figure 4: Location of Charleswood Bridge and Permanent Count Station 47	6
Figure 5: Winnipeg Regional Traffic Zone System.....	10
Figure 6: Variations in the Organization of Transportation Models.....	14
Figure 7: Structure of Winnipeg Model.....	17
Figure 8: City of Winnipeg Zone Types	18
Figure 9: ND-Lea Winnipeg Downtown Model.....	21
Figure 10: Structure of Manitoba Capital Region Transportation Model.....	29
Figure 11: Centroid Connectors for Zone 6611	33
Figure 12: Traffic Data Linked using Topology.....	35
Figure 13: Centroid Connector Equality.....	40
Figure 14: Steinbach and Zone 9510	41
Figure 15: MCRTAN.....	42
Figure 16: Details of an Interchange Rmp (PTH 101 and PTH 7)	42
Figure 17: One way Streets in the Winnipeg Downtown Area	43
Figure 18: Centroid Connectors in the Winnipeg Downtown Area	43
Figure 19: PCS Locations in the Manitoba Capital Region.....	49
Figure 20: Links with P.M. Peak Counts.....	51
Figure 21: Results of Matrix Adjustment Algorithm (10 Iterations).....	53
Figure 22: Results of Matrix Adjustment Algorithm (40 Iterations).....	54
Figure 23: Results of Matrix Adjustment Algorithm (100 Iterations).....	55
Figure 24: Results of Matrix Adjustment Algorithm (200 Iterations)	56
Figure 25: Key Links	57
Figure 26: Trip Generation Component Development Procedure.....	62
Figure 27: Automobile Driver Work Trips Produced Versus Total Employment.....	64
Figure 28: Automobile Driver Work Trips Versus Number of Households	66
Figure 29: Trip Distribution Component Development Procedures.....	69
Figure 30: Trip Assignment Component Development Procedure.....	73

Figure 31: Example of a Link Performance Function	75
--	-----------

LIST OF TABLES

Table 1: Transportation Models from Selected Canadian Cities	22
Table 2: 1996 Statistics Canada Journey-to-Work Database.....	26
Table 3: P.M. Peak Traffic Count Database without Topology Linkage	34
Table 4: P.M. Peak Traffic Count Database with Topology Linkage	35
Table 5: Manitoba Capital Region Transportation Network Attributes	36
Table 6: Manitoba Capital Region Transportation Network Attributes	37
Table 7: Manitoba Capital Region Transportation Network Attributes	38
Table 8: Summary of MCRTAN	41
Table 9: Turn Restriction File.....	44
Table 10: Zone System File.....	45
Table 11: Estimated PMPVTT Flow and Observed PMPVTT Flow in the AB Direction at Key Links.....	58
Table 12: Estimated PMPVTT Flow and Observed PMPVTT Flow in the BA Direction at Key Links.....	59
Table 13: Estimated P.M. Peak Vehicle Total Trips	60
Table 14: ADWT Trip Production Equations Examined.....	63
Table 15: ADWT Trip Attraction Equations Examined	65
Table 16: PMPVOT Trip Production Equations Examined	67
Table 17: PMPVOT Trip Attraction Equations Examined.....	68

1.0 INTRODUCTION

This chapter presents the purpose, background, objectives, scope and organization of the thesis.

1.1 Purpose

The thesis develops the foundation of a model to predict P.M. peak vehicle trips for the Manitoba Capital Region. This model, called the Manitoba Capital Region Transportation Planning Model (MCRTPM), is built on a Geographical Information System for Transportation (GIS-T) platform. Components of the model were calibrated using the 1996 Statistics Canada Journey-to-Work database and the matrix adjustment algorithm with newly developed traffic data from the City of Winnipeg and Manitoba Department of Highways and Government Services (MHGS).

1.2 Background and Need

The City of Winnipeg and the surrounding region are termed the "Manitoba Capital Region" (see Figure 1). The 1996 Census of Canada indicates that the Capital Region has a population of approximately 700,000 people with 625,000 of them residing in Winnipeg (Capital Region Review, 1999). Like most North American metropolitan areas, the City of Winnipeg is experiencing urban sprawl characterized by the rise of suburban communities surrounding the older areas. Klassen (1999) documents the urban sprawl pattern in the region. Growth in the ex-urban communities in the Capital Region,

and large activity shifts in the City of Winnipeg itself have translated into significant changes in the traffic patterns.

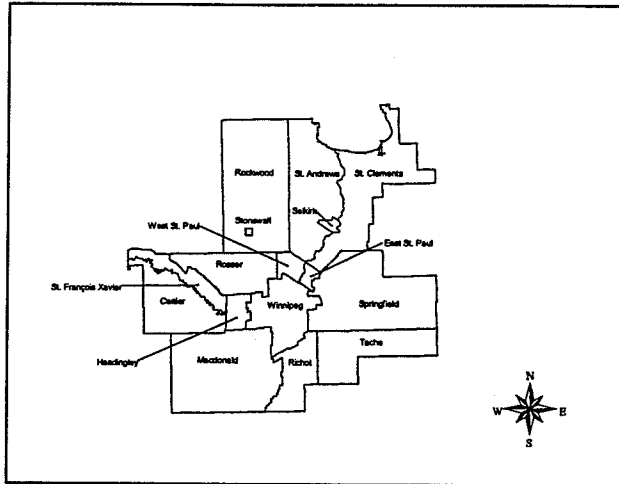


Figure 1: The Manitoba Capital Region

To this day, transportation agencies in the region, like the City of Winnipeg, Manitoba Department of Highways and Government Services (MHGS), Manitoba rural municipalities, Winnipeg Transit, and the Winnipeg Airport Authority perform their own respective transportation planning. The lack of a regional approach to transportation planning has led to a situation in which there is insufficient understanding of the regional traffic characteristics in the region. The Capital Region Review panel highlighted this lack of understanding when they concluded that there is “inadequate information and research for assessing commuting patterns within the region” (1999). In order to increase the effectiveness of transportation planning, there is a need to develop better means to understand, structure, analyze and predict transportation demand (characterized by traffic flows) in the Manitoba Capital Region. This can be achieved through the construction of a model that links the transportation and land-use systems of the region in terms of traffic

flows. This linkage provides a capability to better assess and test a variety of transportation planning alternatives. This capability in turn provides decision makers with quantitative information about the consequences of their decisions, thus allowing objective transportation systems analysis and planning in the region (Mekky, 2000).

In the United States, metropolitan areas have their respective Metropolitan Planning Organizations (MPOs). The MPOs are formed for cooperative transportation decision making for the metropolitan planning area (FHWA, 1994). MPOs are required by the Transportation Equity Act for the 21st Century (TEA-21) to develop transportation plans that consider (FHWA, 2000): (1) the preservation of existing transportation facilities; (2) the consistency of transportation planning with applicable Federal, State and local energy conservation programs; (3) the need to relieve congestion and prevent congestion; (4) the likely effect of transportation policy decisions on land use and development; (5) the programming of expenditure on transportation enhancement activities; (6) the effects of all transportation projects to be undertaken within the metropolitan area; (7) international border crossings; and (8) the need for connectivity of roads within a metropolitan area with roads outside of a metropolitan area. As a result of the United States legislative requirement for transportation plans, many MPOs have developed transportation models within their jurisdictions in order to facilitate the development of the required transportation plans.

In Canada, transportation agencies (municipal, provincial, or regional) are not required to produce transportation plans by law. However, many agencies develop, maintain and

improve transportation planning models in order to facilitate the development of transportation plans.

As well as important shifts in population and activity systems in the region, several developments in the regional transportation network highlight the need for a regional transportation planning model. The completion of the Highway 101 Northeast extension and the opening of the Charleswood Bridge had significant impact on the traffic flow in the region (see Figure 2).

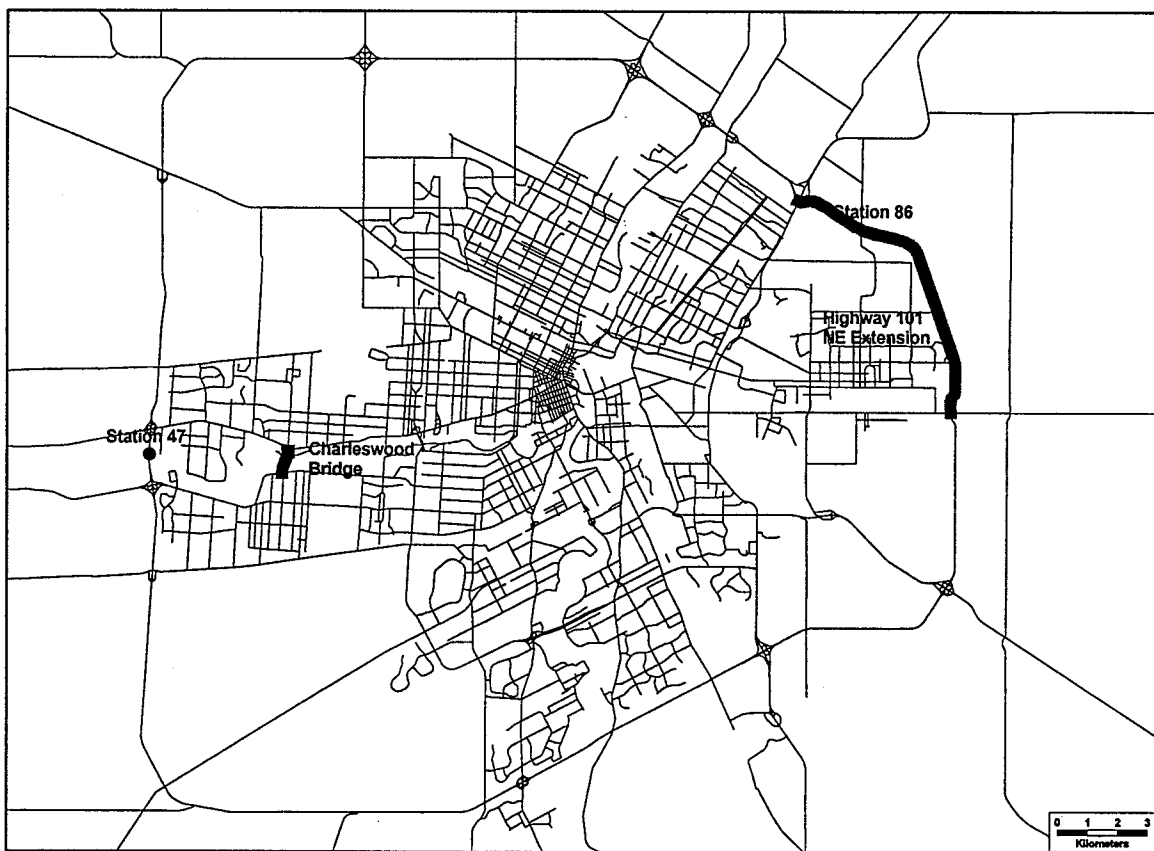


Figure 2: Charleswood Bridge and Highway 101 Northeast Extension

When the Charleswood Bridge was opened in 1996, the Annual Average Daily Traffic (AADT) at Permanent Count Station 47 on Highway 100 decreased from 22,020 (in 1995) to 17,260 (in 1996) (UMTIG, 2000). Figure 3 shows the historical AADT for Station 47. Figure 4 shows a map of the Charleswood Bridge and the location of Station 47.

The Highway 101 northeast extension resulted in an AADT of 3,150 at Station 86 in its first year of operation in 1997. This traffic increased to 3,460 in 1998 and 3,970 in 1999 (UMTIG, 2000). Since the traffic on provincial highways outside of the city has not decreased, this leads to the inference that the traffic on the northeast extension used to be traffic that operated on City streets before the northeast extension was completed.

In the first case, a new transportation facility within the City of Winnipeg led to a substantial decrease (5000 vehicles per day) in traffic flow on a major provincial highway link in the Capital Region. In the second case, a new transportation facility outside of the City of Winnipeg has (presumably) led to a substantial decrease of traffic on certain City streets (3000 vehicles per day).

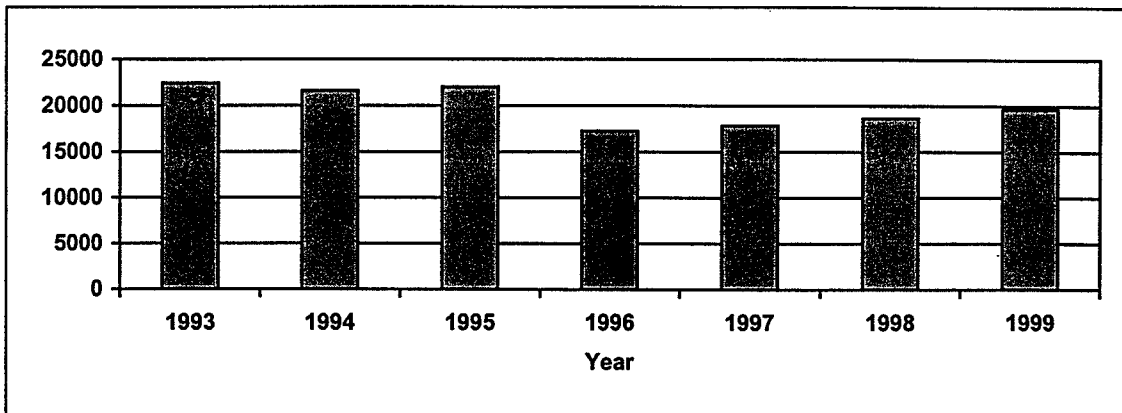


Figure 3: AADT at Station 47 (UMTIG, 1999)

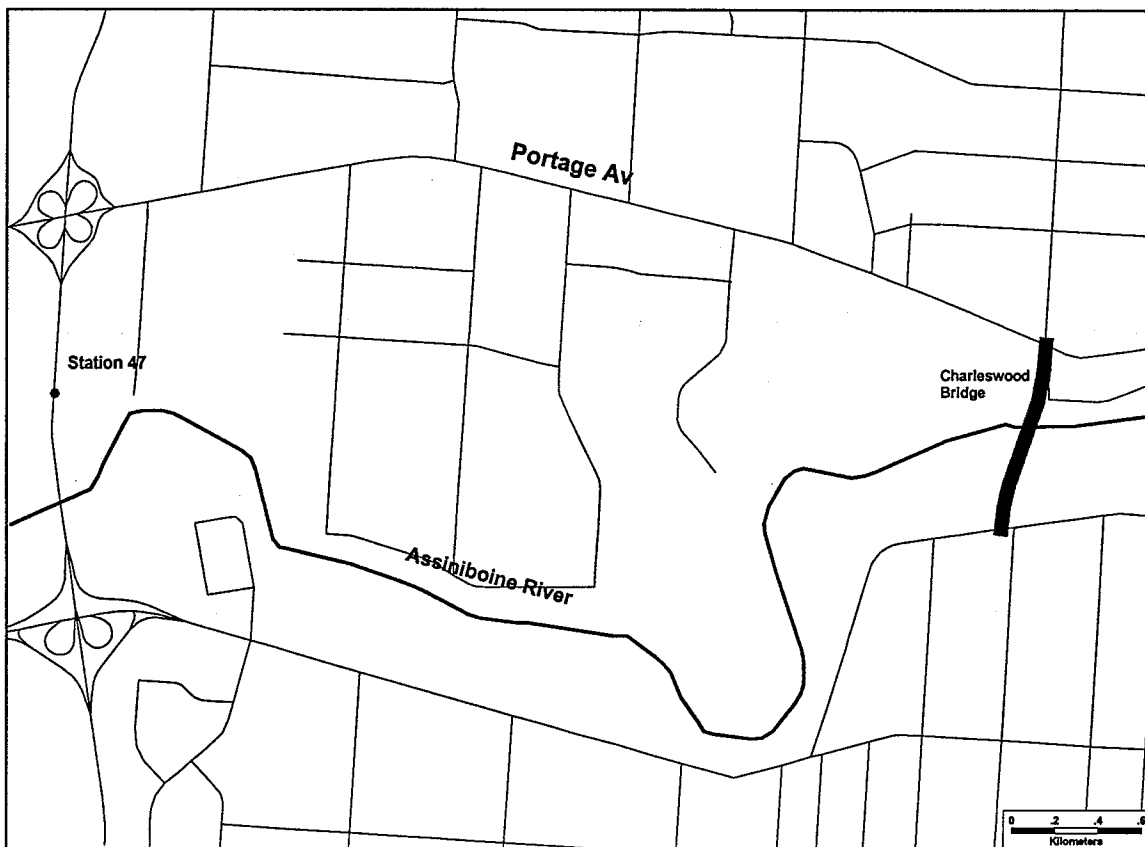


Figure 4: Location of Charleswood Bridge and Permanent Count Station 47

In November 1999, Statistics Canada made available the 1996 Journey-to-Work database for the Manitoba Capital Region. Furthermore, new traffic databases from the Manitoba Highways Traffic Information System (MHTIS) and the City of Winnipeg have also been

made available. In addition, Geographic Information Systems for Transportation (GIS-T) technology has evolved to a level where it is readily accessible and offers an efficient means for transportation modeling. The need for a regional approach to transportation planning, the availability of the Statistics Canada database and new traffic databases, and the evolution of GIS-T technology make the development of a transportation planning model for the Manitoba Capital Region feasible.

At the heart of transportation systems analysis and planning is the understanding and prediction of traffic flows under different transportation and land-use scenarios (Manheim, 1984). These flows are key inputs into basic engineering design and evaluation processes. Flows can be quantified through a variety of measurements. For this research, a P.M. peak hour model was developed. The rationale for this decision is: (1) the P.M. peak is critical for system analysis since area wide traffic volumes and congestion are typically higher (NCHRP, 1998); (2) the P.M. peak accounts for a greater number of trips than the A.M. peak in the region (Hurl, 2000 and UMTIG, 1998); and (3) the lack of a P.M. peak model to supplement the current existing A.M. peak model.

1.3 Research Objectives and Scope

1.3.1 Objectives

The objectives of the thesis are:

- (1) to review, compare and contrast the current transportation modeling practices in Winnipeg and selected Canadian cities.
- (2) to develop the framework and structure for the Manitoba Capital Region Transportation Planning Model (MCRTPM).
- (3) to construct and develop a Manitoba Capital Region Transportation Analysis Network (MCRTAN) on a Geographic Information System for Transportation (GIS-T) platform that is compatible and suitable for the development of the MCRTPM.
- (4) to develop, analyze and integrate P.M. peak traffic data with the MCRTAN.
- (5) to develop an automobile driver work trip (ADWT) matrix from the Statistics Canada 1996 Journey-to-Work database into a form suitable for the MCRTPM development.
- (6) to develop components of the MCRTPM:
 - (a) trip generation equations for ADWT using the ADWT matrix developed in Objective 5.
 - (b) a P.M. peak automobile driver work trip (PMPADWT) matrix using the ADWT matrix developed in Objective 5 and the National Cooperative Highway Research Program (NCHRP) diurnal factor.
 - (c) an estimated P.M. peak vehicle total trip (PMPVTT) matrix using the PMADWT matrix developed in (b), traffic data from the City of Winnipeg and MHGS, and TransCAD's matrix adjustment algorithm (which uses Nielsen's (1993) method).
 - (d) a P.M. peak vehicle other trip (PMPVOT) matrix using the PMPADWT developed in (b) and the PMPVTT matrix developed in (c).

- (e) trip distribution equations for PMPADWT using Statistics Canada 1996 Journey-to-Work data, travel time estimates from MCRTAN, and TransCAD's trip distribution component calibration function.
 - (f) trip distribution equations for PMPVOT using the PMPVOT matrix developed in (d), travel time estimates from MCRTAN, and TransCAD's trip distribution component calibration function.
 - (g) the trip assignment component using Bureau of Public Roads (1964) default link performance function parameters.
- (7) to recommend further developments for the MCRTPM.

1.3.2 Scope

This thesis is limited to the following:

- The region of analysis is the Manitoba Capital Region with the rest of Manitoba considered as large external zones. This zone system is called the Winnipeg Regional Traffic Zone System (see Figure 5).
- The model predicts P.M. peak automobile driver work trips and P.M. peak vehicle other trips.
- Due to the nature of the available data, the level of analysis of the model is zonal (aggregate analysis).
- Objectives 2, 3, 4, 5, and 6(a), 6(b) and 6(c) were the primary concern. Objectives 6(d), 6(e) and 6(f) are were of secondary concern.

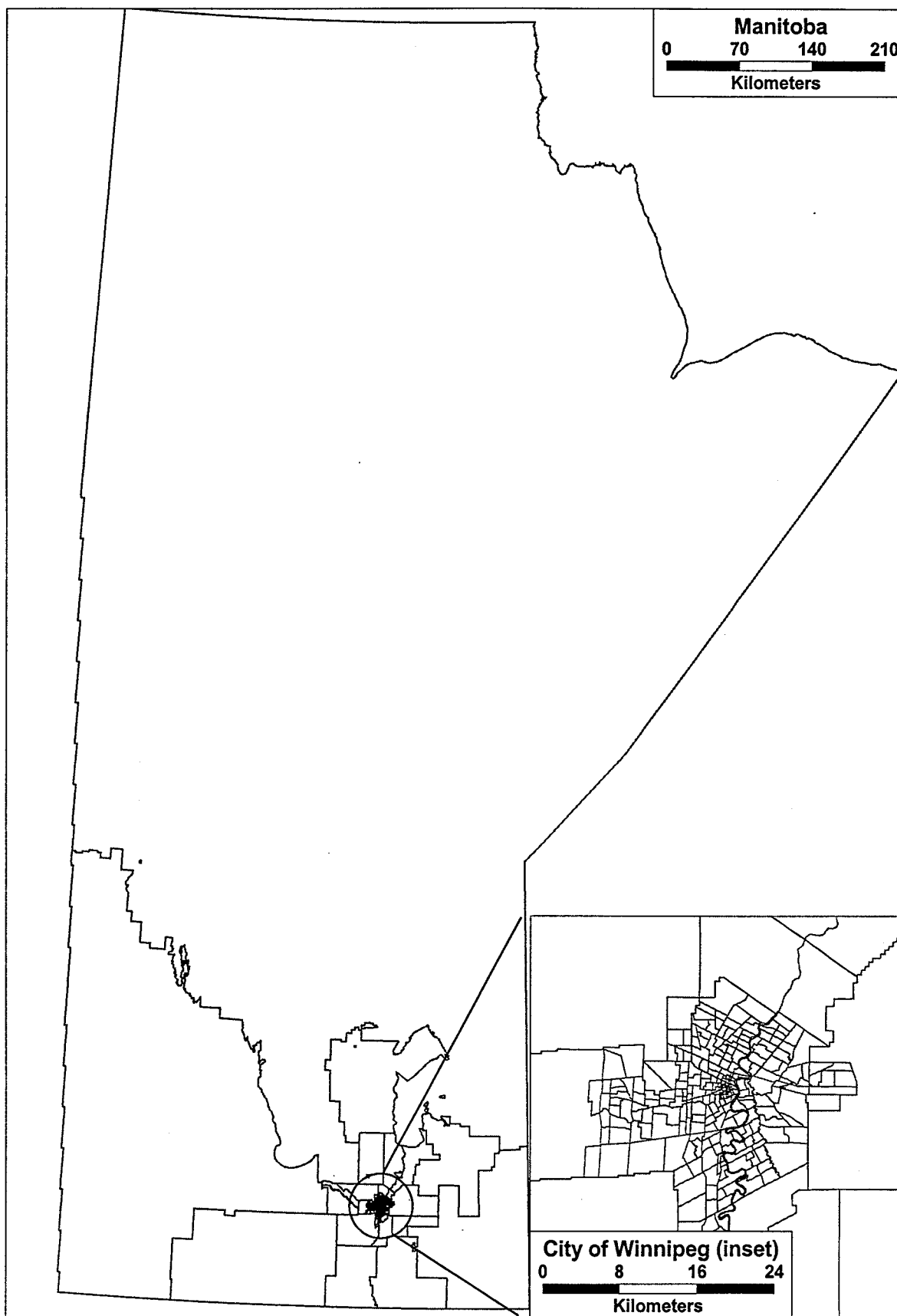


Figure 5: Winnipeg Regional Traffic Zone System
Source: City of Winnipeg Public Works Department
//pc-trans2/d:\users\kean\thesis2\gis\wpg5\countvol.lay

1.4 Thesis Organization

Chapter 1 provides the background and the need for the research.

Chapter 2 examines the generic transportation planning model structure and reviews current transportation planning models in selected Canadian cities

Chapter 3 provides the structure of the Manitoba Capital Region model.

Chapter 4 develops the Manitoba Capital Region Transportation Analysis network (MCRTAN).

Chapter 5 details the development of components of the MCRTPM using the MCRTAN, Statistics Canada 1996 Journey-to-Work database, newly developed traffic databases from the Manitoba Highways Traffic Information System (MHTIS) and the City of Winnipeg.

Chapter 6 provides the conclusions of the research, and proposes work for the further development of the MCRTPM.

Appendix A provides a list of the cartographic, spatial layer and database computer files used in the development of this thesis.

Appendix B shows a sample of the MCRTAN in tabular form.

Appendix C shows the MCRTAN Turn Restriction File in tabular form.

Appendix D shows a sample of Winnipeg Regional Traffic Zone System in tabular form.

Appendix E shows the links in the MCRTAN which contain traffic counts used as input for the matrix adjustment algorithm.

Appendix F shows the different trip production equations for ADWT examined in this research.

Appendix G shows the different trip attraction equations for ADWT examined in this research.

Appendix H shows the different trip production and attraction equations for PMPVOT examined in this research

Appendix I is a report on the Census Place of Work seminar held by the Region of Peel and Statistics Canada on October 20, 2000.

2.0 TRANSPORTATION PLANNING MODELS

This chapter provides an overview of the general transportation planning model structure. Using the structure, transportation planning models from the City of Winnipeg and selected Canadian cities are reviewed, compared and contrasted.

2.1 Transportation Planning Model Structure

A transportation planning model can be classified in terms of its: (1) subsystem components and organization; (2) level of analysis of each subsystem; and (3) technique(s) used in each subsystem.

2.1.1 Subsystem Components and Organization

The four-step sequential modeling method is the most common method for constructing transportation planning models. This method divides the model into four components: (1) trip generation; (2) trip distribution; (3) mode split; and (4) trip assignment. Transportation models can differ between each other in terms of the components present as well the organization of the components within the overall model. Examples of variations in the organization are shown in Figure 6.

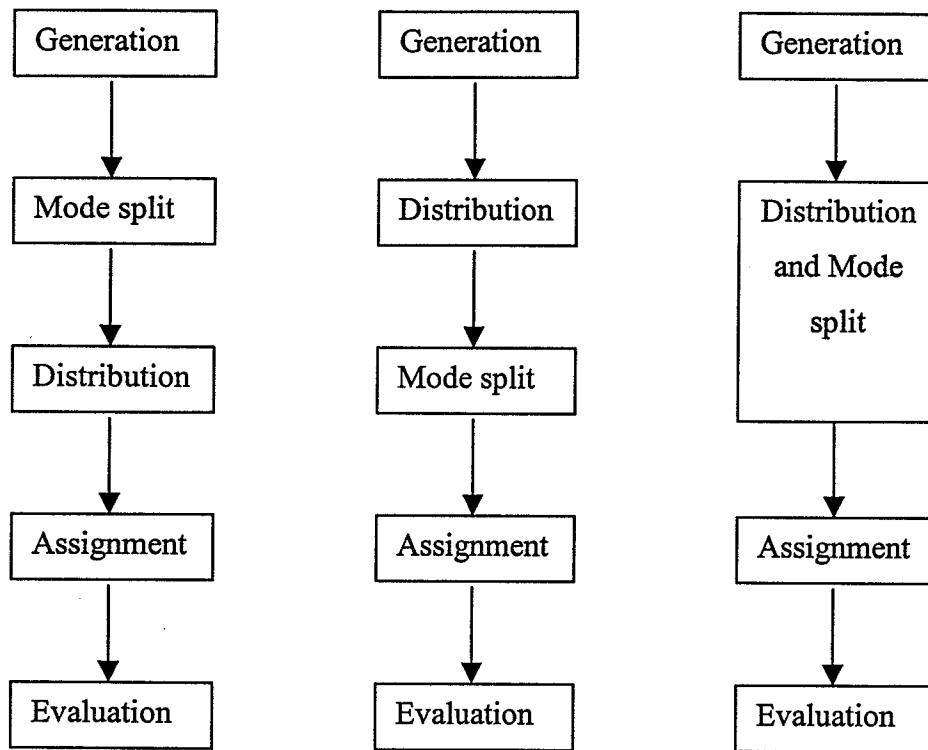


Figure 6: Variations in the Organization of Transportation Models (Mekky, 2000)

The trip generation component predicts the number of trips produced by each zone i (o_i) and the number of trips attracted to each zone j (d_j).

The trip distribution component predicts the number of trips that originate from zone i destined for zone j (t_{ij}). This can be expressed in a matrix form with the origins as rows and the destinations as columns.

The mode split component divides the t_{ij} matrix into several matrices by mode of travel.

The trip assignment component assigns the t_{ij} matrices to travel routes in order to produce the volume (traffic) on each link in the analysis network.

2.1.2 Level of Analysis of Each Subsystem

The level of analysis of each subsystem defines the input data requirements and the accuracy of the results which can be obtained from the model. There are typically three analysis units: (1) zonal; (2) household; and (3) individual.

The zonal analysis unit assumes that all individuals in a zone have identical characteristics. The zone is assumed to have homogeneous land-use within its boundaries. Furthermore, it is assumed that trips begin and end at the centroid of each zone.

The household analysis unit assumes that households with identical characteristics such as income, vehicle ownership or household size have the same travel behaviour. Essentially, this type of aggregation means grouping system elements which are different and assuming that they are identical (Mekky, 2000).

The individual analysis unit uses characteristics of each individual, such as age, sex, income, occupation and vehicle availability, in order to model the travel behaviour of the individual.

Analysis units of households and individuals are often aggregated to the zonal level at one point or another.

2.1.3 Methods Used by Each Subsystem

Mekky (2000) classifies the methods used in each subsystem into three types: (1) mathematical or algorithmic; (2) probabilistic or deterministic; and (3) discrete or continuous variables.

Mathematical methods exist in the form of mathematical equations. Algorithmic methods contain logical instructions. Probabilistic methods describe the probability of an individual using a facility. Deterministic methods predict the number of people using a transportation facility. Discrete variables answer the question in terms of “which one?” (e.g. which mode, which destination, which route). Continuous variables answer the question of “how much?” (e.g. how many trips destined to a zone) (Mekky, 2000).

2.2 Winnipeg Transportation Model (Winnipeg (1992a), Winnipeg (1992b) and Winnipeg (1996))

The Winnipeg Transportation Model is based on the model developed by the University of Montreal as part of the EMME/2 package. Since the development of the model, the City of Winnipeg has conducted travel surveys every five years and used the data to recalibrate and enhance the model. The latest calibration data are based on 1992 City of Winnipeg Travel survey. In 1996, the travel survey was not performed because of budget constraints. Instead, the City of Winnipeg obtained the 1996 Journey-to-Work database from Statistics Canada.

The Winnipeg Transportation Model is maintained on the EMME/2 software. The model predicts the A.M. peak hour traffic divided into two trip purposes: (1) work (which includes post-secondary school); and (2) non-work. The structure of the model is shown in Figure 7. The model is based on the City of Winnipeg Zone System (see Figure 8).

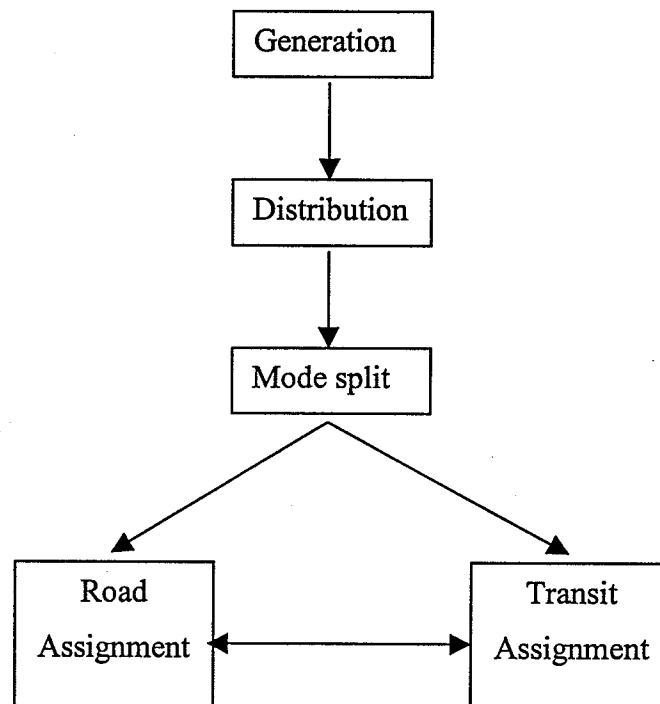


Figure 7: Structure of Winnipeg Model

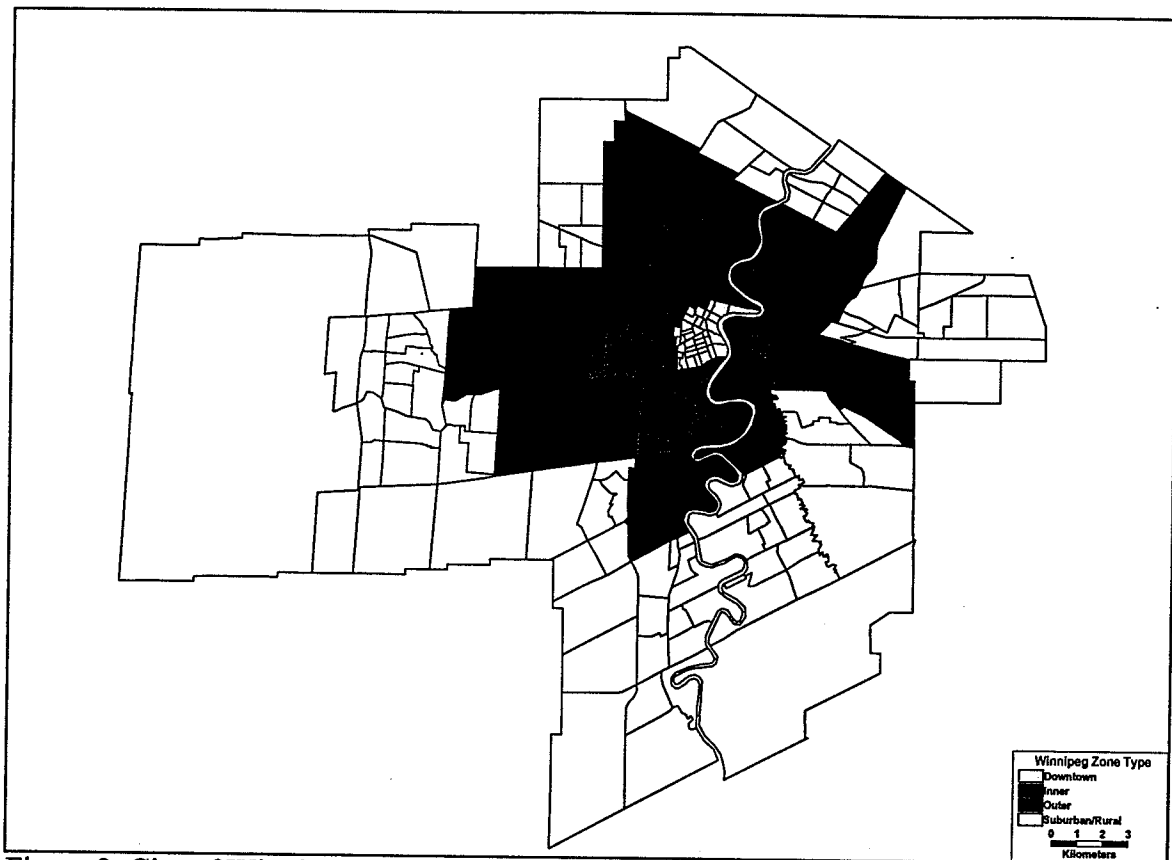


Figure 8: City of Winnipeg Zone Types

There are two types of trip generation equations: (1) trip production; and (2) trip attraction. The trip generation equations were developed using the multiple regression method.

The dependent variable for the trip production equations is the number of person trips produced. The trip production equations are a function of: (1) type of zone (downtown, inner, outer, suburban/rural) (see Figure 8); (2) trip purpose (work, non-work, and total trips); and (3) number of single family residential units and multiple family residential units.

The dependent variable for the trip attraction equations is the number of person trips attracted by each zone. The trip attraction equations are a function of: (1) area of the city (downtown, inner, outer, suburban/rural); (2) trip purpose (work, non-work, and total trips); and (3) number of office employment, retail employment, industrial employment and other employment.

The trip distribution component uses the doubly-constrained gravity model with and exponential friction factor equation. Mathematically, this is written as:

$$t_{ij} = o_i d_j F_{ij}$$

where

t_{ij} is the number of person trips produced in zone i and attracted to zone j

o_i is the number of person trips produced in zone i

d_j is the number of person trips attracted to zone j

F_{ij} is the friction factor matrix expressed as:

$$F_{ij} = \text{EXP} (-\gamma_k c_{ij} + \text{CONST}_k), \text{ for all } K$$

where

c_{ij} is the travel impedance from zone i to zone j (the travel time in minutes)

K is the index of the time intervals

γ is the exponent associated with interval K

CONST_k is a constant added to the exponent on interval K in order to obtain a smooth curve.

The mode split component is formulated as a zonal aggregate logit type model.

Mathematically, this is expressed as:

$$AP = TP / [1 + \text{EXP} (\text{CONST} - x_1 * TT + x_2 * AT - x_3 * A/DU)]$$

where

AP is the number of persons traveling by automobile

TP is the total number of persons

TT is the transit time matrix

AT is the auto time matrix

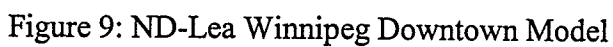
A/DU is the autos per dwelling unit

CONST, x_1 , x_2 , x_3 are calibrated parameters

The mode split component was improved separately in March 1996 using data from the 1992 O-D survey. The mode split component predicts the proportion of transit trips to automobile trips. The resulting mode split equation is a function of: (1) the difference between total transit travel time and total auto travel time; (2) the average walk time to transit from the transit stop at the origin end; (3) the average number of automobiles per dwelling unit at the origin zone; (4) the average parking cost at the destination zone; and (5) the total waiting time for transfers between bus routes.

The number of automobile drivers is obtained by dividing the AP matrix with the number of persons per vehicle matrix (obtained from 1992 O-D survey). The number of transit passengers is obtained by subtracting the AP matrix from the TP matrix.

ND-Lea Consultants (2000) produced a Winnipeg downtown model in order to evaluate the different roadway alternatives connecting the Provencher Bridge and Main Street. The network for the downtown model is shown in Figure 9. The Downtown Model is constructed using the TransCAD software based on traffic data from the City of Winnipeg. The report for this model is unpublished.



2.3 Transportation Models from Selected Canadian Cities

Transportation models from five selected Canadian cities were reviewed, compared and contrasted to the City of Winnipeg model (see Table 1).

Table 1: Transportation Models from Selected Canadian Cities

Jurisdiction	Software	Organization	Analysis Level of Model	Trip Purposes Modeled	Time Period	Calibration Data
City of Winnipeg	EMME/2	Four-Step	Zone	Work and Non-work	A.M. peak	1992 O-D Survey
Regional Municipality of Halifax	QRS II	Four-Step	Zone	Home based work, Home based non-work and Non-home based	A.M. and P.M. peaks	1991 O-D Survey and 1991 Traffic Counts
Greater Vancouver Area	EMME/2	Four-Step	Zone	From work/post-secondary, From home and From other	A.M. and P.M. peaks	1994 Trip Diary Survey
Greater Toronto Area Simplified Model	EMME/2	Four-Step	Zone	Work, Non-work and School	A.M. peak	1996 Transportation Tomorrow Survey (TTS)
City of Edmonton	EMME/2	Nested Logit	Single person. Results aggregated to zones.	For students: Home to school, Home to other purpose, School to home, Other Purpose to Home, Non-home based For Adult workers: Home to Work, Work to Home For Adults and Seniors: Home to Other Purpose, Other Purpose to home, Non-home based	A.M. and P.M. peaks and off-peak period	1994 Household Travel Survey
Region of Peel	EMME/2	Four-Step	Zone	Work, School and Other	A.M. peak	1986 Transportation Tomorrow Survey (TTS)

(Winnipeg, 1992a), (Winnipeg, 1992b), (Winnipeg, 1996), (Vaughan, 1998), (Greater Vancouver Regional District, 1997), (Dalton, 1999), (Dalton, 2000), (Hunt *et al.*, 1998), (Region of Peel, 1996)

All but one are based on the EMME/2 software. All but one of the models reviewed are based on the four-step sequential modeling method. All but one of the models use a zone system as the level of analysis. All the models reviewed predict traffic in the A.M. peak period. Some of the models predict traffic in the P.M. peak.

All the models reviewed were calibrated using travel survey data developed by the respective jurisdictions. Due to the differences in model structure and calibration data, it is impossible to use any model parameters from other cities to construct the Manitoba Capital Region Transportation Model.

3.0 MODEL FRAMEWORK

This chapter develops the framework for the Manitoba Capital Region Transportation Planning Model.

3.1 The 1996 Journey-To-Work Database

Since the development of the Winnipeg Transportation Model, the City of Winnipeg has conducted travel surveys once every five years and used the data to recalibrate the model. In 1996, the travel survey was not performed because of budget constraints. Instead, the 1996 Journey-to-Work database was obtained from Statistics Canada. This database was provided by Statistics Canada to different agencies in Manitoba in different forms:

- The Capital Region Review received specially processed data aggregated to individual municipalities and towns in and around the Manitoba Capital Region with Winnipeg represented as a single zone.
- Manitoba Department of Highways and Government Services (MHGS) received a CD containing aggregated data in the Beyond 20/20 viewer software format. The Beyond 20/20 software is provided with the CD received from Statistics Canada. Due to the form of the received data, no O-D matrix (which is crucial for the development of any transportation model) can be generated from the data.
- The City of Winnipeg Public Works Department and Winnipeg Transit received the data in both the CD form (the same CD as the one received by MHGS) and an Excel file containing socio-economic and Journey-to-Work data aggregated to the Winnipeg Regional Traffic Zone System (see Figure 5).

The Capital Region Review version of the 1996 Statistics Canada Journey-to-Work database is unsuitable for constructing a model because of the fact that Winnipeg is represented as a single zone. If these data were used for model construction, the zone representing the City of Winnipeg would need to be linked by centroid connectors to the provincial highways outside of the city. This means that the model cannot predict traffic on major City streets. The MHGS version of the 1996 Statistics Canada Journey-to-Work database is aggregated to very large zones. This results in small number of observations (i.e. datapoints) which can be used for model construction. Therefore, for this research, only the 1996 Statistics Canada Journey-to-Work data received by the City of Winnipeg Public Works Department/Winnipeg Transit was used. This database is summarized in Table 2.

Table 2: 1996 Statistics Canada Journey-to-Work Database

Population by Sex and by Age Groups
Occupied Private Dwellings by Structural Type
Occupied Private Dwellings by Household Type
Total Population 15-24: Total, Attending School Full Time, Attending School Part Time, Not Attending School
Employed Labour Force 15+: Total by Sex and by Full Time/Part Time
Unemployed Labour Force 15+: Total by Sex
Total Number of Private Households
Household Income
Average Household Income
Household Type by Income
Place of Residence by Place of Work Status by Mode
Place of Residence by Place of Work Status by Full Time/Part Time by Mode
Place of Residence by Place of Work Status by Sex by Age by Income by Mode
Place of Work by Place of Work Status by Mode
Place of Work by Place of Work Status by Sex by Age by Income by Mode
Place of Work by Place of Work Status by Sex by Age by Industry by Mode
Place of Residence by Place of Work by Place of Work Status by Mode

3.2 Platform

In this research, Geographic Information Systems (GIS) is defined as a computer and software system with the capability of integrating spatial data, which represents the real world through “entities”, with conventional databases storing attribute properties. Geographic Information Systems for Transportation (GIS-T) refers to the application of GIS for analysis of transportation related-issues (Lew et. al, 1999).

The MCRTPM is developed on the TransCAD software package. This software incorporates GIS-T data structure and functions with transportation modeling tools.

Built-in algorithms in the software allow transportation models to be built based on the four-step sequential modeling technique. The TransCAD software used in this research is version 3.61. TransCAD (a GIS-T platform) was used for MCRTPM development instead of EMME/2 because a GIS-T platform facilitates integration of the planning model with other spatial and attribute databases such as: (1) the OnTrac Traffic Collision Database for the City of Winnipeg; (2) the City of Winnipeg's Traffic Database; (3) MHGS Traffic Database; (4) Manitoba Natural Resources Digital Orthophotos; (5) City of Winnipeg Digital Orthophotos; (6) Global Positioning System (GPS) survey points; and (7) engineering drawings. The capability to integrate different databases allows: (1) inter-layer analysis of data (i.e. to predict accident rates using collision data from the OnTrac system and predicted traffic flow from the MCRTPM) and (2) a convenient and cost-effective method to update the network (i.e. by using digital orthophotos, GPS survey points, and engineering drawings). In addition, the GIS-T platform offers: (1) a convenient method to import and export spatial and attribute into different formats (i.e. dBase, Access); (2) better cartographic capabilities; and (3) a better interface.

3.3 Model Structure

The model is based on the four-step sequential modeling method minus the mode split component. Previous efforts developed the mode split component based on zonal (aggregate) data recommended the use of disaggregate data to improve the results (Winnipeg, 1996). Since only aggregate data are available at this time, a decision was made not to develop a mode split component for the MCRTPM. The mode split is

captured by using automobile driver trips and other vehicle trips (instead of person trips).

Figure 10 shows the structure of the model.

The model assumes that all trips begin within Manitoba and end in Manitoba. Trips that begin or end outside of Manitoba are not considered.

The model predicts the number of P.M. peak vehicle trips. The trips are divided into two trip types: (1) work trips from place of work (POW) to place of residence (POR) (also referred to as home based work trips), (PMPADWT); and (2) other trips (PMPVOT). For this research, the P.M. peak period is defined as the time between 3:30 P.M. and 5:30 P.M. with the highest traffic per hour.

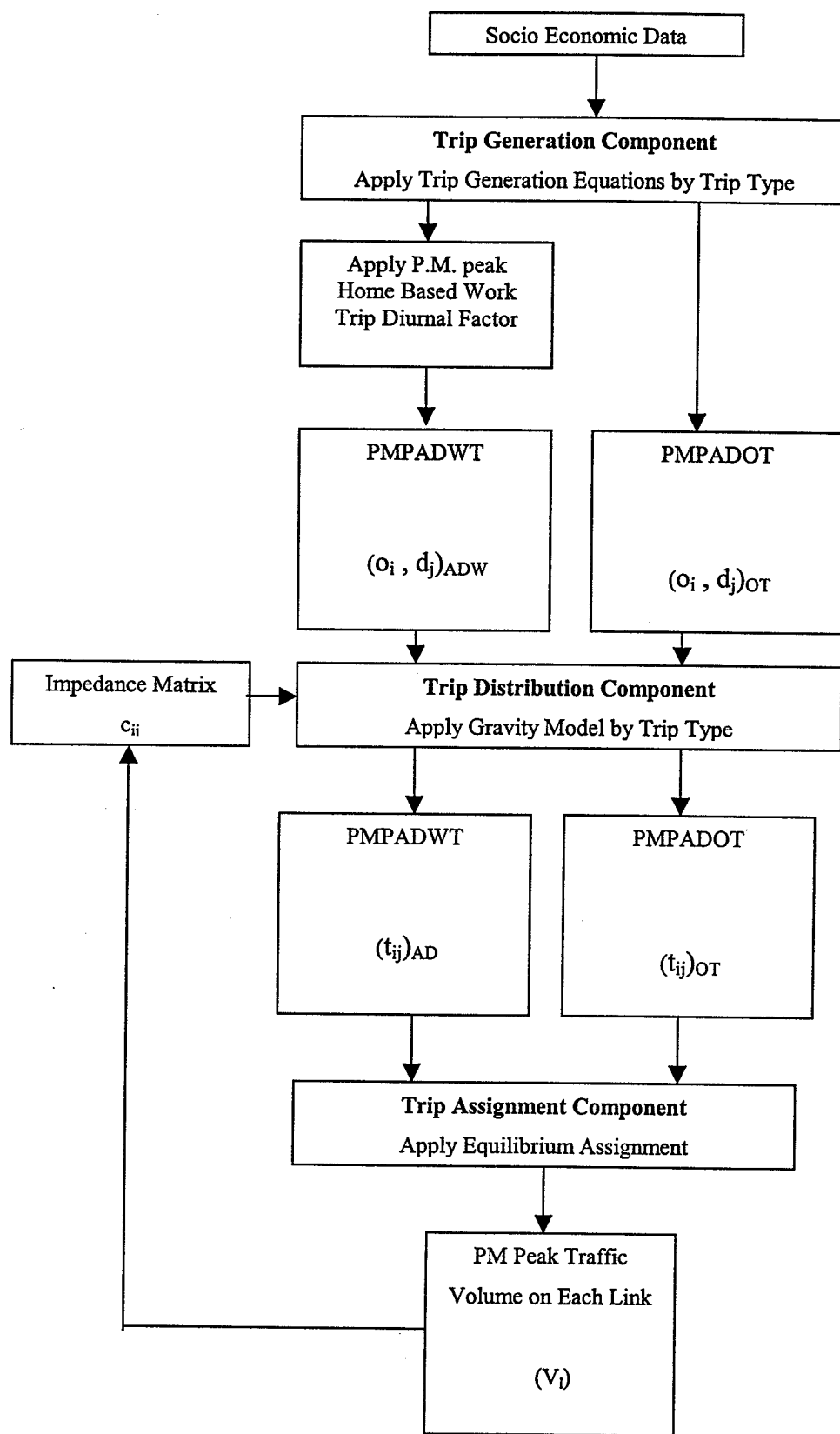


Figure 10: Structure of Manitoba Capital Region Transportation Model

4.0 THE MANITOBA CAPITAL REGION TRANSPORTATION ANALYSIS

NETWORK

This chapter discusses the development of the Manitoba Capital Region Transportation Analysis Network (MCRTAN).

4.1 Background

Prior to this research, there was no spatial layer of the road network in the Manitoba Capital Region. Both MHGS and the City of Winnipeg maintained their own digital road network and it was impossible to perform any transportation planning analysis at a regional level. In December 1999, students from UMTIG worked together with the City of Winnipeg Public Works Department to create the MCRTAN. Detailed documentation of the development of the network can be found in Han (2000).

4.2 Network Construction Details

The network was constructed using spatial data from different sources:

- (1) The City of Winnipeg Public Works Street Center Line map
- (2) The Manitoba Provincial Road Network from MHGS
- (3) The Manitoba Provincial Road Network Fabric from Manitoba Natural Resources
- (4) Orthographic photos from City of Winnipeg Public Works
- (5) Engineering drawings from various sources
- (6) Global Positioning System (GPS) surveys

The network was then modified using the Maptitude 3.2 in consultation with the City of Winnipeg Public Works Department.

4.3 Network Detail and Centroid Connectors

The network detail (network density) of the MCRTAN was determined based on the desired level of prediction. The model is intended to predict traffic on: (1) Provincial Trunk Highways (PTHs) outside the City of Winnipeg; and (2) arterial streets in the City of Winnipeg. The current City of Winnipeg EMME/2 model only contains the major arterial streets. This results in over-prediction of traffic on those arterial streets due to the lack of collector streets (Hurl, 2000). This is addressed in the MCRTAN by including major collectors and routes within the Capital Region. Roads included in the network are: (1) roads defined by the City of Winnipeg as part of the Regional Road system; (2) roads within the City of Winnipeg defined by the Public Works Department as arterials; (3) roads defined by the MHGS as Provincial Trunk Highways (PTHs) and Provincial Roads (PRs); (4) major collector streets within the City of Winnipeg; and (5) roads which were determined to be major routes due to local knowledge (e.g. Wellington Crescent, Gunn Road).

Centroid connectors were added to the network as abstract representations of local streets. The centroid connectors connect the centroids of the zones to the analysis network. The connectors were built based on knowledge of the roads and land-use in the area. The guidelines used for establishing centroid connectors are:

- add multiple centroid connectors to a zone so that an acceptable level of representation of the local street network is achieved. This results in better distribution of trips assigned to the links leading to the zone.
- do not connect centroids to major intersections (a major intersection is defined as an intersection between two arterial streets). This is done to avoid unrealistic traffic assignment to links connected to the major intersection.
- connect centroids to existing endpoints. This is done so that none of the network links are broken into new links due to the construction of the centroid connectors. This ensures that attribute data from the MCRTAN and results from the MCRTPM can be linked to the data from the City of Winnipeg Street Centre Line map which is maintained on the MapInfo software platform.

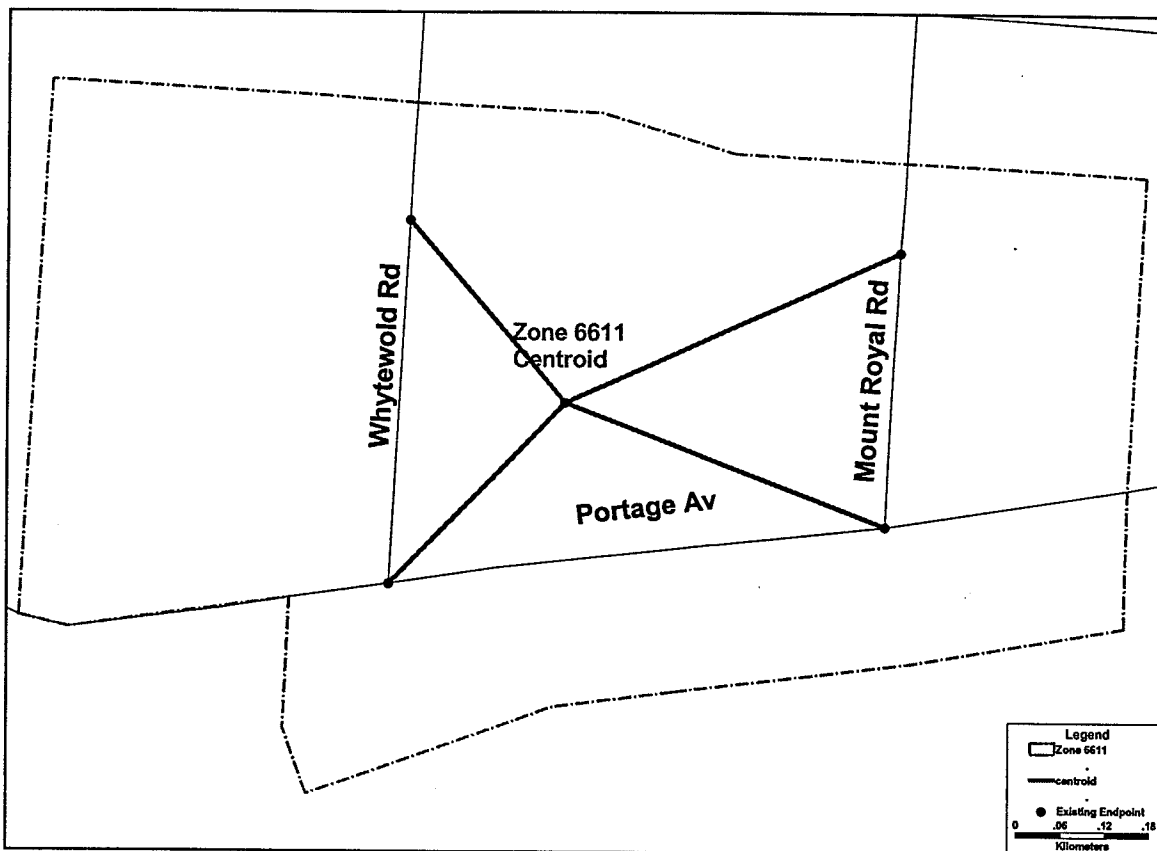


Figure 11: Centroid Connectors for Zone 6611

Figure 11 shows the centroid connectors for zone 6611. Note that: (1) multiple centroid connectors were established to better represent the local streets in the zone; (2) centroid connectors were connected to the intersection of Portage Avenue (an arterial) with Whytewold Road (a collector) and the intersection of Portage Avenue with Mount Royal Road (a collector). Centroid connectors were not connected to any major intersections; and (3) centroid connectors were only connected to existing endpoints.

4.4 Standardized Network Topology

The topology of the network was corrected using a method developed by Han (2000) to the standard system used by MHGS. Generally, the standardized topology is

eastbound/northbound. The notation used to represent the standardized topology direction is “AB” and the reverse direction is “BA”. This means that generally the eastbound direction is denoted as “AB” and the westbound direction is denoted as “BA”. Similarly, the northbound direction is denoted as “AB” and the southbound direction is denoted as “BA”. The standardized topology facilitates the information interchange between different databases containing directional attributes. For example, the P.M. peak traffic count database is structured in a manner so that the flow direction is described by compass direction (see Table 3). By restructuring that database so that the information follows the standardized topology in which flow is described as “AB flow” or “BA flow” (see Table 4), the P.M. peak traffic count database can be linked to the MCRTAN (see Figure 12). This linkage was impossible before the network was modified to the standardized topology. This linkage allows directional attributes to be displayed on a map and analyzed spatially (see Figure 12).

Table 3: P.M. Peak Traffic Count Database without Topology Linkage

Link ID	Flow Northbound	Flow Southbound	Flow Eastbound	Flow Westbound
8808	2473	2618	Not applicable	Not applicable
8809	2541	2511	Not applicable	Not applicable
8310	Not applicable	Not applicable	304	145

Table 4: P.M. Peak Traffic Count Database with Topology Linkage

Link ID	Flow AB	Flow BA
8808	2473	2618
8809	2541	2511
8310	304	145

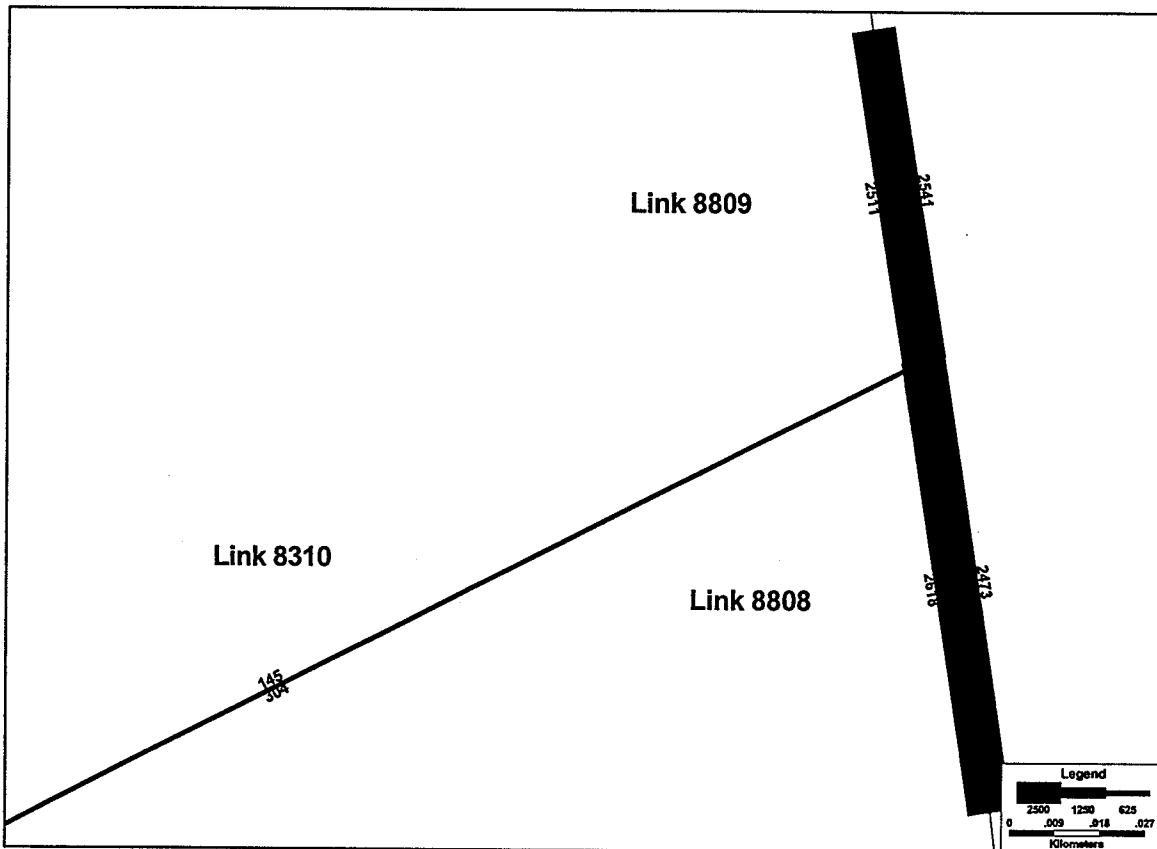


Figure 12: Traffic Data Linked using Topology

4.5 Network Attribution

The construction of the regional model requires that the network be attributed with relevant information. The information attributed into the TransCad geographic file is shown in Table 5, Table 6 and Table 7.

Table 5: Manitoba Capital Region Transportation Network Attributes

Field name	Field type	Source	Information
ID	Integer (4 bytes)	TransCad generated	TransCAD internal ID for the link. Needed for turn restriction data and modeling
Length	Real (8 bytes)	TransCad generated	TransCAD calculated length of the link. In metres.
Dir	Integer (2 bytes)	City of Winnipeg	"0" denotes that there is no directional restriction. "1" means that the link is restricted to travel in the "AB" direction (forward in the standardized topology). "-1" means that the link is restricted to travel in the "BA" direction (reverse direction in the standardized topology).
Name	Character (55 width)	City of Winnipeg	Street name of the link.
Lanes_AB	Real (8 bytes)	City of Winnipeg	Number of physical lanes in the AB direction
OpLanes_AB	Real (8 bytes)	City of Winnipeg	Number of operational lanes during the P.M. peak in the AB direction
Lanes_BA	Real (8 bytes)	City of Winnipeg	Number of physical lanes in the BA direction
OpLanes_BA	Real (8 bytes)	City of Winnipeg	Number of operational lanes during the P.M. peak in the BA direction

Table 6: Manitoba Capital Region Transportation Network Attributes

Field name	Field type	Source	Information
Capacity_AB	Real (8 bytes)	UMTIG	Operational capacity of link in the AB direction based on number of links and adjustment factors. In vehicles per hour. Calculated using an assumed capacity of 900 vph/lane.
Capacity_BA	Real (8 bytes)	UMTIG	Operational capacity of link in the BA direction based on number of links and adjustment factors. In vehicles per hour. Calculated using an assumed capacity of 900 vph/lane.
Class	Character (6 width)	City of Winnipeg	City's original classification
Func_Class	Character (6 width)	City of Winnipeg	City's original classification modified with information from Sherlock's map of Winnipeg (1999) and local knowledge
Network_Class	Character (6 width)	City of Winnipeg	As Func_class but only links an additional "N" notation are considered for the model's analysis.
Assumed_Speed	Integer (2 bytes)	City of Winnipeg	Assumed speed based on Network_class. In km/h. The assumed speed of each link is based on the network class as follows: PTH 100 km/h PR 90 km/h Arterial 60 km/h Collector 50 km/h Centroid Connector (CBD) 25 km/h (Suburban) 40 km/h (Rural) 80 km/h

Table 7: Manitoba Capital Region Transportation Network Attributes

Field name	Field type	Source	Information
Speed_Limit	Integer (4 bytes)	City of Winnipeg	Posted speed limit of the link. In km/h.
PM_Peak_AB_CountVol	Integer (4 bytes)	City of Winnipeg	Observed link volume in the AB direction per hour during peak period (highest 4 consecutive 15 minute intervals between 4:00 and 6:00)
PM_Peak_BA_CountVol	Integer (4 bytes)	City of Winnipeg	Observed link volume in the BA direction per hour during peak period (highest 4 consecutive 15 minute intervals between 4:00 and 6:00)
InitTime_AB	Real (8 bytes)	TransCAD generated	Initial travel time across link the AB direction. In minutes.
InitTime_BA	Real (8 bytes)	TransCAD generated	Initial travel time across link the BA direction. In minutes.
ID_2	Real (8 bytes)	City of Winnipeg	ID of the link. This is used to transfer information from the City's MapInfo/OnTrac map to the MCRTAN network and vice-versa.

The initial travel time in the AB direction and the BA direction (InitTime_AB and InitTime_BA) is calculated using:

If the speed limit were available

$$(1) \text{ Time (in minutes)} = \text{Length (m)} * 0.001 * 60 / \text{Speed Limit (km/h)}$$

If the speed limit were not available

$$(2) \text{ Time (in minutes)} = \text{Length (m)} * 0.001 * 60 / \text{Assumed Speed (km/h)}$$

For centroid connectors (NCHRP, 1998)

$$(3) \text{ Time (in minutes)} = 0.5 * (\text{Area of Zone})^{0.5} / \text{Intrazonal Speed}$$

For zone 9510 centroid connectors

$$(4) \text{ Time (in minutes)} = 19 \text{ km} * 60 / 80 \text{ km/h}$$

The intra-zonal speed used for calculation of travel time on the centroid connectors is based on:

- (1) 25 km/h (for zones in the CBD of Winnipeg)
- (2) 40 km/h (for zones in the Capital Region but not in the Winnipeg CBD)
- (3) 80 km/h (for zones outside the Capital Region)

It was decided to calculate the travel time on centroid connectors independent of the length of the centroid connector. This was done to avoid trips favouring the shorter connector over the longer connector in the same zone. This ensures that all centroid connectors within a zone are equal. Figure 13 shows zone 3714 which has 3 centroid connectors of differing lengths (0.41 km, 0.43 km and 0.70 km). If the travel time on centroid connectors were dependent on the length of the centroid connector, then trips

will favour the shorter centroid connector. This may lead to unrealistic assignment of trips (i.e. more trips will be assigned to the links connected to the shortest centroid connector). Giving all the centroid connectors within a zone the same travel time solves this problem.

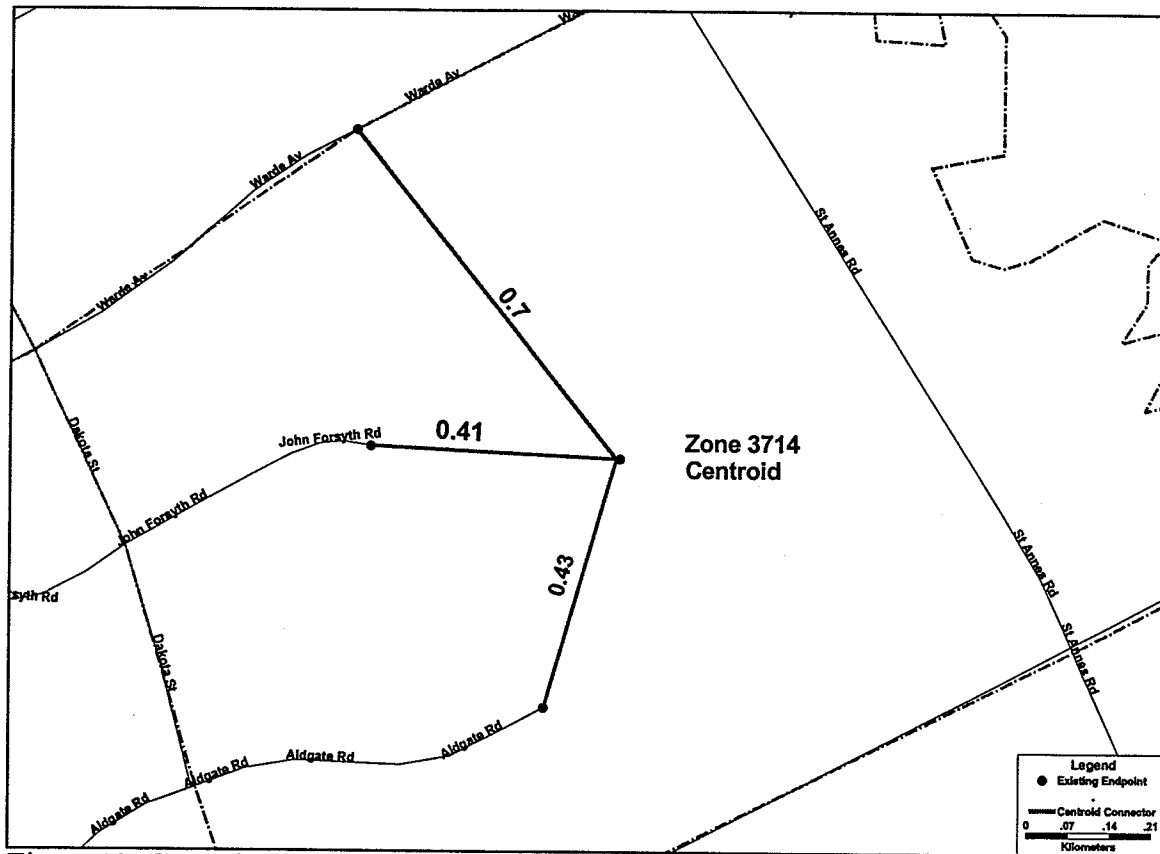


Figure 13: Centroid Connector Equality.

The travel time for the centroid connectors of zone 9510 is calculated differently from the other centroid connectors because the town of Steinbach is located in that zone. The town of Steinbach has significant commuting traffic to Winnipeg (380 trips per day) and from Winnipeg (235 trips per day) (Statistics Canada, 1996). The town of Steinbach is located closer to the network than the actual centroid of the zone (See Figure 14). Thus,

the travel time of centroid connectors in that zone is calculated using the distance of Steinbach to the MCRTAN (19 km). The MCRTAN is summarized in Table 8.

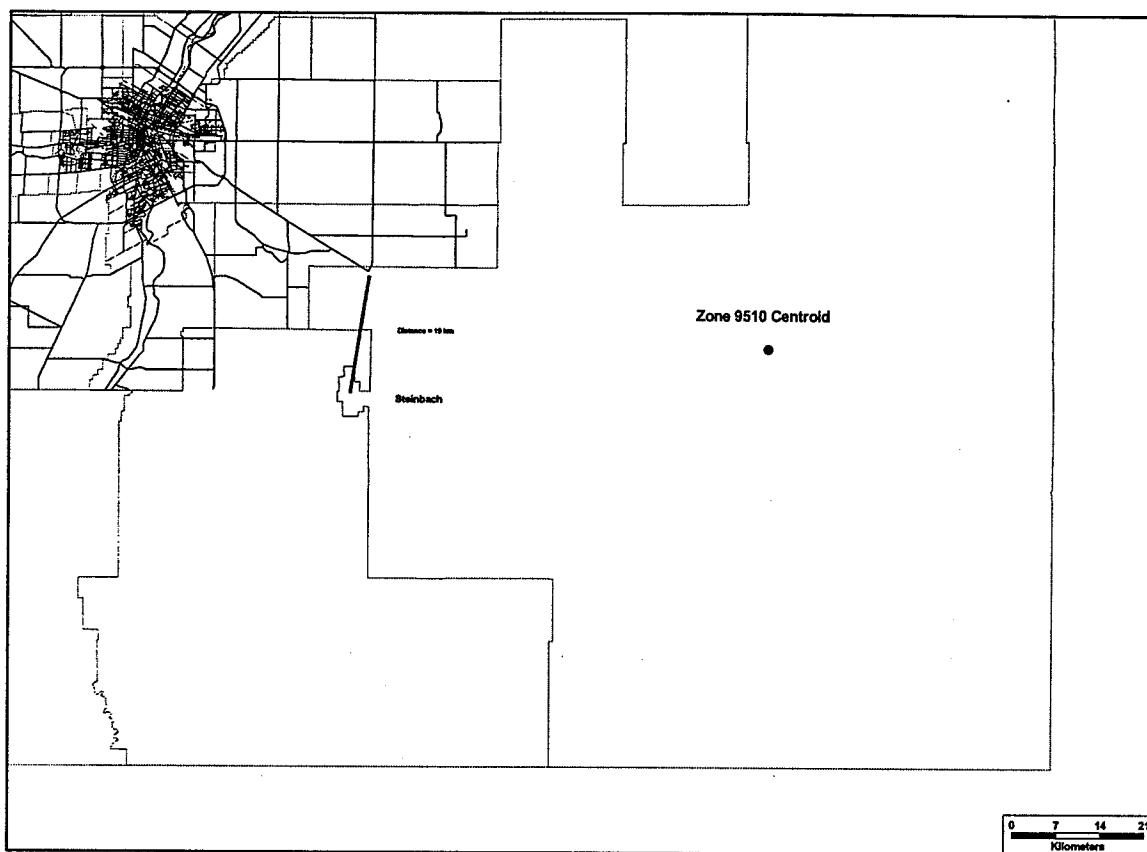


Figure 14: Steinbach and Zone 9510

Table 8: Summary of MCRTAN

Total length (km)	PTH	833.60
	PR	991.14
	City Arterial	442.45
	City Collector	388.75
	City Other	262.90
	Centroid Connector	2320.02
Total links		7803
Total nodes		6303

The MCRTAN is shown in Figure 15, Figure 16, Figure 17 and Figure 18. A sample of the MCRTAN in tabular form is shown in Appendix B.

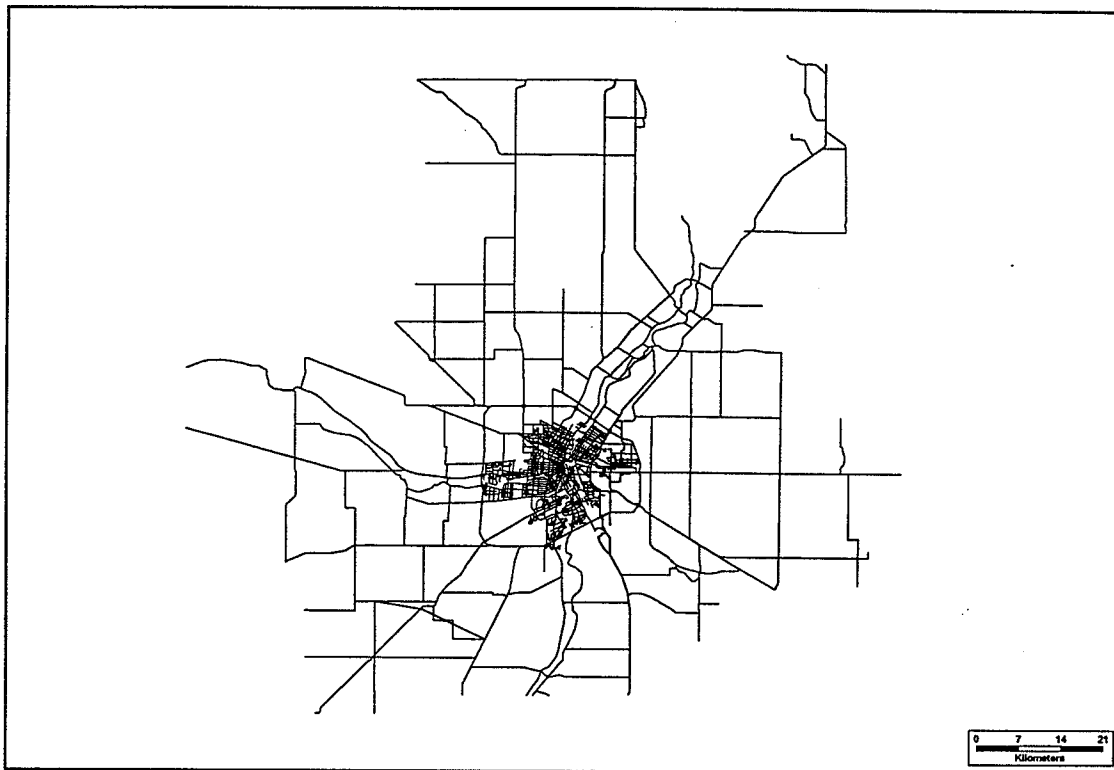


Figure 15: MCRTAN

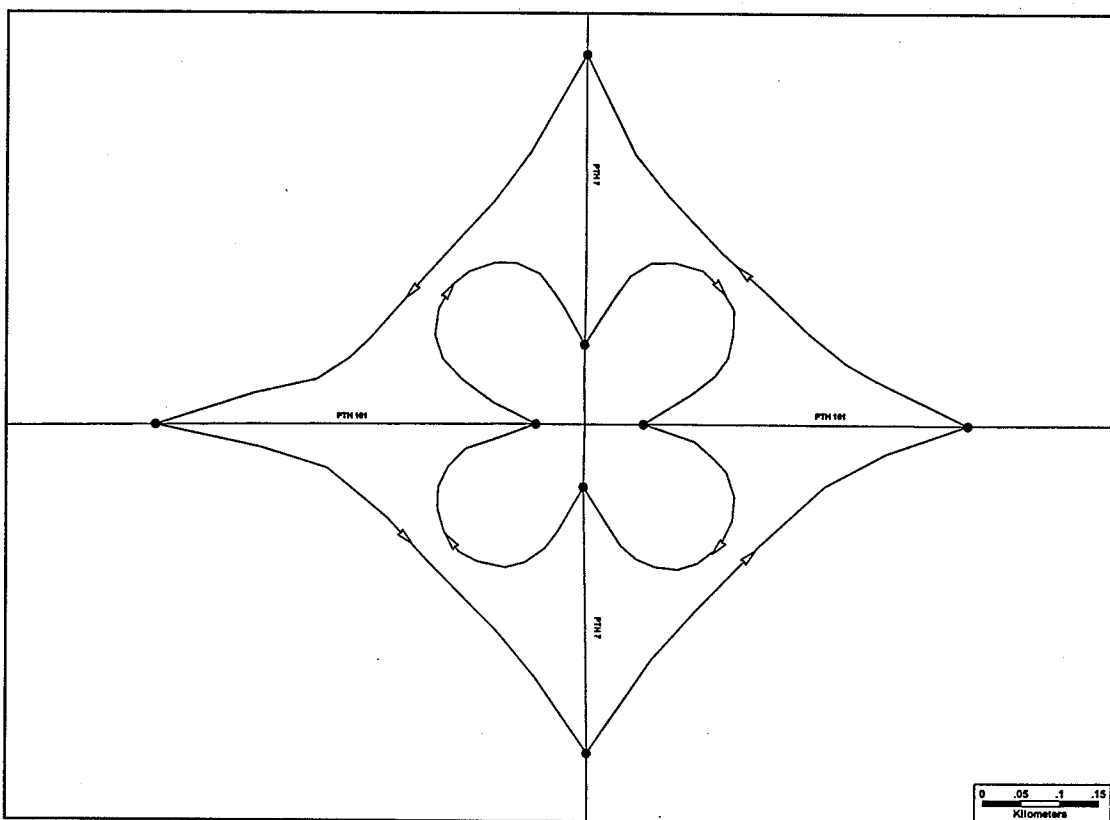


Figure 16: Details of an Interchange Rmp (PTH 101 and PTH 7)

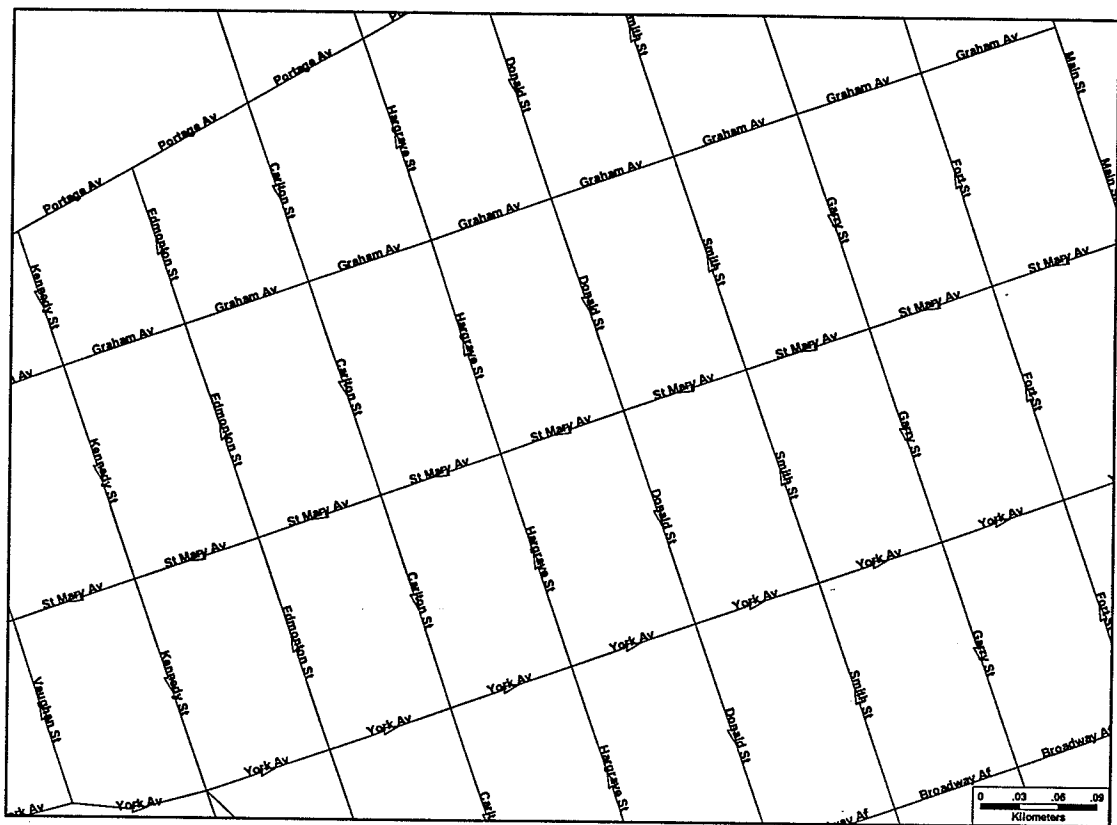


Figure 17: One way Streets in the Winnipeg Downtown Area

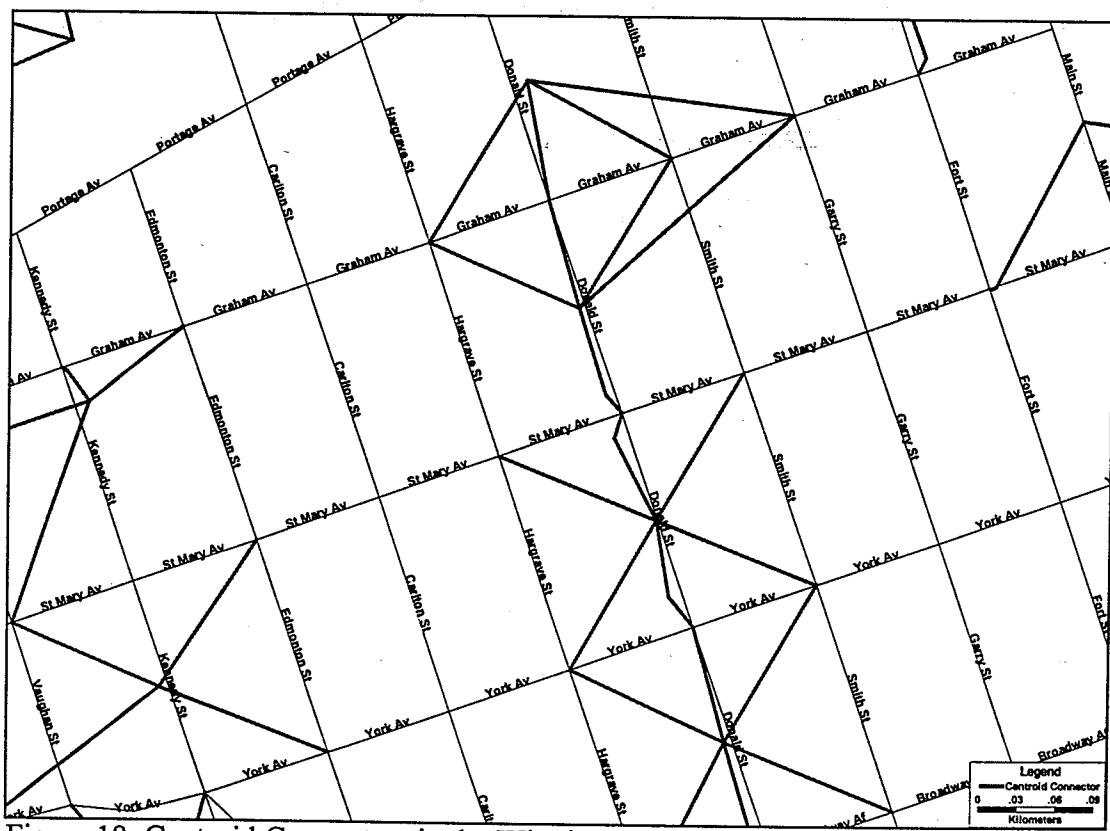


Figure 18: Centroid Connectors in the Winnipeg Downtown Area

4.6 Turn Restrictions

In addition to the network attributes, turn restrictions on the interchange ramps and the City's turning restrictions during the P.M. peak period were entered into the network. The turn restrictions stored in a dBase (dbf) file format documents the restrictions using three fields (see Table 9). The turn restrictions file is shown in Appendix C in tabular form.

Table 9: Turn Restriction File

Field name	Field type	Source	Information
From_Street	Integer	City of Winnipeg	TransCad internal ID for the link where the restriction begins.
To_Street	Integer	City of Winnipeg	TransCad internal ID for the link where the restriction ends.
Penalty	Integer	City of Winnipeg	Column is left empty to prohibit turns.

4.7 Zone system

The zone system is represented in TransCAD as an area file with 289 zones (see Figure 5). This file contains attributes shown in Table 10. A sample of the zone system in tabular form is shown in Appendix D.

Table 10: Zone System File

Field name	Field type	Source	Information
ID	Integer (4 bytes)	TransCAD generated	TransCAD internal ID for zone.
Area	Real (8 bytes)	TransCAD generated	TransCAD calculated area for the zone
Centroid	Integer (4 bytes)	City of Winnipeg	City of Winnipeg's Zone Centroid ID.
Zone	Integer (4 bytes)	City of Winnipeg	City of Winnipeg's Zone ID.
Cen_End_ID	Integer (4 bytes)	UMTIG	ID's of endpoints from the network file corresponding to the centroids of the zone.
Name	Character (32 width)	UMTIG	Name of zone.
Type	Character (16 width)	UMTIG	Type of zone (Large, RM, Town or WPGZONE) corresponds to large zone, rural municipality zone, town zone or zones within the city of Winnipeg
Intra_Speed	Integer (4 bytes)	City of Winnipeg	Assumed intrazonal speed in km/h.
Intra_Time	Real	City of Winnipeg	Intrazonal travel time in minutes calculated using NCHRP (1998).
ID_2	Character (16 width)	City of Winnipeg	City of Winnipeg's Zone Centroid secondary ID.

5.0 COMPONENTS OF THE MODEL

This chapter discusses the components of the MCRTPM model.

The components developed were:

- (a) trip generation equations for ADWT using the
- (b) a P.M. peak automobile driver work trip (ADWT) matrix and the National Cooperative Highway Research Program (NCHRP) diurnal factor.
- (c) an estimated P.M. peak vehicle total trip (PMPADWT) matrix developed in (b), traffic volume, and MHGS, and TransCAD's matrix adjustment (Nielsen's (1993) method).
- (d) a P.M. peak vehicle other trip (PMPVOT) matrix developed in (b) and the PMPVTT matrix.
- (e) trip distribution equations for PMPADWT using the 1996 Journey-to-Work data, travel time estimates, and TransCAD's trip distribution component calibration function.
- (f) trip distribution equations for PMPVOT using the 1996 Journey-to-Work data, travel time estimates from the 1996 Journey-to-Work database, and TransCAD's trip distribution component calibration function.
- (g) the trip assignment component using Bureau of Highway Engineering's default link performance function parameters.

5.1 P.M Peak Automobile Driver Work Trip (ADWT)

The 1996 Journey-To-Work database provides the peak period of travel (POW) of the Manitoba population who travel to work.

aggregated to the Winnipeg Regional Traffic Zone System (see Figure 5). By assuming that those people will travel from their place of residence to their place of work as automobile drivers, the 1996 Journey-to-Work database provides the total 24-hour work trips by automobile drivers. The 1996 Journey-to-Work database does not include students. The 1996 Journey-to-Work database was made available in Microsoft Excel 97 format. The data had non-matching zone numbers for the origin zones with the destination zones. This problem was corrected by processing the initial data in Excel and then exporting the data to the Corel Paradox software. Paradox was used to generate the missing zone numbers. The process resulted in a Dbase 4 file containing the number of automobile driver trips by origin zones and destination zones. This data were then exported to back to Microsoft Excel. The data were also exported to TransCAD and processed to form the Automobile Driver Work Trip (ADWT) matrix (with 285 origins and 285 destinations). The PMPADWT matrix was obtained by applying the P.M. peak Home Based Work Trip diurnal factor to the ADWT matrix. The P.M. peak Home Based Work Trip diurnal factor used was 22.34% which is the percentage of home based work trips occurring during the P.M. peak with respect to the total work trips as specified by NCHRP (1998).

5.2 P.M. Peak Vehicle Other Trip (PMPVOT) Matrix

The matrix adjustment algorithm was used to derive the PMPVTT matrix. The PMAPDTT matrix was then used to produce the PMPVOT matrix. The matrix adjustment algorithm requires: (1) a base year travel matrix; and (2) traffic counts on links. The algorithm adjusts the base year travel matrix in order to produce traffic

volumes to replicate the observed traffic counts on the links. This algorithm is documented in Nielsen (1993).

The base year travel matrix used in this research was PMADWT matrix. The traffic counts used were: (1) P.M. peak counts on City of Winnipeg streets; (2) special interchange ramp counts conducted by the City for this research; and (3) P.M. peak counts for the Provincial Highways derived from Permanent Counting Stations (PCS). The traffic counts were attributed into the analysis network (see Table 7).

5.2.1 P.M. Peak Counts on City of Winnipeg Streets

The P.M. peak counts for the City of Winnipeg streets is derived from the City's traffic count program. The counts used were short-term counts (48 hours) from automatic vehicle counters carried out during summer months in 1998 and 1999.

5.2.2 City of Winnipeg Special Interchange Ramp Counts

In order to improve the results from the matrix adjustment algorithm, special counts were conducted on interchange ramps in the Capital Region. These counts were short term counts (48 hours) performed in September 2000 using automatic vehicle counters.

5.2.3 P.M. Peak Counts for the Provincial Highways

The Manitoba Highways Traffic Information System (MHTIS) develops annual average daily traffic (AADT) estimates for Manitoba provincial highways using methods described in the “Traffic on Manitoba Highways” (1999). The AADT estimates are based on data from Permanent Counting Stations (PCS) and short-term counts. PCS locations in the Capital Region are shown in Figure 19. PCS data are hourly traffic totals which can provide details on the P.M. peak traffic volumes on provincial highways in the Capital Region.

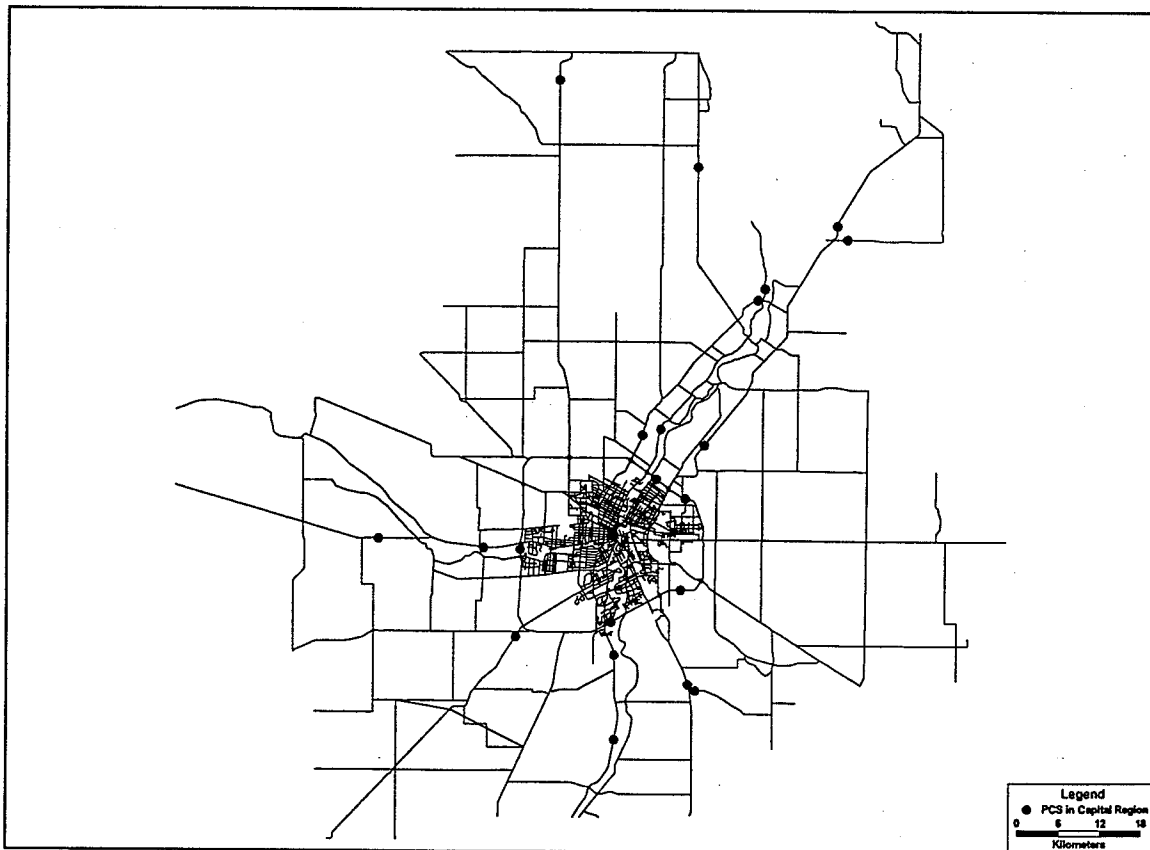


Figure 19: PCS Locations in the Manitoba Capital Region (UMTIG, 2000)

In the situation in which a link has data from both the City of Winnipeg and the province, the data from the province were used. This was because the counts from the PCS station were derived from year-round monitoring compared to the short-term count from the city.

Figure 20 shows the MCRTAN links with P.M. peak counts entered (either from City of Winnipeg Traffic data or the Provincial Highway data). Appendix D shows these links in tabular form.

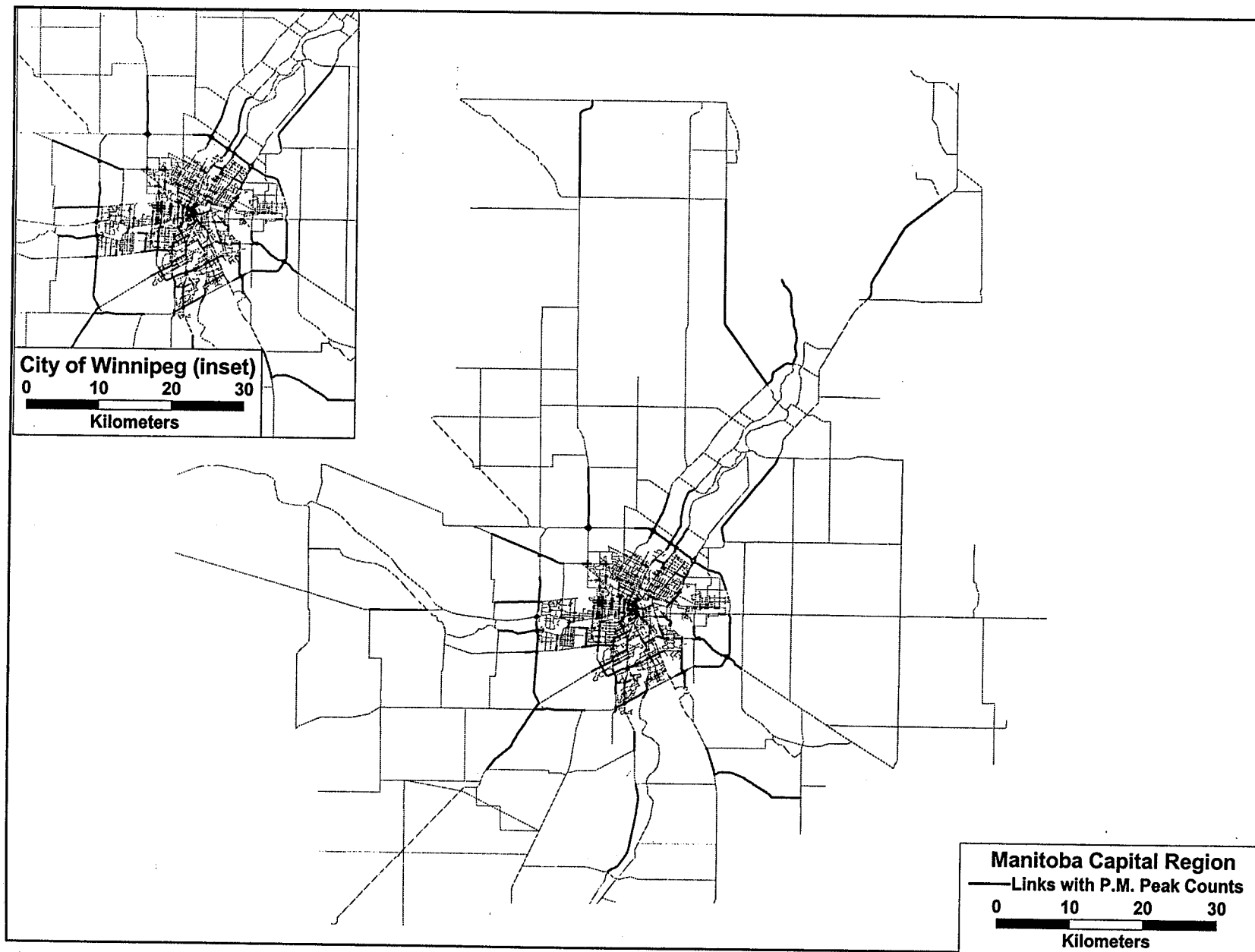


Figure 20: Links with P.M. Peak Counts

//pc-trans2/d:/users/kean/thesis2/gis/wpg5/countvol.lay
(c) UMTIG

5.2.4 Results of Matrix Adjustment Algorithm

The matrix adjustment algorithm was applied using 10 iterations, 40 iterations, 100 iterations, and 200 iterations. The algorithm used the user equilibrium traffic assignment (using the same parameters as discussed in Section 5.5) method to assign the estimated traffic on the links in the network. The matrix adjustment algorithm produced: (1) estimated flow (PMPVTT) assigned to links in the network; and (2) an estimated PMPVTT matrix.

The estimated flow was compared to the observed flows on the links. The comparisons are shown in Figure 21, Figure 22, Figure 23 and Figure 24.

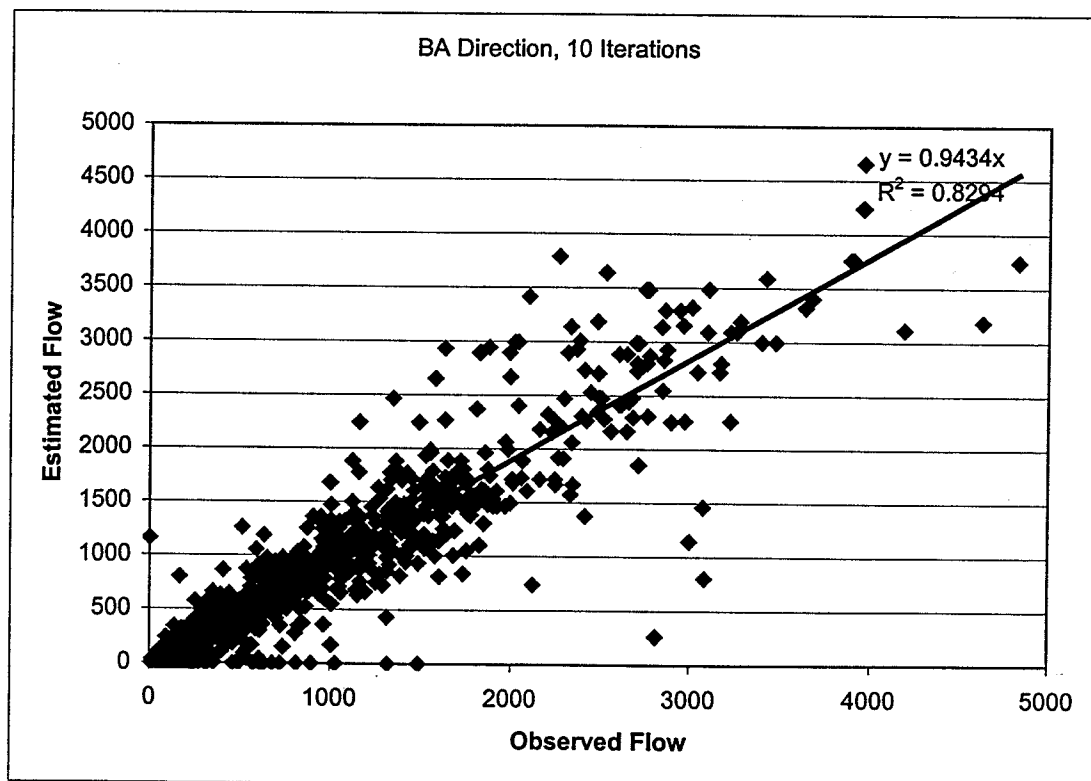
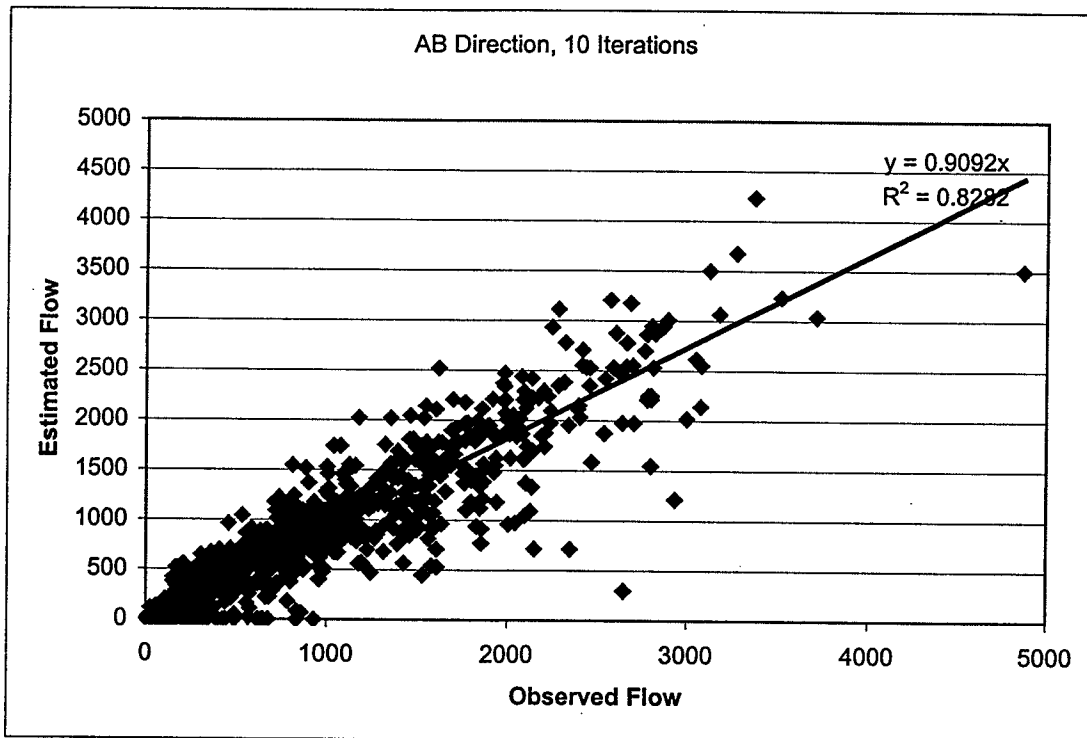


Figure 21: Results of Matrix Adjustment Algorithm (10 Iterations)

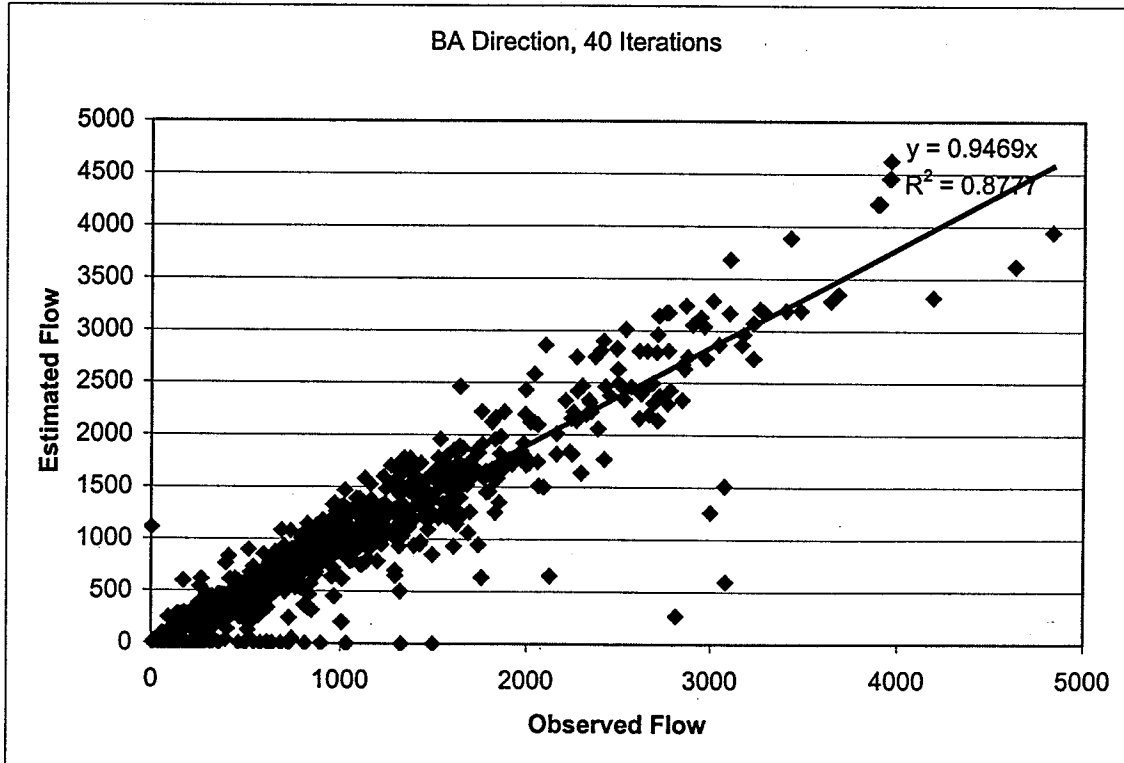
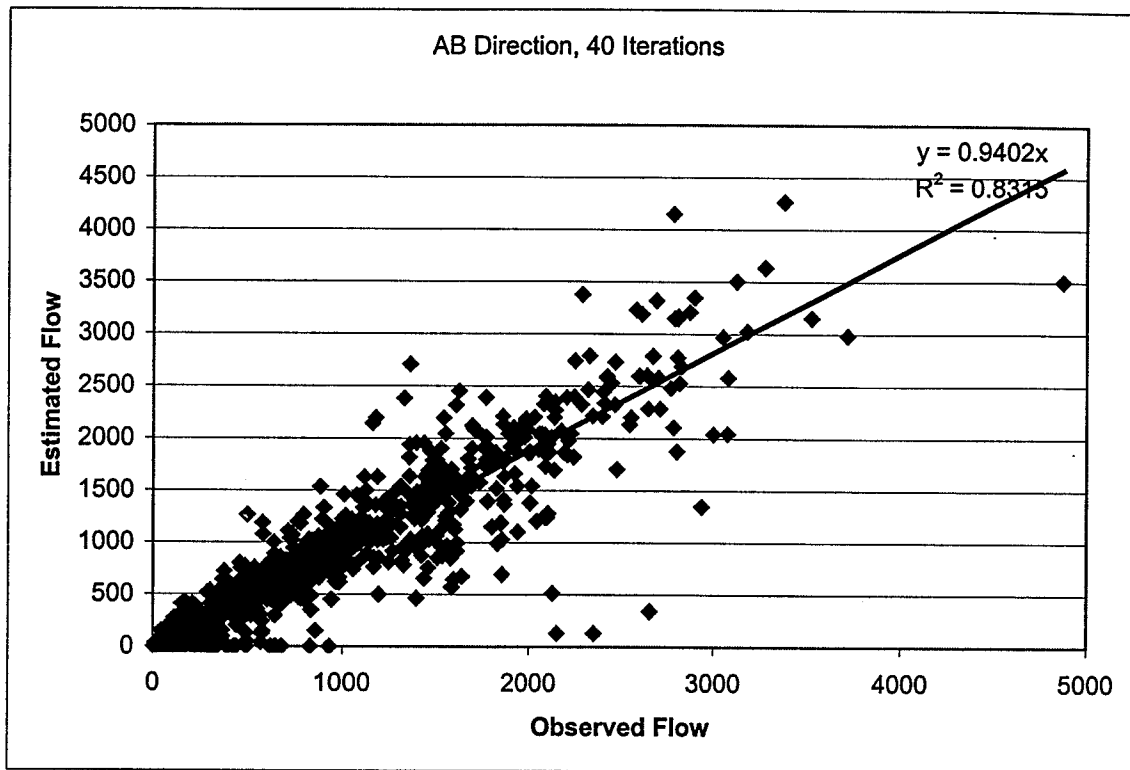


Figure 22: Results of Matrix Adjustment Algorithm (40 Iterations)

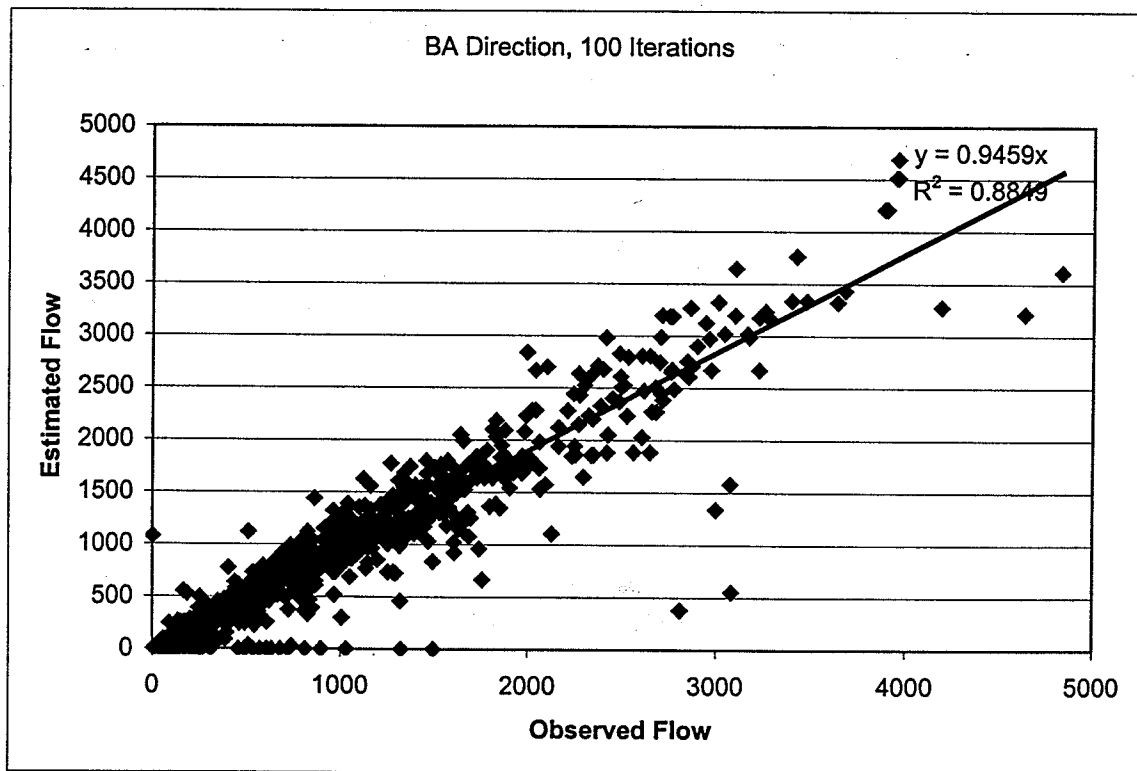
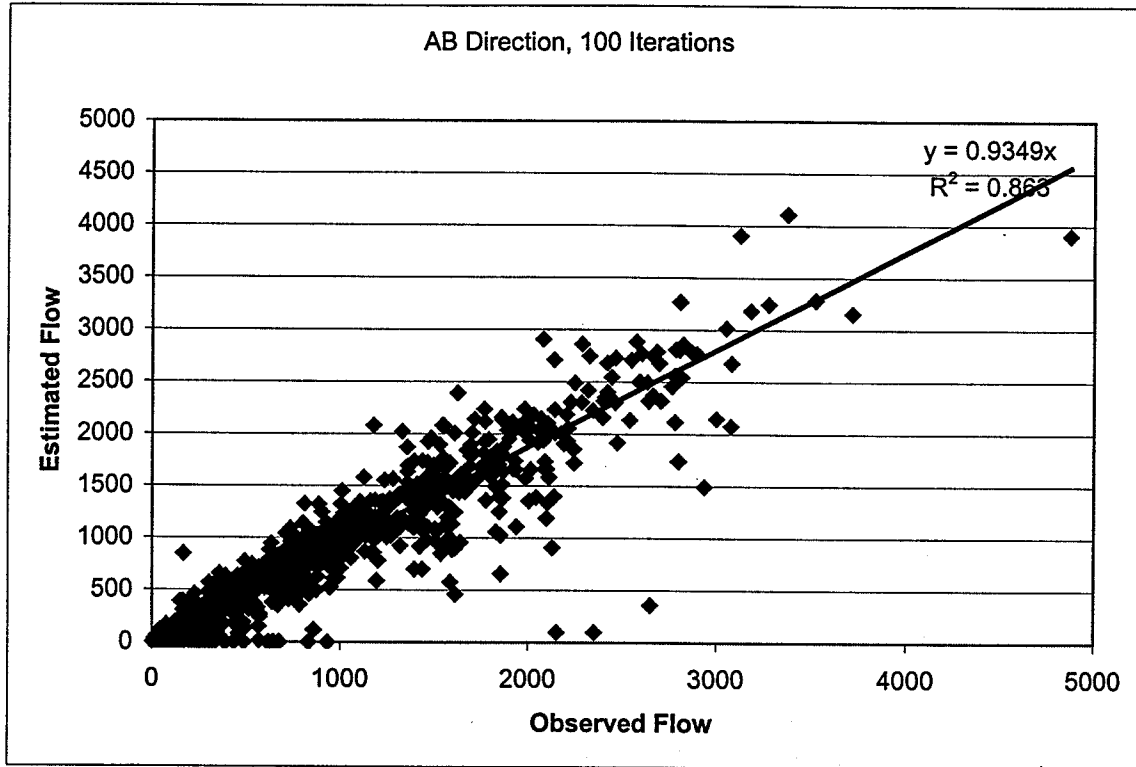


Figure 23: Results of Matrix Adjustment Algorithm (100 Iterations)

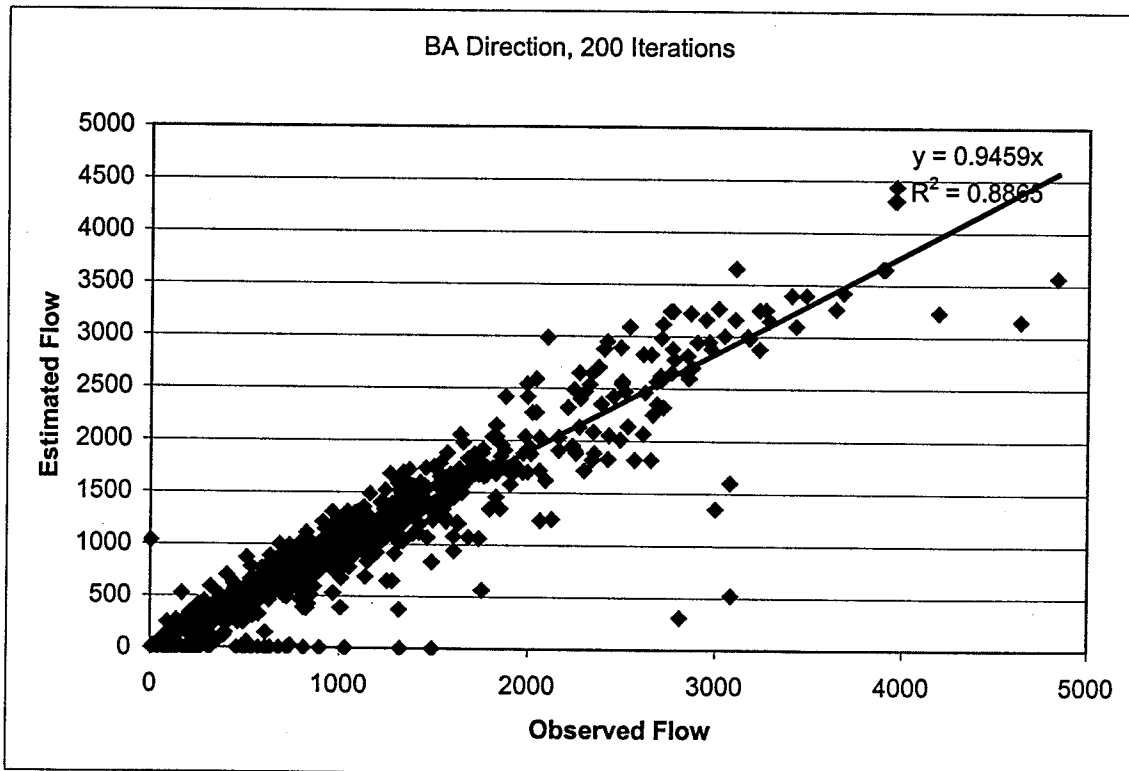
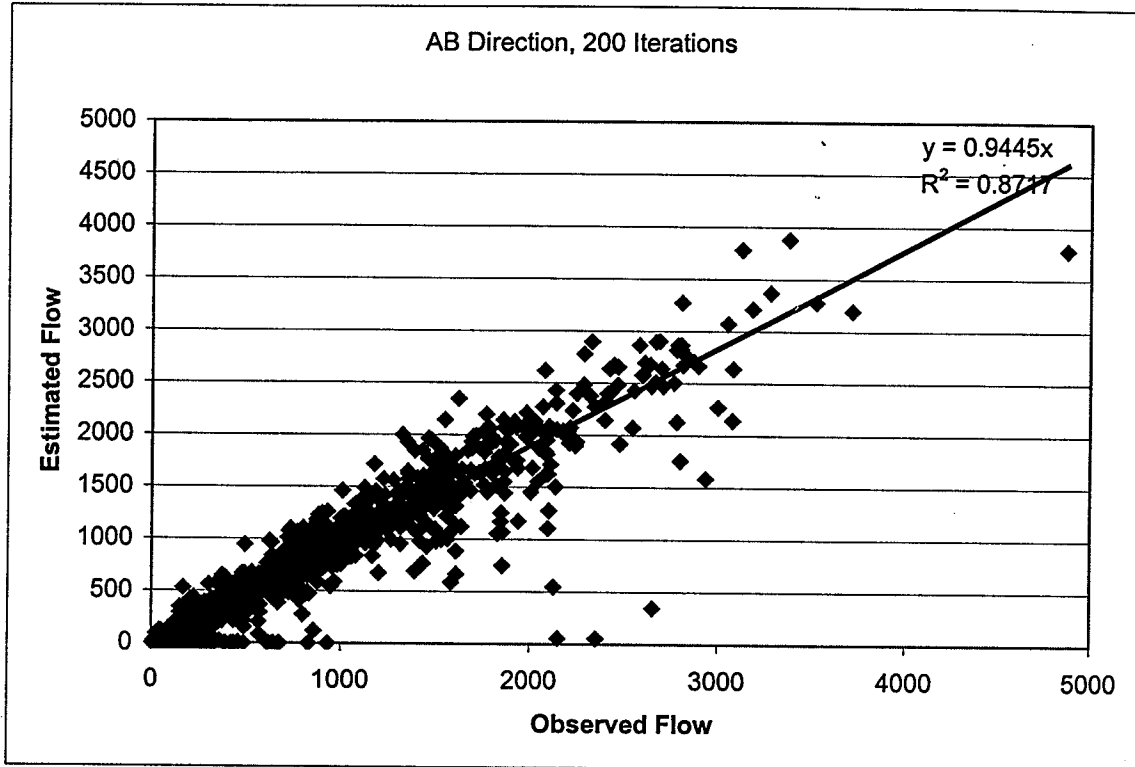


Figure 24: Results of Matrix Adjustment Algorithm (200 Iterations)

The estimated flow was also compared to the observed flow at 25 important links in the network. The links selected were: (1) key bridges; (2) locations with PCS data; (3) along routes known to have significant traffic during the P.M. peak. These links are shown in Figure 25. The comparison is shown in Table 11 and Table 12. Note that there are no entries for flows in the AB direction (in Table 11) for links which are one-way streets in the BA direction. Similarly, there are no entries for flows in the BA direction (in Table 12) for links which are one-way streets in the AB direction.

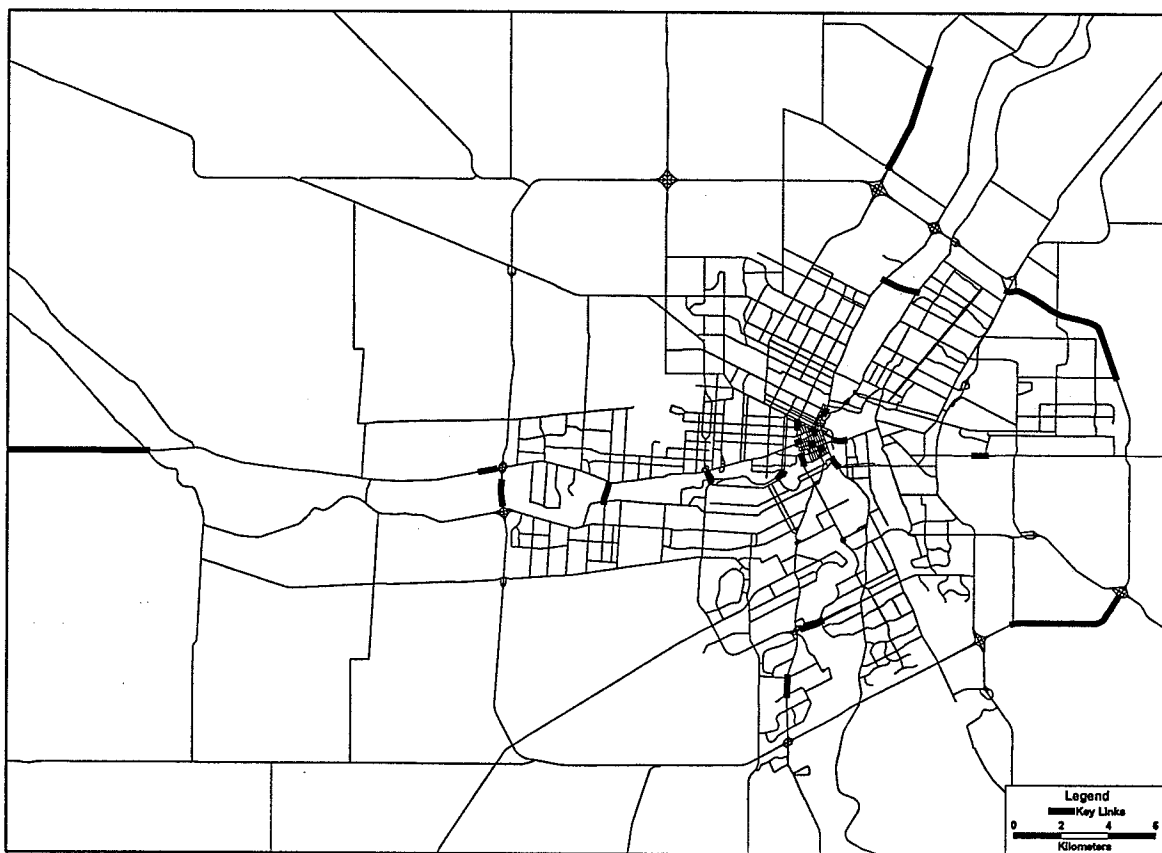


Figure 25: Key Links

Table 11: Estimated PMPVTT Flow and Observed PMPVTT Flow in the AB Direction at Key Links

Dir	ID	Name	Count	10 iter.	40 iter.	100 iter.
-1	1508	Bishop Grandin Bv WB				
-1	13632	St Mary Av				
-1	8506	Maryland Bridge SB				
0	11237	PTH 101	218	464	389	307
0	11211	PTH 100	304	435	413	390
0	11191	PTH 1	490	551	523	504
0	11368	PTH 8	667	792	753	674
0	9960	Osborne St N	998	1094	1051	1153
0	11211	PTH 100	1007	1461	1460	1448
0	9247	Moray St	1135	1522	1367	1246
0	3961	Dugald Rd	1181	1180	833	1176
0	10760	Portage Av	1231	1295	1412	1550
0	988	Balmoral St	1387	1144	948	1094
0	1877	Broadway Af	1451	1005	1082	1362
0	10361	Pembina Hw	1530	1556	1497	1436
0	8124	Main St	1604	2110	2317	2006
0	2659	Chief Peguis TI	1755	1465	1748	1649
0	9676	Norwood Bridge	2086	1618	1243	1661
0	11173	Provencher Bv	2635	2465	2603	2496
0	10688	Portage Av		817	881	893
1	13225	Smith St	1390	760	462	699
1	8505	Maryland Bridge NB	1544	1680	1697	1768
1	1504	Bishop Grandin Bv EB	2763	2698	2482	2458
1	13830	St. James Bridge NB		1823	2264	2303
1	13832	St. James Bridge SB		1675	1879	1970

Table 12: Estimated PMPVTT Flow and Observed PMPVTT Flow in the BA Direction at Key Links

Dir	ID	Name	Count	10 iter.	40 iter.	100 iter.
-1	1508	Bishop Grandin Bv WB	1856	1962	1983	1946
-1	13632	St Mary Av	1127	1379	1580	1370
-1	8506	Maryland Bridge SB	3165	2720	2867	3020
0	11237	PTH 101	172	312	290	257
0	11211	PTH 100	246	398	384	388
0	11191	PTH 1	436	625	529	472
0	11368	PTH 8	320	299	311	319
0	9960	Osborne St N	2270	3786	2748	2638
0	11211	PTH 100	848	873	899	900
0	9247	Moray St	1557	1958	1730	1590
0	3961	Dugald Rd	640	880	724	646
0	10760	Portage Av	2248	1714	1814	1941
0	988	Balmoral St	1006	1470	857	802
0	1877	Broadway Af	982	1025	1001	1180
0	10361	Pembina Hw	2209	2321	2326	2281
0	8124	Main St	1321	1002	1060	1217
0	2659	Chief Peguis Tl	837	905	1017	879
0	9676	Norwood Bridge	3949	4238	4457	4513
0	11173	Provencher Bv	897	0	0	0
0	10688	Portage Av		932	1061	1101
1	13225	Smith St				
1	8505	Maryland Bridge NB				
1	1504	Bishop Grandin Bv EB				
1	13030	St. James Bridge NB				
1	13032	St. James Bridge SB				

At the key links, the estimated flows replicate closely the observed flows (less than 300 trip difference) at all the locations except for Smith Street (which has 700 trip difference).

The matrix adjustment algorithm also produced estimated PMPVTT matrices. The total number of trips in the estimated PMPVTT matrix changed with the number of iterations used (see Table 13).

Table 13: Estimated P.M. Peak Vehicle Total Trips

	10 Iterations	40 Iterations	100 Iterations	200 Iterations
Estimated Trips	160664	182214	191954	198218

The results of the matrix adjustment algorithm are sensitive to the number of iterations used. As the number of iterations increase, the estimated flows approach closer to the observed flows (the overall coefficient of determination, R^2 , increases as the number of iterations increases). In addition, as the number of iterations increase, the total number of trips estimated also increase.

Using the estimated PMPVTT matrix (derived using 200 iterations), a PMPVOT matrix was derived using:

$$\text{PMPVOT} = \text{PMPVTT} - \text{PMPADWT}$$

The PMPVOT matrix produced has negative values in certain cells (10% of the total number of cells have negative values). This is because the estimated PMPVTT are less than the PMPADWT at those cells. The negative values in those cells were rounded to 0 to avoid negative values in the PMPVOT matrix.

5.3 Trip Generation Component

The trip generation component of the transportation planning models is used for predicting the number of trips generated to and from activities in an analysis area (NCHRP, 1998). There are three types of analysis units used in trip generation modeling: (1) zonal; (2) household and (3) individual. The zonal analysis unit is employed in this thesis. Details on using the household and individual as analysis units in trip generation modeling (also known as disaggregate analysis) can be found in Ben Akiva and Bierlaire (1999), Daganzo (1982), and Bhat, Govindarajan and Pulugurtha (1998). The reason that the zonal analysis unit is used in this research is that the 1996 Journey-to-Work data were aggregated to the Winnipeg Regional Traffic zone system. In addition, disaggregate data necessary for constructing the model were not available. Furthermore, although the literature is full of praise for the disaggregate approach, in some cases it has produced disappointing results (Mekky, 1995).

The trip generation component has the following assumptions:

- (1) During the P.M. peak, persons working in a zone will return home after work.

Discretionary trips such as shopping after work are considered other trips.

- (2) The relationship between dependent variable and dependent variable is linear

- (3) Trip generation equations have zero intercept

The most common method of constructing trip generation models is the regression method. This is the method used for constructing the trip generation model for this research. The dependent variable is automobile driver work trips (ADWT). The

regression method develops relationships between the dependent variable and the independent variable. The resulting relationships are expressed using equations. Ortuzar and Willumsen (1994) and Mekky (2000) give details of multiple regression analysis. The procedures taken to develop the trip generation component are shown in Figure 26.

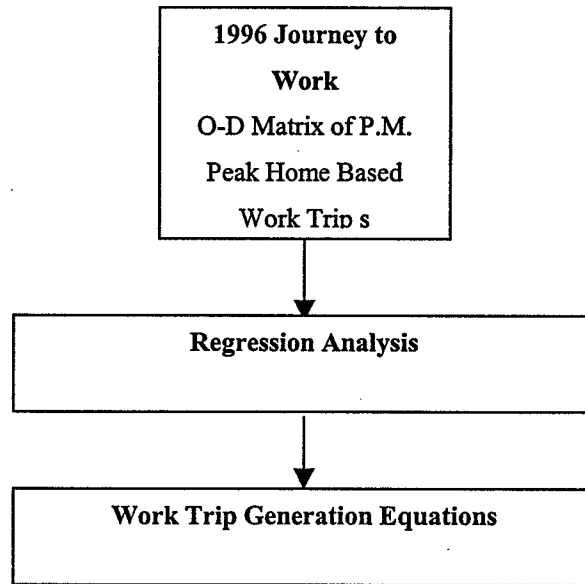


Figure 26: Trip Generation Component Development Procedure

5.3.1 ADWT Production Equation

Since this is a P.M. peak model, for the work trips, the trip production occurs at the place of employment. Using regression analysis, different independent variables were used to derive different trip production equations (see Appendix F). Out of the different equations, one equation was selected based on: (1) the ease of prediction of the independent variable(s); (2) logical signs of coefficients; and (3) magnitude of coefficients. The equations are summarized in Table 14.

Table 14: ADWT Trip Production Equations Examined

Dependent Variable	Independent Variable(s)	Comments
ADWT produced	Total Employment	Independent variable can be predicted. The coefficients have logical signs (positive). The magnitude of the coefficient is logical.
ADWT produced	Number of Employees by industry: (1) primary sector; (2) manufacturing; (3) wholesale retail; (4) finance; (5) Government; (6) accommodation	The coefficients have logical signs (positive). Difficult to predict the independent variables

Based on those criteria, the equation chosen to be the automobile driver work trip production equation is (see Figure 27):

$$(o_i)_{ADW} = 0.7262 (TotEMP_i)$$

where

$(o_i)_{ADW}$ is the automobile driver work trips produced by zone i

TotEMP is the total employment in zone i

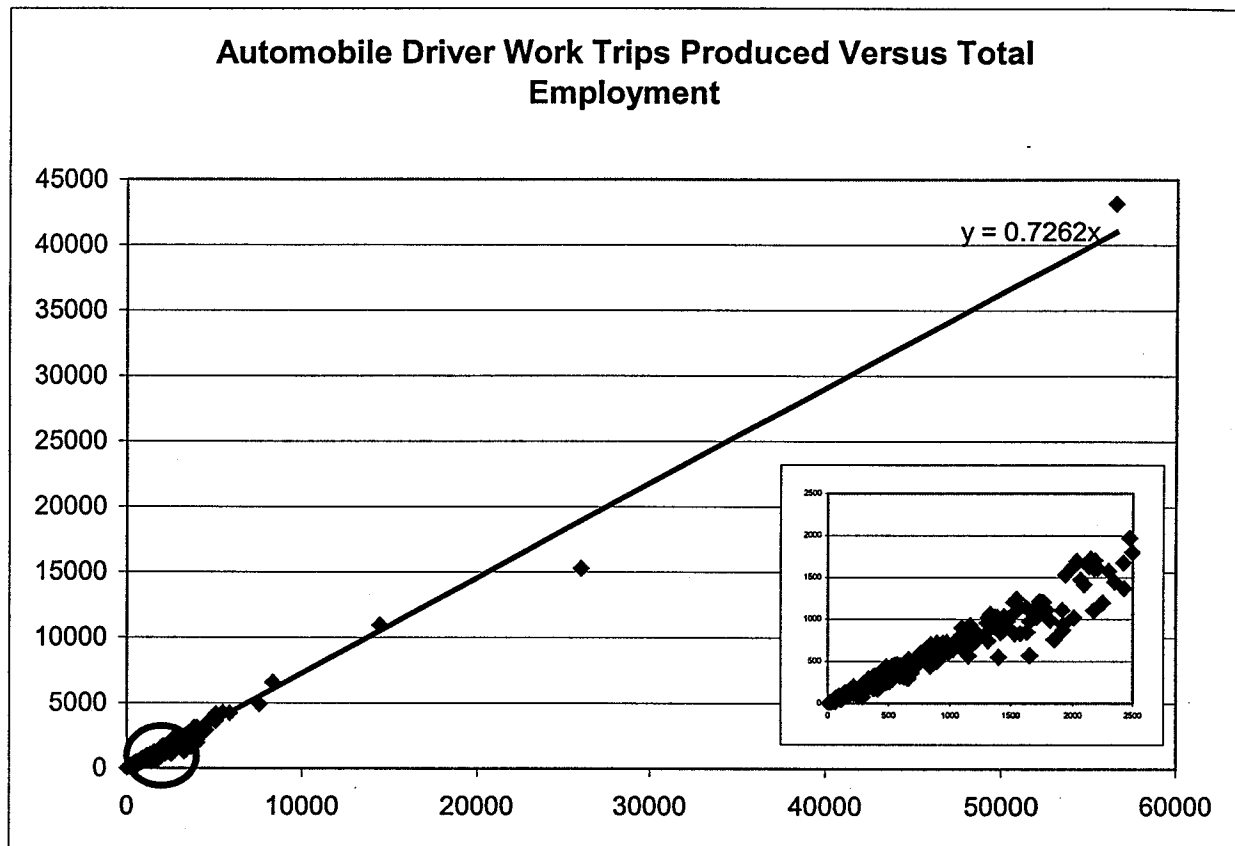


Figure 27: Automobile Driver Work Trips Produced Versus Total Employment

The equation chosen uses total employment as the independent variable. This variable is easier to predict than employment by industry (which is used by the Winnipeg Transportation Model). The coefficient has a logical sign (positive). In addition, the magnitude of the coefficient is less than 1.0. This means there is less ADWT than total employment. This is logical because not all work trips are by automobile drivers. Using the chosen equation, the predicted ADWT produced is 307,676. From the 1996 Statistics Canada Journey-to-Work Database, the number of ADWT trips is 288,305. There is a 6.72% difference between the predicted ADWT produced and the observed ADWT produced.

5.3.2 ADWT Attraction Equation

Appendix G shows the different equations developed and examined. Table 15 summarizes the equations.

Table 15: ADWT Trip Attraction Equations Examined

Dependent Variable	Independent Variable(s)	Comments
ADWT attracted	Population	Independent variable can be predicted. The coefficients have logical signs (positive). The magnitude of the coefficient is logical.
ADWT attracted	Total number of households	Independent variable can be predicted. The coefficients have logical signs (positive). The magnitude of the coefficient is logical. Compatible with existing Winnipeg Transportation Model.
ADWT attracted	Number of households by household size: (1) one person; (2) two persons; (3) three persons; (4) four persons; (5) five or more persons	Independent variables are difficult to predict. The coefficients have illogical signs (negative).
ADWT attracted	Employed labour force	Independent variable is difficult to predict. The coefficients have logical signs (positive). The magnitude of the coefficient is logical.

The equation chosen as the trip attraction equation is (see Figure 28):

$$(d_j)_{ADW} = 0.6397 (HOUSE_j)$$

where

$(d_j)_{ADW}$ is the automobile driver work trips attracted to zone j

$HOUSE_j$ is the number of households in zone j

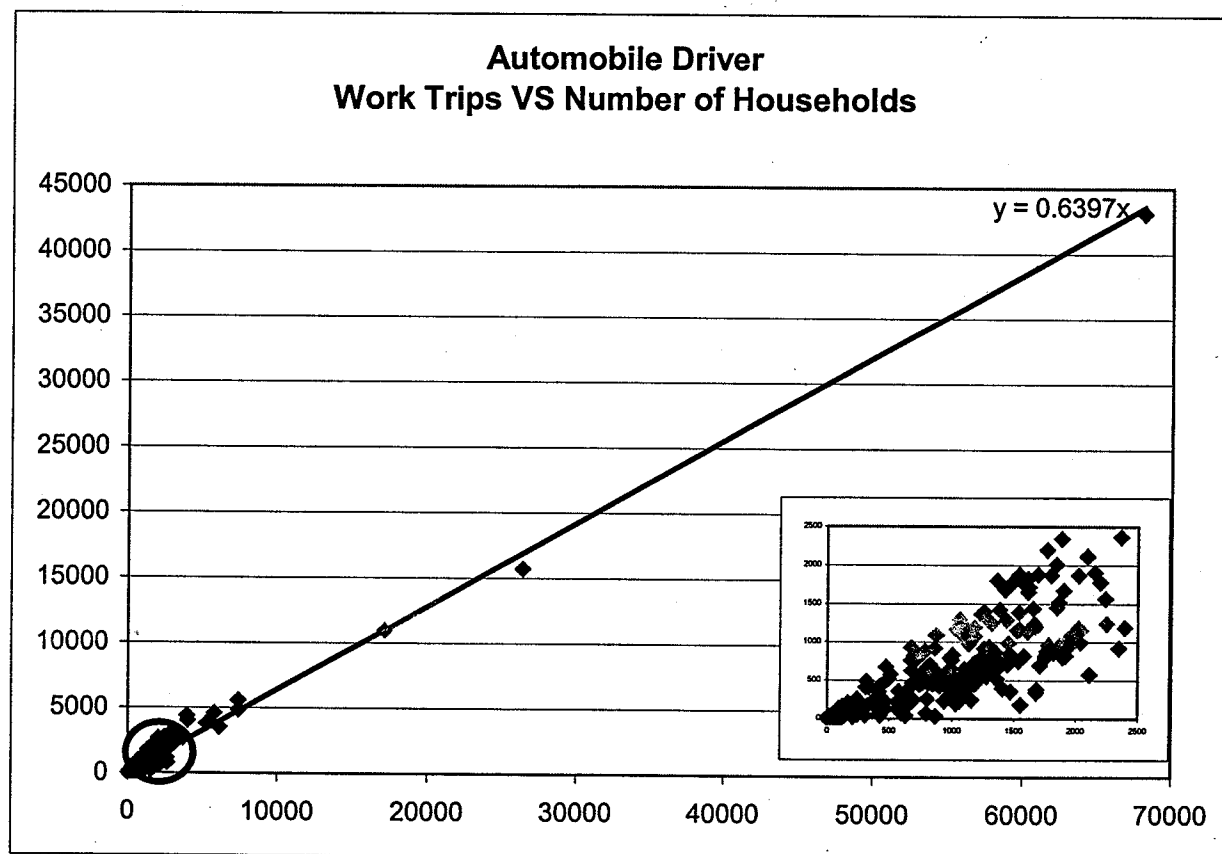


Figure 28: Automobile Driver Work Trips Versus Number of Households

The equation chosen uses number of households as the independent variable. This variable is predictable. The coefficient has a logical sign (positive). In addition, the magnitude of the coefficient is less than 1.0. This means there is less ADWT than the number of households. This is logical because not every household attracts a work trip by automobile drivers. Using the chosen equation, the predicted ADWT attracted is 268,134. From the 1996 Statistics Canada Journey-to-Work Database, the number of ADWT trips is 288,305. There is a 7.00% difference between the predicted ADWT attracted and the observed ADWT attracted.

In this research, efforts were also made to construct trip production and trip attraction equations for the PMPVOT. The equations developed and examined were not satisfactory (illogical coefficient signs and lack of correlation between dependent variable and independent variables) and are summarised in Table 16 and Table 17. The equations examined are shown in Appendix H.

Table 16: PMPVOT Trip Production Equations Examined

Dependent Variable	Independent Variable(s)	Comments
PMPVOT production	Total number of households; Wholesale and retail employment.	Lack of relationship between dependent variable and independent variables
PMPVOT production	Total number of households; Primary sector employment; Manufacturing employment; Wholesale and retail employment; Finance employment; Government employment; Accommodation employment	Negative coefficients

Table 17: PMPVOT Trip Attraction Equations Examined

Dependent Variable	Independent Variable(s)	Comments
PMPVOT attracted	Primary sector employment	Lack of relationship between dependent variable and independent variables
PMPVOT attracted	Total number of households; Wholesale and retail employment.	Negative coefficients. Lack of relationship between dependent variable and independent variables.
PMPVOT attracted	Total number of households	Lack of relationship between dependent variable and independent variables
PMPVOT attracted	Total number of households; Primary sector employment; Manufacturing employment; Wholesale and retail employment; Finance employment; Government employment; Accommodation employment	Negative coefficients. Lack of relationship between dependent variable and independent variables.

5.4 Trip Distribution Component

The trip distribution component predicts the number of trips that originate from zone i destined for zone j (t_{ij}). Figure 29 shows the steps taken to construct the trip distribution component.

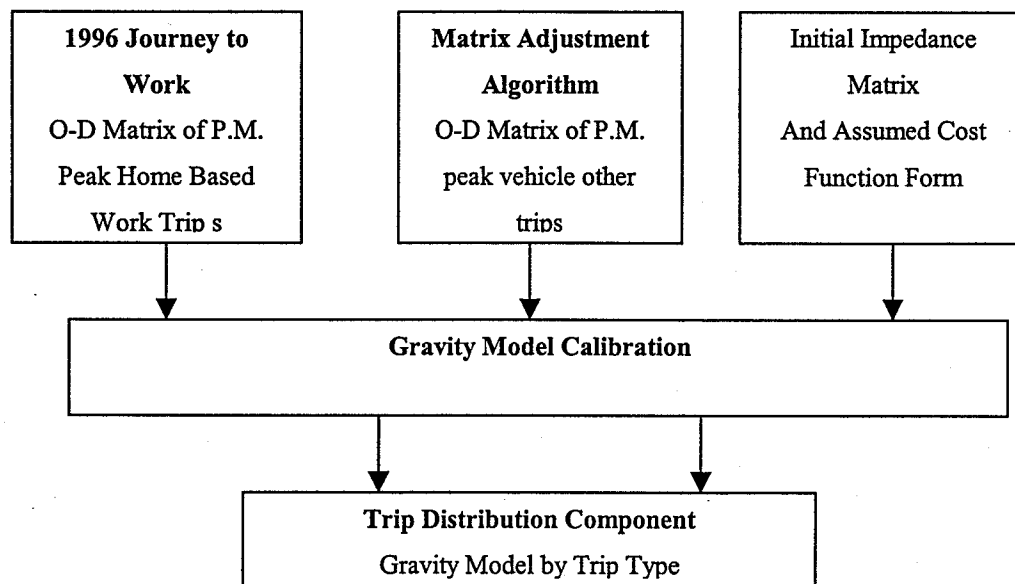


Figure 29: Trip Distribution Component Development Procedures

The trip distribution method used in this research is the “gravity model”. The concept of the gravity model is that groups of people interact more as they become larger and nearer to complementary activities. Newton’s Law of Gravitation was borrowed to mathematically specify this concept. This is written as (Mekky, 2000):

$$t_{ij} = a_i b_j o_i d_j f(c_{ij})$$

where

$$a_i = 1 / \sum_j [b_j d_j f(c_{ij})]$$

$$b_j = 1 / \sum_i [a_i o_i f(c_{ij})]$$

t_{ij} is the number of trips produced in zone i and attracted to zone j

a_i, b_j are balancing factors

o_i is the number of trips produced in zone i

d_j is the number of trips attracted to zone j

$f(c_{ij})$ is the impedance function for travel from zone i to zone j .

subject to the constraints

$$\sum_j t_{ij} = o_i$$

$$\sum_i t_{ij} = d_j$$

There are several forms of impedance functions (Mekky, 2000; NCHRP, 1998):

(1) exponential

$$f(c_{ij}) = \text{EXP}(-x(c_{ij}))$$

where x is a parameter to be calibrated

(2) inverse power

$$f(c_{ij}) = (c_{ij})^{-x}$$

where x is a parameter to be calibrated

(3) gamma

$$f(c_{ij}) = x(c_{ij})^{-y} \text{EXP}(-z(c_{ij}))$$

where x, y, z are parameters to be calibrated

This research uses an exponential impedance function. The exponential impedance function was chosen because the Winnipeg Transportation Model uses an exponential impedance function. The gravity model used for the trip distribution component of the MCRTPM is:

$$t_{ij} = a_i b_j o_i d_j \text{EXP}(-x c_{ij})$$

where

$$a_i = 1 / \sum_j [b_j d_j c_{ij}^{-b}]$$

$$b_j = 1 / \sum_i [a_i o_i c_{ij}^{-b}]$$

t_{ij} is the number of trips produced in zone i and attracted to zone j

a_i, b_j are balancing factors

o_i is the number of trips produced in zone i

d_j is the number of trips attracted to zone j

c_{ij} is travel time from zone i to zone j (in minutes)

x is the parameter to be calibrated

subject to the constraints

$$\sum_j t_{ij} = o_i$$

$$\sum_i t_{ij} = d_j$$

Calibration of the gravity model is the process of determining the best estimates of the model's parameters. This is done by finding values of the parameters which allows the trip distribution component to reproduce the base year matrix with minimum error.

Details can be found in Mekky (2000).

For the calibration of the trip distribution component of the MCRTPM, the following is required:

- the PMPADWT matrix
- the PMPVOT matrix
- the c_{ij} matrix, which is calculated by determining the shortest travel time (InitTime_AB and InitTime_BA) from zone i to zone j along the MCRTAN.

5.4.1 PMPADWT and PMPVOT Trip Distribution Equations

For PMPADWT, x was calibrated to a value of 0.0575. This results in:

$$(t_{ij})_{ADW} = o_i d_j \text{EXP}(-0.0575 c_{ij})$$

For PMPVOT, x was calibrated to a value of 0.0751. This results in:

$$(t_{ij})_{OT} = o_i d_j \text{EXP}(-0.0751 c_{ij})$$

5.5 Trip Assignment Component

The trip assignment component assigns the P.M. peak automobile driver work trip matrix $(t_{ij})_{ADW}$ and the P.M. peak vehicle other trip matrix $(t_{ij})_{OT}$ to travel routes in order to produce the P.M. peak traffic flow on each link in the analysis network. The assumptions for the trip assignment component are:

- (1) all trips begin and end at zone centroids
- (2) trip behavior follows equilibrium theory

5.5.1 Trip Assignment Component Development

Figure 30 shows the steps taken to construct the trip assignment component.

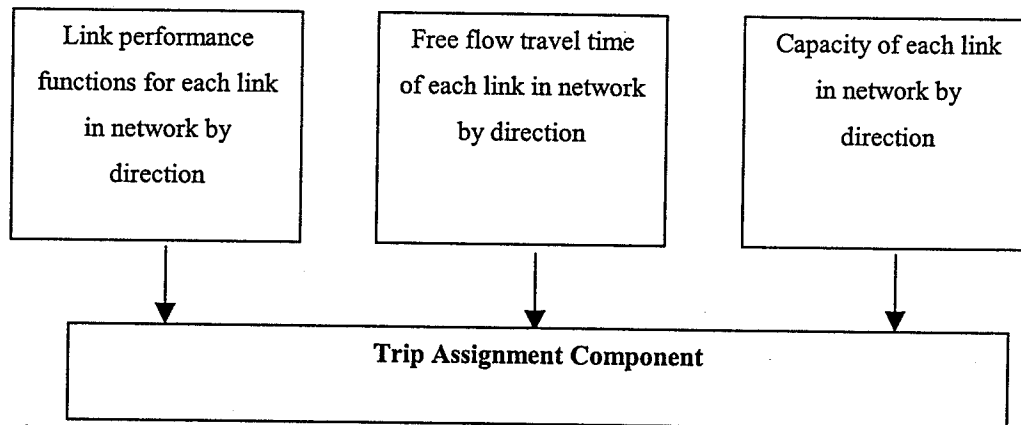


Figure 30: Trip Assignment Component Development Procedure

The trip assignment method used in this research is called the user equilibrium method. This method is based on the concept that "traffic on a network distributes itself in such a way that the travel costs on all routes used from any origin to any destination are equal while all unassumed routes have equal or greater travel costs" (Wardrop, 1952).

Effectively, this means that traffic distributes itself in such a way that no driver can reduce his/her travel cost by using another route (Mekky, 2000). Mathematically, trip assignment using the user equilibrium method is achieved by solving a system of equations which include (Mekky, 2000):

- (1) equations relating travel time to the flow on each link (link performance functions)
- (2) conservation equations for flows entering and leaving nodes
- (3) equilibrium equations where:
 - a. the travel time from one point in the network to another point in the network is the same for routes which were used for travel ($t_{ij}^{\min}$)
 - b. the travel time for all unused routes were equal or greater than $t_{ij}^{\min}$

Link performance functions relate the travel time of a link to the traffic flow on the link (see Figure 31).

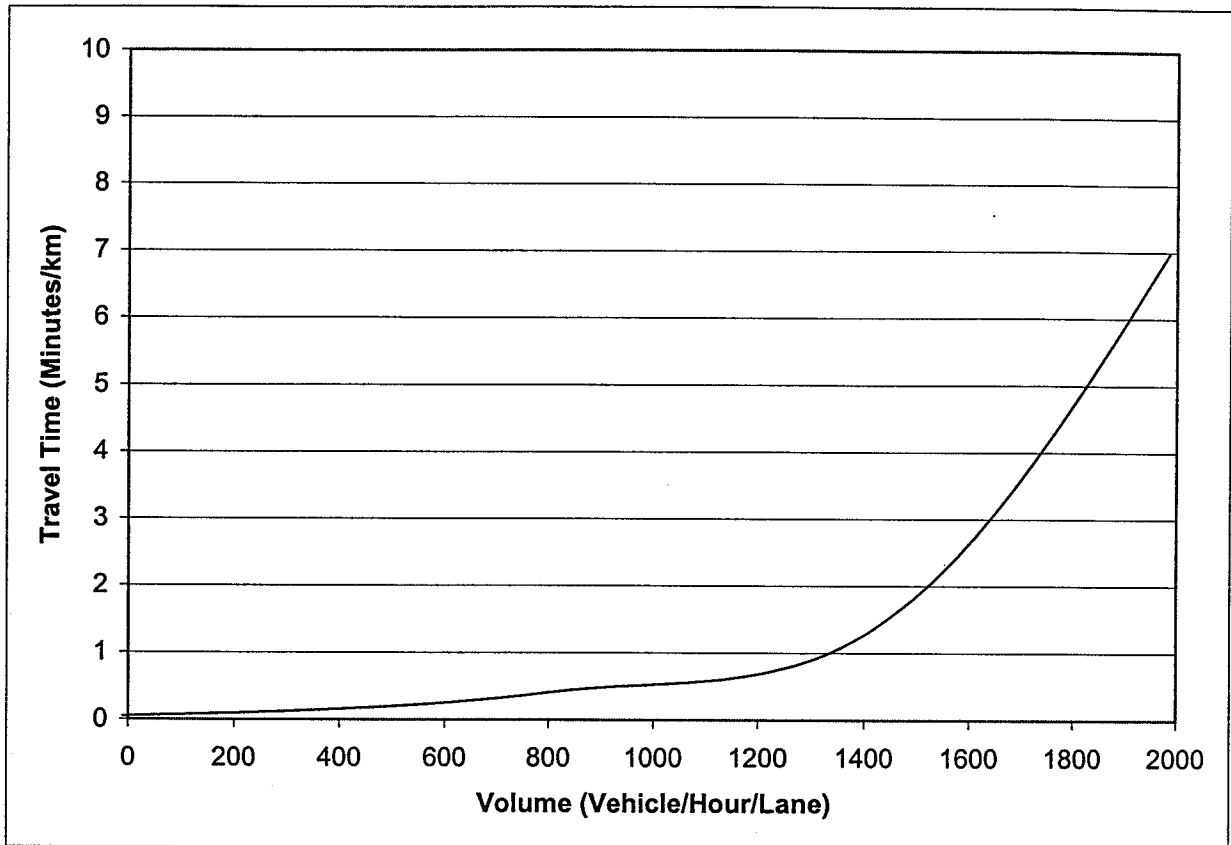


Figure 31: Example of a Link Performance Function (Mekky, 2000)

There are many different forms of link performance functions. One form of link performance functions is specified by the Bureau of Public Roads (1964). Mathematically, the Bureau of Public Roads (BPR) link performance function is written as (NCHRP, 1998):

$$\tau = \tau_0 [1 + \alpha (V / C_p)^\beta]$$

where

τ is the travel time per unit distance

V is the flow

C_p is the practical capacity of the link

$\tau_0 = \tau$ at zero flow

α and β are parameters estimated from data

BPR specifies $\alpha = 0.15$ and $\beta = 4.0$ as default values. This thesis uses those default values in the trip assignment component.

The free flow travel time on a link is calculated based on procedures described in Section 4.5.

The capacity of a link is calculated using:

Capacity (vehicles/hour) = Number of Operational Lanes * 900 vehicles/hour/lane

The capacity is attributed in the MCRTAN as described in Section 4.5.

6.0 CONCLUSION AND FURTHER WORK

This chapter provides the conclusion of the thesis and proposes further work for the MCRTPM.

6.1 Conclusion

Based on the need for a regional transportation planning model, this thesis has developed (using the best available data) the foundation of the Manitoba Capital Region Transportation Planning Model: (1) the framework and structure of the model; (2) the Manitoba Capital Region Transportation Analysis Network (MCRTAN); (3) relevant P.M. peak traffic data; (4) the automobile driver work trip (ADWT) matrix from Statistics Canada 1996 Journey-to-Work database; and (5) components of the MCRTPM. This foundation allows further development to be made to the MCRTPM in order to develop a complete model.

6.2 Discussion and Further Work

6.2.1 ADWT Time Distribution

The PMPADWT is estimated from the ADWT (obtained from the 1996 Statistics Canada Journey-to-Work database) using the NCHRP diurnal factor. Sensitivity analysis has not been performed on this factor and as such the effect of this factor on the components developed in this research is unknown. The 2001 Statistics Canada Journey-to-Work

Database will not contain time distribution information to help refine the diurnal factor for the Manitoba Capital Region (Hurtubise, 2000).

6.2.2 PMPVOT Matrix

In this research, the PMPVOT matrix was estimated using the matrix adjustment algorithm. The estimated link counts matched the observed link counts well. However, satisfactory trip generation equations for the PMPVOT matrix could not be developed using independent variables from NCHRP (number of households and employment by different industries) or the Winnipeg Transportation Model (employment by different industries). This means that there are two possibilities: (1) the PMPVOT matrix developed by the matrix adjustment algorithm is wrong and the trip generation characteristics of PMPVOT can be explained using the independent variables from NCHRP or the Winnipeg Transportation Model; or (2) the PMPVOT matrix developed by the matrix adjustment algorithm is correct and the trip generation characteristics cannot be explained by the independent variables examined. There are no data to validate the PMPVOT matrix developed in this research. At this time, there is very little understanding of the traffic generation and trip distribution characteristics of PMPVOT in the region. In order to develop better PMPVOT trip generation and trip distribution equations, there is a need for additional data in this area.

6.2.3 Trip Generation Component

This research developed trip production and attraction equations for ADWT. There are strong correlations between the dependent variables with the independent variables for the equations produced. This research also attempted to develop trip production and attraction equations for the PMPVOT. However no satisfactory equations were produced. The use of category analysis to develop trip generation equations for the PMPVOT should be investigated.

6.2.4 Trip Distribution Component

This research developed trip distribution equations for PMPADWT and PMPVOT. However, since the PMPVOT matrix developed in this research has not been validated, the validity of the PMPVOT trip distribution equation (which was developed using the PMPVOT matrix) is also uncertain.

6.2.5 Trip Assignment Component

The traffic assignment component used the BPR default parameters for link performance functions. Detailed research would have to be performed in order to determine the link performance functions which should be used for the different links in the MCRTAN.

6.2.6 Refinement of Centroid Connectors

The centroid connectors in MCRTAN were developed based on the three guidelines discussed in Section 4.3. Investigations should be made on the impact of different centroid connector construction on the model calibration results.

6.2.7 Zone System Improvement

The Winnipeg Regional Traffic Zone system is outdated and do not adequately represent the traffic generation characteristics in the Capital Region. Further work should be done to investigate and develop a new zone system for model development.

ADDENDUM

Three attribution errors were found in the MCRTAN on December 18, 2000. Corrections were made to the network and incorporated in the file MCRTNv4.dbd. Certain analysis and calibration results presented in this thesis do not reflect the corrections made to the network on December 18, 2000.

REFERENCES

Ben Akiva, M.E., and Bierlaire, M. (1999) "Discrete Choice Methods and Their Applications to Short Term Travel Decisions", *Handbook of Transportation Science*, Kluwer Academic Publishers, London, United Kingdom.

Bhat, C., Govindarajan, A., and Pulugurtha, V. (1998) "Disaggregate Attraction-End Choice Modeling: Formulation and Empirical Analysis", *Transportation Research Record 1645*, National Academy of Sciences, Washington, D.C., USA.

Brunton, P.J., and Richardson, A.J. (1998) *A Cautionary Note on Zonal Aggregation and Accessibility*, 77th Annual Meeting of the Transportation Research Board, Washington, D.C., USA.

Bureau of Public Roads (1964) *Traffic Assignment Manual*, U.S. Department of Commerce, Urban Planning Division, Washington D.C., USA.

Caliper Corporation (1998) *Travel Demand Modeling With TransCAD 3.1*, Caliper Corporation, Newton, Massachusetts, USA.

Capital Region Review (1999) *Final Report of the Capital Region Review Panel*, Capital Region Review, Winnipeg, Manitoba, Canada.

Clayton, A., Montufar J., Han K., Tan. E., and Lew K. (1999) *Advances in Estimating Truck Traffic*, Presentation at Manitoba Department of Highways and Government Services Pavement Design Workshop, Winnipeg, Manitoba, Canada.

Clayton, A. (1997) *Transportation Engineering I*, Class Notes, University of Manitoba, Winnipeg, Manitoba, Canada.

Daganzo, C.F., (1982) Goodness-of-fit Measures and the Predictive Power of Discrete Choice Models, *Transportation Research Record 874*, National Academy of Sciences, Washington D.C., USA.

Dalton, P. (1999), *GTA Simplified Model Version 3.0 User Manual*, Data Management Group, University of Toronto, Toronto, Ontario, Canada.

Dalton, P. (1999), *GTA P.M. Peak Model User Manual*, Working Draft, Toronto, Ontario, Canada.

Federal Highway Administration (2000) *United States Code 23*, <http://www.fhwa.dot.gov/environment/135.htm>

Federal Highway Administration (1994) *Federal-Aid Policy Guide*, <http://www.fhwa.dot.gov/legregs/directives/fapg/cfr0450a.htm>

Greater Vancouver Regional District (1997), *PM Peak Hour Transportation Model*, Vancouver, British Columbia, Canada.

Han, K. (2000) *Development of an Integrated Geographic Information System Platform for Transportation Applications*, MSc. Thesis Draft, University of Manitoba, Winnipeg, Manitoba, Canada.

Heywood, I., Cornelius S. and Carver S. (1998) *Introduction to Geographic Information Systems*, Longman, Massachusetts, U.S.A.

Hurl, Doug. (2000) *Conversations and Progress Meetings with UMTIG for the Development of the Manitoba Capital Region Transportation Planning Model*, Winnipeg, Manitoba, Canada.

Hunt, J.D., Brownlee A.T. and Doblanko L.P. (1998) *Design and Calibration of the Edmonton Transport Analysis Model*, Transportation Research Board Annual Meeting, Washington D.C., U.S.A.

Hurtubise, Paula (2000), *Conversation during Census Place of Work Seminar*, Mississauga, Ontario, Canada.

Klassen, K. (1999) *Private Choices, Public Costs: Enhancing Equity and Sustainability in the Winnipeg Capital Region*, <http://www.susdev.gov.mb.ca/capreg/klassen.html>

Lew, K., K. Han, J. Montufar, J. Drury, E. Tan, A. Clayton (1999) *Development of a Road Network Management System for Rural Municipalities*, Technical Report, University of Manitoba Transport Information Group, Winnipeg, Manitoba, Canada.

Manheim, M.L. (1984) *Fundamentals of Transportation Systems Analysis*, Volume 1, The MIT Press, Cambridge, Massachusetts, USA.

Mekky, A. (1995) *The Use and Misuse of Simplified Approaches in Travel Forecasting*, Transportation Association of Canada Annual Conference, Victoria, B.C., Canada.

Mekky, A. (2000) *Analytical Transportation Planning*, Second Edition, University of Toronto Short Course Notes, Toronto, Ontario, Canada.

Miller, E.K. (1999), *GTAMODEL Version 1.1*, Presentation Slides, University of Toronto, Toronto, Ontario, Canada.

Montufar, J (1998) *Urban and Regional Transportation Planning*, Lectures, University of Manitoba, Winnipeg, Canada.

National Cooperative Highway Research Program (1998) *Travel Estimation Techniques for Urban Planning*, NCHRP Report 365, Transportation Research Board, Washington, D.C., USA.

ND-Lea Associates (2000) *Evaluation of Alternative Roadway Networks Connecting Provencher Bridge and Main Street*, Winnipeg, Manitoba, Canada.

Nielsen, O.A. (1993) *A New Method for Estimating Trip Matrices from Traffic Counts*, Institute of Roads, Traffic, and Town Planning, The Technical University of Denmark, Paper 1993-3, Denmark.

Oppenheim, N. (1995) *Urban Travel Demand Modeling*, John Wiley & Sons, Toronto, Ontario, Canada.

Ortuzar, J.D. and Willumsen L.G. (1994) *Modeling Transport*, Second Edition, John Wiley & Sons, Toronto, Ontario, Canada.

Region of Peel (1996) *Region of Peel Travel Demand Forecasting Model*, Region of Peel, Ontario, Canada.

Sherlock (1999) *Sherlock's Map of Winnipeg and Surrounding Areas*, Sherlock Publishing Limited, Winnipeg, Manitoba, Canada.

Statistics Canada (1996) *Custom Geocoded Data for the Manitoba Capital Region Review Panel*, Winnipeg, Manitoba, Canada.

TransPlan 2010 Steering Comitee (1998) *Winnipeg TransPlan 2010*, Winnipeg, Manitoba, Canada.

University of Manitoba Transport Information Group (2000) *Traffic on Manitoba Highways 1999*, Winnipeg, Manitoba, Canada.

University of Manitoba Transport Information Group (1998) *City of Winnipeg Traffic Information System Development Phase 2*, Winnipeg, Manitoba, Canada.

Vaughan Engineering Associates Ltd. and Delcan Corporation (1998) *GoPlan Traffic Model Investigation Final Report*, Halifax, Nova Scotia, Canada.

Winnipeg, (1996) *Transportation Planning Model Improvements Study Modal Split Model*, Winnipeg, Manitoba, Canada.

Winnipeg, (1992a) *Transportation Planning Modeling Procedure*, Winnipeg, Manitoba, Canada.

Winnipeg, (1992b) *Computer Files for 1992 Calibration Working Notes*, Winnipeg, Manitoba, Canada.

APPENDIX

Appendix A

List of Cartographic, Spatial Layer, and Database Files used in the Thesis

Cartographic Files

Figure	Software	Filename	Location
Figure 1	ArcView	Fig1.wmf	//pc-trans2/d:\users\kean\capitalregionpaper\
Figure 2	TransCad	charleswood&NEextension.map	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
Figure 4	TransCad	chrleswood.map	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
Figure 5	TransCad	Zone.lay	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
Figure 8	TransCad	winniperzones.map	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
Figure 9	TransCad	Basenetwork.map	//pc-trans2/d:\users\kean\thesis2\gis\dtmodel\
Figure 11	TransCad	Centroidexamples2.map	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
Figure 12	TransCad	Topology.map	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
Figure 13	TransCad	Centroidexample1.map	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
Figure 14	TransCad	Area.map	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
Figure 15	TransCad	Network.map	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
Figure 16	TransCad	Ramp.map	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
Figure 17	TransCad	Oneway.map	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
Figure 18	TransCad	Centroidconnector.map	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
Figure 19	TransCad	Pcs.map	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
Figure 20	TransCad	Countvol.lay	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
Figure 25	TransCad	Keylinks.map	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\

Spatial layer Files

Spatial Layer	Software	Filename	Location
MCRTAN	TransCAD	MCRTNv4.dbd	//pctrans2/d:\users\kean\thesis2\gis\wpg5\
MCRTAN network file	TransCAD	Net1.net	//pctrans2/d:\users\kean\thesis2\gis\wpg5\
Winnipeg Regional Traffic Zone System	TransCAD	WPGMB83.dbd	//pctrans2/d:\users\kean\thesis2\gis\wpg5\
Winnipeg Regional Traffic Zone System Centroids	TransCAD	WPGMB83c.dbd	//pctrans2/d:\users\kean\thesis2\gis\wpg5\
Manitoba Highways Traffic Counters	TransCAD	MBSTN00.dbd	//pctrans2/d:\users\kean\thesis2\gis\wpg5\

Database Files

Database	Software	Filename	Location
ADWT matrix and PMPADWT	TransCAD	VD_POW_POR1996.mtx	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
Turn Restriction	TransCAD	Turnrest1.dbf	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
Trip generation spreadsheet	Excel	Workingcopy3.xls	//pc-trans2/d:\users\kean\thesis2\data\ newtripgeneration\
ADWT trip production	JMP	Worktrip_production1.jmp	//pc-trans2/d:\users\kean\thesis2\data\ newtripgeneration\
ADWT trip attraction	JMP	Workingcopy3.jmp	//pc-trans2/d:\users\kean\thesis2\data\ newtripgeneration\
PMPVOT trip production	JMP	Othertrip_production2.jmp	//pc-trans2/d:\users\kean\thesis2\data\ newtripgeneration\
PMPVOT trip attraction	JMP	Othertrip_attraction2.jmp	//pc-trans2/d:\users\kean\thesis2\data\ newtripgeneration\
PMPVTT (10 iterations)	TransCAD	EstimatedPMpeaktotal.mtx	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
PMPVTT (40 iterations)	TransCAD	EstimatedPMpeaktotal2.mtx	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
PMPVTT (100 iterations)	TransCAD	EstimatedPMpeaktotal3.mtx	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
PMPVTT (200 iterations)	TransCAD	EstimatedPMpeaktotal4.mtx	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
PMPVTT link volumes (10 iterations)	TransCAD	EstimatedPMpeaktotal.bin	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
PMPVTT link volumes (40 iterations)	TransCAD	EstimatedPMpeaktotal2.bin	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
PMPVTT link volumes (100 iterations)	TransCAD	EstimatedPMpeaktotal3.bin	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
PMPVTT link volumes (200 iterations)	TransCAD	EstimatedPMpeaktotal4.bin	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\

PMPVOTT (10 iterations)	TransCAD	OthertripsPMpeak. Mtx	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
PMPVOTT (40 iterations)	TransCAD	OthertripsPMpeak2.mtx	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
PMPVOTT (100 iterations)	TransCAD	OthertripsPMpeak3.mtx	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
PMPVOTT (200 iterations)	TransCAD	OthertripsPMpeak4.mtx	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
PMPVOTT (200 iterations, negative cells rounded to zero)	TransCAD	othertripsPMpeak4_fixed.mtx	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\
Impedance Matrix (c_{ij})	TransCAD	inittime_impedance1.mtx	//pc-trans2/d:\users\kean\thesis2\gis\wpg5\

Appendix B

Sample of the MCRTAN in Tabular Form

Appendix C

MCRTAN Turn Restriction File in Tabular Form

FROM ID	TO ID	PENALTY
11208	11615	
10348	11586	
11210	11608	
10347	11582	
11614	10427	
11609	10428	
11587	11208	
10347	11587	
623	7806	
623	623	
11222	11660	
11184	11668	
11188	11539	
11251	11570	
11540	11222	
11540	11567	
11661	11184	
11661	11540	
11667	11251	
11667	11661	
11567	11186	
11567	11667	
11252	11636	
11345	11645	
11254	11618	
11347	11644	
11254	11635	
11643	11635	
11619	11345	
11619	11643	
11646	11252	
11646	11619	
11635	11347	
11635	11646	
11363	11649	
11246	11620	
11365	11648	
11244	11638	
11647	11246	
11647	11637	
11637	11365	
11637	11650	
11650	11244	
11650	11621	
11621	11363	
11621	11647	
11245	11245	
11364	11364	
11253	11253	
11346	11346	
11374	11653	
11249	11622	
11376	11652	
11247	11640	
11375	11375	
11248	11248	
11654	11247	
11654	11623	
11623	11374	
11623	11651	
11651	11249	
11651	11639	
11639	11376	
11639	11654	
11549	11551	
11616	11550	
11551	11250	
11550	11250	
11550	11549	
11617	11307	
11617	11642	
11257	11255	
11657	11218	
11543	7245	
7255	11565	
11564	11219	
11564	11669	
11670	7254	
7246	11657	
11220	11541	
7244	11566	
11602	7240	
11602	11563	
11563	11604	
11604	7240	
11604	11603	
11603	11602	
10348	11581	
11587	11609	
11581	11210	
11581	11614	
11212	11674	
11212	11613	
11544	11214	
11214	11658	
11655	11214	
11655	11569	
11568	11243	
11568	11672	
11672	11213	
11672	11659	
11659	11213	

FROM ID	TO ID	PENALTY
11659	11545	
10813	11596	
11215	11629	
10814	11591	
11234	11611	
11610	10814	
11610	11597	
11597	11234	
11597	11630	
11630	10813	
11630	11590	
11590	11215	
11590	11610	
11629	10813	
11596	11234	
11611	10814	
11591	11215	
11600	11233	
11233	11631	
11601	11233	
11601	11625	
11598	11626	
11626	10873	
10976	11598	
11599	11632	
11632	10977	
10972	11599	
11644	11254	
11618	11345	
11645	11252	
11638	11347	
11345	11643	
11643	11254	
11347	11646	
11252	11619	
11246	11637	
11365	11650	
11244	11621	
11363	11647	
11620	11363	
11649	11244	
11638	11365	
11648	11248	
11249	11639	
11376	11654	
11247	11623	
11374	11651	
11653	11247	
11640	11376	
11652	11249	
11622	11374	
11551	11616	
11250	11549	
11671	7254	
11566	11219	
11307	11642	
11570	11186	
11668	11251	
11660	11184	
11539	11222	
11186	11667	
11251	11661	
11184	11540	
11222	11567	
11219	11669	
11542	7248	
7240	11563	
11582	11210	
11608	10346	
11586	11208	
11615	10347	
11210	11614	
11208	11609	
11674	11212	
11674	11613	
11675	11212	
11212	11612	
11675	11612	
11612	11674	
11613	11675	
11571	11243	
11243	11672	
11213	11659	
11213	11545	
11214	11569	
11659	11240	
11544	11658	
10813	11590	
11215	11610	
10814	11597	
11234	11630	
11625	11600	
11631	11601	
11233	11625	
11600	11631	
11627	11626	
11633	11632	
11532	7252	
11532	11559	
7252	11559	
11559	11533	
11533	7252	

FROM ID	TO ID	PENALTY
7252	11581	
11533	11581	
11562	2959	
11562	11532	
11560	2959	
11548	3699	
11548	11664	
3699	11664	
11547	3699	
11547	11665	
3699	11665	
11663	50	
13831	13829	
7084	10810	
11582	13833	
10808	11592	
11530	10809	
10808	11595	
11595	2477	
2475	11530	
11594	2475	
2475	11531	
11594	11531	
11531	11417	
11553	10413	
11585	11553	
11580	11554	
11554	10415	
10415	11580	
11554	11565	
10415	11585	
11558	4022	
4022	4022	
4022	4159	
11558	4159	
11555	4022	
11555	11536	
4022	11536	
11537	7058	
11538	7058	
11536	11557	
11588	11187	
11588	11606	
11187	11606	
11589	11187	
11187	11605	
11589	11605	
11529	10418	
10418	11584	
11529	11584	
10418	11579	
10419	11583	
10419	11578	
1509	1507	
617	7807	
635	9746	
636	9747	
984	10821	
987	12628	
1884	9961	
1890	13022	
2267	5240	
2479	9545	
2887	10689	
3685	7777	
3890	9705	
4298	1397	
4558	547	
4782	5244	
5247	4178	
6749	37	
7775	8125	
7776	8124	
8853	5001	
8851	11495	
8111	308	
8124	309	
8124	3694	
8115	5245	
8126	6058	
8153	6063	
8125	7776	
8108	8445	
8120	10854	
8161	11802	
8131	12849	
8153	14047	
8132	14048	
8424	570	
8419	571	
9057	10688	
9370	11491	
9383	4985	
9424	14849	
9529	4603	
9544	11417	
9662	10594	
9960	9291	
9961	1873	
10414	15806	
10363	9830	
10577	6803	

FROM ID	TO ID	PENALTY
10842	647	
10843	646	
10834	1893	
10691	2267	
10830	15754	
10693	3735	
10761	3801	
10758	4598	
10695	4952	
10691	5641	
10854	8118	
10737	9249	
10695	9693	
10800	13588	
10801	13588	
10795	12952	
10831	13031	
10832	13030	
10693	13225	
10820	13374	
10689	14562	
10851	14732	
11173	14128	
11802	8162	
12545	3942	
13215	7819	
13859	3058	
13852	3070	
13398	4980	
13865	14225	
14067	12090	
14499	4840	
1397	13763	
1873	9961	
4783	10696	
8058	8126	
8125	5990	
10689	2867	
10692	3735	
14062	12090	
2501	14874	
2501	14854	
3735	5241	
3735	5242	
3738	10692	
3738	10693	
3742	11957	
3750	13947	
4021	4561	
4952	5243	
4952	5244	
5240	5645	
5644	5241	
5913	6614	
6061	14055	
8106	15280	
8107	15280	
9055	13641	
9954	3107	
9964	9291	
9928	767	
9948	11862	
9927	13946	
9962	15654	
10373	14503	
13454	6292	
13008	9710	
13222	5242	
13222	5243	
13848	9423	
3693	14175	
14507	4059	
14506	13080	
14509	13080	
557	3636	
14854	2501	

Appendix D

Sample of the Winnipeg Regional Traffic Zone System in Tabular Form

ID	AREA	CENTROID	ZONE	SUPERZON	CEN END	NAME	TYPE	INTRA SE	INTRA TIME	ID 2
288	535584.81	288	9580	122	10528	N MB	Large	80	274.43	288
283	11936.68	283	9510	117	10526	SE MB (inc. Steinbach)	Large	80	14.25	283
282	4544.38	282	9500	116	10527	NE of the City (inc. Beasejour,	Large	80	25.28	282
268	857.39	268	9020	102	10513	St Clements (inc. parts of Broke	RM	80	10.98	268
280	812.03	280	9140	114	10512	St. Andrews	RM	80	10.69	280
289	7057.98	289	9570	123	10529	N of Cap Region (inc. Gimli and	Large	80	31.50	289
277	1202.18	277	9110	111	10511	Rockwood	RM	80	13.00	277
276	441.35	276	9100	110	10509	Rosser	RM	80	7.88	276
275	207.38	275	9090	109	10508	St. Francois Xavier	RM	80	5.40	275
287	60728.82	287	9550	121	10521	W and SW MB	Large	80	92.41	287
284	3537.91	284	9520	118	10525	S MB (inc. Niverville)	Large	80	22.31	284
270	560.82	270	9040	104	10516	Tache	RM	80	9.04	270
269	1099.79	269	9030	103	10515	Springfield	RM	80	12.44	269
267	42.82	267	9010	101	10520	East Saint Paul	RM	80	2.45	267
281	26.57	281	9150	115	10514	Selkirk	Town	80	1.93	281
279	88.34	279	9130	113	10524	West Saint Paul	RM	80	3.52	279
231	9.23	231	7810	29	10655		WPGZONE	40	2.28	231
230	2.88	230	7803	29	10752		WPGZONE	40	1.23	230
228	1.55	228	7601	29	10731		WPGZONE	40	0.93	228
226	5.96	226	7500	28	10654		WPGZONE	40	1.83	226
200	8.00	200	6720	25	10717		WPGZONE	40	2.12	200
273	108.27	273	9070	107	10519	Headingley	RM	80	3.90	273
274	556.59	274	9080	108	10518	Cartier	RM	80	8.85	274
288	13029.12	288	9540	120	10523	S MB (inc. Carman)	Large	80	42.80	288
285	2532.17	285	9530	119	10522	S MB (inc. Morris)	Large	80	18.87	285
265	5.42	265	8600	32	10657		WPGZONE	40	1.75	265
266	9.51	266	8610	32	10656		WPGZONE	40	2.31	266
271	342.06	271	9050	105	10517	Richot	RM	80	6.94	271
105	38.19	105	3800	11	10544		WPGZONE	40	4.51	105
104	11.51	104	3720	9	10551		WPGZONE	40	2.54	104
99	3.69	99	3702	9	10552		WPGZONE	40	1.44	99
83	8.65	83	2402	8	10554		WPGZONE	40	2.21	83
77	5.67	77	2710	6	10555		WPGZONE	40	1.79	77
69	4.09	69	2800	6	10556		WPGZONE	40	1.52	69
75	3.58	75	2704	6	10557		WPGZONE	40	1.42	75
76	1.90	76	2705	6	10558		WPGZONE	40	1.05	76
73	2.09	73	2702	6	10744		WPGZONE	40	1.08	73
66	6.20	66	2503	5	10660		WPGZONE	40	1.87	66
55	2.49	55	1530	2	10659		WPGZONE	40	1.18	55
56	2.24	56	1800	32	10658		WPGZONE	40	1.12	56
148	14.83	148	4910	17	10533		WPGZONE	40	2.89	148
145	8.16	145	4903	17	10530		WPGZONE	40	2.14	145
102	3.89	102	3713	11	10547		WPGZONE	40	1.48	102
103	2.18	103	3714	11	10545		WPGZONE	40	1.10	103
101	1.47	101	3712	11	10546		WPGZONE	40	0.91	101
93	1.87	93	3502	11	10585		WPGZONE	40	0.97	93
92	0.75	92	3501	11	10583		WPGZONE	40	0.65	92
98	4.23	98	3701	9	10585		WPGZONE	40	1.54	98
85	2.59	85	3402	9	10584		WPGZONE	40	1.21	85
86	1.37	86	3403	9	10553		WPGZONE	40	0.88	86
84	2.57	84	3401	9	10596		WPGZONE	40	1.20	84
81	2.11	81	3300	8	10597		WPGZONE	40	1.09	81
62	1.73	62	2401	8	10625		WPGZONE	40	0.99	62
70	0.74	70	2611	6	10628		WPGZONE	40	0.64	70
71	1.77	71	2612	6	10561		WPGZONE	40	1.00	71
68	0.95	68	2512	5	10563		WPGZONE	40	0.73	68
72	1.52	72	2701	6	10560		WPGZONE	40	0.93	72
74	2.40	74	2703	6	10559		WPGZONE	40	1.16	74
65	1.25	65	2502	5	10743		WPGZONE	40	0.84	65
64	2.86	64	2501	5	10562		WPGZONE	40	1.27	64
48	1.12	48	1432	4	10683		WPGZONE	40	0.79	48
53	1.79	53	1521	2	10681		WPGZONE	40	1.00	53
54	1.85	54	1522	2	10662		WPGZONE	40	0.96	54
199	5.70	199	6710	25	10714		WPGZONE	40	1.79	199
206	4.11	206	6910	25	10710		WPGZONE	40	1.52	206
168	1.68	168	5911	21	10678		WPGZONE	40	0.97	168
169	1.53	169	5912	21	10677		WPGZONE	40	0.93	169
170	5.00	170	5920	21	10595		WPGZONE	40	1.68	170
272	1152.86	272	9060	106	10505	MacDonald	RM	80	12.73	272
262	1.29	262	8526	34	10759		WPGZONE	40	0.85	262
261	1.77	261	8525	34	10762		WPGZONE	40	1.00	261
260	1.40	260	8524	34	10755		WPGZONE	40	0.89	260
244	0.71	244	8402	35	10754		WPGZONE	40	0.63	244
229	1.37	229	7602	29	10753		WPGZONE	40	0.88	229
224	0.81	224	7412	29	10751		WPGZONE	40	0.68	224
225	0.93	225	7413	29	10732		WPGZONE	40	0.72	225
221	1.22	221	7402	28	10733		WPGZONE	40	0.83	221
220	0.83	220	7401	28	10709		WPGZONE	40	0.68	220
222	0.99	222	7403	28	10653		WPGZONE	40	0.75	222
189	1.39	189	6502	24	10730		WPGZONE	40	0.88	189
227	4.73	227	7510	28	10715		WPGZONE	40	1.63	227
194	1.87	194	6622	24	10716		WPGZONE	40	1.03	194
195	1.84	195	6701	25	10722		WPGZONE	40	0.96	195
142	6.32	142	4810	16	10537		WPGZONE	40	1.89	142
139	6.57	139	4720	16	10538		WPGZONE	40	1.92	139
140	1.75	140	4801	16	10540		WPGZONE	40	0.99	140
141	1.90	141	4802	16	10541		WPGZONE	40	1.03	141
144	2.48	144	4902	17	10536		WPGZONE	40	1.18	144
198	1.08	198	6704	25	10720		WPGZONE	40	0.78	198
205	1.19	205	6902	25	10718		WPGZONE	40	0.82	205
204	1.68	204	6901	25	10711		WPGZONE	40	0.97	204
202	1.23	202	6802	25	10712		WPGZONE	40	0.83	202
165	2.21	165	5801	21	10679		WPGZONE	40	1.11	165
166	3.56	166	5802	21	10680		WPGZONE	40	1.42	166
167	10.05	167	5900	21	10676		WPGZONE	40	2.38	167
50	0.78	50	1512	32	10747		WPGZONE	40	0.66	50
52	0.76	52	1514	32	10750		WPGZONE	40	0.65	52
51	0.89	51	1513	32	10749		WPGZONE	40	0.71	51
67	0.55	67	2511	5	10626		WPGZONE	40	0.55	67
100	1.61	100	3711	11	10548		WPGZONE	40	0.95	100
143	2.30	143	4901	17	10535		WPGZONE	40	1.14	143
95	2.85	95	3512	11	10578		WPGZONE	40	1.27	95

Appendix E

Links in the MCRTAN which contains Traffic Counts used for the Matrix Adjustment

Algorithm

Appendix F

Trip Production Equations for ADWT

Response: ADWT_produced

Summary of Fit

RSquare	?
RSquare Adj	?
Root Mean Square Error	333.3834
Mean of Response	1037.068
Observations (or Sum Wgts)	278

Lack of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack of Fit	213	30322261	142358	19.6031
Pure Error	64	464770	7262	Prob>F
Total Error	277	30787031		0.0000
			Max RSq	0.9998

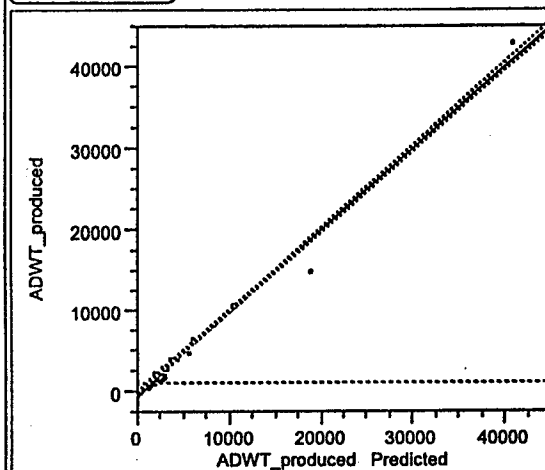
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob> t
Intercept	Zeroed	0	0	?	?
Tot_Emp		0.7261619	0.00476	152.56	0.0000

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
Tot_Emp	1	1	2586797994	23274.18	0.0000

Whole-Model Test

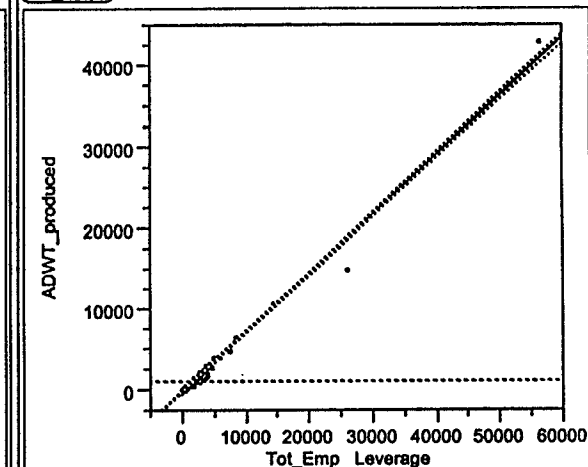


Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2586797994	2.5868e9	23274.18
Error	277	30787031	111144.5	Prob>F
C Total	278	2617585025		0.0000

Tested against reduced model: Y=0

Tot Emp



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
2586797994	23274.18	1	0.0000

response: ADWT_produced

Summary of Fit

RSquare	?
RSquare Adj	?
Root Mean Square Error	43.0904
Mean of Response	1037.068
Observations (or Sum Wgts)	278

Lack of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack of Fit	271	504844.89	1862.90	9.3145
Pure Error	1	200.00	200.00	Prob>F
Total Error	272	505044.89		0.2566
			Max RSq	1.0000

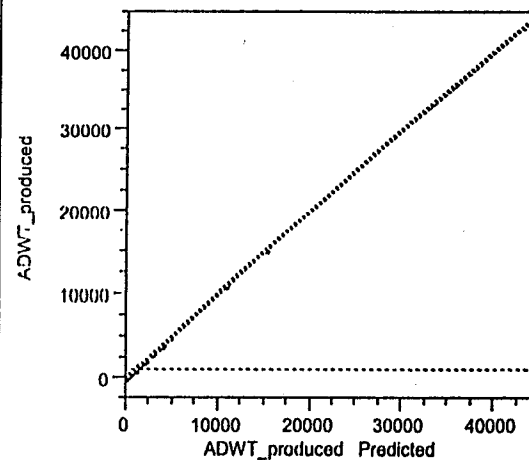
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob> t
Intercept	Zeroed	0	0	?	?
Prime		1.0862974	0.022448	48.39	0.0000
Manu		0.969534	0.006958	139.35	0.0000
Wholesale		0.993017	0.017128	57.98	0.0000
Finance		0.9654391	0.021156	45.64	0.0000
Government		0.9819683	0.007043	139.43	0.0000
Accomodation		1.0970909	0.030174	36.36	0.0000

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
Prime	1	1	4348259	2341.824	0.0000
Manu	1	1	36054763	19417.87	0.0000
Wholesale	1	1	6241388	3361.399	0.0000
Finance	1	1	3866886	2082.573	0.0000
Government	1	1	36096352	19440.27	0.0000
Accomodation	1	1	2454633	1321.982	0.0000

Whole-Model Test

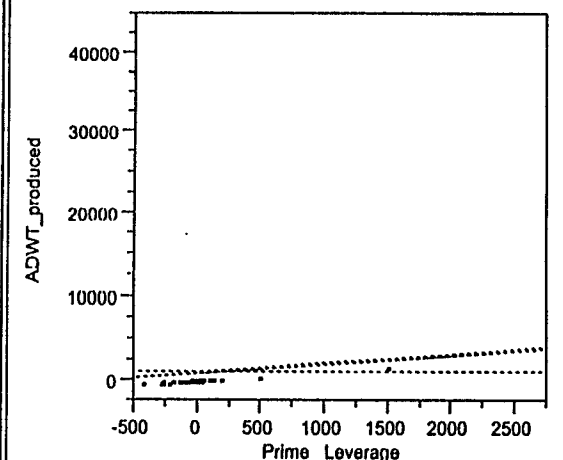


Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	6	2617079980	4.3618e8	234911.7
Error	272	505044.889	1856.783	Prob>F
C Total	278	2617585025		0.0000

Tested against reduced model: Y=0

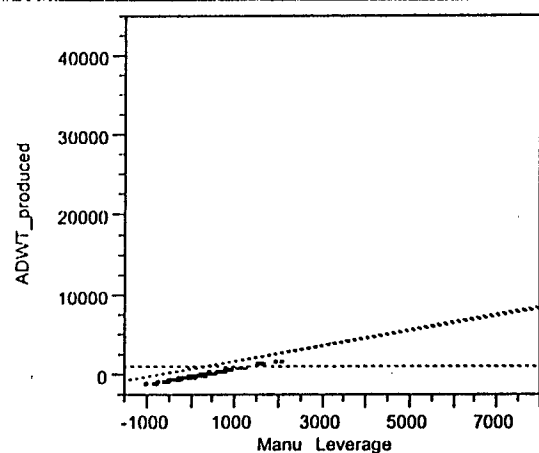
Prime



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
4348259.1	2341.824	1	0.0000

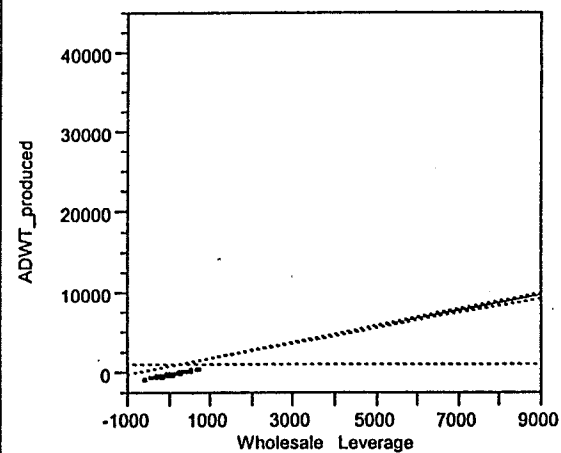
Manu



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
36054763	19417.87	1	0.0000

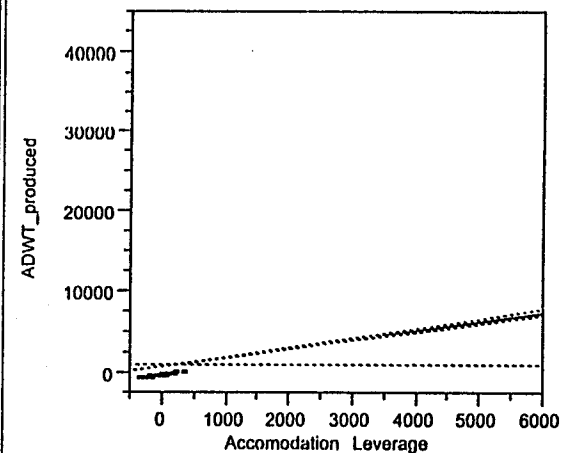
Wholesale



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
6241388.1	3361.399	1	0.0000

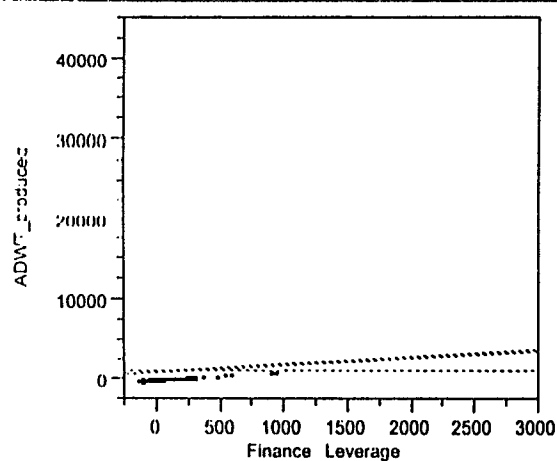
Accomodation



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
2454632.7	1321.982	1	0.0000

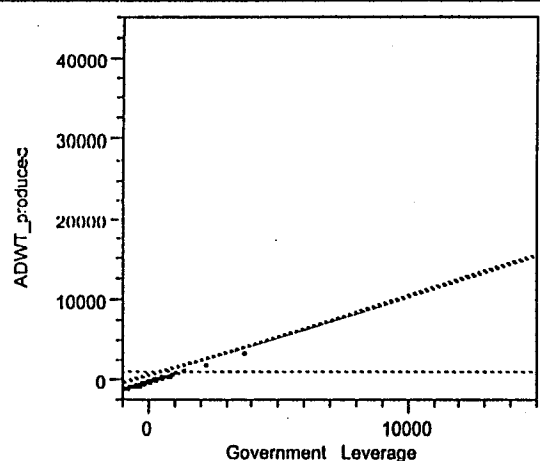
Finance



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
3866880.4	2082.573	1	0.0000

Government



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
38080352	10440.27	1	0.0000

Appendix G

Trip Attraction Equations for ADWT

Response: ADWT_Attracted

Summary of Fit

RSquare	?
RSquare Adj	?
Root Mean Square Error	476.3326
Mean of Response	1139.545
Observations (or Sum Wgts)	253

Lack of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack of Fit	229	56796379	248019	14.9883
Pure Error	23	380592	16547	Prob>F
Total Error	252	57176971		0.0000
			Max RSq	0.9999

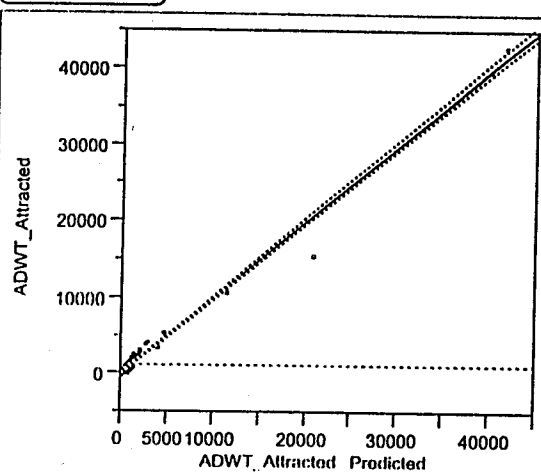
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob> t
Intercept	Zeroed	0	0	?	?
Population		0.2385235	0.002243	106.33	0.0000

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
Population	1	1	2565158404	11305.6	0.0000

Whole-Model Test

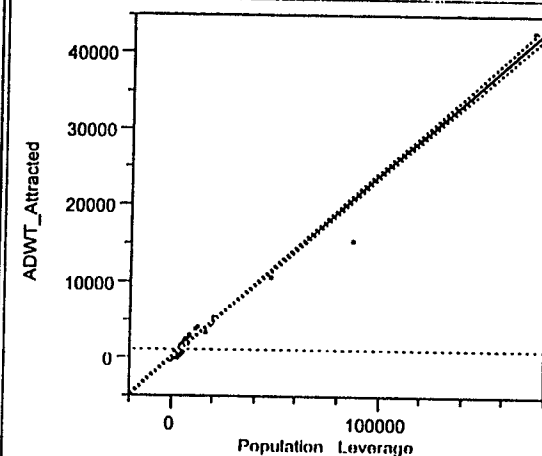


Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2565158404	2.5652e9	11305.6
Error	252	57176970.9	226892.7	Prob>F
C Total	253	2622335375		0.0000

Tested against reduced model: Y=0

Population



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
2565158404	11305.6	1	0.0000

response: ADWT_Attracted

Summary of Fit

RSquare	?
RSquare Adj	?
Root Mean Square Error	433.0005
Mean of Response	1139.545
Observations (or Sum Wgts)	253

Lack of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack of Fit	204	43651161	213976	2.8561
Pure Error	48	3596167	74920	Prob>F
Total Error	252	47247328		0.0000
			Max RSq	0.9986

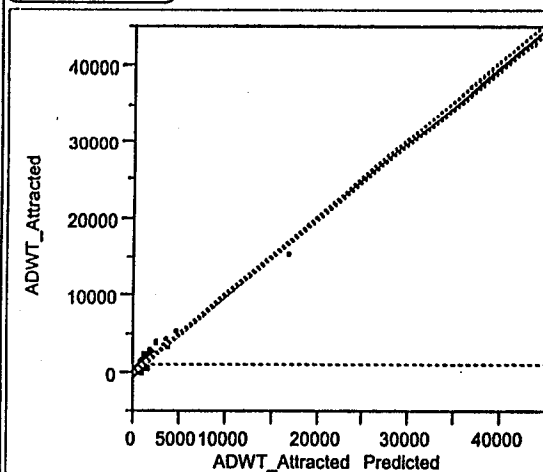
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob> t
Intercept	Zeroed	0	0	?	?
Household_Total		0.6396847	0.005458	117.19	0.0000

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
Household_Total	1	1	2575088047	13734.58	0.0000

Whole-Model Test

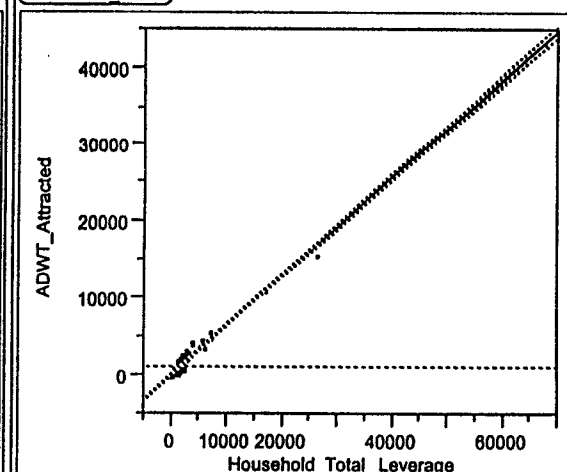


Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2575088047	2.5751e9	13734.58
Error	252	47247328.1	187489.4	Prob>F
C Total	253	2622335375		0.0000

Tested against reduced model: Y=0

Household_Total



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
2575088047	13734.58	1	0.0000

Response: ADWT_Attracted

Summary of Fit

RSquare	?
RSquare Adj	?
Root Mean Square Error	232.0723
Mean of Response	1139.545
Observations (or Sum Wgts)	253

Lack of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack of Fit	214	13107569	61250.3	5.0104
Pure Error	38	464537	12224.7	Prob>F
Total Error	252	13572107		0.0000
			Max RSq	0.9998

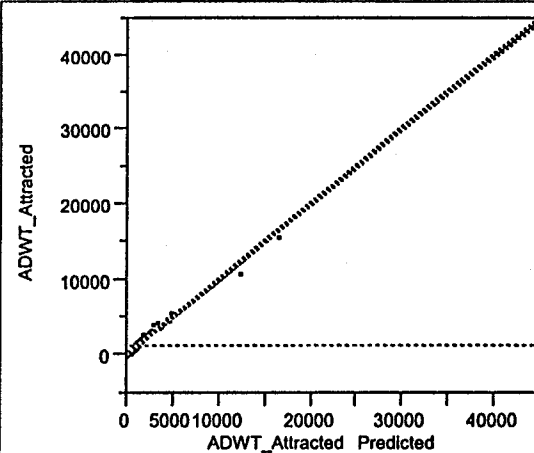
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob> t
Intercept	Zeroed	0	0	?	?
ELF_Total		0.5251741	0.002386	220.09	0.0000

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
ELF_Total	1	1	2608763268	48438.19	0.0000

Whole-Model Test

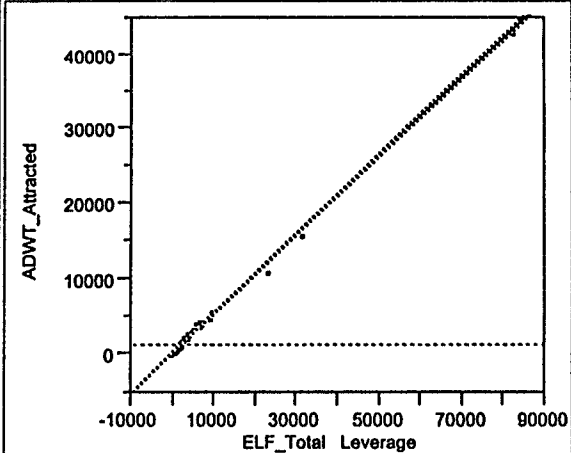


Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2608763268	2.6088e9	48438.19
Error	252	13572106.7	53857.57	Prob>F
C Total	253	2622335375		0.0000

Tested against reduced model: Y=0

ELF_Total



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
2608763268	48438.19	1	0.0000

Response: ADWT_Attracted

Summary of Fit

RSquare	?
RSquare Adj	?
Root Mean Square Error	170.2196
Mean of Response	1139.545
Observations (or Sum Wgts)	253

Lack of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack of Fit	246	7185664.6	29210.0	876.3006
Pure Error	2	66.7	33.3	Prob>F
Total Error	248	7185731.3		0.0011
			Max RSq	1.0000

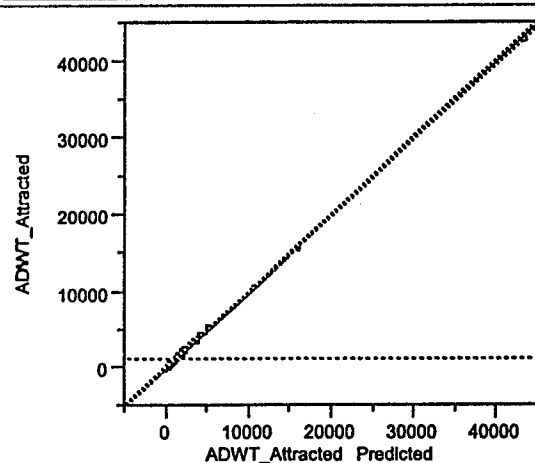
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob> t
Intercept	Zeroed	0	0	?	?
1_person		-0.166719	0.06643	-2.51	0.0127
2_persons		0.716254	0.082801	8.65	0.0000
3_persons		-0.58734	0.231936	-2.53	0.0119
4_persons		4.2659607	0.202689	21.05	0.0000
5_persons+		-0.88073	0.076249	-11.55	0.0000

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
1_person	1	1	182500	6.2986	0.0127
2_persons	1	1	2168098	74.8272	0.0000
3_persons	1	1	185807	6.4127	0.0119
4_persons	1	1	12834927	442.9698	0.0000
5_persons+	1	1	3865820	133.4204	0.0000

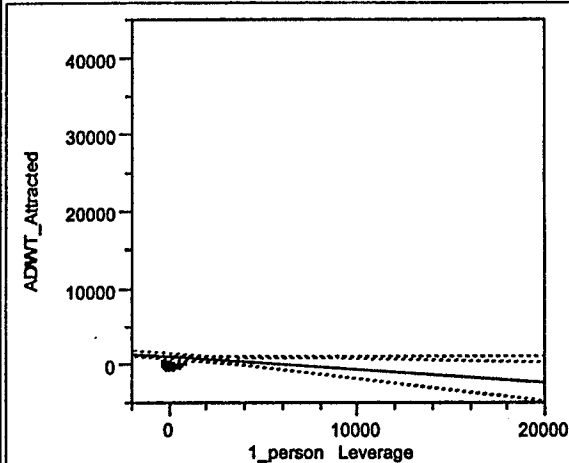
Whole-Model Test



Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	5	2615149644	5.2303e8	18051.25
Error	248	7185731.3	28974.72	Prob>F
C Total	253	2622335375		0.0000
Tested against reduced model: Y=0				

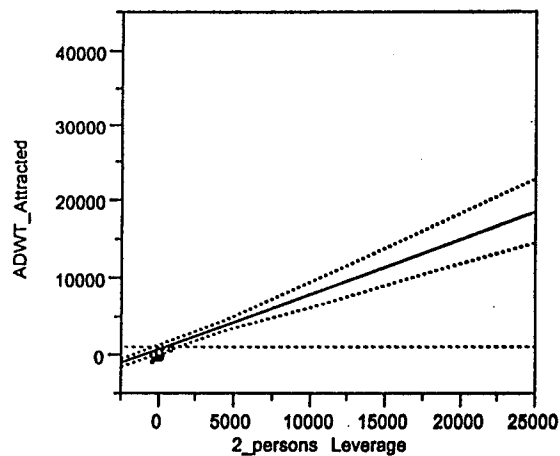
1 person



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
182500.48	6.2986	1	0.0127

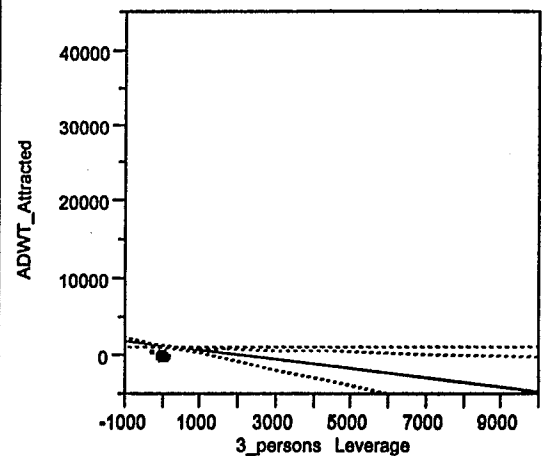
2 persons



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
2168097.5	74.8272	1	0.0000

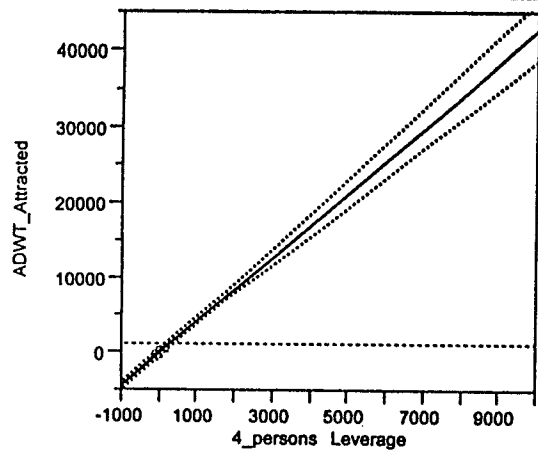
3 persons



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
185807.24	6.4127	1	0.0119

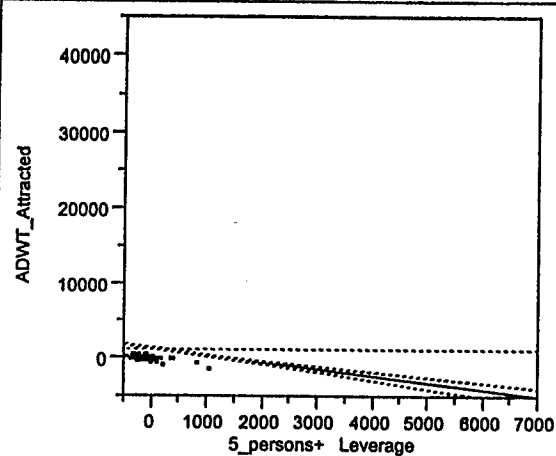
4 persons



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
12834927	442.9698	1	0.0000

5 persons+



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
3865820.3	133.4204	1	0.0000

Appendix H

Trip Production and Attraction Equations for PMPVOT

Response: PMPVOT_produced

Summary of Fit

RSquare	?
RSquare Adj	?
Root Mean Square Error	760.8758
Mean of Response	542.9548
Observations (or Sum Wgts)	246

Lack of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack of Fit	242	141224659	583573	33.5749
Pure Error	2	34762	17381	Prob>F
Total Error	244	141259421		0.0293
			Max RSq	0.9998

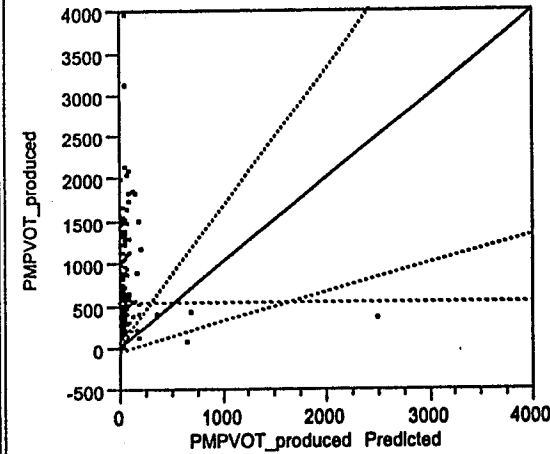
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob> t
Intercept	Zeroed	0	0	?	?
wholesale		0.2010642	0.249074	0.81	0.4203
household total		0.0102656	0.031587	0.32	0.7455

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
wholesale	1	1	377260.73	0.6516	0.4203
household total	1	1	61147.48	0.1056	0.7455

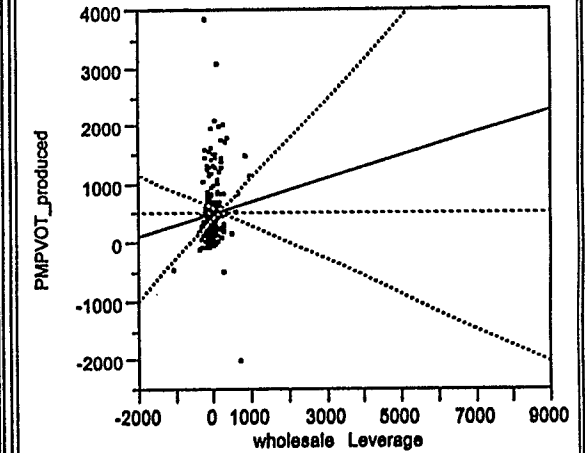
Whole-Model Test



Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	7892682	3946341	6.8166
Error	244	141259421	578932	Prob>F
C Total	246	149152104		0.0013
Tested against reduced model: Y=0				

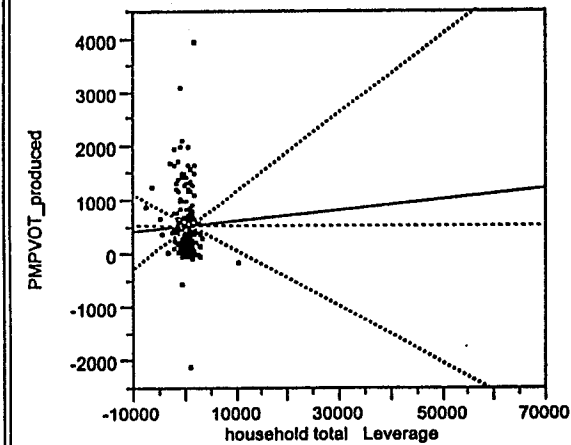
wholesale



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
377260.73	0.6516	1	0.4203

household total



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
61147.475	0.1056	1	0.7455

Response: PMPVOT_produced

Summary of Fit

RSquare	?
RSquare Adj	?
Root Mean Square Error	682.3985
Mean of Response	542.9548
Observations (or Sum Wgts)	246

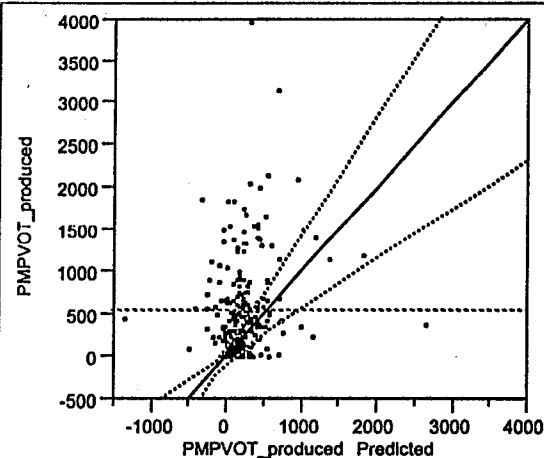
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob> t
Intercept	Zeroed	0	0	?	?
primary		-2.700063	0.445883	-6.06	0.0000
manufactu		1.021577	0.170573	5.99	0.0000
wholesale		-1.246445	0.377888	-3.30	0.0011
finance		0.5904879	0.360019	1.64	0.1023
government		0.0410464	0.118416	0.35	0.7292
accomodation		0.2416407	0.639021	0.38	0.7057
household total		0.1294472	0.041145	3.15	0.0019

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
primary	1	1	17075831	36.6696	0.0000
manufactu	1	1	16703155	35.8693	0.0000
wholesale	1	1	5066355	10.8798	0.0011
finance	1	1	1252702	2.6901	0.1023
government	1	1	55951	0.1202	0.7292
accomodation	1	1	66586	0.1430	0.7057
household total	1	1	4609308	9.8983	0.0019

Whole-Model Test

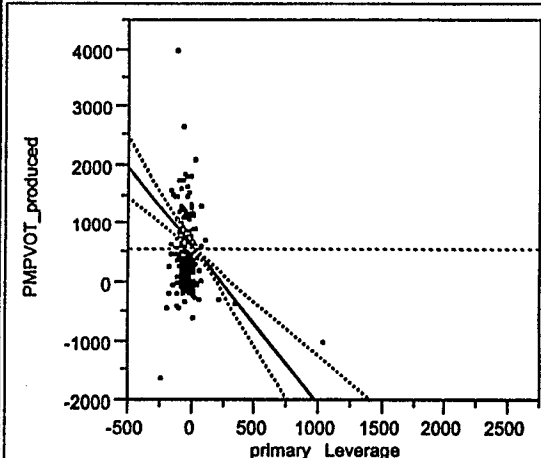


Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	37857534	5408219	11.6139
Error	239	111294570	465668	Prob>F
C Total	246	149152104		0.0000

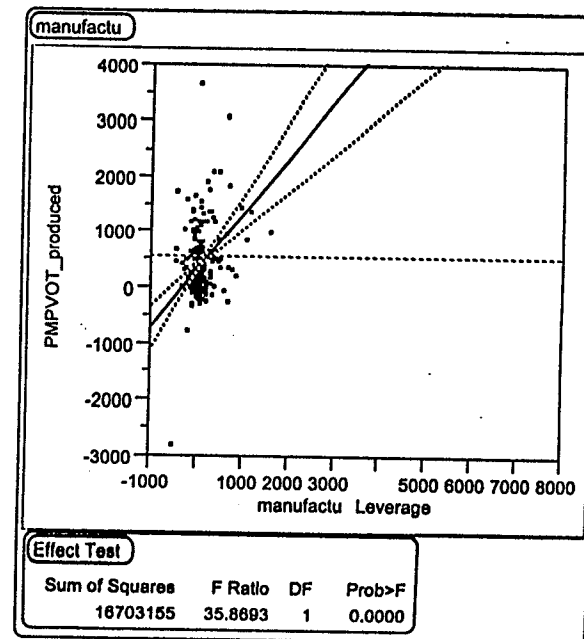
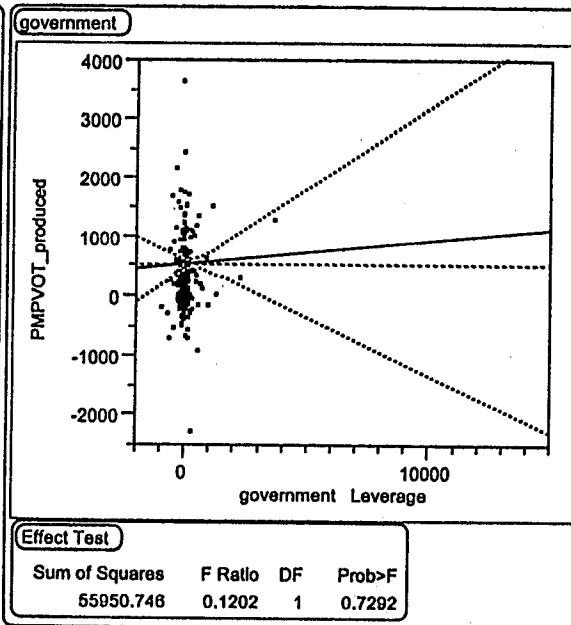
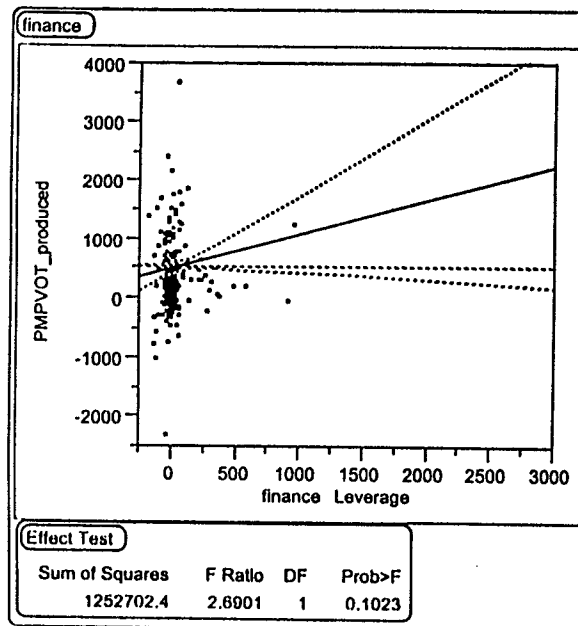
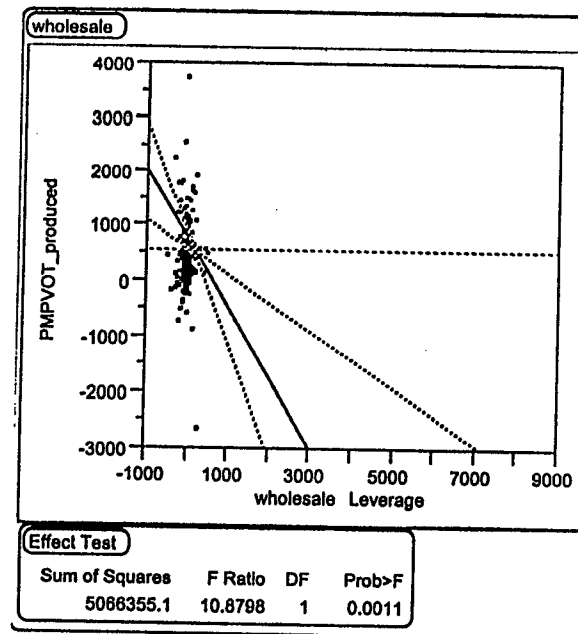
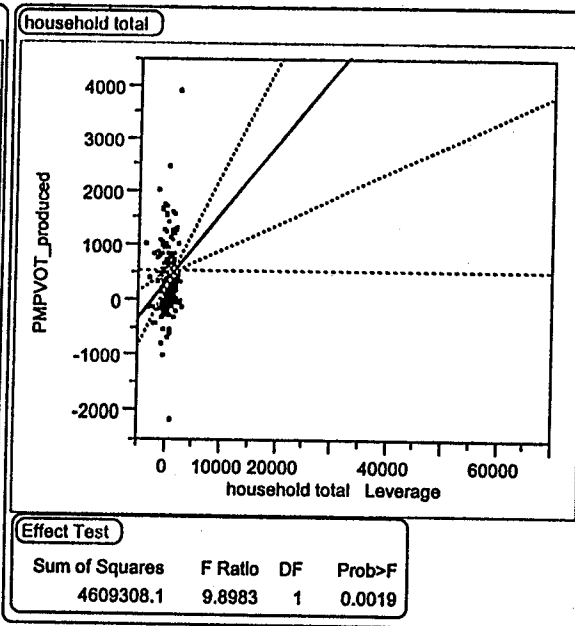
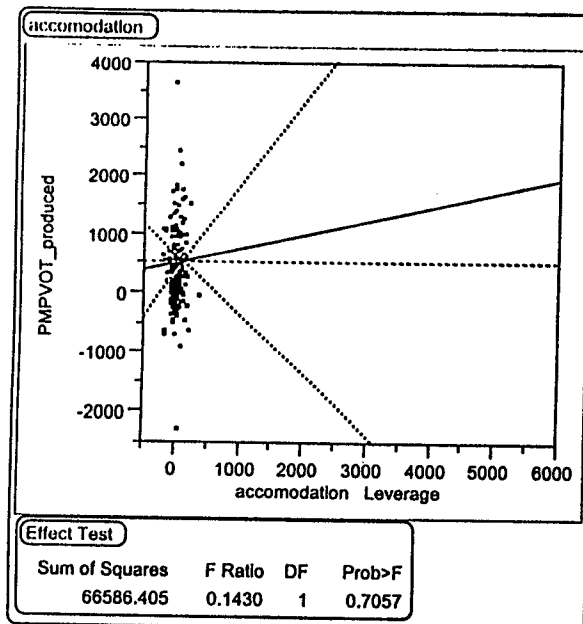
Tested against reduced model: Y=0

primary



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
17075831	36.6696	1	0.0000



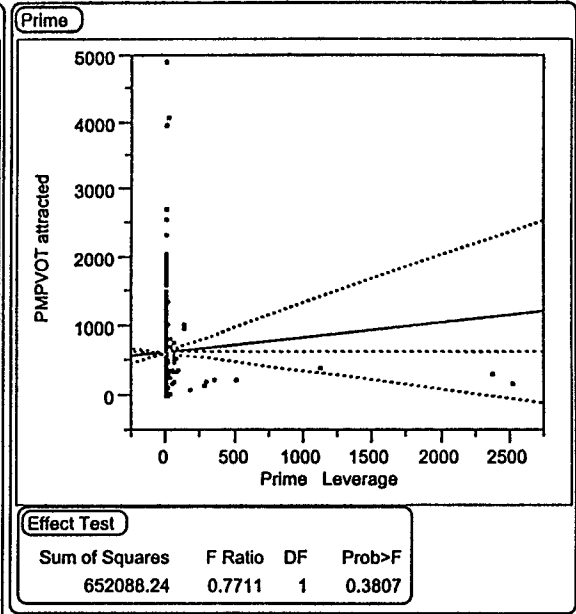
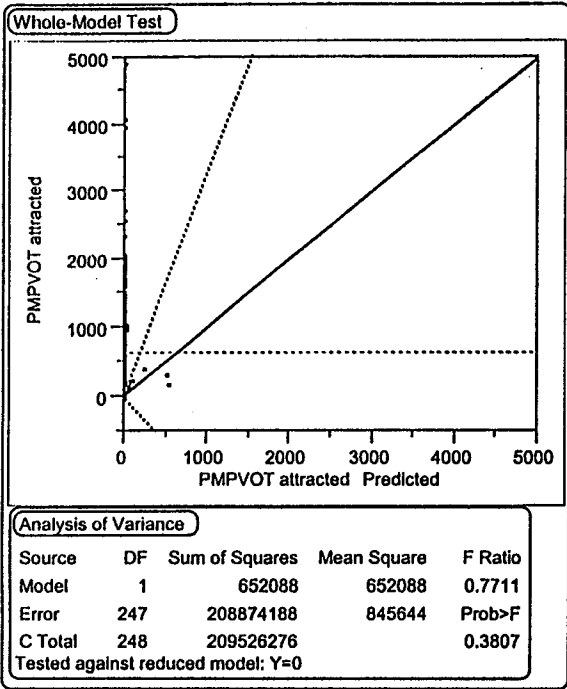
Response: PMPVOT attracted

Summary of Fit		
RSquare		?
RSquare Adj		?
Root Mean Square Error	919.5893	
Mean of Response	639.7723	
Observations (or Sum Wgts)	248	

Lack of Fit				
Source	DF	Sum of Squares	Mean Square	F Ratio
Lack of Fit	22	108822877	4946494	11.1239
Pure Error	225	100051311	444672	Prob>F
Total Error	247	208874188		0.0000
				Max RSq
				0.5225

Parameter Estimates					
Term		Estimate	Std Error	t Ratio	Prob> t
Intercept	Zeroed	0	0	?	?
Prime		0.2155748	0.245493	0.88	0.3807

Effect Test					
Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
Prime	1	1	652088.24	0.7711	0.3807



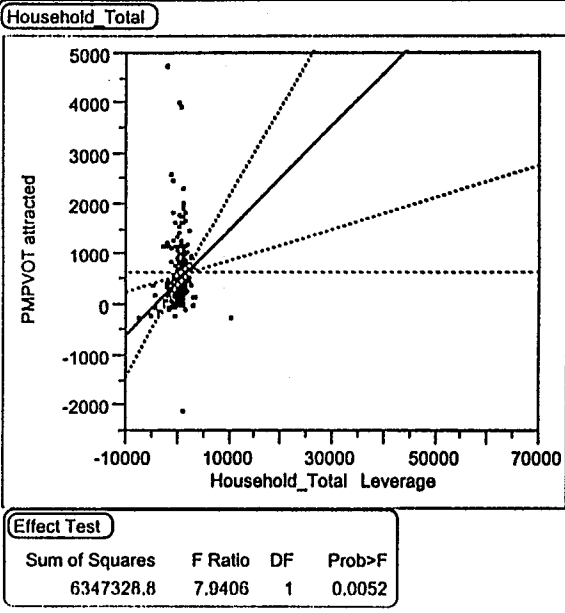
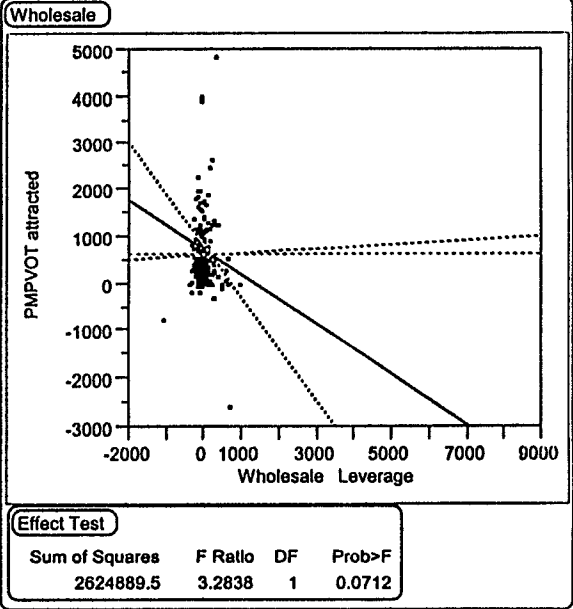
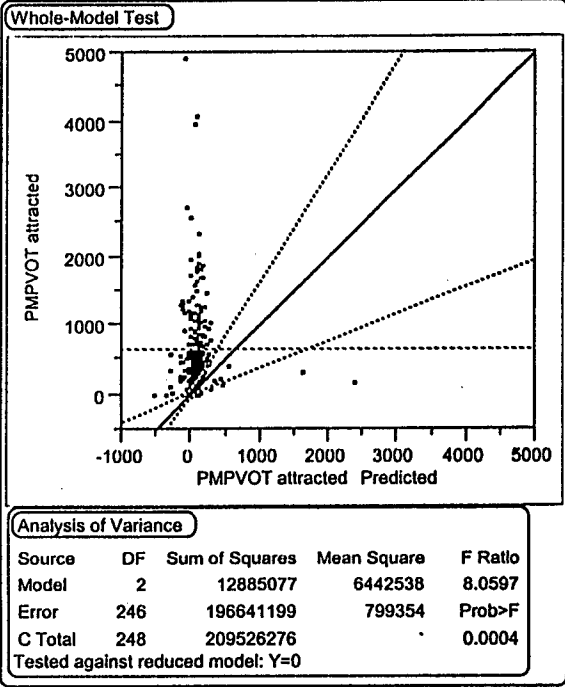
Response: PMPVOT attracted

Summary of Fit	
RSquare	?
RSquare Adj	?
Root Mean Square Error	894.0663
Mean of Response	639.7723
Observations (or Sum Wgts)	248

Lack of Fit				
Source	DF	Sum of Squares	Mean Square	F Ratio
Lack of Fit	242	195061344	806039	2.0408
Pure Error	4	1579856	394964	Prob>F
Total Error	246	196641199		0.2569
			Max RSq	0.9925

Parameter Estimates					
Term		Estimate	Std Error	t Ratio	Prob> t
Intercept	Zeroed	0	0	?	?
Wholesale		-0.527165	0.290912	-1.81	0.0712
Household_Total		0.1041947	0.036976	2.82	0.0052

Effect Test					
Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
Wholesale	1	1	2624889.5	3.2838	0.0712
Household_Total	1	1	6347328.8	7.9406	0.0052



Response: PMPVOT attracted

Summary of Fit

RSquare	?
RSquare Adj	?
Root Mean Square Error	898.19
Mean of Response	639.7723
Observations (or Sum Wgts)	248

Lack of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack of Fit	201	189899942	944776	4.6401
Pure Error	46	9366147	203612	Prob>F
Total Error	247	199266089		0.0000
			Max RSq	0.9553

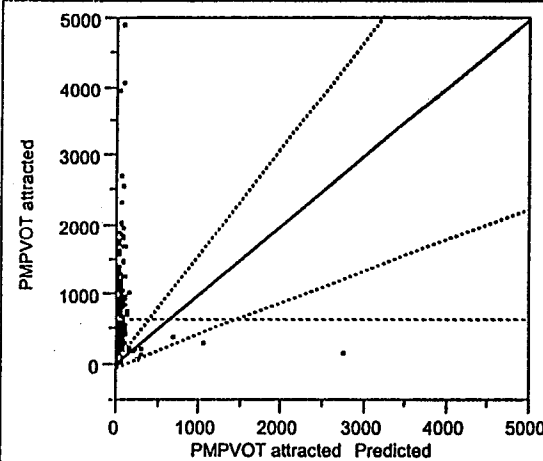
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob> t
Intercept	Zeroed	0	0	?	?
Household_Total		0.0403783	0.011322	3.57	0.0004

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
Household_Total	1	1	10260187	12.7180	0.0004

Whole-Model Test

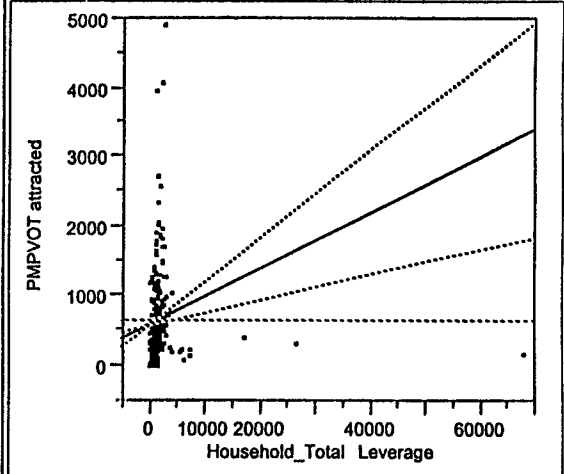


Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	10260187	10260187	12.7180
Error	247	199266089	806745.3	Prob>F
C Total	248	209526276		0.0004

Tested against reduced model: Y=0

Household_Total



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
10260187	12.7180	1	0.0004

response: PMPVOT attracted

Summary of Fit

RSquare	?
RSquare Adj	?
Root Mean Square Error	819.9137
Mean of Response	639.7723
Observations (or Sum Wgts)	248

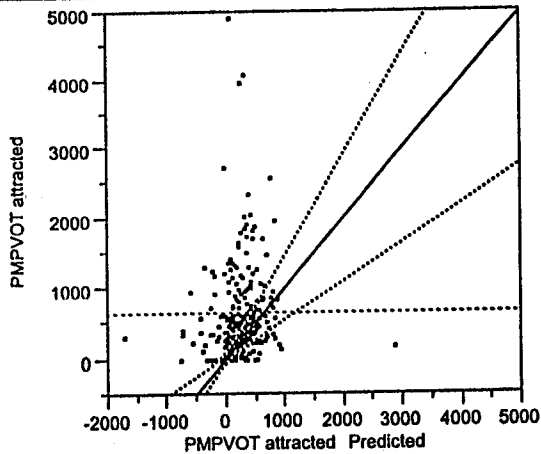
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob> t
Intercept	Zeroed	0	0	?	?
Prime		-3.510289	0.535008	-6.56	0.0000
Manu		0.6351469	0.185356	3.43	0.0007
Wholesale		-1.337055	0.458035	-2.92	0.0038
Finance		0.1634512	0.450938	0.36	0.7173
Government		-0.160611	0.141608	-1.13	0.2578
Accomodation		-0.222624	0.771837	-0.29	0.7733
Household_Total		0.3221611	0.050738	6.35	0.0000

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
Prime	1	1	28940154	43.0492	0.0000
Manu	1	1	7893555	11.7418	0.0007
Wholesale	1	1	5728465	8.5212	0.0038
Finance	1	1	88324	0.1314	0.7173
Government	1	1	864793	1.2864	0.2578
Accomodation	1	1	55928	0.0832	0.7733
Household_Total	1	1	27103068	40.3164	0.0000

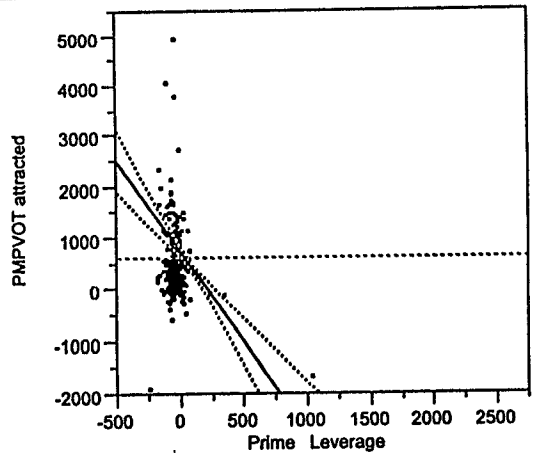
Whole-Model Test



Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob>F
Model	7	47511994	6787428	10.0965	
Error	241	162014282	672258		0.0000
C Total	248	209526276			
Tested against reduced model: Y=0					

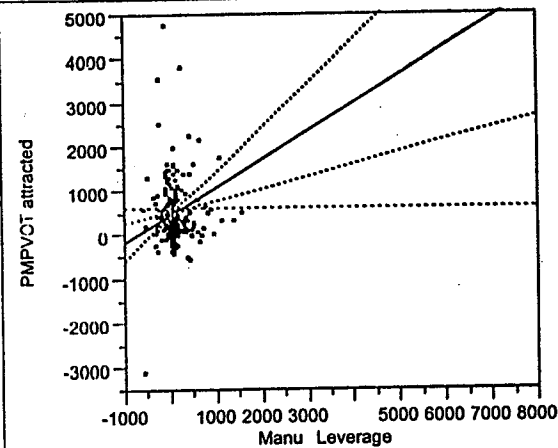
Prime



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
28940154	43.0492	1	0.0000

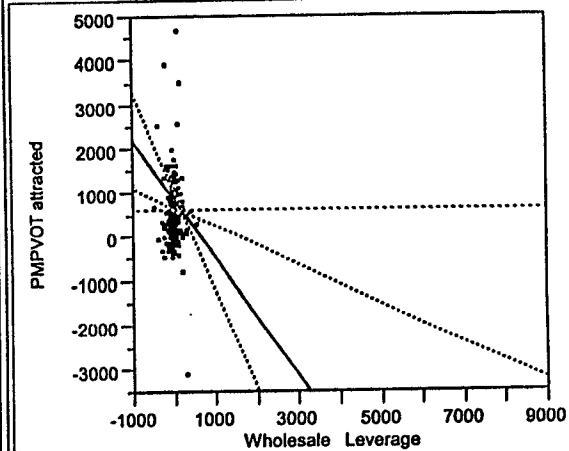
Manu



Effect Test

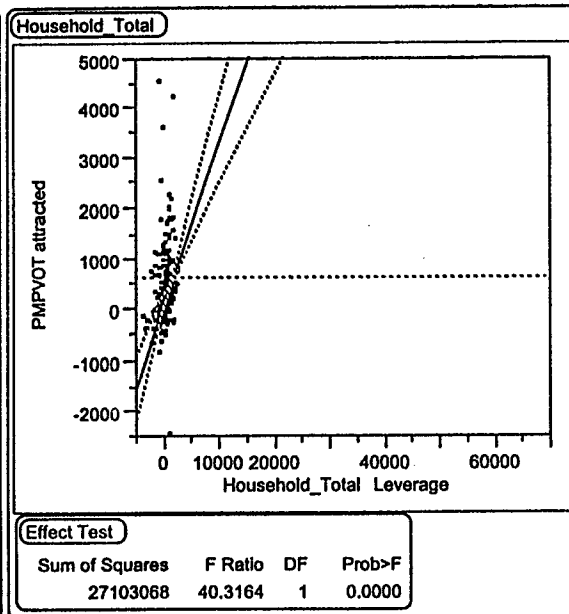
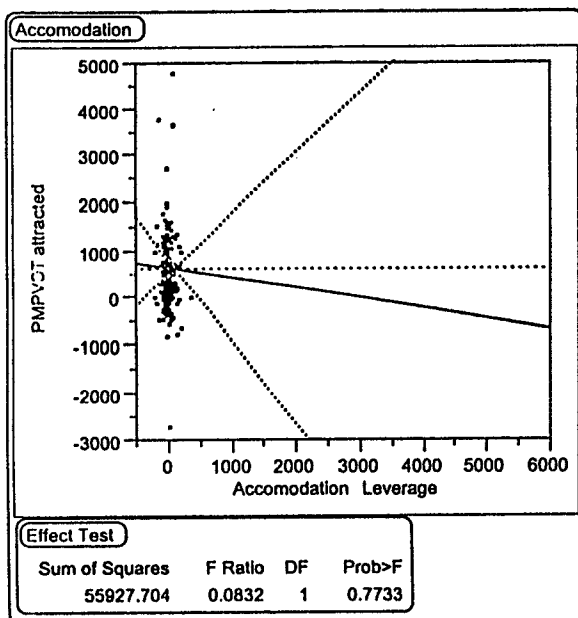
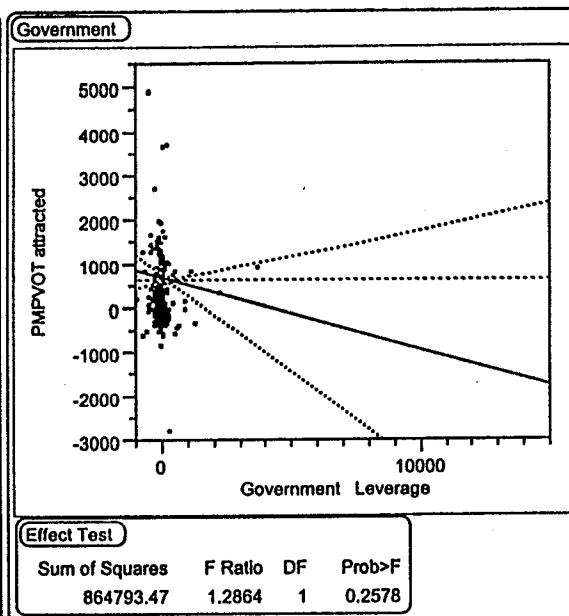
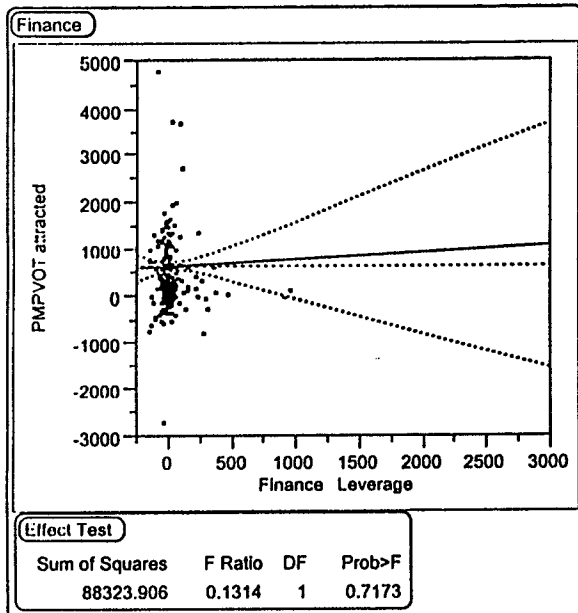
Sum of Squares	F Ratio	DF	Prob>F
7893555.1	11.7418	1	0.0007

Wholesale



Effect Test

Sum of Squares	F Ratio	DF	Prob>F
5728464.6	8.5212	1	0.0038



Appendix I

Report on Census Place of Work (POW) Seminar (October 2000)

On October 20, 2000, Kean Lew and Kai Han attended the Census Place of Work Data (POW) Workshop held by the Region of Peel and Statistics Canada in Toronto. Over 130 people with interest in transportation planning attended the workshop. The source and processing of the data are presented together with the state of the practice of the POW data. Problems associated with the data were discussed. Potential linking with other data sources and the enhancing transportation survey within census were investigated as well. Key issues discussed during the one-day workshop are listed below:

Census POW Data

The Census includes one question asking whether you have a constant workplace and what is the postal code of the work place. From this data, work trips can be estimated. Since the Census has a sample rate of 20%, which is much higher than most of the other surveys, and the trip information can be related to social, economic status of the people, it is a very useful data set with which to conduct transportation analysis.

Transportation Related Use of POW Data

Provincial, Regional and City transportation planning divisions (in Ontario) use POW data to study transportation trends in the community, e.g., mode split, geographical distribution of the commuting trips, and the effect of economic factors on transportation.

Quality of POW Data

Census POW data can be viewed as a simple journey to work survey. It has a sample rate of 20%. When bad data (including not-geocodeable) are considered, the sample rate

drops to approximately 15%. Compared with other transportation surveys, such as the Greater Toronto Area's Transportation of Tomorrow Study (TTS), which has a sample rate of 5%, Census POW data have a better sample rate, but are less complete in their survey scope. Since length of the Census is a critical concern, only a limited number of questions regarding transportation can be included. Therefore, in the 2001 Census, questions concerning travel start/end time can not be added. This situation limits the usability of this POW data.

The Cost of Census Data

Statistics Canada operates on a cost-recovery policy. The Federal government is paying for the cost of the initial Census and data processing. The cost associated with the data is for the data distribution process. Contrary to the U.S free-data policy, Statistics Canada has a cost-recovery policy, which eliminates the potential wide usage of the data and "serious" study on the data. Manitoba is not on the list of users of 2001 POW data, and the City of Winnipeg has not yet decided whether or not to obtain the POW data for 2001.

Consensus of the Users of Census POW Data

Many users wish that Statistics Canada would provide the census POW data for free. This will encourage more transportation agencies to use the data. People also wish to receive a higher level of flexibility with respect to the raw data. Customized report is highly pursued. A free licensing policy is also desired to facilitate data sharing among users. Many Users suggest providing Internet downloading service to lower the cost

associated with data distribution. It is also the general consensus that academic usage of the data should be supported by Statistics Canada.

Issues Related to Census Data

Census data are filtered by Statistics Canada. To protect the privacy of individuals, the data associated census areas with a small number of people are not available and removed from distribution. Therefore, it is impossible to obtain data for small transportation zones which is required for certain transportation applications.