THE IMPACT OF ROAD AND PARKING PRICING ON TRAFFIC CONGESTION IN THE MAJOR SHOPPING AREAS OF REGIONAL CITIES

A Thesis submitted by

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ABSTRACT

Over several decades, road authorities around the world have implemented road pricing to help reduce traffic congestion. Most implementations of pricing have been for Central Business Districts (CBD) of very large cities, which usually incorporate a range of retail and commercial activities. The studies have typically reported road pricing to be a successful means to reduce traffic congestion. Regional cities also experience traffic congestion in their CBD but the nature of the activities is different from large cities, in that shopping is a major activity. Raising the cost of road use and parking in a regional city CBD area would be expected to affect the number of trips made (trip generation), trip chaining patterns and mode of travel choice. The research problems were the congestion resulting from shopping trips to the CBDs of regional cities, and the lack of research on regional cities, shopping behavioural knowledge in the case of road pricing and increasing parking pricing, and the price elasticity of shopping demand in regional contexts. The research objectives were to understand the reasons for traffic congestion in the CBDs of regional cities, to identify the key variables governing shopping activity in regional cities, and to investigate the effect of road pricing and increasing parking pricing on shopping trip congestion in regional cities' CBDs. This thesis presents an investigation into the impacts of the introduction of road charges and increasing parking fees on shopping trips in the Central Business Districts of Australian regional cities.

The research methodology started with choosing a typical regional city. The regional city of Toowoomba, Queensland. Australia was selected as a representative case study and demographic data obtained. A survey was designed to examine the predominant variables in shopping activity and to source views on any impact on consumer behaviour by the introduction of road pricing and increasing parking pricing. The survey instruments were LimeSurvey tool and hardcopy questionnaires. The completed obtained responses were 304 responses. Survey data was also used to construct a Toowoomba shopping trips numerical predictive model. The four-step traditional method was used to construct the model. The model was validated by comparing the observed shopping trips to the shopping centres with the predicted shopping trips resulting from the model. The model was designed and constructed to predict the impact of changes in road pricing and increased parking pricing on

shopping trips. Lastly, the model was applied for transferring the study results to other Australian regional cities. Transferring the results of the model depended on the similarity of the characteristics between the other regional cities and the case study city.

The main shopping habits in the selected regional city were that shopping locally was preferred, that shopping within the CBD was more often undertaken by females than males for all four directions of travel, and that travelling from home to shopping centres in the CBD was by car. So, the study helped in understanding shopping habits, the governing variables, and the distribution of shopping trips. These were the first and second objectives of the research, and answered the first and second research questions of the study. In regard to the third objective of the research and answering the third and fourth research questions, the study demonstrated that introducing road pricing and increasing parking pricing were techniques that could be applied to assist in managing traffic congestion demand in the CBDs of regional cities. The results for increased pricing indicated a reduction in shopping trips to the CBD as a result of reducing frequency of shopping in the CBD, changing of shopping destinations, and moving towards increased use of public transport to the CBD. The effect of introduction road pricing on shopping trips was that 57% of the CBD shoppers would shop less at the CBD. Similarly, 55% of respondent's indicated increasing parking pricing by $4 per hour would significantly affect their shopping in the CBD. It was also noted that about 25% of the research sample would chose to change to the use of public transport to the CBD if road pricing or increased parking pricing ($4) were introduced .The results of the research study would be applicable in other Australian regional cities with similar demographics.

Certification of Thesis

This Thesis is entirely the work of ***Mieaad Taha Yasieen Alhellow*** except where otherwise acknowledged. The work is original and has not previously been submitted for any other award, except where acknowledged.

Principal Supervisor: **Professor Ron Ayers**

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Student and supervisors signatures of endorsement are held at the University.

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Abbreviations

AADT	Annual Average Daily Traffic
ABS	Australian Bureau of Statistics
ALPR	Automated License Plate Recognition
ALS	Area Licensing Scheme
CBD	Central Business Districts
DTA	Dynamic Traffic Assignment
EMME	Equilibre Multimodal, Multimodal Equilibrium
ERP	Electronic Road Pricing
FHWA	Federal Highway Administration
HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
ICT	Information and Communications Technology
LOS	Level of Service
NSW	New South Wales
O-D	Origin-Destination
OECD	Organisation of Economic Cooperation and Development
QLD	Queensland
RARA	Rural and Regional Australia
SPSS	Statistical Package for the Social Science
STA	Static Traffic Assignment
TAS	Tasmania
TDM	Travel Demand Management
SA	South Australia
TRC	Toowoomba Regional Council
USA	United States of America
USQ	University of Southern Queensland
V/C	Volume-to-Capacity
VIC	Victoria
VMT	Vehicle Miles Travelled
WA	Western Australia

Chapter One

Introduction

1.1 Background

Increase in average and overall vehicle ownership around the world continues to occur due to population growth, improved living standards and urbanisation. Often the increase in vehicle ownership outpaces the development of the road network and consequently increased traffic congestion occurs. Congestion is costly in terms of the delays to travel for both individuals and road freight. There are also secondary costs such as noise and air pollution that contribute to a general decrease in the amenity of urban living. For example, De Palma and Lindsey (2011) have shown that the annual overall traffic congestion cost in England is around 15 billion Euros ($A 30 billion), which is about 1.5% of England's gross domestic product. An earlier study, which looked at Germany and France found the proportion of gross domestic product loss was about 1.3% and 0.9% respectively (Carey & Srinivasan 1993). In a study conducted by the Texas Transportation Institute on traffic congestion in major cities of the United States, it was reported that in 2007 traffic congestion imposed an annual delay of 4.2 billion vehicle-hour and extra fuel consumption of 2.8 billion gallons, which cost 87 billion US dollars (Bowerman 2007). The cost of congestion for the Australian capital cities was estimated to be around $A 16.5 billion for the 2015 financial year, having grown from about $A 12.8 billion from 2010 (McGuirk & Argent, 2011). Similar patterns are evident in many other countries around the world and this has led to research into methods to relieve the consequences of congestion. There are many methods for reducing congestion, and one of them is road pricing. Some strategies have major limitations but the strategy of road pricing has proved successful in managing congestion and improving the level of services. Road pricing strategies have been used on the roads of capital, and major urban cities but has not been used in regional cities. This research investigates the use of road pricing and parking pricing as a means of reducing traffic congestion in regional cities.

Australia is a country that has a growing population in most of its capital cities and many of its regional cities. Such population growth has meant increased levels of road traffic congestion, and as growth continues so will congestion. Australia’s population

is projected to increase by 8.2 million people over the period from 2011 to 2031. The bulk of this growth will occur in major cities, which are forecast to grow by almost 7 million people by 2031 (Infrastructure Australia 2016). The population growth rate in Queensland ranges from 0.64% to 2.85% for the years from 2011 to 2019 and this means an additional 30,000 to 130,000 people in the overall population for each year. Interstate and overseas migration are the main reasons behind Queensland's population growth (Population Australia n.d.). The Australian government is focusing on settling migrants in regional areas in order to ease pressure on the capital cities (The Conversation 2019). An analysis by RMIT University (2020) indicated that the most liveable regional cities in Australia were Wollongong in New South Wales, Toowoomba in Queensland and Launceston in Tasmania. Population increases in recent years in these regional cities has caused increasing traffic congestion (Department of Infrastructure, Energy and Resources 2012) (Regional Australia Institute 2019).

The expansion of regional cities resulting from the increase in population is causing an increase in shopping trips in those cities, including in their CBDs. The next chapter shows the details of the increase in shopping trips in the regional cities. There is a lack of research on the effect of shopping trips on congestion in regional cities and the impact of road pricing and increasing parking pricing on reducing congestion in regional cities. This research dealt with reducing congestion in the CBDs of regional cities by using road pricing and increasing parking pricing. These methods of reducing congestion do not require large expenditure on the construction of new roads or expenditure on maintaining the existing infrastructure.

Further factors causing increased traffic congestion are the densification of city areas and the increase of car ownership in the community. For instance, data from the Census of Population shows the population density in Toowoomba, Queensland, increased from 12.3 to 12.9 persons/km2 between 2013 and 2018. Census figures from 2016 indicated that in Toowoomba (Local Government Areas) 37.1% of occupied private dwellings had two motor vehicles, compared to the Australian figure of 36.2% (ABS 2016).

There are several widely used mechanisms for reducing congestion. Capacity expansion and capacity upgrades are the most common options for congestion

management. Capacity expansion is an investment in additional capacity such as extra highway lanes while capacity upgrades consist of new technologies to increase the efficiency of existing infrastructures. Capacity upgrades include applications of ICT (Information and Communications Technology), for instance optimization of traffic signalling, real time routing and intelligent traffic signals (Black &Larson 2006). Other means of alleviating congestion include increasing the use of public transport high occupancy vehicles through high occupancy vehicle lanes on identified roadways (Stopher 2004). Another common mechanism to relieve congestion is related to transport management such as giving priority for public transport vehicles (Abdelghany et al. 2006). These various approaches can also be integrated to achieve synergies to reduce congestion as the population grows and traffic volumes increase.

This research focuses on the use of road and parking pricing. This strategy utilizes ICT technology to charge vehicles for their use of roads and to increase parking charges at destinations. This strategy can be especially effective in areas experiencing severe congestion due to very high vehicle usage. The strategy can be refined by varying charges according to road type, road vehicle type, registration details or time of the day or week and to significantly increase parking charges.

1.2 Research Question

The research question is:

What is the possibility of reducing shopping trips in the Central Business Districts (CBDs) of Australian regional cities through the application of road and parking pricing to reduce congestion?

The research question was approached by considering the following:

1. What are the characteristic habits of shopping (e.g. most visited shopping centre, usual mode of travel, frequency of trips by mode of transport, and the usual days and times for shopping) in Australian regional cities?

2. What are the predominant demographic characteristics that govern shopping activity (e.g. gender, age group, household size, and car ownership) in Australian regional cities?

3. What is the opinion of people on possible levels of road pricing and what level of road and increased parking pricing that would encourage trips to move from the CBD to other shopping places?

4. How are shopping trips distributed in a regional city network, and would the distribution of shopping trips differ after road pricing and increased parking pricing?

Determining the characteristic habits of shopping helps in understanding the reasons for traffic congestion in the CBD's of regional cities. This includes characteristics such as the trip frequency and the specific mode of travel for shopping. Also, identifying the dominant demographic characteristics governing shopping activities helps identify the suitable solutions for congestion management. This can include the shifting of trips for dominant age groups in shopping from CBD shopping centres as a solution in managing CBD congestion. Modelling the distribution of shopping trips in a regional city network helps understand shopping trip traffic in the road network and helps investigate the increases and decreases of this traffic in cases of road pricing and increasing parking pricing. The opinion of people regarding pricing levels helps to inform the price at which they would shift from CBD shopping.

1.3 Objectives of the study

The aim of the research was to quantify the impact of increasing road pricing and increasing parking pricing on shopping trips within regional cities using Toowoomba, Queensland as a case study. The study focused on constructing a model for regional city shopping trips; using the city shopping trips model to represent the current shopping trips situation. It explored the probable impact of pricing on shopping trips; and applying the results to other regional cities. The research did not consider all trip types (e.g. shopping, work, business, etc.) but instead focussed exclusively on shopping trips. In addition, the modelling for the research focussed on major shopping precincts within the city, rather than individual shops.

Toowoomba was selected based on the consideration of several key parameters such as population, gender, age group, household size, and car ownership. Chapter two explains in further detail the selection of Toowoomba as the case study. The main components of the research are:

1. To understand the reasons of traffic congestion in the CBD's of regional cities, by investigating the traffic congestion caused by shopping trips and shopping habits in a selected regional city.
2. To identify the key variables governing shopping activities in regional cities in order to produce suitable solutions to manage congestion resulting from shopping trips to the CBD's of regional cities.
3. To model shopping trips distribution in a regional city network and the effects of road and parking pricing on shopping activities. Modelling the effects of road pricing and increasing parking pricing help to investigate the effects of the two cases on congestion resulting from shopping trips to the CBD's of regional cities.

A schematic illustrating the framework of thesis is provided in Figure 1.1 and the development and validation of the model in Figure 1.2.

1.4 Research Contribution

The research outcomes provide new information and tools for regional city managers to manage CBD congestion. It could be used as a solution in traffic management in regional cities to improve the traffic in the CBDs of those cities. Adoption of new road and parking regimes will reduce investment in high cost whole of life physical infrastructure such as road pavements, traffic control mechanisms and parking stations.

The research makes a significant contribution by providing a strategy for managing congestion, as the decision to change shopping destinations from the CBD to other shopping destinations in regional cities will assist to reduce traffic on the roads of CBDs. This will have an important effect in many aspects for several regional cities. The main significance of the study is in reducing traffic delay time for roads in the CBD's of regional cities and improving trip times during peak shopping hours. This has a significant effect on improving the environment and improving safety in the CBDs of those cities.

The road congestion expense for Australia is estimated to be $15 billion p.a., while the cost of traffic crashes is around $35 billion p.a (The Australasian Railway Association 2010). This will continue to increase with higher rates of car ownership and the

insufficient state of the present transport infrastructure. So, there is a serious need for investment in transport infrastructure to improve the economic and social prosperity of Australia (The Australasian Railway Association 2010). McKindlay (2013) states the need for a strategy of successful road pricing to raise revenues and to reduce congestion.

Most past research has been focused on using work trips to investigate cases of traffic congestion in large cities and has largely neglected studying effects of shopping trips on congestion in regional cities. The model created in the research for regional city shopping trips will provide many benefits including enhanced management of congestion, improved understanding of consumer behaviour, reduced capital expenditure on physical infrastructure and increased income through road and parking pricing.

The outcomes of this study indicate that introducing road pricing and increasing parking pricing will significantly encourage the use of public transport in regional cities. They also indicate that the pricing level can help reduce congestion. A decrease in the costs of congestion has positive influences on the economy of regional cities, which in turn contributes to the country's economy.

1.5 Thesis organization

The thesis investigates the effect of shopping trips in a selected regional city, and studies shopping behaviour related to road pricing and increased parking pricing in this city. Chapter one introduces the research topic and study scope. This includes the research question, objective and aim of the study, and the study's significance. Chapter two reviews both pricing and non-pricing strategies for easing congestion, explores the effect of pricing strategy on other international cities and reviews past research studies of shopping trips. In addition, it provides an explanation for the selection of a typical regional city as a case study for the present research. Chapter three provides details of the data collection methods as well as reviews the first part of the data analysis. It provides information of the characteristics of the study area and people's behaviour for shopping. Chapter four presents methodologies and discusses the concepts of the traditional four step model. Chapter five introduces the results of the constructed regional city shopping trip model, results of trip generation including mode choice, trip distribution for the current shopping situation, for road pricing and increasing

parking pricing situations, and traffic assignment in the regional city network. Chapter six introduces the result of the second part of data analysis regarding investigating people's opinions of the selected regional city according to the whole research population, gender, and age group on possible levels of pricing. The chapter also presents the results as tables, and figures for shopping trips in the network of a regional city as a whole road network and in the CBD's road network of the regional city in the case of road pricing and in the case of increasing parking fees. The results in this chapter represent the whole research population as well as the characteristics of shopping activity for different gender and age groups in a regional city. Chapter seven is the conclusions and recommendations for the future studies as a possible research extension. Figure 1.3 shows comprehensive thesis flow and the connection between research questions, objectives, and chapters.

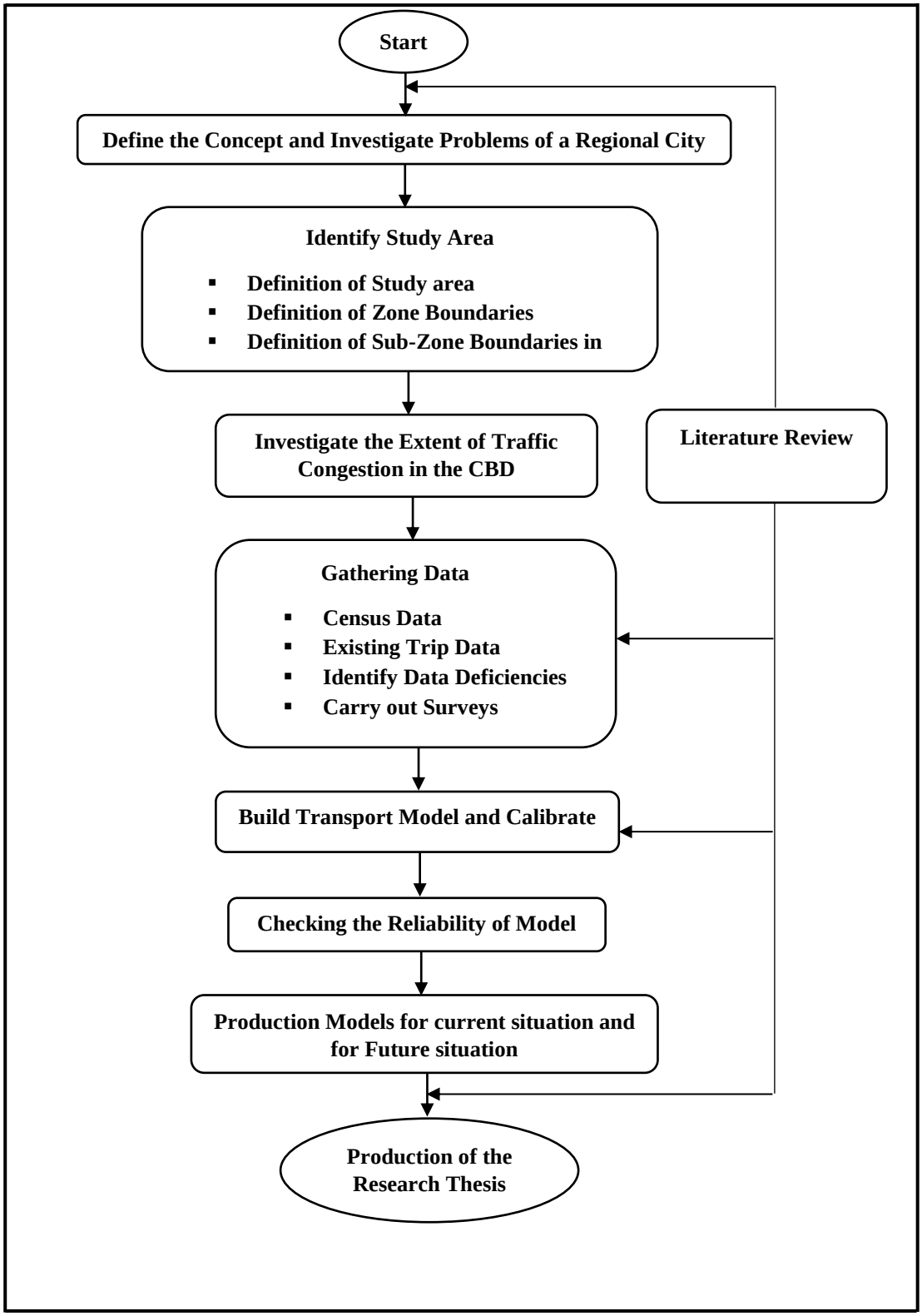


Figure 1.1: A framework of Thesis

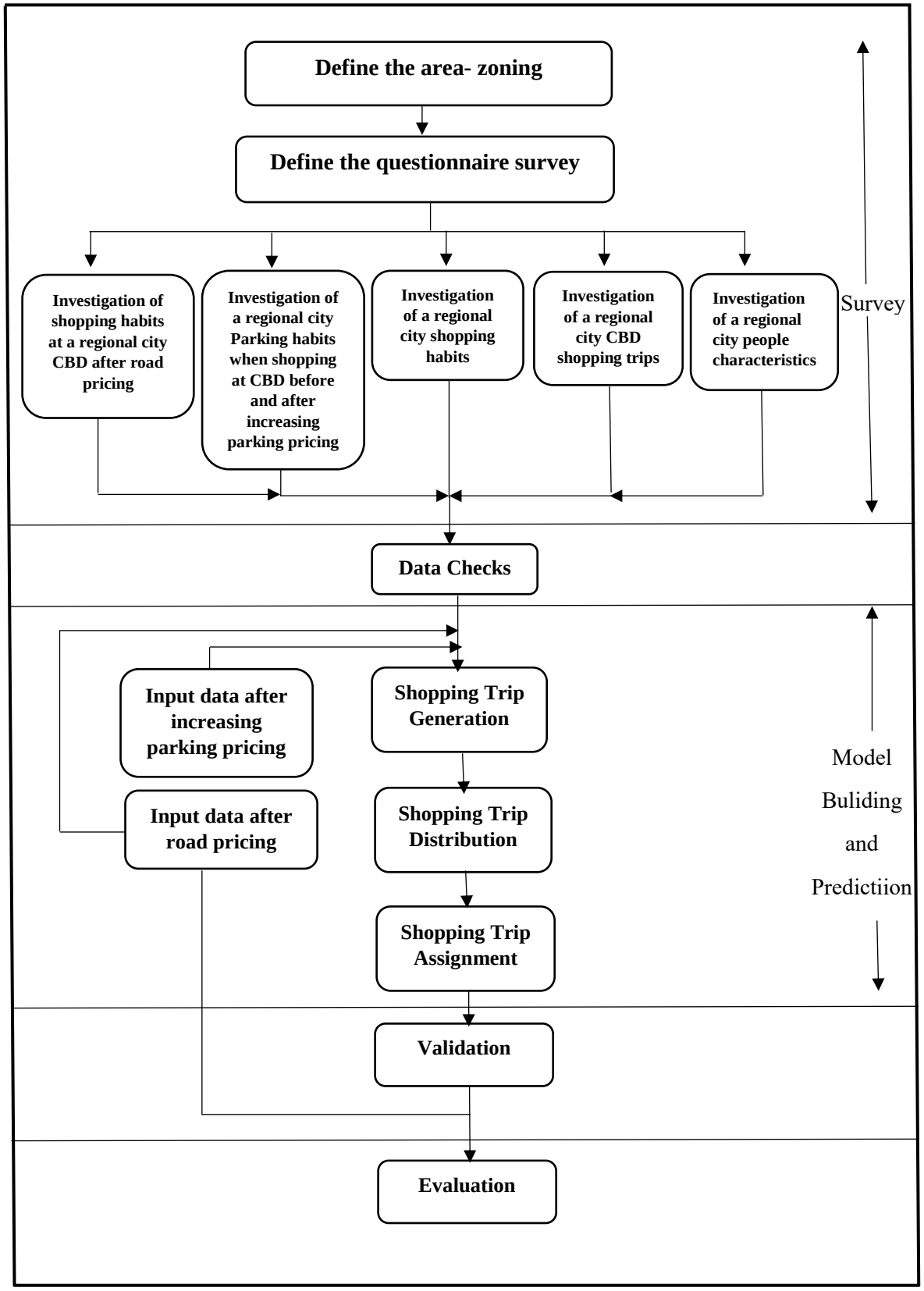


Figure 1.2: Comprehensive regional city shopping trip planing process model

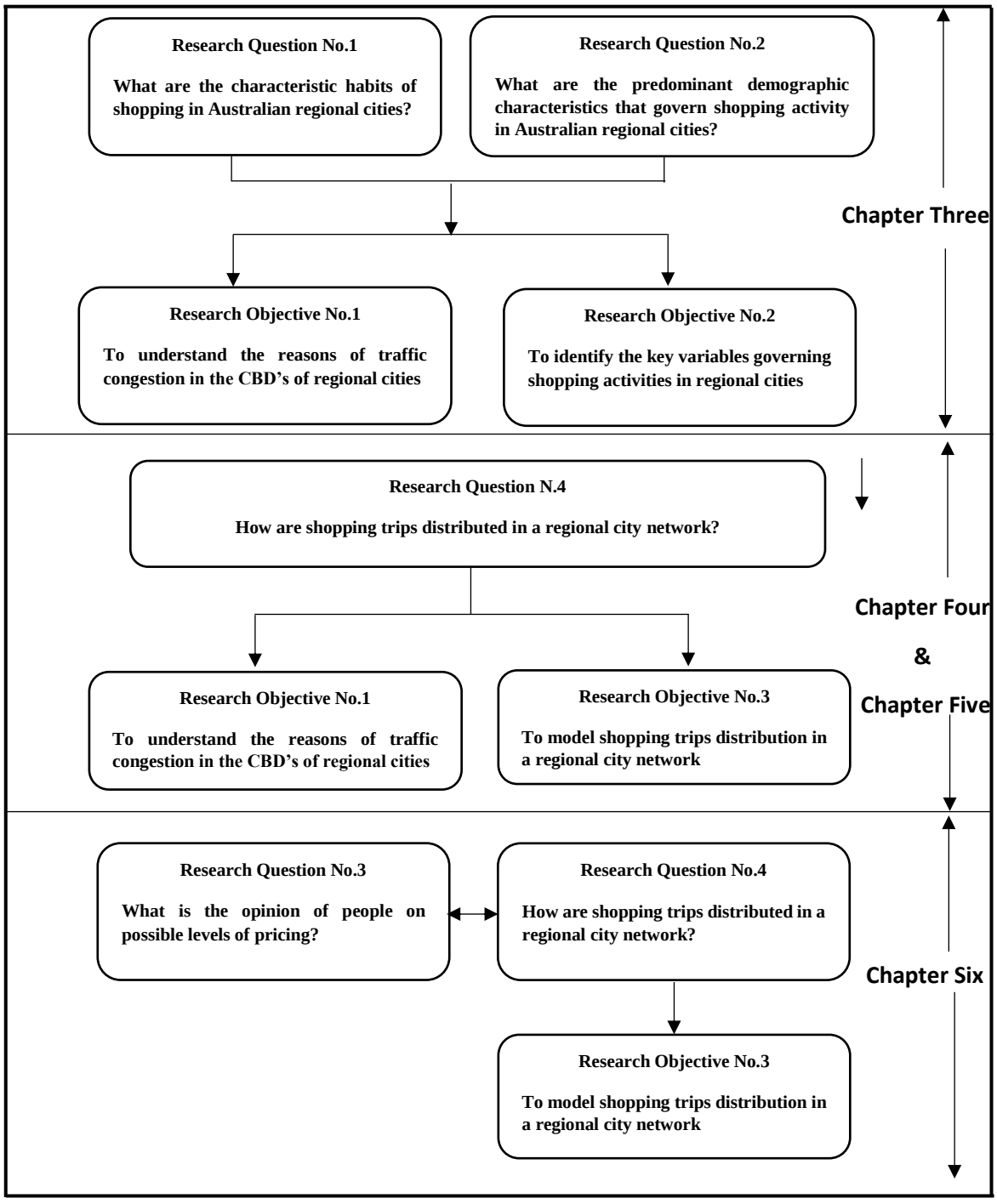


Figure 1.3: Comrehensive thesis flow and the connection between research questions, objectives, and chapters

Chapter Two

Literature Review

2.1 Introduction

Reducing traffic congestion is an important issue that sometimes requires changes in transport management polices to alter travel behaviour. The use of road pricing and parking pricing policies as effective solutions for traffic management is the focus of this research. This chapter reviews the international literature related to congestion studies, road pricing, parking pricing, and the impact of shopping centres on congestion.

In this chapter, the literature provides information on shopping centres' attractiveness, variables affecting shopping, and habits of shopping in different geographic contexts. This information helps understand reasons for congestion resulting from shopping trips and variables affecting shopping activity in different contexts. This helps determine the gap in the literature on the regional cities that is required to achieve objectives one and two of this research, and therefore this literature is useful to answer the first and the second research questions.

Existing research literature also provides information on reducing congestion by different strategies including road pricing and parking pricing. It also provides studies on the impacts of the two cases of road pricing and parking pricing in different geographic contexts. The lack in the literature was gaps in the studies using the two strategies in regional cities. Investigating objective three of the research depends on these gaps in the literature, and therefore the literature supports answering the third and fourth questions of the research.

2.2 Strategies for reducing road traffic congestion

Road traffic congestion has significantly increased around the world over the last few decades. The congestion effect impacts negatively not only on the users of the road but on quality of life in general. Several researchers have highlighted traffic congestion effects such as delays to emergency services (Hashim et al. 2013), and cost and travel time increases (Kale & Dhok 2013) where the delays resulting from increased travel time is a serious financial effect (Hoffman, Berardino & Hunter 2013). The emissions

of road transport is a major contributor in the total emissions of transportation which contribute to air pollution.

Congestion occurs when the demand for travel on a system exceeds the available capacity (Stopher 2004). There are several reasons for traffic congestion to occur. One reason is a halting in the vehicle flow and another reason is the situation of a bottleneck where a number of traffic lanes converge to a smaller number of lanes. These situations can lead to a sharp decrease in speed, and an exceeding of road capacity by an increase in traffic volume.

The factors and issues of the traffic congestion problem provide the objectives of traffic congestion relief as being a process to reduce travelling delay (Zhao, Xu & Srinivasan 2013), improve the performance of the traffic network (Long, Szeto & Huang 2014), and reduce the cost of travel (Foulds et al. 2014). Solutions to traffic congestion problems include several strategies, such as traffic routing, restricting turning movement, traffic signal control optimization, and road pricing. A number of strategies to relieve congestion are widely utilized and some of these are discussed in detail in the following sections.

2.2.1 Rationing

This strategy is used to reduce demand by discouraging peak-period travel, limiting access to congested areas. This involves limiting (rationing) the service consumption so that the system is able to function without demand overwhelming the capacity (Black & Larson 2006). Rationing may take place by limiting the permission to use specific segments of roadway (e.g. high occupancy lanes). Another method of rationing requires road users to request permission to travel particular routes at certain times of day. This takes into consideration the number of applicants and the determined capacity of each roadway segment and grants permission to a limited number of passages (Johnston, Lund & Craig 1995). Rationing can be implemented in a discriminatory or non-discriminatory manner. Discriminatory methods favour one group over another based on selected attributes. It may be used to ensure that disadvantaged groups have access to limited resources, for example handicap parking spaces and imposing bans on commercial vehicles during certain hours. Non-discriminatory rationing is often instituted without control of the allocation. Ramp metering for freeway access is an example of non-discriminatory rationing. Rationing

allows those who continue to receive the service to do so at the normal level of service quality. Rationing enables a portion of the demand to be served with little need for additional investment. Road space rationing, uses a revenue-neutral credit-based system, and by using it, the benefits are directly returned to residents rather than to governments or road owners. Its benefits are to limit peak period trips (TDM Encyclopedia 2019).

2.2.2 Public transport

This is a strategic approach of substitution which involves alternative development for the congested service. For example, substitution of driving automobiles with public transit. It should be noted however, that substitution can be restricted by the preferences of the consumer, since ideal substitutes can be rare (Black & Larson 2006).Increasing the use of public transport and ridership are a direct means of alleviating congestion. Another common mechanism to relieve congestion is related to transport management such as giving priority for public transport vehicles.

2.2.3 Allocation by trip purpose

Another strategy is allocation by trip purpose. Allocating roadway capacity according to the purpose of the user's trip, is already undertaken by existing traffic systems. Police, emergency fire and medical trips are usually allocated the required roadway capacity for this. This may be implemented by requiring all other traffic to leave the roadway to make adequate capacity available. The purposes of such high-priority trips are seen as important that no delay is warranted (Johnston, Lund & Craig 1995).

2.2.4 Allocation path

High occupancy vehicle (HOV) lanes is a roadway allocation method to alleviate congestion. The aim is to increase the use of high occupancy vehicles, and a common method to achieve this is the use of high occupancy vehicle lanes on identified roadways (Stopher 2004). In this method, a part of a multi-lane highway is allocated for the use of high occupancy vehicles such as buses, and cars with a minimum number of passengers. HOV lanes are more effective where land-use, travel patterns and society are conducive to bus use and carpooling, where they have the potential to both increase passenger flow and decrease average per capita travel time (Johnston, Lund & Craig 1995).

Additional modern strategies represented by vehicle routing techniques have also been applied to avoid congestion. It is possible to locate, track, and measure traffic density on various roads by an intelligent agency concerned with road infrastructure (Ma et al. 2009). Intelligent devices in vehicles are capable of collecting live data and using that data for planning purposes (Bishop 2000; Zito et al. 2011). This makes it possible to enable a vehicle to avoid roads where congestion is likely to occur and to use alternative routes. The use of GPS systems embedded in most smart phones is an example of such technologies. In addition, Horng (2014) proposed an innovative mechanism for congestion alleviation that can help by using a navigation device that assists vehicles get directions after setting the origin and the destination locations. This mechanism can calculate the status of congestion of the upcoming segment of road.

As outlined earlier, in many countries traffic congestion in urban areas is a major recurring problem due to increased urbanization and increased availability of relatively affordable vehicles (Gokulan & Srinivasan 2010). Increased congestion due to these factors is not as pronounced in Australia as in many other countries due to the increase of travel being less dependent on general prosperity levels (BITRE 2015). However congestion in Australian cities does incur substantial economic and social costs. Improvements in road capacity will represent large-scale investments over coming decades. This will involve finding new and innovative techniques to utilise existing infrastructure, including: motorways, urban arterials, urban arterials, and central business districts.

2.2.5 Road pricing

Transport pricing policies have been a subject of research for many decades. They have become more important in public debate because pricing measures are expected to alleviate many existing traffic and transport problems. Road pricing is considered as a way to reduce congestion, help fund infrastructure, increase efficient road usage and provide more funding for alternative public transport modes (The Australasian Railway Association 2010).

Road pricing has attracted the attention of analysts and policy makers as an economic measure to reduce congestion (Rouwendal & Verhoef 2006; McFadden 2007). Numerous studies and papers also show that road pricing can be an effective traffic management tool (e.g. Bonsall et al. 2007; Hensher & Puckett 2007). It affects travel

demand by changing the cost profiles of travel over modes, times of the day and routes and thus leads to a more efficient use of road network capacity. However, efforts to investigate the impacts of road pricing on motorists' behaviour can be hampered by the scarcity of good data before and after the introduction of road pricing. In Europe, although road pricing schemes have been considered and evaluated in several cities (e.g. Santos & Rojey 2004; De Palma, Lindsey & Niskanen 2006), only a few (e.g. the Norwegian toll rings, the London Congestion Charging scheme and the Stockholm congestion charging trial in 2006) have been implemented and provided some useful data (Ieromonachou, Potter & Warren 2006; Santos & Bhakar 2006).

In the USA, there is some experience with tolled HOV (High Occupancy Vehicle) lanes and time-variable tolls, which were used to develop travellers' behavioural models (Brownstone & Small, 2005; Holguin-Veras, Cetin & Xia 2006). To date, most of the studies on travellers' behaviour under road pricing have been based on Stated Preference (SP) surveys (e.g., Burris & Pendyala, 2002; Washbrook, Haider & Jaccard 2006). Singapore has the longest experience with road pricing schemes aimed at reducing peak period congestion. Road pricing was first implemented in 1975 in the form of the Area Licensing Scheme (ALS) and then upgraded in 1998 to the Electronic Road Pricing (ERP) system. The effects of ERP on traffic have been described in a number of research studies such as Keong (2002), Olszewski and Xie (2005) and Olszewski (2007).

- **The impact of road pricing on congestion reduction**

Congestion pricing on highways can have broad effects on the entire transportation system by shifting the demand for transportation services away from peak period highway use. A reduction in the incentive to drive during peak periods can shift some traffic to the off peak, which increases the efficiency of the road system (Nielsen 2004). This reduces the demand for additional road capacity. Some motorists will continue to drive during the peak period but are more likely to share rides with others or change the destinations of their trips (Olszewski & Xie 2005). Sharing rides with others also increases the efficiency of the system by increasing the number of people per vehicle during peak periods. Some motorists will also shift to mass transit mode. The improvement in traffic flows that would result from congestion pricing can improve mass transit service reliability and speed (Sugiyanto et al. 2010). The increase

in the use of mass transit can also increase transit revenues and these revenues can be put towards increasing service frequency or route coverage. Congestion pricing can also reduce the demand for new highway development. This would decrease the demand for capital expenditure on road development in response to growing population and travel demand (Lindsey 2012).

- **The impact of road pricing on traffic safety**

Road pricing can have both positive and negative impacts on traffic safety (e.g. Elvik et al. (2009); and Eenink et al. (2007)). Crash risks can be reduced if road pricing reduces overall traffic flows, or flows on high risk road links or at high risk times of the day. In addition, mode choices can affect crash risks. The results of Eenink et al. (2007), which are based on model calculations in the Netherlands, suggest that a general reduction in car travel due to comprehensive road pricing may have significant positive safety impacts (13% less fatalities in their research). On the other hand, some drivers may avoid tolls by using un-tolled, higher risk routes. In addition, rising average speeds may result in more serious crashes even if the overall number of (less serious) collisions decreases.

- **The impact of road pricing on environment**

Each type of road pricing has a wide range of impacts on the environment. The main environmental potential of charges (regarding emissions and noise) is their ability to relieve congestion and improve the smoothness of traffic. For example, in Singapore, between 1998 and 2007, the decrease in average ownership cost for a medium sized car was about 40% while the average usage charge rose by about 20% as a result of higher vehicle operating costs from using ERP (Lew & Leong 2009). Car owners working in the CBD have to bear the additional costs but this may be offset by the savings in fuel consumption with smoother traffic flow, although there are limited studies that quantify this impact. In addition, some researchers argue that cordon pricing results in a reduction in overall vehicle kilometres travelled (May & Milne 2000).

Improvements in traffic flow reduce emissions and noise. Mode choices in favour of public transport, walking, and cycling offset exhaust fumes and noise. The scaling of charges can also encourage the purchase of cleaner cars, although legislative control already has a dominant impact on the development of vehicle technologies and,

ultimately, on the types of car available on the market. Reducing emissions and noise levels, which are harmful to health, improves the quality of life significantly and reduces associated damage costs. Exposure to pollutants is known to cause a number of health problems such as respiratory problems and heart disease. Most impacts, arising from reduced traffic, will be beneficial. There should be an overall reduction in carbon emissions (Mitchell, Namdeo & Milne 2005) as well as reductions in local pollutants (Daniel & Bekka 2000) and noise, and improved air quality.

- **Road pricing types**

There are different types of road pricing such as road tolls, congestion pricing, cordon (area) tolls, High Occupancy Toll (HOT) lanes, and vehicles use fees. Road tolls are a common way to finance bridge improvements and highway (TDM Encyclopedia 2019). Tolls are charged for each vehicle entering a link at a certain time (The Australasian Railway Association 2010), and are a charge-for-service, with revenues devoted to roadway costs for the project. As the experiences overseas show, toll charges can be used as means to achieve the environmental objective of reducing emissions and congestion mitigation, and used for demand management. Toll charges are found in Australia particularly in the capital cities of eastern states. This is used to recover the cost of construction and maintenance of roads infrastructure (The Australasian Railway Association 2010). Congestion pricing aims to reduce rush hour traffic volumes to manageable levels, by using higher prices at congested times and locations, and lower prices for less congested conditions. It can be designed to avoid the need to add capacity on existing roadways as a demand management strategy or it can be used in order to increase revenue. A "cordon" is a conceptual ring around an area usually a city centre and in practice results in multiple charging points on the cordon at entry points to the area. A cordon approach is used in both London and Singapore (Florida 2005). Cordon tolls are charges which are paid by road users for driving in a particular area such as a city centre. They may apply only at peak periods, for example on weekdays. High Occupancy Toll (HOT) lanes are a subset of High Occupancy Vehicle (HOV) lanes. These allow more vehicles to use the HOV lanes while keeping the aims for raising revenue and mode shifting. Vehicle-use fees apply distance-based charges which can be used for financing roadways or reducing traffic effects such as congestion, pollution and crashes. HOT lanes are commonly used in the United States. Cost of vehicle use are a type of road pricing (TDM Encyclopedia

2019). There are various ways of measuring the fees of vehicle use including per vehicle-mile (or Kilometre), vehicle-year, passenger-mile (or Kilometre), and household-year. Fees of vehicle use are either fixed fees or variable fees. Fixed fees are unaffected by distance while the variable fees increase with distance. Registration and vehicle taxes, and insurance, and vehicle lease or purchase are types of fixed fees, the variable or the marginal cost includes fuel, fuel taxes and oil, and maintenance and repair (Victoria Transport Policy Institute 2017).

The Australasian Railway Association (2010) showed the road pricing models in international cities, the purpose of the models, and the impacts of road pricing. The models were as follows:

- In Sweden, the models were the cordon pricing and variable cost based on day time. The models' purposes were to manage congestion and protect the environment. The impact of road pricing was a reduction in congestion in the city centre by 20% and a decrease in emissions of 10%-14%.
- In the United Kingdom, the models were cordon pricing and flat daily rate. The models' purposes were to manage congestion and protect the environment. The impact of road pricing was a reduction in congestion in the city centre up to 25%.
- In Singapore, the models were cordon pricing and expressway pricing by time of day and vehicle class. The models' purposes were to manage congestion. The impact of road pricing achieved the average road speed targets which were 20-30 kph on roadways and 45-65 kph on expressways.
- In Germany, the models were Mass Distance Heavy Vehicle Charging based on the axle loads on highways and the emissions class. The model's purpose was to generate revenue, promote the principle of user pay, and protect the environment. The impact of road pricing was a decline in truck trips by 7%, shifting of 58% less trucks polluting, and a violation rate less than 2%.

Major road pricing reforms have been initiated throughout Asia and Europe, with the supporting of transport infrastructure and significant success in improving the transport network (The Australasian Railway Association 2010). Road pricing is now

used in many areas across the world using different road pricing mechanisms, but initial work was done in Singapore, London, Stockholm and Germany.

In 1975, Singapore started to charge drivers who entered the downtown area during the peak hour period. The scheme was in the form of an Area License Scheme (ALS) (Vickrey 2020). Variable toll charges are used in Singapore as this method is simple and cheap and it can be used as a tool to manage the demand (The Australasian Railway Association 2010). Singapore shifted to using an automated electronic charging system in 1998 where devices and camera are used for reading license-plates and then the payment is made by debit card through electronic devices set in the vehicles (PRIMER n.d.). The congestion in the central business district was significant at the time of introducing the scheme so the objective of the scheme was the relief of congestion (Amelsfort & Freij 2018). It proved to be a great success. The outcome was an immediate 73% decrease in use of private cars and a 30% increase in the use of carpools (PRIMER n.d.). The improvements in the speed of traffic flow was 30kmph on arterial roads and 45kmph on freeways during rush hours (The Australasian Railway Association 2010).

The discussion about using congestion charging in London was carried out for some decades before it was introduced in February 2003. The implementation of the scheme from the start was using electronic Automated License Plate Recognition (ALPR) cameras for enforcement (Amelsfort & Freij 2018). The scheme's aim was to reduce traffic congestion (Amelsfort & Freij 2018). The outcomes were that the traffic volumes declined by 16% for all vehicles entering the zone of charging and by 30% for all chargeable vehicles plus an improvement in journey speeds (Amelsfort & Freij 2018). The central London congestion pricing scheme resulted in a decline in vehicle crashes of 4% and a reduction of pedestrian crash injuries of 6% (TDM Encyclopedia 2019). An increase in bus and bicycle numbers by 25% and 49% respectively also occurred during the period (Vickrey 2020).

Congestion pricing and cordon charging has been successfully used in Sweden by moving to use greater public transport, changing behaviour, reducing urban congestion, and raising revenues where the charges have gone to improving the networks of urban public transport (The Australasian Railway Association 2010). The discussion of a Stockholm congestion tax started in the 1990s before the tax was

introduced in January 2007 on a permanent basis. The first six months of 2006, Stockholm introduced a trial, then in September conducted a referendum (Amelsfort & Freij 2018). The trial meant a good level of public awareness, and this helped in judging the benefits to the stakeholders (The Australasian Railway Association 2010). The trial stage included bus services improvement, ride-and-park, and addition rail capacity (Amelsfort & Freij 2018). The trial was considered a success. Traffic volume decreased by 22% per day on average and emissions dropped over 30%. Not all of Stockholm's municipalities held referendum at that time for congestion tax but a majority 53% voted for the pricing from those that did hold a vote (Ministry of Transport 2018.). The scheme was then introduced permanently. The area of pricing was larger than the CBD of the inner city. The scheme was extended in 2016 to include a ring road component. The scheme technology was to use monitoring cameras to charge the tax. The aims of the scheme were to relieve traffic on the roads which were mostly overloaded, improve the average speed, and reduce emissions. One of the outcomes was a decrease in traffic by 20% since the first implementation of the scheme (Amelsfort & Freij 2018).

Charging heavy vehicles in Germany is a type of pricing which is used because the heavy vehicles inflict much higher damage on roads than light vehicles. The idea is to target the most serious contributors to road damage. One of the positive results was a 58% shift to truck models with more fuel efficient configurations (The Australasian Railway Association 2010).

Road pricing reforms are essential if Australia is to have a productive, efficient and sustainable transport network. One of the major concerns for the Australian economy had been identified as the stagnation of productivity performance. The Organisation of Economic Cooperation and Development (OECD) has also indicated the continued 15% deficit in the productivity levels between Australia and other major OECD countries. So, Australian governments have placed transport at the centre of national reforms aimed at improving productivity performance (The Australasian Railway Association 2010).

Road pricing can relieve congestion in urban transportation, such as in Manhattan, Brooklyn, and Williamsburg (Tri-State Transportation Campaign 2018). It is also used in capital cities including London and Stockholm, and is used in major global cities

including New York (Tri-State Transportation Campaign 2018). It is also used in the island nation state of Singapore (Tri-State Transportation Campaign 2018). Thus, road pricing has been used in different geographical contexts but it has not been used in regional contexts. So, this research fills this gap by applying road pricing in a regional context.

Research has shown that road pricing is one solution to ensure productive, efficient and sustainable transport networks of big cities. While road pricing should have a similar impact in regional cities the magnitude and type of impact requires further research based on travel patterns and demographics.

Bundaberg, is one of the regional centres in Queensland. The proportion of shopping trips in this city is 28%, which is the highest percentage of trips compared to other trips (Household Travel in Bundaberg 2012). Also the trips for the purpose of shopping in the other regional cities, Gayndah, Kingaroy, and Tin Can Bay/Cooloola are also the highest proportion of trips with 33%, 30%, and 42% respectively (Household Travel in Gympie, Gayndah, Kingaroy and Tin Can Bay / Cooloola 2012). In Cairns, two in every three active transport trips are for shopping and recreation (Queensland Government 2017). Most of the regional cities have congested streets in the CBD such as in the CBD of Bundaberg (Jll 2015), lack of car parking in the CBD such as in Townsville and lack of reliable public transport (Project Management 2017).

The policies of the regional plan 2009-2031 for South East Queensland were to improve accessibility by connecting active transport, plan new public transport facilities and routes, and support walking and cycling. The policies with principles ensuring development can be provided with new transport infrastructure, employment, and community services or make use of existing infrastructure (Catchments 2009). Road pricing has the potential to support the policies of the regional plan 2009-2031 without expenditure on building new facilities or maintaining existing infrastructure. It solves the transport problems of the regional cities by encouraging the use of public transport and walking.

2.2.6 Parking Pricing

For many years, it has been recognized that parking policy is a powerful and efficient tool in Traffic Demand Management (TDM) where it may be implemented to commuter, non-commuter and residential parking to address a variety of financial,

social, economic, and environmental objectives. In particular, parking pricing policies can generate revenue for operators, serve as tools to support commercial success and residential quality of life, and at the same time help manage travel demand, reduce congestion and travel time, as well as decrease vehicular emissions (Greene & Plotkin 2011).

Experimental evidence shows increasing parking pricing raises the total cost of a motor vehicle trip, which may lead to a variety of changes in travel and location choices (Deakin et al.1996). Increases in parking pricing would be expected to affect the number of trips made (trip generation), trip chaining patterns and mode choice.

Due to the various types of parking supply, there is competition between different parking services (Kunze et al.1979). In the long term, if parking pricing is not implemented systematically over an area, it could lead to an increase in trips to destinations that offer free parking or at a lower price (Vaca & Kuzmyak 2005). The management of public parking, public incentives (such as parking tax) and transit alternatives can all influence the impact of parking pricing.

A number of studies have observed the short-term impact of parking pricing. Three separate studies in San Francisco, Toronto, and Dublin have shown that for every 10 percent increase in parking price, there would be an average of three percent decrease in demand for parking spaces (Gillen 1977; Kelly & Clinch 2009). This elasticity of demand estimate is the most commonly found, but there are studies showing larger decreases in parking demand as price increases. In other words, when alternative parking is available, parking demand can fall at the same rate as the price increase, as shown in Hensher and King's (2001) study in the Sydney central business district (CBD). A high price elasticity (-1.015) was estimated for travellers who chose to park elsewhere in the CBD, rather than choosing to park closer to their final destinations (Hensher & King 2001). When alternative parking such as a lower priced facility or free off-site parking, is available, raising the price of parking at a particular location may simply shift parking to nearby parking sites or change parking duration.

Parking charges are an important policy influencing residents' travel mode split and even traffic conditions. Different parking rates create different effects on travel mode. Surveys tracking parking pricing changes in Los Angeles city centre and suburbs have shown that when employers stopped paying for parking, the number of solo drivers

decreased substantially from between 19 and 81 percent depending on the location. Likewise, the use of private vehicles as a commuting mode had decreased by 15 -38 percent after the removal of parking subsidies (Willson & Shoup 1990; Surber, Shoup & Wachs 1983). The effect of parking fees at work places can potentially affect the mode choice for the journey to work. For example, the majority of car drivers to work have free parking in Norway and six out of ten workers have free parking in Oslo with the result that most drive to work. Thus, the trend of a traveller's transport mode changes with the parking rates and parking pricing encourages the use of alternative modes.

Australian regional cities have great potential for population growth and sustained economic development as they have an attractive lifestyle and diverse industry. The regional cities are attractive investments which lead to job creation in retail, business, education, health and government services. However, the growth in regional cities is accompanied by increasing demand on services in their CBDs. such as rising demand on car parking. Examples of this include car parking demand rising in the CBD of Ballarat (City of Ballarat2018), lack of parking in the Townsville CBD (City of Townsville 2017) and in Mildura (Mildura Rural City Council 2018). Parking management strategies are used in most of the regional cities. The strategies depend on time and location in order to manage demand. These strategies are effective for modifying demand, which mitigates traffic congestion. But this strategy has limitations because traffic may fill up the freed up parking. So, the parking management strategy for the CBD of regional cities is required to be supplemented by other strategies for achieving the best outcome to manage demand.

Parking Pricing can have significant transportation impacts. Even modest parking fees can affect vehicle travel patterns. Frank et al. (2011) used detailed data on various urban form factors to assess their impacts on vehicle travel and carbon emissions. Their analysis indicates that parking pricing can have significant impacts on vehicle travel and emissions. Increasing parking fees from approximately $0.28 to $1.19 per hour reduced VMT by 11.5% and emissions by 9.9%. A study by ICF (1997) indicated that a $1.37 to $2.73 increase in parking fees reduced auto commuting 12-39%, and when matched with transit and rideshare subsidies, reduced total auto trips by 19-31%. This early study demonstrate that parking fees have a clear effect on the mode of commute.

Some studies have considered parking pricing policies' impact on congestion. Free parking increases the financial incentives to drive, and increases congestion both from increased traffic flow and the search for parking (Jansson 2010). A review of 16 studies on 11 cities conducted between 1927 and 2001 found that at any one time approximately 30 percent of the vehicles in the central business districts were cruising for parking. Cruising has several negative impacts on the amenity of cities, as it can lead to substantial increases in distance travelled, fuel use and emissions (Shoup 2006).

New parking and road polices will not only affect the performance of the road network but also the shopping activities at shopping areas and individual stores. Consequently, a decline in trips to these areas will occur when road and parking pricing is applied because commuters may choose to visit other centres in response to road and parking policies or choose to park their vehicles further away from the retail area or use another mode of transport. Strategies of managing congestion aim to improve the level of services of the roads and improve transportation and accessibility. However, some of the strategies have limitations. For example, the strategy of supply management such as constructing new infrastructure or maintaining existing infrastructure requires large funds. The strategies of access management that are used for safety and reduce congestion such as enforcing using specific road links, have some limitations because of its strong reliance on enforcement, and creating new congestion in other roads as a result of diverting the road traffic. Road pricing proved a successful strategy for traffic management, and has economic and safety benefits.

Research into the effects of road and parking pricing on shopping activities in regional cities remains limited. This research study concentrates on the effects of road and parking pricing for shopping trips in the CBD of regional cities.

2.3 The impact of shopping centres on congestion

Shopping centres have an impact on traffic congestion as trips increase to some centres because of the attractiveness of the centres and/or because of the type of retail activities available. Shopping centres have various peak periods and the time spent inside shopping centres varies. All of these are factors that affect road and parking congestion.

Applying pricing on roads in a commercial area influences shopping location choice, travel distance, selection of stores, shopping centre characteristics and parking

facilities. These are among the attributes that are most important for explaining and predicting commuter trips. The use of attractiveness measurements in the context of consumers' choices of shopping centres has been reported earlier. According to Teller and Reutterer (2008), a shopping centre is attractive when it is preferable at different stages of the process of buying. In addition, Anselmsson (2006) proposed that the impact of attractiveness could be reflected in the number of visits to the shopping centre, retention time and the amount of spend per visit. Leszczyc, Sinha, and Timmermans (2000) have shown that store choice is a dynamic decision and can be conceptualized as a problem of deciding when and where to shop. The first decision is the traditional store location choice problem. The second is the shopping trip incidence problem relating to the timing of shopping trips. Increased shopping trips to specific shopping centres or to shopping centres in vital places such as CBDs would cause road congestion on roads leading to those shopping centres. Congestion is affected by the attractiveness of shopping centres and by retail type.

2.3.1 Attractiveness of shopping centres

The attractiveness of shopping centres means shoppers prefer to shop at those shopping centres for a range of reasons. This could increase demand on parking around the areas of shopping centres and increase the level of traffic, resulting from shopping trips. Mikołajczyk et al. (2014) state that generally shopping centre attractiveness is related to the number of shops located in one place, and the offering of varied products. This makes shopping easier for customers. In another approach, it is easy for customers to switch shopping centres as most of the shopping centres are offering similar services and goods because of the increasing number of shopping malls (Aliagha et al. 2015).

It has been found that shoppers choose a store based on two primary reasons. The first reason is convenience. According to Ismail El-Adly (2007), to make a shopping mall more attractive, the management of the shopping mall should provide comfort and convenience to consumers in terms of parking spaces, resting places, security and maintaining cleanliness in the shopping mall. The second reason is merchandise (quality of stores), where the shoppers tend to selectivity because of the variety of merchandise and stores.

There are various dimensions that can be identified as relevant in the establishment of attractiveness for shoppers: mall essence, general popularity and promotional

programs, personal service, recreational options, and internal and external atmosphere. The empirical studies conducted by Reynolds, Ganesh and Luckett (2002) and Sit, Merrilees and Birch (2003), show mall essence, known in previous studies as the essence of choice at the shopping centre, was the most important dimension in shopping centre attractiveness. The second most important was general popularity and promotional programs. This dimension has some similarity with the economic variable called sales and promotion by Rajagopal (2009). In third place, personal service gives shopping centre personnel a significant role in the perception of the attractiveness of a shopping centre. The fourth dimension, recreational options, supports previous results (Reynolds, Ganesh & Luckett 2002; Sit, Merrilees & Birch 2003; Ismail El-Adly 2007) in which the shopping centre is perceived as a place not only for shopping but also for relaxation, entertainment and socialisation. Finally, the last contribution to the perception of shopping centre attractiveness was internal and external atmosphere, also described by other authors as location and facilities, atmospherics and accessibility (Sit, Merrilees & Birch 2003) or logistic related factors (Rajagopal 2009).

2.3.2 Classification of retail activities

The type of shopping effects the choice of the destination of shopping and the number of which in turn causes localised traffic congestion near the preferred destination. According to Sinha, Banerjee and Uniyal (2002) the main types that attract shoppers can be classified as: Grocery/Fruits and Vegetables, Consumer Durables, Composite (Books and Music, Accessories, and Lifestyle Products), and Apparel Stores.

It is necessary that retail centres remain convenient despite the community changes. The consumer has become more discerning because of several factors such as increasing awareness of the consumer, mobility and affluence. In addition factors related to the change in social trends such as rising individualistic lifestyles and womens' role changes are important (Reimers & Clulow 2004).Carpenter and Moore (2006) found that the shopper's race, gender, household size, income and education were factors influencing a household's shopping frequency. The households with large families, and low income and education were more frequent shoppers. Also female participants were more frequent shoppers compared to males. Kim and Park (1998) state that more planned or routine grocery shopping trips result from high opportunity cost. For instance, Saturday or Sunday may be the only days to go grocery shopping

for people who are employed full-time, because of time constraints. Budget constraints on grocery shopping habits are related to the variable of household income. In general, store choice is likely to be influenced by both the nature of products and household characteristics.

This research investigates the impacts of pricing on shopping trips to CBD and requires data on road and traffic characteristics, household characteristics and shoppers' opinions. A variety of survey types were employed to obtain the required information.

2.4 Selection of Study Area

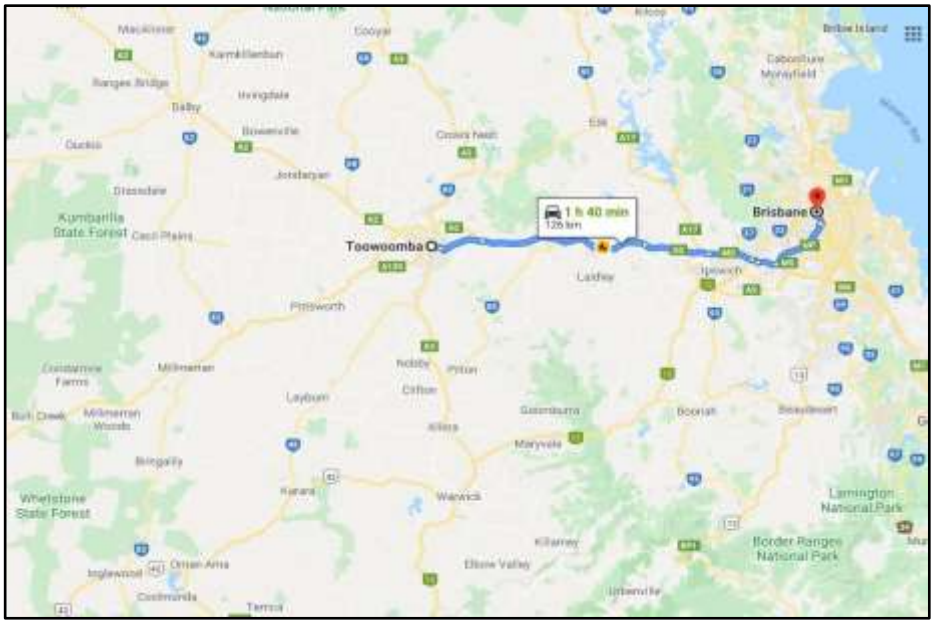
2.4.1 Toowoomba as a Typical Regional City

Ninety-nine percent of the Australia's landmass lies outside of the country's five major metropolitan areas (Sydney, Melbourne, Brisbane, Adelaide, and Perth). This is variously described and defined as country Australia, rural Australia, regional Australia, and rural and regional Australia (RARA) (Budge & Chesterfield 2011). The descriptions appear to imply a dispersed agriculturally based non-urban population, as almost all (81%) of Australians live in capital cities (ABS 2011)). As Brett (2011) comments in Quarterly Essay, Australia's political vocabulary no longer contains the word 'country' as a word for the settled countryside. It has been broadly replaced by 'rural' for areas of sparse population and 'regional' for major non-metropolitan centres. Regional cities are defined differently in every Australian state but can be said to provide central points to access essential infrastructure, services, business, employment and education. Regional cities for the purpose of this research are defined as being outside of the state capital cities and associated metropolitan areas. They provide services for local residents as well as those in surrounding towns and rural areas.

The main characteristic of Australia's settlement pattern has been the growth of, and the continuing focus on, the two largest cities, Melbourne and Sydney, and the growth of Perth and Brisbane together with the expanded metropolitan areas of each. On the other hand, the sustained growth of a limited number of major inland and coastal regional centres has been accompanied by the spreading out of the population of much of inland rural Australia (Budge & Butt 2009). Launceston, Bunbury, Coffs Harbour, Townsville and Cairns are large regional centres, all having a coastal location, and having grown strongly. They have been accompanied by a network of inland regional

centres such as Toowoomba, Albury-Wodonga, Bendigo, Ballarat and Wagga Wagga, each of which have strong population growth. Also, the population of the hinterland in the towns and rural areas has grown (Budge & Chesterfield 2011). Budge and Butt (2009) showed that the rise of these major regional population centres was between 40,000 and 500,000.

Toowoomba is a regional Australian city in the Darling Downs region of Queensland. It is located 126 km west of Queensland's capital city Brisbane by road as shown in Figure 2.1. The projected population of Toowoomba in 2041 is 196,825 and the population change is about 1% p.a (Queensland Government Statistician's Office 2018).



Source: (Google Maps, 2020). Available at : https://www.google.com/maps/dir/toowoomba/brisbane/@-27.6442029,152.1570496,9.5z/data=!4m13!4m12!1m5!1m1!1s0x6b9644ba48e3658f:0x400eef17f20bf50!2m2!1d151.9506696!2d-27.5598212!1m5!1m1!1s0x6b91579aac93d233:0x402a35af3deaf40!2m2!1d153.0251235!2d-27.4697707

Figure 2.1: Toowoomba City location

Table 2.1 shows that Toowoomba is a typical regional city in comparison with other regional cities in Australia.

The table shows the following about Toowoomba:

- Toowoomba is among the larger regional cities in Australia.
- The percentage of retail trade is approximately the same in each of the retail cities and Toowoomba is close to the average percentage, and within a standard deviation of the mean.

- The percentage of technicians and trades workers as percentage of total employment for Toowoomba is very close to the average percentage, and within a standard deviation of the mean.
- The number of businesses by industry is regard as an indicator of a city's economic condition and helps in predicating the direction of local production of the city. The number of businesses varies widely in regional cities because the industries are influenced by geographic position, climate-weather condition, and earth surface features. The number of businesses by industry figure of 15,394 for Toowoomba is indicative of a city where workforce plays an important role as a result of increasing population.
- The amount of daily traffic on the main street of the regional cities varies widely and does not correlate well with city population. The reason for the poor correlation is that some main streets are national or state highways, whereas in other cases the main street's purpose is almost solely as an access to CBD activities (e.g. Townsville). The AADT figure of 23,000 vehicles per day for Toowoomba is indicative of a city where the main street plays a mixed role of through traffic access and CBD access.
- The registered motor vehicles per head of population does not vary much between regional cities and the figure for Toowoomba is close to the average.

Thus, Toowoomba is shown to have several characteristics which are typical of an Australian regional city and well suits its use as a case study for this research.

2.4.2 The Central Business District (CBD) of Toowoomba

Toowoomba City is the principal activity centre for the Darling Downs and for many of the rural towns west of Ipswich. Toowoomba has a wide range of shopping, commercial, educational and entertainment facilities. The city area has a large central business district (CBD) and a number of suburban shopping centres as shown in Table 2.2. The CBD is busy and traffic volumes on inner city streets are periodically high.

Toowoomba CBD has developed as a multi-functional mixed-use activity centre incorporating retail, commercial office, entertainment, community services and residential activities. These uses make it an important focal point for economic activity and community life. The CBD has changed significantly in the past few years with the two-way of Russell St, the development of the outer circulating road, the building of

the new library, the activation of Civic Square, the QIC Grand Centre development, the ongoing transformation of Walton Stores and the streetscaping projects in the northern part of the CBD.

Currently, Toowoomba CBD floorspace for retail is 187,000 m2, office is 74,500 m2 and for bulky goods is 30,000 m2. This indicates that the predominant activity is retail (Humphreys Reynolds Perkins Planning Consultants 2009). Grand Central is the largest retail centre within the Toowoomba CBD, with an estimated 90,000m2 of floor space (AGC 2016). The majority of this centre (96.5%) is occupied by retail tenancies (Humphreys Reynolds Perkins Planning Consultants 2009).

Table 2.1: Demographics, economic and traffic conditions for some regional cities in Australia

Regional City	Type of Regional City	Population (no.)	Retail Trade % (2016)	Technicians and trades workers-- as % of Total Employed (2016)	Total number of Businesses by Industry (2016)	Approx. AADT in Main Street (2014)	Registered motor vehicles (%)		
							1 Motor Vehicle	2 Motor Vehicles	3 or more Vehicles
Albury, NSW	Inland	51,076	11.5	14.7	4,493	22000	37.6	35.9	15.0
Ballarat, Vic	Inland	101,686	11.3	14.4	8,082	21000	35.9	36.9	16.7
Ballina, NSW	Coastal	41,790	11.6	13.7	4,138	22000	37.3	38.0	15.2
Bunbury, WA	Coastal	31,919	12.1	17.8	3,011	18370	37.2	36.7	15.7
Burnie, Tas	Coastal	18,895	13.3	14.3	1,153	10784	38.2	34.1	16.1
Cairns, Qld	Coastal	156,901	10.6	15.0	13,646	50000	36.5	37.0	15.4
Coffs Harbour, NSW	Coastal	72,944	12.2	13.5	5,667	26000	37.7	36.3	15.8
Greater Bendigo, Vic	Inland	110,477	11.4	14.5	7,726	27000	32.8	37.9	19.8
Gympie, Qld	Inland	49,559	11.4	15.8	4,351	22000	35.0	35.6	20.5
Horsham, Vic	Inland	19,642	11.8	14.3	2,149	17000	33.0	36.2	20.7
Launceston, Tas	Coastal	65,274	12.3	13.1	5,273	26000	37.7	32.7	16.4
Mildura, Vic	Inland	53,878	12.3	13.5	5,205	17000	32.8	35.7	19.9
Muswellbrook, NSW	Inland	16,086	8.8	20.0	1,006	19000	33.1	37.7	18.2
Port Augusta, SA	Coastal	13,808	11.6	13.6	602	16000	37.5	32.7	15.9
Port Hedland, WA	Coastal	14,469	6.7	25.3	746	11000	27.2	39.2	23.5
Townsville, Qld	Coastal	186,757	9.9	15.1	12,006	25000	33.7	39.5	18.1
Toowoomba, Qld	Inland	160,779	9.5	15.1	15,394	23000	33.6	37.1	20.3
Wagga Wagga, NSW	Inland	62,385	10.9	15.6	5,291	12000	34.1	37.8	18.4
Wentworth, NSW	Inland	6,794	8.3	12.8	731	5000	27.7	39.3	21.2
Wodonga, Vic	Inland	39,351	11.1	16.6	2,786	25000	33.4	40.4	17.5
Average			11.0	15.5			34.7	36.8	17.9
Standard Deviation			1.56	2.85			3.10	2.02	2.43

Source of Population, Retail Trade, Technicians and trades workers, Number of Businesses by Industry and Registered Motor**:** Australian Bureau of Statistics (ABS), 2016. 2016 census. *Australia. Queensland .Local Government Areas*. Date accessed: 21/03/2020. Available at: https://itt.abs.gov.au/itt/r.jsp?databyregion#/

Source of AADT: Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2014. *Traffic on the national road network, 2013–14.* Australian Government. Date accessed: 12/07/2020. Available at: https://www.bitre.gov.au/sites/default/files/is_080.pdf

Table 2.2: Important Shopping Centres studied in Toowoomba

No.	Shopping Centres	Retail Floor Area (m^2)
1	**Grand Central**	90,000**
2	**Kearney springs**	46,647*
3	**Clifford Gardens**	32,082*
4	**Wilsonton**	17,681*
5	**North point**	6,417*
6	**The range**	6,160*
7	**High street plaza**	5,220*
8	**Drayton**	3,563*
9	**Westridge**	2,720*
10	**Betros Bros**	1,568***

* Economic Associates Pty Ltd., 2013. *Commercial & retail land needs review – Component 1. 13002 Report Rev 0*. Toowoomba Regional Council. Date Accessed: 20/3/2020. Available at: http://www.tr.qld.gov.au/testcat/commercial-and-retail-land-needs-component-1-final-report

** AGC., 2016. Grand Central Shopping Centre Toowoomba. News. *Architectural Glass and Cladding Association.* Date Accessed: 16/3/2020. Available at: https://agcproducts.com.au/news/grand-central-shopping-centre-toowoomba/

*** Area measured in Google maps

2.4.3 CBD Congestion in Regional Cities

Increasing traffic congestion appears to be a problem in many CBDs around the world. For example in Saudi Arabia, the increase of population and car ownership in regional cities has resulted in a large increase in the number of trips to CBDs between 2004 and 2013 (Lillo 2014). The volume-to-capacity (V/C) ratio for main roads in the CBD of Kimberley (South Africa) were found to have increased significantly when assessment of traffic congestion for South African cities was studied by Das and Keetse (2015). The effects of increasing congestion in regions of the U.S.A are outlined in a paper by Hartgen, Fields and Moore (2009). Their conclusion was that congestion reduction needed to be a central element of regional economic development strategies in USA cities if economic competitiveness was to be maintained.

In Australia, research found that there was an average of 3.5 trips per person per day going to CBDs in different regional cities, regardless of distance of travel (Goudie 2002). This figure of 3.5 trips per person per day is quite high and represents heavy traffic flows in CBDs (Budge & Chesterfield 2011). For the period 2003-2013 the

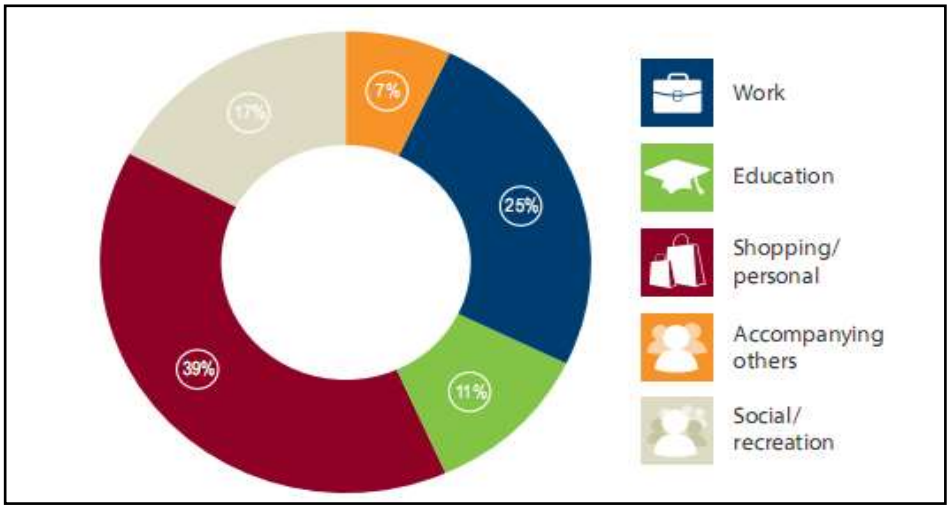
population of Queensland increased by an average of 2.2% per year. For 2012-2013, it was 1.9%. The average annual growth of the regional cities of Cairns and Townsville was 2.0% for both cities from 2003-2013 (Queensland Government Statistician's Office 2015). Queensland Treasury (2020) shows that the growth in Queensland's retail trade rate was 13.2%. This growth rate is the third highest retail trade growth rate in Australia, where Tasmania was the highest increase (15.0%).

Future economic and population growth in Toowoomba is expected to continue strongly until at least 2031. As a result of developments in economic and retail trade, traffic congestion is expected to increase. Transport strategy proposals to 2031 indicate significant levels of congestion by 2031 in the Toowoomba road network (Toowoomba Regional Council 2014), with 2031 daily traffic flows estimated to be up to 41,000 vehicles per day in some CBD streets such as James Street and Russell Street (Humphreys Reynolds Perkins Planning Consultants 2009).

Increasing population leads to increasing total car ownership. Analysis of the car ownership of the households in Toowoomba in 2011 shows that 87.7% of the households owned at least one car (Toowoomba Regional Council 2016). The current high percentage of vehicle ownership, plus increasing population, means that there will be increasing congestion on the streets of Toowoomba. Toowoomba as a regional city has a high percentage of shopping trips and as such new traffic management strategy for Toowoomba would be appropriate to cope with further growth of the city and improve overall access. The solution is to look for new technical solutions to manage the congestion in this regional city and current technology allows the use of road and parking pricing to help solve congestion. Road pricing and increasing parking pricing have achieved reductions in congestion in large overseas cities and the same underpinning theories can be for Australian regional cities.

- **Shopping Trips in Central Business Districts**

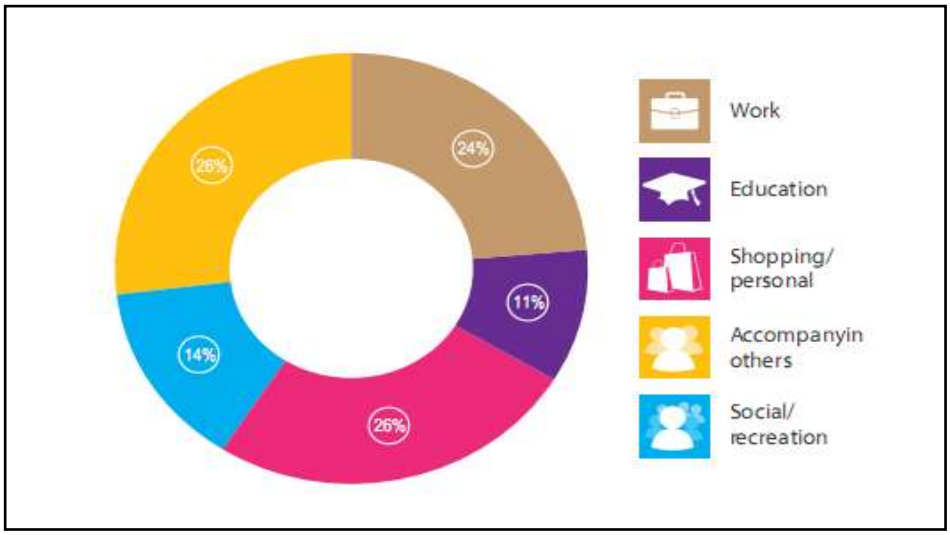
The purpose of trips which cause congestion are different in the CBDs of regional and capital cities. The most common reason for making a trip and congestion in regional cities such as Cairns is for shopping (Transport and Main Roads 2015). Figure 2.2 below shows the proportion shopping trips are 39% for all trips in terms of primary purpose of the trip.



Source: Transport and Main Roads., 2015. *Household travel in Cairns: A summary of results from the 2014 Cairns Household Travel Survey*. Queensland Government Department of Transport and Main Roads. Date accessed: 4/06/2020. Available at: https://www.publications.qld.gov.au/dataset/queensland-travel-survey/resource/128fd4ac-52f1-458c-894a-9fb5f2edf5f9

Figure 2.2: Proportion of all trips made in Cairns in terms of primary purpose of the trip

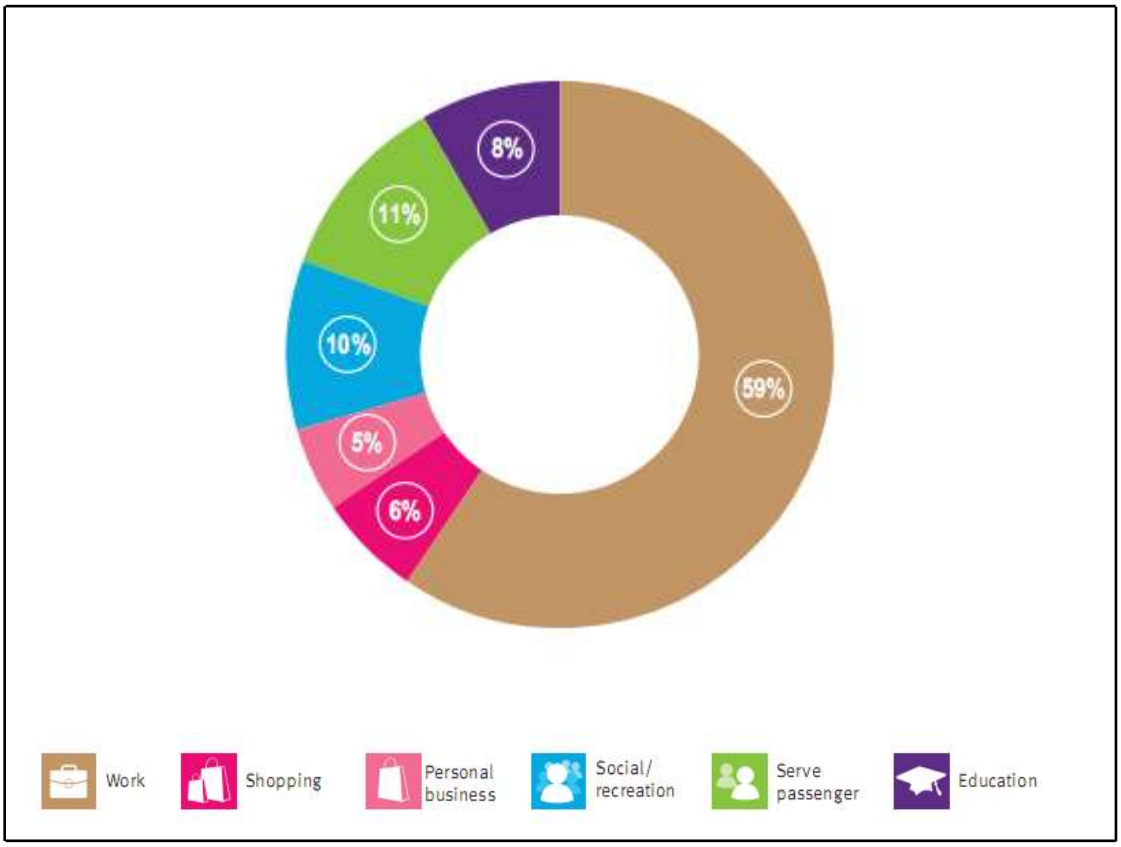
The similar percentage of shopping trips in Toowoomba, as shown in the pie chart below, was 26% (Transport and Main Roads 2012):



Source: Transport and Main Roads., 2012. *Household travel in Toowoomba: A summary of results from the 2011 Toowoomba Household Travel Survey*. Queensland Government. Date accessed: 4/06/2020. Available at: https://www.publications.qld.gov.au/dataset/queensland-travel-survey/resource/20b0174b-a500-43b3-8d25-90ee9c946696

Figure 2.3: Proportion of all trips made in Toowoomba in terms of primary purpose of the trip

As stated earlier, the purpose of trips and causes of congestion are different in the CBDs of capital cities such as Brisbane. The Brisbane CBD has a very high density of jobs, and this is reflected in the dominance of the trip profile by work trips. The CBD surrounds have a greater proportion of social and recreation and education trips. Figure 2.4 shows the percentage of trips according to purpose for the CBD of Brisbane:



Source: The State of Queensland., 2012. *Travel in south-east Queensland*. Queensland Government. Department of Transport and Main Roads. Date accessed: 4/06/2020. Available at: https://www.publications.qld.gov.au/dataset/queensland-travel-survey/resource/4a42e431-82bc-48b6-a41a-4539283b3e0d

Figure 2.4: Proportion of all trips made in Brisbane in terms of primary purpose of the trip

The percentage of work trips was 59% (The State of Queensland 2012) and it is obvious that much congestion in the CBD of regional cities is more likely to be caused by shopping trips than by work trips.

2.4.4 Literature Gaps

The issue of traffic congestion is an international problem as the literature has shown. The pricing of roads and parking is a relatively new strategy for congestion management and the research has shown pricing to be an effective solution for easing congestion in large cities. The review of the contemporary literature has shown however, that such research has not been significantly extended to Australian regional cities. Toowoomba City has been identified as a good regional city case study to investigate the impact of implementation of pricing strategies in congestion management in regional cities.

The following points summarizes the gaps in the past studies when applied to regional cities. This research addresses those gaps.

1- Causes of congestion in regional cities.
2- Variables controlling shopping trips in regional cities.
3- Habits of shopping in CBD's of regional cities.
4- Habits of parking in regional cities.
5- Opinions of people on possible level of road pricing in regional cities.
6- Using road pricing as solution to ease congestion in regional cities.
7- Increasing parking pricing to relieve congestion in regional cities.
8- Habits of shopping at the CBDs in regional cities after pricing.

2.5 Conclusion

This chapter examined the international contemporary literature and reviewed related past studies, reviewed information on congestion studies, road pricing, parking pricing and the impact of shopping centres on congestion. It outlined the rationale for the selection of Toowoomba as a case study area.

The gaps in previous studies were also identified and the research planned to investigate strategies to reduce congestion in the CBD road networks of regional cities was outlined. While previous research has shown that road pricing and parking pricing have potential for reducing congestion in large urbanised cities those strategies have not been investigated for the road networks of regional cities.

Chapter Three

Research Methodology

3.1 Introduction

This chapter describes the methodologies employed to determine and obtain the data sets required to design and construct the model. It covers the design and construction of a questionnaire to obtain data related to demographics, shopping habits, CDB trips, and road and parking pricing. The processes adopted were:

- Determining the data necessary, deciding on an appropriate type of survey, and determining the objectives of the survey. These are described in sections 3.2 to 3.5.3 of this chapter.
- Designing and constructing a questionnaire to gather the required data. There were two sets of questions included in this study. The first set of questions regarding demographic data, shopping habits and CBD trips formed the first part of the survey document. The second set of questions which dealt with road pricing and increasing parking pricing formed the second part of the survey. Both sets of questions are described in sections 3.5.3 to 3.6; and
- Analysing the data using the Statistical Package for the Social Science (SPSS). This is described in section 3.6. Further analysis of the data is included in chapter six of the thesis.

3.2 Overall research approach

The CBD of Toowoomba forms an important hub for the city, occupying a large area and characterized by many shops, recreational facilities and commercial activities. It includes a large shopping complex/mall (Grand Central), which is much bigger than other shopping centres located within and around Toowoomba. Grand Central contains a large range of items and various products and is characterized by its area, the number of large shops, and its variety of smaller shops. These meet the various requirements of a diverse range of people, including many refugees and students attracted to Toowoomba in recent years. The complex as the largest integrated shopping area in Toowoomba, makes it the destination of many shoppers from across the Toowoomba region. The Grand Central complex was expanded in 2017 to provide more shops, items and services.

The CBD area surrounding Grand Central includes other important shops and commercial services such as medical and social services. As a result of this concentration of shopping and services the major roads leading to the CBD experience traffic congestion, especially at shopping peak periods at late morning and early afternoon. As vehicle volumes continue to increase a solution needs to be found to best suit the ongoing development and expansion of the CBD. Methods that differ from the usual costly physical infrastructure solutions need to be considered and investigated.

This research considers varying the attractiveness of CBD shopping in Toowoomba, by the selective application of road and parking pricing strategies. As discussed earlier, road pricing has been successful in alleviating congestion in very large cities in other countries and it is expected that appropriate road pricing for major roads surrounding and leading to the CBD of Toowoomba would relieve the congestion. Since the CBD is relatively small, it is likely that such pricing could only be needed on certain days of the week and at specific times to reduce congestion. Also, increasing the pricing of shopping centre parking, and the fees for other types of parking in the CBD, would also assist in reducing congestion.

In order to investigate the application of road and/or parking pricing on congestion in the CBD of Toowoomba it was decided to model the application of these strategies based on the existing traffic flow. The following underpinning information was required as data to be used to design and develop the transport model to be able to effectively and efficiently predict likely travel patterns as road and parking prices were varied.

1. Demographic characteristics of Toowoomba's suburbs.
2. Statistical data on the current shopping behaviour of people in Toowoomba and surrounding areas.
3. The likely impacts on shopping behaviours if road pricing were introduced or parking prices were varied.

3.3 Gathering of existing data and identification of its limitations

The major source of existing data for the research was the Australian Bureau of Statistics (ABS). ABS publications include many statistics for Toowoomba suburbs (ABS 2016), including:

- People (e.g. demographics, education, cultural, language diversity and employment).
- Families (e.g. family composition and employment status of couple families).
- Dwellings (e.g. dwelling structure, household composition and mortgage, and rent).
- People's employment and information about travel to work and other information about workers (e.g. information about employed people aged 15 years and over who travel to work).
- Mode of traveling for each suburb in Toowoomba such as people who travelled to work by public transport and people who travelled to work by car as driver or passenger.

The ABS publications do not include the following statistics for Toowoomba suburbs:

- Information about shoppers and people's shopping trips.
- Mode of travel for shopping.

Also, the other types of survey trips such as household travel survey do not include the specific information for shopping trips in Toowoomba such as destination of shopping, number of shopping trips, and number of shopping trips at roads of Toowoomba.

In addition, information was also sought from Toowoomba Regional Council (TRC). TRC did not have shopping traffic data, however it had data on the total traffic volumes across its road network. The traffic volumes represented all types of trips within the network but lacked any classification of shopping trip data.

3.4 Identification of new data required

Having considered the existing data available from ABS and TRC, it was decided that the following additional data was needed for the research:

- The demographic characteristics of people involved in shopping in each suburb, in the form of age groups, gender and average people per household. This assisted in providing a profile of the predominant demographic characteristics that govern shopping activity in Australian regional cities. Data on private dwellings and demographics was obtained from the ABS to assist with data verification.

- S Vehicle statistics of each household to investigate motor vehicle ownership and use for shopping in Toowoomba. This helps to understand the effect of economic conditions on the decision of shoppers to change their CBD shopping destination as a result of road pricing and increasing parking pricing.
- Data about shoppers and their mode of travel for shopping. This helps investigate the shopper's characteristics and shopping habits currently and after road pricing and increasing parking pricing.

3.5 Development and application of shopper survey

The questionnaire was constructed to provide information on shopping behaviour and the relationship of that behaviour with demographic characteristics. The survey was distributed to a sample of people in 18 residential zones plus the other four outer zones (Table 3.1) of Toowoomba to collect information about their demographic characteristics, their shopping habits and their mode of travel to shopping. Shopping habits, parking habits and likely behavioural changes and parking for increased parking fees and charging for roads were also assessed. The survey obtained 304 responses, which were then analysed. The following sub sections of this chapter consider; the planning of the survey, the gathering of the data and the results of the survey and discussion of those results.

3.5.1 Type of survey

Interviews, focus groups, and observation are methods of data collection (Frechtling 2002). An investigation of these techniques found certain limitations for this study. One of the disadvantages of interviews is the inconsistencies across interviews as a result of flexibility (Frechtling 2002). There is also a concern that the participant might be uncomfortable sharing information, so the interviews need more cooperation from the participants to achieve reliable data collection. Thus there was a concern that interviews are not suitable to provide the information for this study that needs cooperation of the participants and needs a large number of participants. The feature of focus groups is the use of group interaction to generate insights and data (Frechtling 2002), but focus groups have drawbacks such as lack of privacy in addition to the potential for one or two participants to dominate the group. Also, given that

observation techniques are expensive and time consuming (Frechtling 2002), focus groups and observation methods are not suitable methods for accurate data collection in this research. The important aspect of answering the research question of the possibility of reducing congestion to the CBD, is achieved through obtaining accurate information for shopping trips. This information was insights into four subtopics, was sought through questionnaires from a large number of participants. The questionnaire has advantages such as that the respondents can answer questions in their own time, also the questionnaire provides anonymity that may encourage participants to answer more honestly. So, the questionnaire was the most suitable data collection technique to obtain the information needed to answer the research question.

The research aims necessitated the use of a questionnaire to obtain quantitative data from shoppers across Toowoomba. The questions posed were both of the yes/no type and open ended types that allowed respondent's reflection. The final survey was administrated in both hard paper copy format and as an on-line survey using Lime Survey. LimeSurvey is regarded as an excellent open online source survey tool used by educational institutions in over 19 countries (Iku Anket n.d). It is a free survey application that presents a powerful and flexible way for survey creation and administration. The web application allows development and publishing of online multi-lingual and multi-question surveys (Jayasundara, Wickramasuriya &Shakila 2010). LimeSurvey allows users to quickly construct intuitive, online question and answer surveys for tens to thousands of participants. A survey contains through various interconnected databases: languages, questions, sub questions, question groups, question attributes, default answers, answers, assessments, quotas, quota members and settings of quota language (LimeSurvey n.d).

3.5.2 Objectives of Survey

To assist with the design of the survey a matrix was constructed linking the objectives with the need and how to obtain information and ranking each objective from High to Low Importance.

Objective	Why the information needed	How to gather information	Rated importance
To investigate the no. of trips for each zone to the shopping centres.	To investigate the congestion which results from shopping trips to the shopping centres in CBD and the zones.	By computing number of trips between the zones and number of trips to the CBD.	High Importance
To investigate the suitable cost of parking when the shopper park at CBD.	To relieve congestion in CBD by managing the parking in controlling on its pricing.	By gathering information of time spending inside of shopping centres in CBD, knowing which location are preferred to park for each direction.	High Importance
To investigate the effects of road pricing on behaviour of shoppers.	To estimate no. of trips to the CBD after introduction of road pricing.	By knowing the shopper's behaviour after introducing the road pricing**,** such as (estimating the new shopping trips, times of shopping, time and day of shopping, mode of going to shop and time spending inside of shopping centres in CBD.	High Importance
To identify the important variables of shopping activities in each zone as example: Gender, age, no. of people in each household, and Motor vehicles).	To identify the key variables governing shopping activities in each zone.	By knowing household characteristics for each zone (age ….etc.).	Medium Importance

Objective	Why the information needed	How to gather information	Rated importance
To investigate using public transport.	To reduce congestion result from using private cars by charging these types of cars when they are going to shop.	By knowing the mode of going to shop	Medium Importance
To investigate the order of the highest directions export shopping trips to CBD and other shopping centres.	To arrange the directions according to no. of shopping trips to CBD and other shopping centres.	By knowing times of shopping per month in each direction.	Medium Importance
To investigate the most congested roads around the CBD.	To investigate congestion in the roads of the CBD.	By knowing what road they use when they are going to shopping centres in CBD.	Low Importance
To determine the most congested hours of day and days of week.	a) To determine the peak hours periods and peak days for shopping for each zone to distribute the shopping trips by introducing a CBD congestion charge during peak periods on most shopping days. b) To check the differences between current shopping situation and the situation after pricing.	By gathering information about the usual shopping time of day and days of shopping for each zone.	Low Importance

An analysis of the matrix resulted in the final questionnaire having 19 questions arranged in five groups of general information, usual habits for shopping, central business district trips, parking in the CBD, and road pricing for the CBD. The literature indicated that the questionnaire should fall in the 10 to 25 questions range to optimise responses (May 2010).

The survey took approximately ten minutes for a respondent to answer as determined through a pretesting survey, as explained in later paragraphs. The researcher designed and managed the survey.

Appendix A.1 provides a copy of the questionnaire used in the research.

3.5.3 Validity and Reliability Testing of Questionnaires

Measuring the accuracy and consistency of research instruments (particularly surveys) is known as validity and reliability (Bolarinwa 2015). The accuracy of the questionnaire necessarily leads to the accuracy of the findings. As part of the creation of the survey validation tests were undertaken in the research preparation stage before the field survey was conducted. The validation included internal validity, external validity, face validity and reliability.

- **Internal validity**

Internal validity of the survey refers to the accuracy of the questionnaire results. A survey's internal validity reflects the confidence that the survey design and implementation have minimized or eliminated bias and that the findings are illustrative of the true relationship between exposure and outcome. Bias is the tendency of a statistic to overestimate or underestimate a parameter (Chaplin et al. 2018). Bias can cause estimates of association to be either larger or smaller than the true relationship. It can occur as a result of sampling or measurement errors.

The study was designed to minimize bias in survey design and implementation by giving consideration to participant difference across a wide range of factors, such as gender, age, suburb of residence, and the number of persons in family. Each participant was classified in the appropriate categories; gender consisted of four categories (female, male, other, and no answer) and age group had five categories (15-29 years, 30-44 years, 45-59 years, 60-74 years, and 75 years and over).

Residences consisted of all 22 relevant Toowoomba suburbs (Table 3.1) plus 4 external zones to ensure procurement of data from all sex and age categories across Toowoomba. There was no limitation on the number of persons in a family that could participate, which helped to create knowledge on behaviour by different sized families with different levels of income.

The second type of bias occurs at the time individuals are selected for study inclusion (Pannucci and Wilkins 2010). During the implementation of the survey stage of this research, the random sampling of participants was undertaken with the assistance volunteers from students and staff of at the University of Southern Queensland (USQ), and staff from primary school and churches in Toowoomba. Randomized studies where the outcome is unknown at the time of enrolment are less prone to selection bias (Pannucci and Wilkins 2010). The selection process minimised bias in the distribution of the survey for this research.

- **External validity**

External validity is the validity of generalization (possibility causative) to represent the results of the study to other situations and to other people (Chaplin et al. 2018). The results of this survey can be generalized to larger populations. For example, the sample of each suburb can be broadened to all of the people in the suburb because of the stable situations in aspects of availability of shopping centres and travel distance of shopping to the CBD or the nearest shopping centres. The samples from each suburb can reflect the true situations in that suburb and the results can be generalized.

- **Face Validity**

Face validity is a part of content validity. It is established by a survey expert reviewing the questionnaire of the researcher and concluding that it measures the characteristic or trait of interest (Bölenius et al. 2012). Face validity includes the expert looking at the items in the survey and concurring that the test for the idea which is being measured is a valid measure just on the face of that idea (Sangoseni et al. 2013). This implies they are assessing whether each of the measuring items is suitable for any given conceptual domain of the idea. In this study, the questions of survey were developed to achieve the concept of face validity, each question in the survey was carefully constructed to ensure it would be understood by participants, gained accurate information and achieved suitable data for the research. To ensure face validity the

design of the survey was examined by the supervision team for the research, as well as by a professional university librarian and an experienced statistician.

After initial design of the questionnaire, it was further evaluated in three steps: pre-testing, pilot testing and the actual field survey. The survey instrument required very little change in the first two steps. The pre-testing step demonstrated that the survey questions were well understood and sufficient to meet the objectives of the research. The first version of the questionnaire was administered online and hardcopies to pre-test the instrument among 20 participants. The benefits of pre-testing the survey were estimating the questionnaire completion time, which averaged approximately ten minutes, and improving the appearance of the questions of the survey in terms of spelling, grammatical structure, font type and design, and structure. Comments from pre-testing respondents resulted in the addition of explanatory maps or extra text. The final version of the questionnaire dealt with all the results, feedback and comments from the pre-testing survey.

- **Reliability**

Reliability is the degree to which any measurement procedure, or a questionnaire produces the same results when replicated (Bolarinwa 2015). Reliability needs to access the instrument used over time. In the research, the reliability was tested for two purposes. First for assessing the measurement instruments by checking the answers in two methods of collecting the data (on-line survey and hardcopies). Second for testing the answers reliability of the sample by testing them at different times. Paper copies and on-line survey were used at two times, first time on 29 November 2017 and second time on 3 December 2017. By sending the survey to the same sample of participants (40 respondents) reliability was assessed by comparing the two sets of answers.

Assessing measurement instrument reliability was achieved by a commonly used method for testing and composite reliability, namely the use of Cronbach's alpha test (available on SPSS software). Gefen et al. (2000) suggests that a reliability value above 0.7 is satisfactory. The reliability of the questionnaire was demonstrated to be satisfactory with values between 0.74 and 1.0 as is shown in Appendix A, Table A.1.

3.5.4 Ethical Considerations

Australian law imposes general and specific responsibilities on researchers and institutions to govern human research and ensure participant rights. Institutions are responsible for establishing procedures for the ethical review of human research. The degree of risk involved in the research determines the level of review that should be undertaken at various levels. Human research proposal must meet the requirements of the National Statement and be ethically approved before research can begin (National Health and Medical Research Council 2015).

The main issues in the National Statement related to the research were:

- **Recruitment of USQ employees and students (as participants)**

Since the research involved the recruitment of USQ students permission was sought and obtained from the Deputy Vice-Chancellor (Students and Communities). Also, since the research involved the recruitment of USQ employees permission to recruit staff was obtained from the Senior Deputy Vice-Chancellor.

- **Benefit and Risk**

The research must justify any risks of harm or discomfort to participants. The likely benefit may be to the wider community, participants or to both (National Health and Medical Research Council 2015; British Psychological Society 2013).

It was expected that this research would benefit the Toowoomba community and participants by providing more equitable access to the CBD shopping centre for the general population through integrated traffic congestion control techniques.

There were no anticipated risks beyond normal day-to-day living associated with participation in this research.

- **Data Access and Security**

The survey responses were received by the website provided by LimeSurvey and soft data was stored on a USQ very secure storage area. Hard copies of survey responses were scanned and saved to a password protected computer and paper copies were stored in a locking filing cabinet before shredding.

- **Participant Overview**

Members of the community were participants in the survey. Invitations were extended to a school and several churches of Toowoomba with the request to forward the survey to staff and others who may be able to participate. Posters were also displayed on advertisement boards of the Refectory at the USQ Toowoomba campus to recruit students.

Parties who were invited to be participants in the research included:

- Investigative team,
- Participants (snowballing) and,
- Third party organisations (who forwarded the invitation of the researcher onto other participants).

- **Criteria Questionnaire Distribution**

The people who answered the questionnaire were shoppers. The respondents were from Toowoomba community from churches, students and staff of the University of Southern Queensland (USQ), community groups at USQ, and staff of a local primary school.

The random distribution of the survey was used in order to avoid bias in the sample. The questionnaire distribution was organized using the principle of equitable distribution. The principles of the program were based on:

1. Non-limited geographic distribution. The survey distribution covered all four directional areas of Toowoomba. It was distributed in churches located in the four directions, the distribution was not in a specific directional area. The survey was also available through the USQ Community Noticeboard group and posters. The USQ community is from different geographic locations in Toowoomba, they are not from a specific directional area.
2. Non-specific gender or age group. The survey was distributed to different gender and age groups. The churches receive people from different gender and age groups. The community groups of USQ and school are also mixed males and females and age groups. So, there was no bias for specific gender or for age groups in the distribution of the survey in communities and in churches.

3. Non-influenced answers. This was achieved by using suitable techniques for collecting data from the participant. The questionnaire method helped the participant to answer comfortably and limit any potential influencing bias.
4. Non-particular ability for answering. This was achieved by providing two versions of the survey, one electronic (LimeSurvey) and one in hardcopy. The LimeSurvey tool facilitates participants who prefer using technology, and hardcopies serve respondents who do not have the ability to answer using technology.

Questionnaire distribution was valid and reliable because it used the correct method of recruiting participants, this was by allowing both male and females and all age groups from different abilities the opportunity to respond to the questionnaire in ways that reduced potential limitations.

- **Data Collection Methods**

Participants were invited to participate in an online or paper-based survey. The online survey was hosted by the online LimeSurvey with completed surveys being returned through clicking the 'submit' button. Paper based surveys were distributed to participants directly by the researcher or left at third party organisations with a collection box for participants to return a completed survey. The survey collection boxes were monitored by the administration at the third-party organisations, with the researcher collecting surveys on a regular basis. No personal/ identifiable information was requested from participants.

- **Documentation**

The USQ Human Research Ethics Committee required attaching the approval of the assisting institutions which would contribute to distribution of the questionnaire and approval was obtained from the school and churches involved.

The research commenced only after ethical approval was granted by the USQ Human Research Ethics Committee after satisfying all required conditions.

3.5.5 The Pilot Study

To improve the data collection method a pilot study was conducted to evaluate the feasibility in terms of such as time and cost before administering the final survey. The pilot study helped to estimate sample size based on response rate, evaluate the research

instrument, and confirm the reliability and validity of the trial results (Van Teijlingen & Hundley 2010).

The pilot survey was provided to 40 respondents with 34 answering the questionnaire for a response rate of 0.85. It was concluded that the survey was relatively easy for the respondents to answer, confidential, cost effective and easy for the researcher to collect and analyse.

- **Methods of Pilot Study**

The pilot study was distributed to 40 people, representatively across suburbs with the 34 answers covering all suburbs. The respondent's home location/suburb was determined by people known to the researcher. Those people were from the four direction areas of Toowoomba, and they helped to provide the respondents' contact through social media to the researcher. The researcher contacted each participant via social media and subsequently provided a formal email with the link of the survey. Paper copies of the questionnaire were sent to the people who preferred paper copies. An information sheet including the ethics approval number was provided to all participants.

3.6 Actual Field Survey

3.6.1 Collection Procedure and Competence

To ensure that participants understand the intent of the survey and that participation was to voluntary the noted to participants and to the third parties:

1- The benefits of the research.
2- The two methods of completing the survey (online website and/or hard copies)
3- The fact that the survey did not need any identifiable or personal information
4- The approximate time taken to complete the survey.
5- Contact details for the USQ Human Research Ethics office
6- Details on how to contact the principal researcher and supervision team

Finally, if participants agreed to take part in this research, they were asked their preferred method of undertaking the survey.

3.6.2 Field Survey

The range of appropriate sample size for this type of study is from 30 to 500 (Roscoe 1975, in Halim & Ishak 2014). A sample size of more than 500 will cause problems leading to error (Halim & Ishak 2014). This will also effect the formation of an accurate picture of the population (Sekaran 2000, in Halim & Ishak 2014). Thus, Sekaran (2000) suggested that the ideal sample size is not too large (500) and not too small (Sekaran 2000, in Halim & Ishak 2014). Thus, the sample size for this study within the acceptable range.

The field survey was the primary method employed to gather information which was not available through secondary sources. LimeSurvey had the ability to receive the answers directly after participant submission and also the ability for data to be entered from papers by the icon of Data Entry and the data from 55 paper based responses were entered this way. The total responses received was 359, including 304 full responses and 55 incomplete responses. The response rate for the main survey also was 85%.The data was exported to Excel software for data cleansing, sorting and coding prior to importing into SPSS software version 24 for additional data coding and analysis. Details of quantitative analysis procedures and findings are provided in the next section.

3.6.3 Traffic Count Survey

In this study, a traffic count survey of six Toowoomba shopping centres was undertaken in order to validate the Toowoomba shopping trips model. The constructed model outputs are the values of estimated assigned shopping trips on Toowoomba network roads. The estimated shopping trips were compared to the observed shopping trips to verify that the modelled trips represent the observed trips.

A traffic count survey was run for six weeks. It was run for the six shopping centres shown in Table 5.9. One week observed for each shopping centre on the weekdays from Monday to Sunday, from 8 am to 8 pm except Saturday and Sunday where the observation was from 9am to 6 pm. The observations work required (8) observers working for six shifts, each shift was 2 hours, each two observers working for two hours at one shopping centre road entrance. The number of shopping trips was counted for each day. Then, the average shopping trip was counted for the seven days for each road entrance of the shopping centre. This represented the counting procedure of

observed shopping trips to the shopping centre. The same procedure of observation was repeated for each shopping centre to obtain the observed shopping trips to shopping centres.

3.7 Data analysis

In order to analysis the data using SPSS, the data must be classified to a specific level of measurement, with a label that depends on the type of data (nominal, ordinal and scale). The Ordinal variables are the variables which have two or more categories that can be ordered or ranked (Mertler and Reinhart 2016) (McDonald 2016). In Ordinal variables, SPSS can rank the answers from the most positive, to the middle response, to the least positive. For example, the distance usually travelled to shop ("less than 1Km", "1Km-5Km", "over 5K"), The Nominal variables have categories, but they do not have a natural ranking or order. Example of the nominal variable would be classifying where people live in the suburb by direction from the city centre. Scale variables are measurement variables, in the sense that the variables have numeric values. These variables include a set interval between the ordered categories such as numbers of trips makes each week by each transport mode of travel. SPSS was used to: to summarise respondent's demographic characteristics; to describe details of variables of participant's shopping and parking habits, and to describe the shopping habits of respondents after pricing. The descriptive statistics were reported using a frequency distribution approach as explained in the next section.

3.7.1 General results of survey

The general results of the survey are described below but the full analysis of the results as they relate to road and parking pricing are presented in chapter six. Each respondent completed five groups of questions which were:

i. General information which included the demographics characteristics.
ii. Usual habits for shopping include shopping activities in zones.
iii. Central Business District Trips of the respondents.
iv. Parking habits in the CBD.
v. Road pricing for the CBD which includes respondent's habits after pricing.

An analysis of the survey data from the questionnaire follows:

- **General Information -Demographics Characteristics**

The survey was used to collect information about shoppers, and the results cross-checked with ABS census data. The purpose of cross-checking was to ensure the accuracy of shopping trips to the CBD represented by the survey data.

The demographic characteristics of interest were population, gender, age group, household size and motor vehicle ownership. In the research, demographic data on the respondents was collected using categorical variables shown in Tables 3.1 to 3.5. Overall, this data represented the variation in participants' shopping and parking habits.

In order to gain a macro view of travel patterns and shopping habits in Toowoomba, it was necessary to aggregate the survey data into a small number of larger regional zones within the city. The respondent data was therefore aggregated from the 18 residential zone plus the other four outer zones into four regional zones based on direction from the city centre. These four "super zones" were designated as North, South, East and West. Conceptually, this is one way that many people think of the distribution of population or facilities in Toowoomba (e.g. the number of people in the eastern area of Toowoomba or the number of parks in the northern area of Toowoomba).

A minimum sample size of 30 for each category is necessary where samples are to be broken into subsamples (males/females, juniors/seniors, etc.) (Roscoe 1975, in Sekaran 2000, in Halim & Ishak 2014). In this study the sample size for each category was more than 30. So, it has achieve the condition that noted by Roscoe (1975) and Sekaran (2000).

The criteria of achieving a random sample was taken into account when the survey was distributed to avoid bias and satisfy the validity and reliability for distribution of the survey. Table 3.2 shows that the majority of survey respondents were females (68.2%). This is possibly because males do not shop as frequently as females in the CBD and saw no reason to participate. The differences between survey data and ABS data shown in Table 3.2 are less than ±20%. The maximum average differences in table 3.2 was 16.2. There is a reasonable discrepancy between gender sample and ABS. The shopper in the family should answer the survey. The most answering the questionnaire was females because they are the shoppers. In a situation such as this it

is almost impossible to achieve a completely unbiased sample. The sample size from each of the four directions was sufficiently large to give a reasonable reflection of the shopping habits of the total population of that direction.

The data in Table 3.3 shows that the majority of respondents were from the ages between 30 to 74 years. These results of the survey are typical in terms of ABS data as seen in Table 3.3. The differences shown in this table indicate an acceptable level of divergence between the ABS data and the survey results and it can be concluded that age group is an acceptable variable to use in the study.

As shown in Table 3.4 and the details in Appendix B, Table B.1**, s**urvey question four provided information on household size for the sample from each zone**.** The survey results for the household size are reasonable with the greatest variation between ABS data and survey data being 0.5% for the north and west directions.

The data in Table 3.5 shows that most households in Toowoomba have 1 or 2 vehicles and the full details in Appendix B, Table B.2. The number of households with more than 2 vehicles is small and the overall results of the survey are congruent with the ABS data. Table 3.5 shows most of the differences between ABS and survey data were within ±10%.

Table 3.1: Comparison of ABS Data and survey for population for each direction

Direction	Zone	Population						
		ABS			Survey			Diff. of percentages (%ABS-%Survey)
		Population of Zones	Total Population of Direction	Percentages of the direction people from the total population	Count of Sample		Percentage of the direction Sample from the whole sample	
					Zones	Directions		
North	Harlaxton	2547	19537	*18.4	8	58	19.1	-1
	North Toowoomba	2953			15			
	Rockville	3237			16			
	Wilsonton Heights	2669			9			
	Outer Northern Areas (Highfields)	8131			10			
South	Darling Heights	5192	26961	25.4	20	118	38.8	-13
	Kearneys Spring	8552			22			
	Middle Ridge	7141			42			
	South Toowoomba	5224			22			
	Outer Southern Areas (Top camp)	852			12			
East	Centenary Heights	6063	25408	24.0	11	64	21.1	+3
	Mount Lofty	3775			10			
	Rangeville	8312			24			
	Redwood	170			5			
	East Toowoomba	5244			6			
	Outer Eastern Areas (Withcott)	1844			8			
West	Drayton	1710	34036	32.1	7	64	21.1	+11
	Glenvale	6353			14			
	Harristown	8555			15			
	Newtown	9596			10			
	Wilsonton	5955			10			
	Outer Western Areas (Kingsthorpe)	1867			8			
Total Population			105942					

*(19537/105942)*100=18.4

Table 3.2: Comparison between ABS data and survey of gender for the four directions of Toowoomba

Direction	Total Sample	Total Population of Direction	ABS				Survey				Diff. of percentages (%ABS-%Survey)	
			Male		Female		Male		Female		Male	Female
			Count	(%)	Count	(%)	Count	(%)	Count	(%)		
N	58	19537	9599	*49.1	9938	50.9	22	37.9	36	62.1	+11.2	-11.2
S	118	26961	12948	48.0	14013	52.0	37	31.4	81	68.6	+16.6	-16.6
E	64	25408	12064	47.4	13344	52.6	19	29.7	45	70.3	+17.7	-17.7
W	64	34036	16035	47.1	18001	52.8	18	28.1	46	71.9	+19.0	-19.1
Total							96		208			
Average				47.9		52.1		31.8		68.2	+16.1	-16.2

*(9599/19537) *100

Table 3.3: Comparison of ABS data and survey of age groups for the four directions of Toowoomba

Dir.	Total count	Total Sample	ABS										Survey										Diff. of percentages (%ABS-%Survey)				
			15-29 Years		30-44 Years		45-59 years		60-74 years		75 years and over		15-29 Years		30-44 Years		45-59 years		60-74 years		75 years and over		15-29 Years	30-44 Years	45-59 years	60-74 years	75 years and over
			Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)					
N	15564	58	3754	*24.1	3425	22	4024	25.9	3090	19.9	1271	8.2	9	15.5	17	29.3	13	22.4	9	15.5	10	17.2	+8.6	-7.3	+3.5	+4.4	-9.0
S	21586	118	5698	26.4	5193	24.1	4527	21.0	3734	17.3	2434	11.3	11	9.3	35	29.7	29	24.6	34	28.8	9	7.6	+17.1	-5.6	-3.6	-11.5	+3.7
E	20560	64	4576	22.3	4513	22	5183	25.2	4117	20.0	2171	10.6	6	9.4	12	18.8	23	35.9	19	29.7	4	6.3	+12.9	+3.3	-10.7	-9.7	+4.4
W	27559	64	7526	27.3	6152	22.3	5826	21.1	4898	17.8	3157	11.5	6	9.4	16	25.0	19	29.7	18	28.1	5	7.8	+17.9	-2.7	-8.6	-10.3	+ 3.7
Tot.													32		80		84		80		28						
Ave.				25.0		22.6		23.3		18.8		10.4		10.9		25.7		28.2		25.5		9.7	+14.1	-3.1	-4.9	-6.8	+0.7

*(3754/15564) *100

Table 3.4: Comparison of ABS data and survey for household size for each direction

Direction	Average Household Size (No. of Persons)				Diff. of percentages (%ABS-%Survey)
	ABS			Survey	
	Total direction households (A)	Total population of direction (B)	Average household size (no. of persons) for direction (B/A)	Average household size	
North	7714	19537	2.5	3.0	-0.5
South	10772	26961	2.5	2.6	-0.1
East	10584	25408	2.4	2.7	-0.3
West	14543	34036	2.3	2.8	-0.5

Average weekly shopping trips per household were close numerically and achieved by various modes. The four directions of Toowoomba have around the same range of weekly trips as shown in Appendix C, Table C.1. The percentage of total shopping trips from the four directions were very similar as was the average of weekly shopping trips per household. Table C.1 in Appendix C shows that Toowoomba households are usually undertaking between 2 and 6 shopping trips per week. This variation probably relates to the size of the families, the economic situation of the household, and the availability of transport options.

Table 3.6 also shows a low percentage of shopping trips by bus, and the preferred mode to travel to shop was by car. Most Toowoomba shoppers traveled a distance between 1 km and 5 km as shown in Table 3.7. More detail is provided in Appendix D, Table D.1.

Table 3.5: Comparison of ABS data and survey for motor vehicles owning

Dir.	ABS				Survey				Diff.			
	None (%)	1 Motor Vehicle (%)	2 Motor Vehicle (%)	3 or more Motor Vehicle (%)	None (%)	1 Motor Vehicle (%)	2 Motor Vehicle (%)	3 or more Motor Vehicle (%)	None	1 Motor Vehicle	2 Motor Vehicle	3 or more Motor Vehicle
North	19.1	38.5	34.6	15.6	9.3	52.1	24.7	13.9	+9.8	-13.6	+9.9	+1.7
South	4.9	32.0	38.9	20.9	6.4	41.5	39.4	20.3	-1.5	-9.5	-0.5	+0.6
East	3.7	29.2	39.8	20.8	11.1	29.3	34.3	25.4	-7.4	-0.1	+5.5	-4.6
West	7.6	35.3	35.3	18.5	8.8	35.4	34.9	20.8	-1.2	-0.1	+0.4	-2.3

Table 3.6: Shopping trips in a week with various mode in Toowoomba from the sample

Direction	Total Shopping Trips (Count)	Walking (%)	Bicycle (%)	Motor Bike (%)	Car (%)	Bus (%)	Taxi (%)
North	253	9	2	1	83	1	3
South	455	9	3	2	82	4	1
East	243	11	5	1	80	1	3
West	255	6	1	0	91	2	0
Average	302	8.8	2.8	1.0	84.0	2.0	1.8

Table 3.7: Percentage of people indicating distance between home and usually visited shopping centre

Direction	Less than 1 Km	1 Km - 5 Km	More than 5 Km
	(%)	(%)	(%)
North	6.9	55.2	37.9
South	6.8	77.1	16.1
East	9.4	65.6	25.0
West	7.8	68.8	23.4
Total	7.6	68.8	23.7

• Usual Habits for Shopping

The questionnaire survey allowed respondents to nominate their first, second and third favourite shopping centre and how often they attended each centre. The data on the number of shopping trips between the zones and the number of trips to the CBD provided information about the congestion caused by shopping trips in Toowoomba. The data was used later as input data for the Toowoomba shopping trips model to determine the distribution of daily shopping trips between the various zones and Toowoomba shopping centres. Table 3.7 and Tables E.1, E.2, and E.3 in Appendix E show that each zone has a high number of trips to the nearest shopping centre.

Shopping in the CBD of Toowoomba is influenced by the household and economic situation for each corresponding compass point area. Figures for shopping in the CBD from each of these areas were all high as seen in Table 3.8. The counts of CBD shoppers are shown in Tables 3.9 to 3.11 with details shown in Appendix F, Tables F.1, F.2, F.3, F.4 and F.5 for the top three preferred shopping centres. The reasons of the small differences in percentages of shopping for the four directions might be related to household size and economic situation, represented in the data by motor

vehicle ownership. In the east area of Toowoomba, the CBD shoppers were the highest percentages in motor vehicles ownership as shown in Table 3.9, with details in Appendix F, Table F.1. This was a likely reason for the high percentage of shopping in the CBD from the eastern area. The highest rate of average household size of the north area is shown in Table 3.8, which linked to the high percentages of motor vehicle ownership for this direction and the high percentages of the CBD shopping from the north. The similarity in the CBD shopping from the south and west result from the similarity in the high percentages of motor vehicle ownership and rate of average household size for those areas. The activity of shopping in the CBD in Toowoomba is seen to be influenced by the average household size and motor vehicle ownership.

Table 3.8: Total population with household size shopping trips to CBD

Direction	Sample	Average Household Size	Shoppers of CBD of Sample (Counts)	Shoppers of CBD of Sample (%)	Total population (ABS)	Projected Shoppers from Total Population
N	58	3.0	51	88	19537	17193
S	118	2.6	96	82	26961	22108
E	64	2.7	59	92	25408	23375
W	64	2.8	51	79	34036	26888
Total	304		257		105942	89564
Average		2.8		85		

As indicated previously survey results showed that the majority of CBD shopping is undertaken by females rather than males. The percentage of female CBD shoppers from each direction was more than 50% as seen in Table 3.10 with details in Appendix F, Table F.2. The percentages of females shopping in the CBD were higher from the east and west areas. Most of the shopping was done by females either because they were more interested in shopping, or they had the responsibility of shopping. Because of these high percentages of females the opinion, attitudes, and behaviours of females on shopping after any implementation of road or parking pricing were important to investigate.

Table 3.9: Counts and percentages of Toowoomba CBD shoppers who owning a motor vehicle

Dir.	Shopping at the CBD with Motor Vehicles ownership status	None	1 Motor Vehicle	2 Motor Vehicle	3 or more Motor Vehicle	Total	Total Sample
North	Total shoppers at the CBD	1	30	14	6	51	58
	Total people owning motor vehicle from the sample	5	31	14	8		
	Percentages of shoppers CBD from the motor vehicle owners (%)	*20	97	100	75		
	Percentages of shoppers CBD from the direction sample (%)	**2	52	24	10	88%	
South	Total shoppers at the CBD	2	31	41	22	96	118
	Total people owning motor vehicle from the sample	7	44	45	22		
	Percentages of shoppers CBD from the motor vehicle owners (%)	29	70	91	100		
	Percentages of shoppers CBD from the direction sample (%)	2	26	35	19	82%	
East	Total shoppers at the CBD	4	20	20	15	59	64
	Total people owning motor vehicle from the sample	9	20	20	15		
	Percentages of shoppers CBD from the motor vehicle owners (%)	45	100	100	100		
	Percentages of shoppers CBD from the direction sample (%)	6	31	31	23	92%	
West	Total shoppers at the CBD	2	15	23	11	51	64
	Total people owning motor vehicle from the sample	6	22	23	13		
	Percentages of shoppers CBD from the motor vehicle owners (%)	34	68	100	85		
	Percentages of shoppers CBD from the direction sample (%)	3	23	36	17	79%	
Average		3%	***33%	32%	17%	85%	

*** Total shoppers at the CBD /Total people owning motor vehicle from the sample = (1/5) *100=20%**

**** Total shoppers at the CBD / Total Sample = (1/58) *100=2%**

***** The average percentage of shoppers CBD who owning a motor vehicle = ((52/100) + (26/100) + (31/100) + (23/100))/4=33%**

Table 3.10: Gender counts and percentages of the sample visiting shopping centres in the Toowoomba CBD

Direction	Shopping at the CBD with Gender status	Male	Female	Total	Total Sample
North	**Total shoppers at the CBD**	19	32	51	58
	Total Gender of the sample	22	36		
	Percentages of shoppers CBD from the gender (%)	*86	89		
	Percentages of shoppers CBD from the direction sample (%)	**33	55	88%	
South	**Total shoppers at the CBD**	35	61	96	118
	Total Gender of the sample	37	81		
	Percentages of shoppers CBD from the gender (%)	95	75		
	Percentages of shoppers CBD from the direction sample (%)	30	52	82%	
East	**Total shoppers at the CBD**	18	41	59	64
	Total Gender of the sample	19	45		
	Percentages of shoppers CBD from the gender (%)	95	91		
	Percentages of shoppers CBD from the direction sample (%)	28	64	92%	
West	**Total shoppers at the CBD**	15	36	51	64
	Total Gender of the sample	18	46		
	Percentages of shoppers CBD from the gender (%)	83	78		
	Percentages of shoppers CBD from the direction sample (%)	23	56	79%	
Average	**Percentages of shoppers CBD (%)**	28%	***57%	85%	

***Total shoppers at the CBD / Total Gender of the sample = (19 /22) *100= 86%**

**** Total shoppers at the CBD /Total Sample = (19/58) *100=33%**

***** The average percentage of shoppers CBD of females= ((55/100) + (52/100) + (64/100) + (56/100))/4=57%**

The majority of CBD shopping is undertaken by the age groups of 30 years to 74 years for the four directions as shown in Table 3.11, with details in Appendix F, Table F.3. These tables also show small percentages of shoppers from the age group 15-29 years. The age group 75 years and over also form a low percentage for CBD shopping. The opinions and decisions in the face of pricing for age groups from 30 years to 74 years are important due to their high representation.

One of the survey objectives was to determine the most congested times of the week by gathering information about the usual shopping time of day and days of shopping for each zone. The respondents indicated their usual days and times of shopping however, some respondents chose the option “other” and commented that there were no specific usual times or days for their shopping habits.

Weekend days were shown to be the most congested days especially Saturday and details are provided in Appendix G, Tables G.1, G.2, and G.3. The data shows the days people usually go shopping for their first three preferred shopping centres and for the four directions. The tables show that the weekdays are not as busy as weekends days.

Traffic at various times of the day contribute to congestion as a result of shopping. Shopping activity was busiest in the period from 10 am to 6 pm for visits to the top three preferred shopping centres for the four directions. The detailed data is provided in Appendix H, Tables H.1, H.2, and H.3.

Table 3.11: Age groups counts and percentages of the sample visiting shopping centres in the Toowoomba CBD

Dir.	Shopping at the CBD with Age Groups status	15-29 Years	30-44 Years	45-59 years	60-74 years	75 years and over	Total	Total sample
North	Total shoppers at the CBD	6	16	11	8	10	51	58
	Total Age Groups of the sample	9	17	13	9	10		
	Percentages of shoppers CBD from the age groups (%)	*67	94	85	89	100		
	Percentages of shoppers CBD from the direction sample (%)	**10	28	19	14	17	88%	
South	Total shoppers at the CBD	8	31	22	28	7	96	118
	Total Age Groups of the sample	11	35	29	34	9		
	Percentages of shoppers CBD from the age groups (%)	73	89	76	82	78		
	Percentages of shoppers CBD from the direction sample (%)	7	26	19	24	6	82%	
East	Total shoppers at the CBD	6	11	23	16	3	59	64
	Total Age Groups of the sample	6	12	23	19	4		
	Percentages of shoppers CBD from the age groups (%)	100	92	100	84	75		
	Percentages of shoppers CBD from the direction sample (%)	9	17	36	25	5	92%	
West	Total shoppers at the CBD	4	14	14	15	4	51	64
	Total Age Groups of the sample	6	16	19	18	5		
	Percentages of shoppers CBD from the age groups (%)	67	88	74	83	80		
	Percentages of shoppers CBD from the direction sample (%)	6	22	22	23	6	79%	
Average	Percentages of shoppers CBD (%)	8%	23%	***24%	21.5%	8.5%	85%	

***Total shoppers at the CBD / Total age groups of the sample = (6/9) *100=67%**

**** Total shoppers at the CBD /Total Sample = (6/58) *100=10%**

***** The average percentage of shoppers CBD for age group 45-59 years= ((19/100) + (19/100) + (36/100) + (22/100))/4=24%**

- **Central Business District Trips**

Table 3.12 and Appendix H, Table H.4 show the number and percentages of CBD shoppers travelling for long trips of up to 20 min that may create congestion in roads in the four directions. Table 3.13 and the details are in Appendix H, Tables H.5 show that on average about 65% of respondents from the four directions stayed at shopping centres from 1 hour to 3 hours. This causes a load on parking facilities especially at shopping centre parking, as can be seen from Table 3.14 where most of the shoppers indicated that they normally park at shopping centre car parks when shopping in the CBD.

Table 3.12: The time it usually takes to travel from home to the CBD by car

Dir.	Less than 5 minutes	5 - 10 minutes	Between 10 and 20 minutes	20 - 30 minutes	More than 30 minutes
	(%)	(%)	(%)	(%)	(%)
North	*13.8	17.2	46.6	17.2	5.2
South	4.2	38.1	50.8	5.1	1.7
East	17.2	48.4	26.6	6.3	1.6
West	12.5	39.1	43.8	4.7	0.0
Average	11.9	35.7	42.0	8.3	2.1

Table 3.13: Time spend inside shopping centres when shopping at the CBD

Direction	Up to 20 minutes	Between 20 minute and 1 hour	1 hour - 3 hour	More than 3 hour
	(%)	(%)	(%)	(%)
North	5.2	29.3	62.1	3.4
South	2.5	29.7	65.3	2.5
East	3.1	31.3	64.1	1.6
West	3.1	25.0	67.2	4.7
Average	3.5	28.8	64.7	3.1

Table 3.14: CBD shoppers' normal parking habits

Direction	Shopping Centre Carpark	Kerbside Parking on Roads	Off-Street Council Carpark
	Count	Count	Count
North	50	19	14
South	106	25	14
East	59	23	6
West	58	17	5
Total	273	84	39

Investigation of the most congested roads around the CBD was one of the survey's objectives. This was investigated by asking the shoppers which roads they use when travelling to the CBD. This information also helped to investigate congestion in those roads after pricing. The main roads of Toowoomba that would be used in travelling to the CBD were listed in question thirteen in the questionnaire and some participants

added additional roads. Table 3.15 shows various frequencies of persons using specific roads regarding shopping activity. The reason given for using such a route by participants, was that the selected route provided the shortest distance to their preferred shopping centre/s.

The main streets of West Street, Hume Street, and Ruthven Street were the heaviest used roads because they lead to most of the major shopping centres. Margaret and Herries streets were also well used due to their close location to Grand Central and Betros Bros shopping centres.

Table 3.15: Survey frequency of using roads when go to shop in the CBD

Major Roads to Toowoomba CBD	Frequency
West Street	80
Hume Street	99
James Street	77
Bridge Street	57
Ruthven Street	142
Margaret Street	75
Herries Street	84
Taylor Street	50
Campbell Street	22
Kitchener Street	30
North Street	41
Stenner Street	38
Spring Street	32
Alderley Street	34

3.7.2 Summary of Results

A clear picture of the governing variables in shopping activity in Toowoomba was obtained through the survey and the survey results were verified with ABS data. The investigation of the convergence between ABS data and survey data were for the variables of population, gender, age groups, household size, and motor vehicles ownership. The results show that these variables are suitable for use to investigate shopping activity in Toowoomba.

Investigation of the modes of transport for shopping trips shows that the preferred mode to shop in Toowoomba was via car, and the distance from residence to shopping was usually between 1 km and 5 km. This indicates that shopping locally is preferred in Toowoomba, and helped to explain the contribution to traffic congestion in the CBD resulting from nearby, adjacent surrounding zones.

The activity of shopping in the CBD is slightly higher from the north and east directions, very likely because of the higher economic situation of residents in these areas.

Shopping within the Toowoomba CBD is more often undertaken by females than males for all four directions. The percentages of shopping in the CBD by females were very similar, however the east has a slightly higher percentage. The age group 30 to 74 years was the most prevalent group engaging in shopping activities. While all weekdays have significant shopping activity the weekends are the busiest days, especially Saturdays. The peak period of shopping time is between 10 am and 6 pm.

It was concluded that travelling from home to shopping centres in the CBD by car contributes towards congestion on Toowoomba roads in and near the CBD. The heaviest usage of roads was the roads near shopping centres and roads which are the shortest paths to shopping centres.

Spending time up to 3 hours inside of shopping centres was typical for CBD shoppers. This resulted in crowded parking across the CBD. The preferred parking for shoppers was at shopping centre car parks, however kerbside parking on roads and at off-street council carparks was also popular.

3.8 Conclusion

One of the most important requirements for research is the methodology adopted to ensure adequate and accurate data collection. This chapter explained the methodology used to design, construct and conduct the survey and the collection of data for analysis.

This chapter had three sections where in section one, explanation was provided about identification of the data required, the appropriate type of survey to be used and its objectives. The second section was about gathering of the data including the steps involved in conducting the survey. The survey included two types of questions with the first type about the demographic data and shopping habits and trips to the CBD. The second type of questions were regarding parking pricing and road pricing. The analysis of these second type of questions is discussed later in chapter six. The last part of the chapter provided details of the data analysis for the first type of questions in the survey.

Chapter Four

Transport Model

4.1 Introduction

This chapter provides the rationale, development and details of a transport model as a valid tool for predicting shopping trips and travel modes for roads in Toowoomba. The constructed model uses the traditional four step transport model approach of trip generation, a gravity model for trip distribution, a consideration of travel mode choice and the use of the all-or-nothing method for traffic assignment.

The decision to travel for shopping, known as shopping trip generation, is explained in section 4.2. Generated shopping trips from each residential zone are then distributed to the shopping centre zones of Toowoomba based on preferred shopping destination choices determined from the survey of residents. This second stage of shopping trip modelling is presented in section 4.3. In the mode choice step different shopper modal alternatives such as car and bus are considered. Section 4.4 of this chapter discusses the preference modes for shopping in Toowoomba. The allocation of shopping trips to road links is the fourth step of modelling (traffic assignment) and is discussed in section 4.5. The ability of the model to represent "real life" requires validation and this aspect is discussed in section 4.6.

4.2 Trip Generation

Trip generated seeks to model the numbers of trips from (produced) to (attracted) to each zone. Trip production and trip attraction are two sub-models within trip generation. Trip generation can be modelled by a function of socio-economic and land use attributes in a linear mathematical equation. For example, Trip production can be a linear equation that estimates the average rate of produced trips per household.

In the trip generation matrix, each cell in the trip matrix indicates either the number of trips produced from each origin zone or attracted to each destination zone. The fundamental balancing for a trip generation matrix is that the total number of trips produced from all origin zones equals the number of trips attracted to all destination zones (CrimeState 2004). In this study, residential locations were considered as origins and shopping centre locations were considered as the destinations. The number of

shopping trips originating from the study zones was equal to the number of shopping trips ending in shopping centres.

It is desirable that the trip generation model captures the characteristics of the actual distribution of trips (CrimeState 2004). A simple model reflects the most common characteristics in the region of study. The model in this study used many important characteristics of the study area, for instance household size, and economic situation represented by car ownership, age and gender.

The data of shopping trip preferences used in the trip generation of the Toowoomba model formed the basis for the later distribution and assignment of shopping trips to the road network of Toowoomba. After the construction and validation of the model, the survey data indicating changes in the preference for CBD shopping trips was used to generate new trip generation results for the cases of when road pricing or increasing parking fees. This data was applied in the model for each level of charge and the model results showed consequently different distributions and different assigned shopping trips to the roads of the CBD and the surrounding areas.

The accuracy of the input data depends on the source of the data. Previous studies commonly used the estimated trip productions and attractions from equations as the inputs to the four- step model. Rezaeestakhruie (2017) indicates that the studies which depend on input variables estimated by equations are more likely to contain errors from the type of mathematical operation, for instance the addition/subtraction operation, multiplication operation, or exponentiation in which the input variables are involved. The error in input variables is also likely to increase if the variables are sourced from other models. The difference in this study to previous studies is in using primary survey data as an input to the four-step model instead of using the estimated trip generation and attraction or using input data from other sources. In addition, the input data was for shopping trips in Toowoomba which has not been addressed in previous studies. This study avoided some errors which could occur in estimating the input data from equations, such as the errors resulting from the accuracy of using equation coefficients. The study estimated shopping trip distribution based on shopping trip data obtained from the survey.

In the trip generation stage, the statistical balancing of origin and destination numbers is an essential step, implemented to achieve a balanced situation (CrimeState 2004).

This was a basic step for building the model of this study in order to move into the next step of modelling which is trip distribution.

4.3 Trip Distribution

The prediction model of the number of trips occurring between each origin zone and each destination zone, is represented by a matrix called the trip distribution matrix (CrimeState 2004). Methods of trip distribution are normally categorised into Growth Factor Methods and Synthetic Methods. Growth Factor Methods includes Constant Factor Method, Average Factor Method and Fratar Method. Synthetic Methods are the Gravity Type Models and Opportunity Models (CIV3703 n.d). The Growth Factor Methods assume that the traffic flow rate will increase at a uniform rate within each zone, based on the increase in trip volumes from generation and/or attraction zone growth. The relative growth rates at origins and destinations are represented by the method of growth factor model which is suitable for short-term planning. In this method, it assumes that the general growth rate will apply to each cell in the matrix of the study area and that it is a uniform growth rate. The method is used if the only information for the study area is a general growth rate. So, the same growth factor is assumed for all generation zones as well as attractions. Growth Factor Methods do not consider changes in travel cost, but they are simple to understand and useful in short-term trend extrapolation (Mathew 2011).

Growth Factor Methods are simpler than Synthetic Methods, but have the disadvantage of not providing a measure of the resistance to travel (they do not consider the travel impedance factors effect). Synthetic Methods allow incorporation of the effect of differing planning strategies e.g. distance. The Gravity model is the most widely used method of the Synthetic Methods. The gravity model is often considered for trip distribution (Ortuzar & Willumsen 2001). Individual behaviour regarding making decision about trips is taken into account by using probability theory in opportunity models to model the selection process.

In this study, the method used to distribute trips was a gravity model. The shopping trips originating in each origin zone were allocated to shopping centre destinations, based on the data collected from the survey. In gravity models, the trips between origins and destinations are directly proportional to attraction and inversely proportional to impedance. Impedance was the discounting or resistance in travel

between residential zones and shopping centres. The impedance is the distance squared in the traditional gravity model, the denominator is the distance in the model (CrimeState 2004). The closer the residential zone and the shopping centre are to each other, the more likely there is to be interaction between them.

According to the imposed constraints level, it can be categorized as the gravity model if it is singly constrained, doubly constrained or unconstrained. If the estimated trip distribution matrix is added horizontally and vertically, it matches the observed zonal trip production and attraction in the gravity model, the production matrix categorized as the doubly constrained gravity model. This type of model has tended to have a high degree of accuracy (Herijanto & Thorpe 2005). The doubly constrained gravity model used in this study produces an estimated shopping trip distribution matrix that if summed horizontally and vertically, matches the observed shopping trip production and attraction.

In the step of trip distribution, the total number of produced and attracted shopping trips must be equal. There are a number of reasons why investigation of shopping trip distributions could be useful, for example to be able to apply the model to a different data set for a studied zone or set of zones, or to predict future shopping trips. In this study, the model was applied to a different data set from which it was calibrated in order to use the model to forecast future shopping trip distribution if road pricing or increased parking pricing were to occur. The model was calibrated using current trip generation data so that the modelled distribution of trips represented the existing distribution of trips determined from the questionnaire survey. The model was then used to calculate the new trip distributions after the input data was adjusted to account for the changed preferences of shoppers following the possible introduction of (i) road pricing charges, and (ii) increased parking charges.

The model was run for several scenarios and produced an output for each purpose. The scenarios investigated the impact of road pricing on shopping trips, and the impact of increasing parking pricing at different levels on shopping trips. Each scenario was run by inputting data for the production and attraction shopping trips to each studied shopping centre, then the trips distributed by using the method of Gravity Model, and then represented on the road network map in the assignment step. The results achieved objective numbers one and three of this study by investigating the current distribution traffic resulting from shopping trips, and predicting future shopping trips distribution

in the case of road pricing, and in the case of increasing parking fees by various levels of pricing.

4.4 Mode Choice

It is normal for users to explore different options available to reach their destination, particularly in regard to the mode of travel they will use. The probability of a user selecting a particular mode is based on “utility” and “disutility”. Utility means the service ability to satisfy people’s needs while disutility represents the experiences of users in using the service in terms of cost (CIV3703 n.d).

Mode choice is affected by a range of factors, like characteristics of the trip maker (such as car ownership and income), characteristics of the trip (such as home - school, home - work, shopping, starting time) and system characteristics. These factors are evaluated by considering the travel cost, and other parameters (e.g. environment circumstances) (CIV3703 n.d). In the four-step model, the route choice is an analysis that illustrates which travellers will use which type of mode. The mode such as car, bus, and bike could be competitive alternatives. A logit model is the most popular model adopted to estimate mode choice and discrete choice modelling.

The trip generation within the Toowoomba shopping trip model considered the aggregation of motor bike, car, truck and taxi trips. A low percentages of bus trips were found to be used for shopping in Toowoomba. Although truck shopping trips were also considered in this study, the survey found zero truck shopping trips occurred. So, as few heavy vehicle trips were generated for shopping, and there were no other available modes in Toowoomba such as train or tram, the mode choice step was omitted from the modelling.

4.5 Traffic Assignment

Once the origins and destinations of the individual trips are known (from the trip distribution process), the modelling considers the actual route of trips through the network. This process is known as traffic assignment (CIV3703 2012). Static Traffic Assignment (STA) and Dynamic Traffic Assignment (DTA) are the two main approaches which can be used for the assignment. Static models are used when there are many scenarios to study; if the high degree of accuracy is not known in the input data; or when the computational resources are limited to spend on traffic assignment

(Motamed n.d). De Maio, Musolino and Vitetta (2012) stated that STA is used when path choice, travel demand, and transport networks are consistent in a reference time. These are the stationary conditions of a transport system which are simulated by STA.

DTA models are used in the case of emergency conditions that happened in a transport system such as a temporary link, travel demand peaks, and variations of node capacity. Motamed (n.d) stated that the dynamic models are appropriate when details of information on traffic flow are needed (e.g. when long queues form), when the major aim of the study is the dynamic traffic control (e.g. traffic signals, variable tolls, and work zone studies) or bottlenecks, and when the network has high level of congestion.

Traffic assignment, as the fourth step of the traditional transport model, is implementing by assigning traffic to links. The most commonly used methods of traffic assignment are all-or nothing assignment, assignment by the use of diversion curves, capacity restrained assignment, and multipath proportional assignment (CIV3703 2012).

All or nothing assignment means all future predicted trips are assigned to the lowest cost route (i.e. the lowest cost route between zone centroids). The second common assignment is a diversion curve assignment. It is developed based on cost, to consider the traffic proportion using an improved or new route compared to the existing route. The third popular assignment is a capacity restrained assignment. This method starts with an all or nothing assignment and then traffic is diverted to other routes, so as to achieve all routes having an equal cost or travel time (i.e. the equilibrium condition). The total trips in the assignment are distributed using speed-flow relationships over several routes. The fourth common assignment method is a multipath proportional assignment. It is used in the case of the availability of many alternate travel paths, such as in urban areas. It depends on the perceptions of drivers as to the "best" route between different points (e.g. minimum congestion, minimum travel time, minimum number of traffic signals). Future predicted traffic is assigned over all feasible routes (CIV3703 n.d).

The method of all-or-nothing assignment is based on the assumption that there are no congestion effect; that the same attributes for routes are considered; and that the link cost is fixed. The assumption is that all drivers perceive the same cost, and this means that every driver from a particular origin to a particular destination must chose the

same route. Thus, all drivers are assigned to one route between an origin point and a destination point and no driver is assigned to other routes, which are regarded in this case as less attractive. This assumption is reasonable if the alternative routes are very different in cost (Ortuzar & Willumsen 2001). The routes of Toowoomba network vary in distances which makes differences in the costs of using them. The principle of the all-or-nothing method were adopted in assigning shopping trips on Toowoomba network.

Traffic assignment was implemented depending on the constructed network (nodes and links) by using an Emme 4.3 software package. The purpose was to obtain the optimal route between zone centroids. The links for shopping flows were determined by the Emme 4.3 software depending on the distance between residential zones and shopping centre zones.

A Microsoft Excel spreadsheet was used to determine the formulas that related the distributed shopping trips matrix as the input to the flows of the links as the outputs. The formulas were essential to quantify the propagation of trips from the inputs to the outputs in the traffic assignment in prediction stage. The final predicted shopping trips which are represented on the Toowoomba network links were equal to the sum of the assigned shopping trips on the joint links. In the process of estimation in each run the flows are displayed on the network.

The Toowoomba shopping trip model was employed to represent the current shopping trips and the predicted shopping trips after adopting road pricing and parking fees increases. This was achieved by entering data of production and attraction shopping trips from all the studied zones to all the studied shopping centres. After investigating the effect of pricing on shopping trips, it was noted that some traffic volumes on roads of the CBD had changed significantly, as trips had moved from the CBD shopping area to the other shopping centres, while the traffic volumes on some of the CBD perimeter links increased because of the shifted traffic.

4.6 Validation

Model validation is essential to check the ability of a model to perform accurately. Comparing the observed values with those predicted by a model evaluates the ability of the model. It is possible to use independent datasets or externally supplied data to compare with the modelled values.

For this study, the actual shopping vehicle volumes to shopping centres were observed by traffic count surveys to validate the model. Actual link shopping trips were compared with the modelled results in the validation stage. As expected, since the model was based on accurate data gained by the questionnaire survey, it provided accurate and valid outcomes for the input shopping trips and correlation matrices used. The small differences between observed trips and trips predicted by the model indicated the ability of the model to perform accurately.

4.7 Conclusion

This chapter has shown the types of models considered and explained how and why the methods in the model were employed to predict shopping trips. The methods used in the construction of the Toowoomba shopping trips model were based on the data gathered from the questionnaire survey for trip generation. The gravity model approach was used to distribute the shopping trips among destinations. Traffic shopping volumes between particular zones of origin and destination were assigned to the existing road network based on the all-or-nothing principle. The validity and the efficiency of the model were also addressed.

Chapter Five

Results of Transport Modelling for Shopping in Toowoomba

5.1 Introduction

The previous chapter outlined the development of the four-step transport planning model adopted for the research. This chapter addresses the modelling and estimations of the number of shopping trips in Toowoomba at the current time (2018). The modelling is based on the whole population of the study area and the current situation with respect to parking pricing. In section 5.2, an explanation is given of the zone and network layouts adopted for this study. Sections are the traditional four-step model flowchart representation in a normal modelling sequence, as displayed in Figure 5.1a. The mode split was however performed early in the study, as shown in Figure 5.1b. Section 5.3.1 presents the trip generation by determining the number of trips from each origin, and 5.3.1 the number of trips attracted by each destination, for the current situation of shopping trips and for the trips after pricing variations. Section 5.3.2 discusses the proportion of shopping trips for each mode of transportation (i.e. the computations are for mode choice). Section 5.4 matches the origins with destinations using trip distribution by the gravity method. This match was done for both the current trips and for the trips after pricing variations. Section 5.5 deals with traffic assignment, allocated shopping trips between origins and destinations by specific modes. Section 5.6 describes the validation of the model and the summary of modelling is outlined in section 5.7.

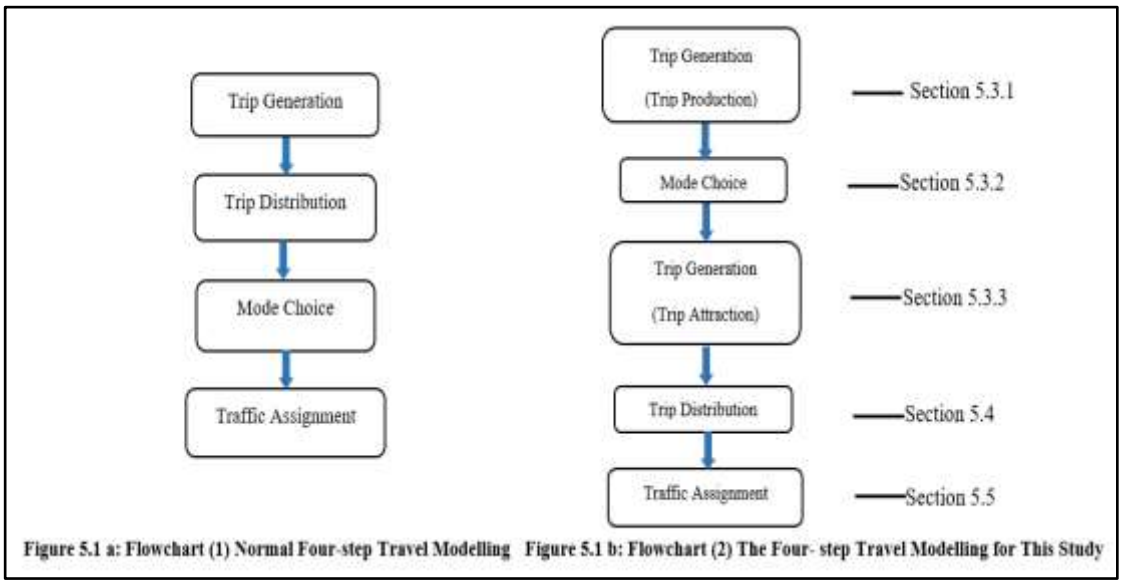


Figure 5.1 a: Flowchart (1) Normal Four-step Travel Modelling **Figure 5.1 b: Flowchart (2) The Four- step Travel Modelling for This Study**

5.2 Area of the Study

5.2.1 Zoning

This step involved the definition of the area to be studied. The Toowoomba city area was divided into internal zones as shown on the map in Figure 5.2. This zoning was based on zones indicated in Toowoomba Regional Council's community profile (Toowoomba Regional Council n.d). Internal zones were numbered randomly from 1 to 18 and external zones from 19 to 22. Table 5.1 shows the list of studied zones.

Internal zone boundaries were determined by major roads. Zone boundaries were based on the boundaries used by the Australian Bureau of Statistics (ABS), so that statistical data from the ABS could be used in the study. Toowoomba was an important destination of overseas migration between 2006 and 2011 (Toowoomba Regional Council 2017), which created expansion of the city in recent decades. The cordon of the study area is represented by the Toowoomba "city" boundary, and includes the majority of residences. It is these internal zones within the cordon that contain most of the residences generating the major shopping activities of Toowoomba. However, it was important to also include some external zones in this study because there are shoppers coming to the inner zones of Toowoomba from adjacent outer areas. The ten (10) major shopping centres were identified for the area, and these centres were designated as the zones of destination for the research. Other smaller shopping centres also exist but shopping activity in these centres was minimal and not considered in either the survey work or the modelling.

5.2.2 Network Description

The Emme 4.3 transport modelling software package was used in the initial stages of the work to construct the network, but it was found simpler to perform the remainder of the modelling work using Microsoft Excel. The Emme network of Toowoomba shown in Figure 5.3 represents the important major roads as node linkages (drawn at the same scale as the zone map, Figure 5.2) and the nodes represent major road intersections. The nodes were assigned a unique number, so that road links could be identified by end node numbers (e.g. 27-28). Note that for clarity Figure 5.3 does not show all node numbers. Emme has the capacity to store several attributes for each link, but the characteristic which was important for this study was link length.

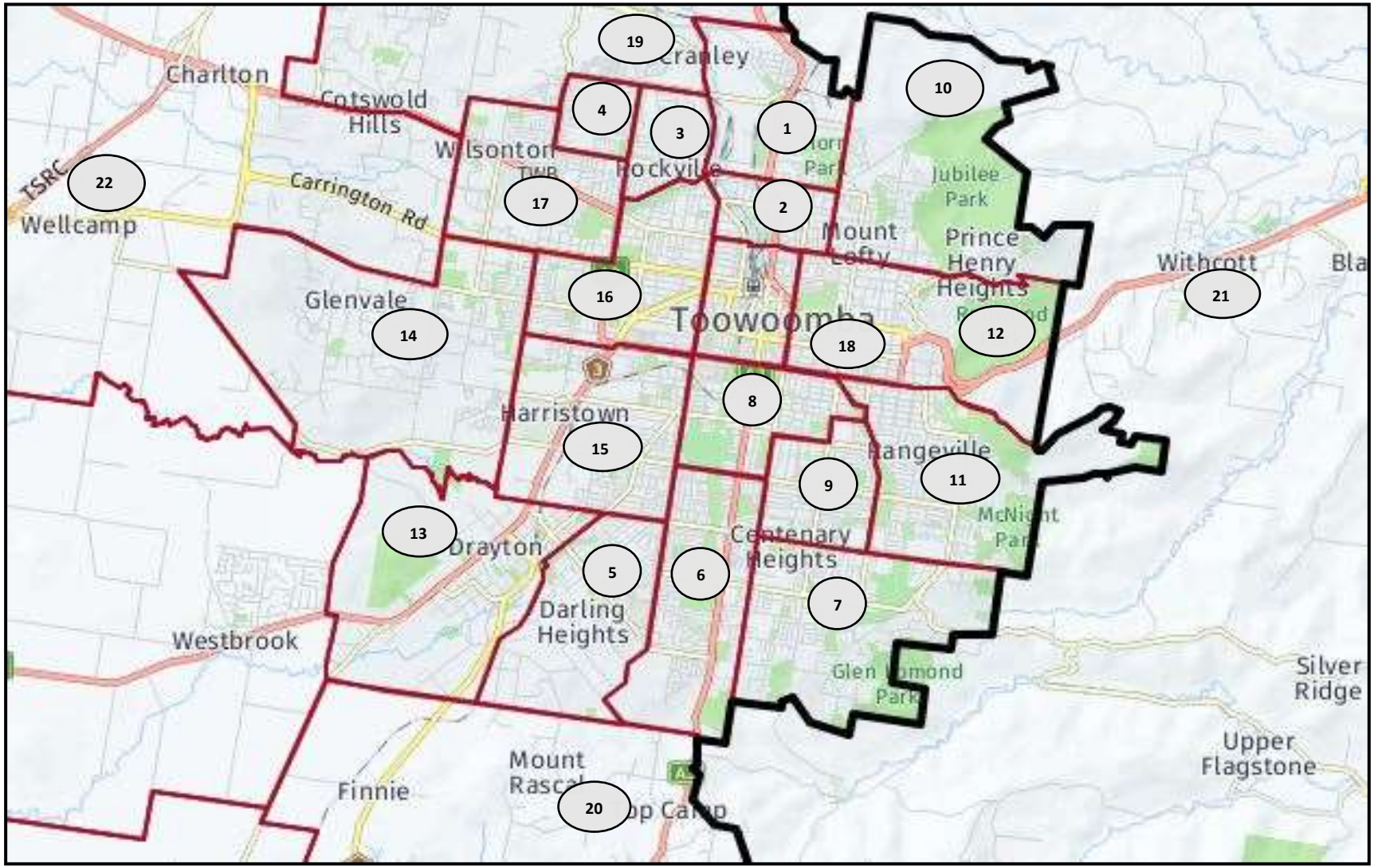


Figure 5.2: Map zones for Toowoomba

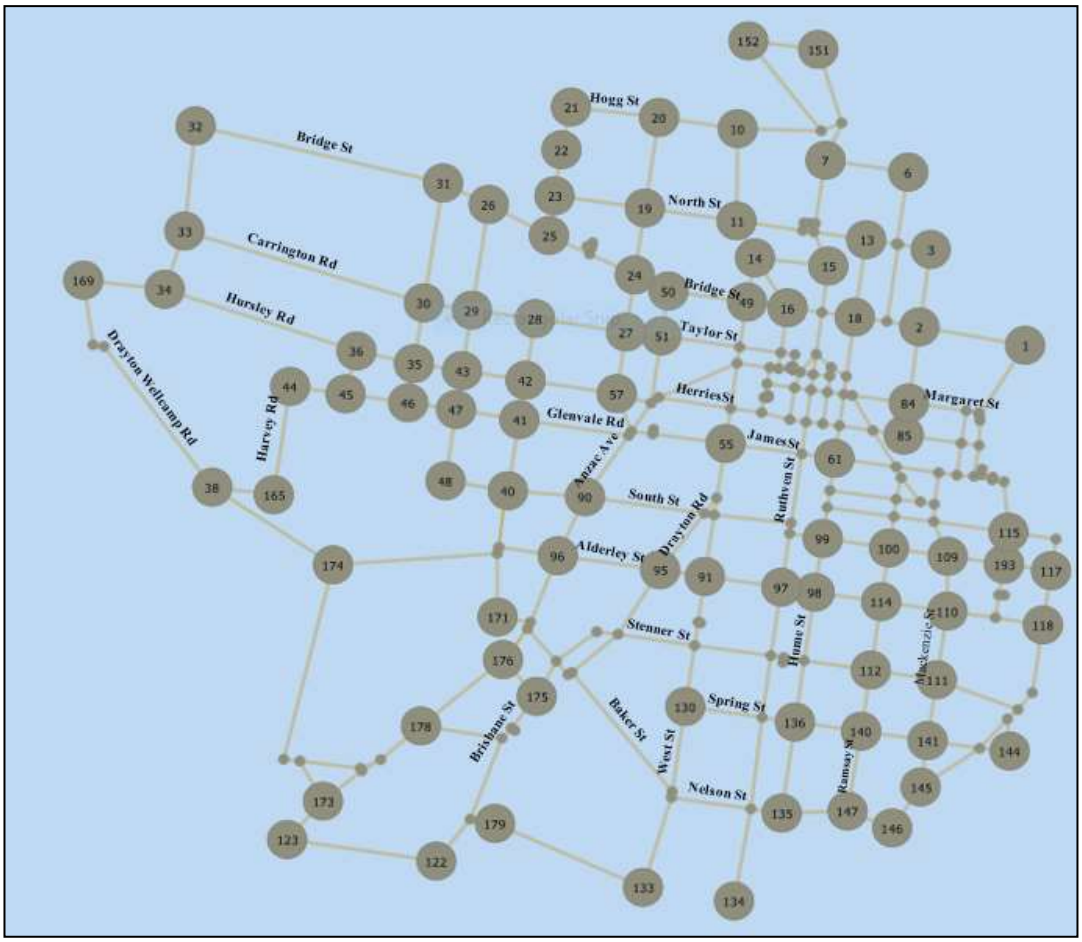


Figure 5.3: Emme network of Toowoomba

The centroid of each zone was the location in from which all zone traffic was assumed to originate. This is standard transport modelling practice. For modelling purposes, the centroid location was chosen to be the closest major intersection node to the actual physical location of the centroid. Table 5.1 provides the node numbers of the centroid of suburbs and shopping centres. Figure 5.4 shows the locations of those shopping centres in the CBD of Toowoomba and Figure 5.5 shows the location of the other major shopping centres in Toowoomba.

Table 5.1: Node numbers of the centroid of suburbs and shopping centres on the map of Toowoomba

Residential Trip Production Zones			Shopping Centre Trip Attraction Zones	
Zone No.	**Zone**	**Centroid No.**	**Shopping Centres**	**Centroid No**
1	**Harlaxton**	7	**Clifford Gardens Shopping Centre**	167
2	**North Toowoomba**	15	**Kearneys Spring Shopping Centre**	183
3	**Rockville**	11	**Grand Central Shopping Centre**	187
4	**Wilsonton Heights**	21	**Drayton Shopping Centre**	189
5	**Darling Heights**	93	**High Street Shopping Centre**	190
6	**Kearneys Spring**	136	**Northpoint Shopping Centre**	194
7	**Middle Ridge**	147	**The Range Shopping Centre**	199
8	**South Toowoomba**	149	**Westridge Shopping Centre**	201
9	**Centenary Heights**	114	**Wilsonton Shopping Centre**	206
10	**Mount Lofty**	2	**Betros Bros Shopping Centre**	207
11	**Rangeville**	117		
12	**Redwood**	80		
13	**Drayton**	176		
14	**Glenvale**	46		
15	**Harristown**	95		
16	**Newtown**	27		
17	**Wilsonton**	25		
18	**East Toowoomba**	84		
19	**Outer Northern Areas**	152		
20	**Outer Southern Areas**	133		
21	**Outer Eastern Areas**	116		
22	**Outer Western Areas**	169		

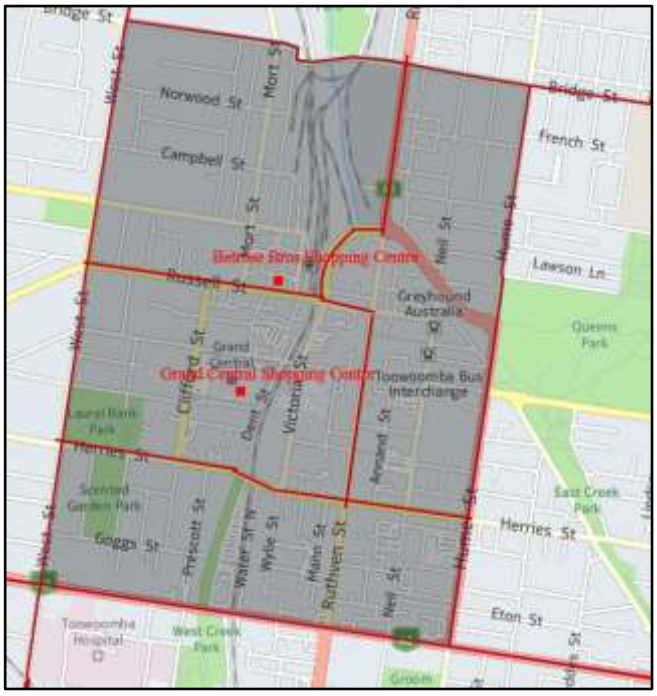


Figure 5.4: The studied Shopping Centres in Toowoomba City (CBD)

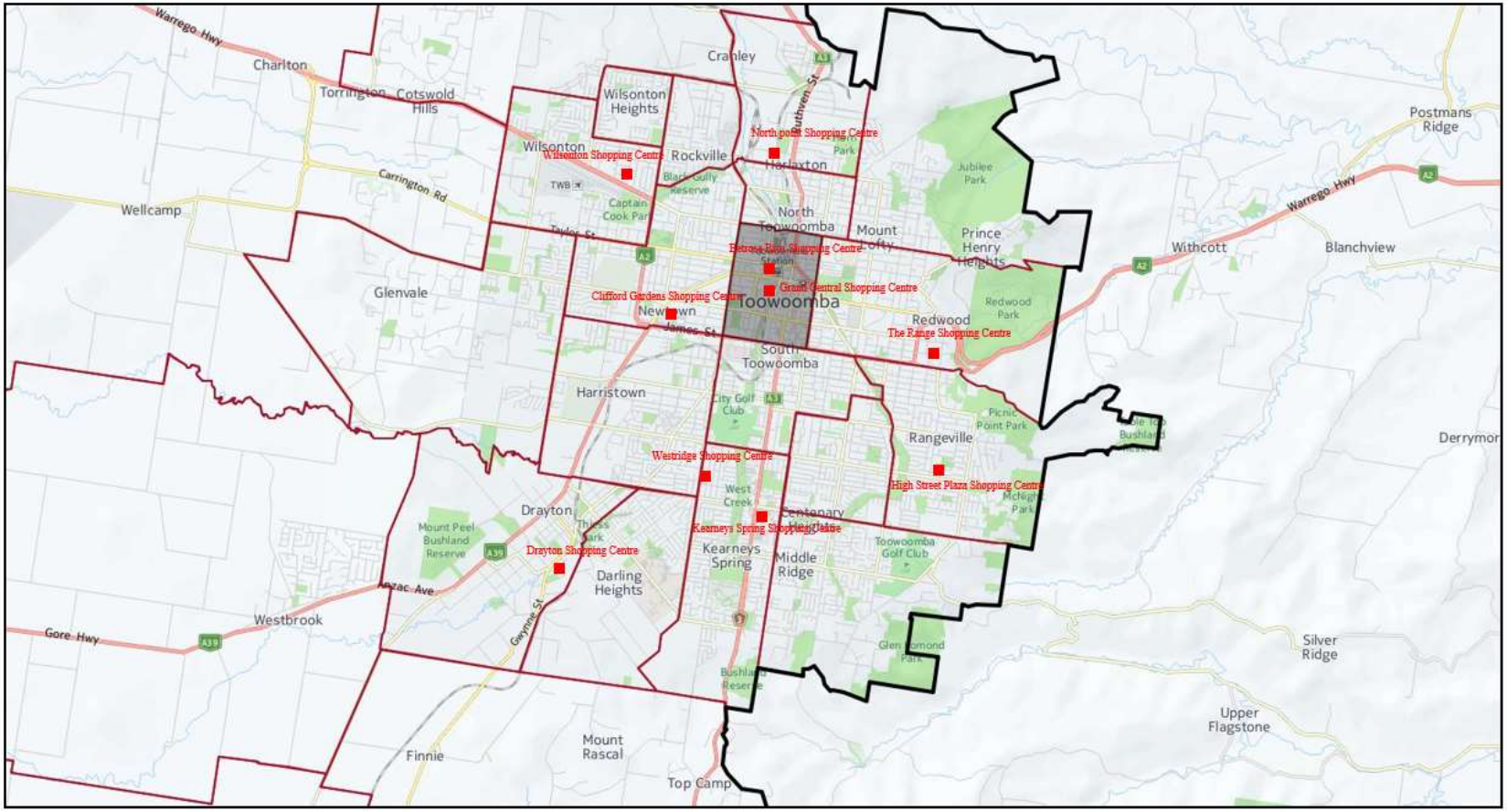


Figure 5.5: Major Shopping Centres in Toowoomba City

5.3 Trip Generation Analysis

After dividing the study area of Toowoomba into zones, the next task was to calculate the number of shopping trips that each residential zone generated, and the number of trips attracted to each of the ten-shopping centre attractions.

5.3.1 Trip Production

Shopping trip production determined the number of origins of shopping trips in each study zone. The number of shopping trips to and from a residential zone is predominantly related to the socioeconomic characteristics of the shoppers. These are quantified using parameters related to land use and shopper characteristics. The first important characteristic is the population density. The residential density affects the average number of shopping trips per day. This research for shopping trips was based on the outcomes of the questionnaire survey, which gathered data on average weekly shopping trips. Calculation of the number of daily trips per zone was based on the number of households, determined from ABS data. The second characteristic was the social and economic character of the shoppers. This characteristic involves measures such as education level, average family income, and car ownership. These characteristics influence the number of trips. The survey allowed identification of the residential zone for respondents, so that the shopping trips per zone was a reflection of the varying socio-economic character across the city. Other factors such as road congestion, parking, and other environmental attributes also affect the number and timing of shopping trips that the study area produces. Road pricing and increasing parking pricing in the CBD have an effect on the frequency of shopping in the CBD, use of public transport, CBD shoppers parking habits, and time spent inside shopping centres when shopping at the CBD.

Shopping trips vary according to household characteristic. The survey provided information about household of membership and the average weekly shopping trips per household. From this information the average weekly shopping trips per household for each zone could be calculated. For example, Table 5.2 shows the average weekly shopping trips per household varies from 2 to 6.07 trips, calculated from the questionnaire data. Using the average weekly shopping trip rate per household and the number of households per zone obtained from ABS data, the average daily shopping trips per zone was derived. These figures varied from 34 for the Redwood zone to 2742

for the Newtown zone but the large difference in the figures is purely a reflection of the different population levels of the various zones. The average daily shopping trips per 1000 population production varies from 102 to 394 as shown in Table 5.2. This also a reflection of the different household size and different economic level of the zones.

Table 5.2: Average daily shopping trips for each zone

No.	Zone	Average WEEKLY shopping trips per household	No. of households in zone	Average DAILY shopping trips for zone	Average DAILY shopping trips per 1000 population for zone
1	**Harlaxton**	5.13	1107	*811	318
2	**North Toowoomba**	6.07	1342	1164	394
3	**Rockville**	5.47	1349	1053	325
4	**Wilsonton Heights**	4.00	1112	635	238
5	**Darling Heights**	4.00	1854	1060	204
6	**Kearneys Spring**	4.45	3718	2366	277
7	**Middle Ridge**	4.26	2550	1553	217
8	**South Toowoomba**	3.36	2375	1141	218
9	**Centenary Heights**	5.00	2526	1804	298
10	**Mount Lofty**	3.40	1510	733	194
11	**Rangeville**	4.04	3463	2000	241
12	**Redwood**	3.60	65	34	200
13	**Drayton**	4.43	684	433	253
14	**Glenvale**	4.29	2353	1441	227
15	**Harristown**	4.47	3889	2481	290
16	**Newtown**	4.40	4362	2742	286
17	**Wilsonton**	5.10	2589	1886	317
18	**East Toowoomba**	5.00	2384	1703	325
AVERAGE FOR INTERNAL ZONES		4.47			
19	**Outer Northern Areas (Highfields)**	3.25	2804	1302	160
20	**Outer Southern Areas (Top Camp)**	6.00	275	236	277
21	**Outer Eastern Areas (Withcott)**	4.50	636	409	222
22	**Outer Western Areas (Kingsthorpe)**	2.00	667	191	102
AVERAGE FOR OUTER ZONES		3.94			

*(5.13*1107)/7

In this study, the average of trips per household was taken to represent the trip per household in calculation of the trip production. So, if the characteristics of each of the households in a zone was considered to arrive at a representative figure of trip per household this would make the step more accurate. Also, considering the characteristics of the survey respondents, such as neighbourhood urban, would help improve the trip generation step.

5.3.2 Mode Choice

Shopping trips in the Toowoomba area are via various transport modes with the majority of trips by private vehicle travelling on public roads. However, the survey of shopping activities in Toowoomba included the provision for respondents to identify shopping trips made by a variety of modes including walking and bicycling. Walking trips predominantly use footpath, separated from roadways, and do not impact on vehicular traffic congestion. Bicycle trips may use the roadway but in Toowoomba there is a reasonable cycle path network that caters for a large percentage of cycle trips. For these reasons, walking and cycling trips were removed from the total trip numbers. Table 5.3 shows the percentage of walking and bicycling shopping trips for each zone. Table 5.4 presents the daily shopping trip production for each zone after removing the walking and cycling trips. The final trip production in Table 5.4 contains the trips by modes that would actually contribute to road traffic congestion. In conclusion, walking and cycling shopping trips were not included in trip production because they may use roads but do not significantly contribute to traffic congestion.

Table 5.3: Percentages of walking and cycling production shopping trips of surveyed zones

Zone	Total production shopping trips for zone	Sum of walking and bicycles trips percentages (%)	Trips of walking and bicycles	New trip production for zone
Harlaxton	811	0	0	811
North Toowoomba	1164	12	140	1025
Rockville	1053	20	211	843
Wilsonton Heights	635	26	165	470
Darling Heights	1060	18	191	869
Kearneys Spring	2366	18	426	1940
Middle Ridge	1553	11	171	1382
South Toowoomba	1141	11	126	1016
Centenary Heights	1804	28	505	1299
Mount Lofty	733	25	183	550
Rangeville	2000	7	140	1860
Redwood	34	7	2	31
Drayton	433	0	0	433
Glenvale	1441	0	0	1441
Harristown	2481	18	447	2035
Newtown	2742	13	356	2385
Wilsonton	1886	9	170	1717
East Toowoomba	1703	27	460	1243
Outer Northern Areas	1302	0	0	1302
Outer Southern Areas	236	0	0	236
Outer Eastern Areas	409	0	0	409
Outer Western Areas	191	0	0	191
	27176		0	23484

Table 5.4: New trip production percentages after removing walking and cycling trips of surveyed zones

Zone No	Mode of Trans. / Zone of Gen.	Walking (%)	Bicycle (%)	Total Percentages
1	**Harlaxton**	0	0	0
2	**North Toowoomba**	8	4	12
3	**Rockville**	16	4	20
4	**Wilsonton Heights**	23	3	26
5	**Darling Heights**	15	3	18
6	**Kearneys Spring**	13	5	18
7	**Middle Ridge**	6	5	11
8	**South Toowoomba**	9	2	11
9	**Centenary Heights**	22	6	28
10	**Mount Lofty**	19	6	25
11	**Rangeville**	5	2	7
12	**Redwood**	7	0	7
13	**Drayton**	0	0	0
14	**Glenvale**	0	0	0
15	**Harristown**	15	3	18
16	**Newtown**	13	0	13
17	**Wilsonton**	9	0	9
18	**East Toowoomba**	14	13	27
19	**Outer Northern Areas**	0	0	0
20	**Outer Southern Areas**	0	0	0
21	**Outer Eastern Areas**	0	0	0
22	**Outer Western Areas**	0	0	0

Table 3.6 earlier showed that the highest percentages of shopping trips in Toowoomba were made by car. Car usage for shopping trips ranges between 56% and 100% across the zones, while the range for walking trips is 0 to 23%, and the range for bicycle trips is 0 to 13%. Motor bike trips range from 0 to 6%, and taxi trips from 0 to 14%. The percentage of bus shopping trips was low with the highest percentage being 8% for a zone. Survey respondent comments regarding non- utilisation of buses indicated that: (i) several respondents live an excessive distance from bus stops; (ii) bus services have limited time coverage, (e.g. not available in the evening); (iii) greater shopping time flexibility is needed for shopping (e.g. for people with heavy work commitments); (iv) some participants feel too restricted by the regulated arrival and departure times of buses; (v) waiting time for buses can be excessive; and (vi) some participants enjoy shopping by bicycle or walking and regard it as recreation and/or exercise.

The bus shopping trip statistics were checked from an observed bus user survey to verify the result of the respondents' answers. Observations at the bus station at Clifford Gardens shopping centre, for example, showed that only a small percentage of people were using the buses to access the shopping centre, about 7%. As a result of the questionnaire and observed study, the bus shopping trips were not separately modelled. Bus trips were included with other road vehicle shopping trip modes in the modelling (motor bike, car, bus, truck, and taxi).

5.3.3 Trip Attraction

The CBD of Toowoomba attracts many different shopping trips. Grand Central and Betros Bros are the two focal points within the main CBD shopping area. The CBD attracts a large number of trips from the zones closest to the CBD, for example from Middle Ridge, Kearneys Spring and South Toowoomba, and attracts less trips from the zones further away, as shown in Table 5.5. The table also shows that the Grand Central shopping centre attracts reasonably high numbers of trips from different origins, both close and far. In addition, it shows the destination choices of shoppers in the same zone vary, but in general, they prefer the nearest shopping centres. As an example, the majority choice of shoppers from Darling Heights, Kearneys Spring, and South Toowoomba was the Kearneys Spring Shopping Centre. However, there was also a significant number of shopping trips to the CBD from these areas. The survey participants had the option to choose the three shopping centres they visited most often and to indicate how often they visited each one on a monthly timeframe. The survey

results have been compiled so that there are three matrices for trip attraction, with each matrix representing the number of trips attracted to each shopping centre monthly from the 22 zones. The resultant matrix from the first preference shopping centre contained the greatest number of shopping trips as shown in Table E.1 in appendix E. The summation of the three matrices represents the attraction matrix for monthly shopping of the sample as shown in Table 5.5. Summation of trips derived from the sample to each shopping centre have then been converted to the whole population's daily attraction trips. The new trip attraction matrix as shown in Table 5.6 has then been used in the modelling.

Table 5.5: Total shopping trips attraction

A total Attraction Matrix (summation of three attraction matrices for the top three preferred shopping centres to visit monthly)												
	Location of Shopping Centre in the Suburb	**Newtown**	**Kearneys Spring**	**Toowoomba City**	**Drayton**	**Rangeville**	**North Toowoomba**	**East Toowoomba**	**Kearneys Spring**	**Wilsonton**	**Toowoomba City**	
Suburb Number	**Shopping Centre / Suburb**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
		Clifford Gardens	**Kearneys Spring**	**Grand Central**	**Drayton**	**High Street**	**Northpoint**	**The Range**	**Westridge**	**Wilsonton**	**Betros Bros**	
1	**Harlaxton**	16	0	26	48	0	6	0	0	0	0	
2	**North Toowoomba**	17	8	61	0	0	53	2	0	0	0	
3	**Rockville**	40	3	55	0	0	18	0	0	69	10	
4	**Wilsonton Heights**	10	0	49	0	0	12	0	0	33	0	
5	**Darling Heights**	23	123	58	16	0	0	0	10	0	0	
6	**Kearneys Spring**	26	165	53	0	12	0	15	12	0	0	
7	**Middle Ridge**	39	293	123	7	20	4	17	42	0	8	
8	**South Toowoomba**	27	109	57	6	0	0	16	15	1	0	
9	**Centenary Heights**	2	44	62	0	19	0	7	30	0	6	
10	**Mount Lofty**	2	1	32	0	0	58	15	0	12	0	
11	**Rangeville**	7	133	67	0	61	0	60	0	0	4	
12	**Redwood**	3	29	11	0	0	0	6	0	0	0	
13	**Drayton**	24	27	7	20	0	0	0	0	0	0	
14	**Glenvale**	112	11	25	1	0	0	0	0	3	0	
15	**Harristown**	70	55	69	0	0	0	0	5	0	0	
16	**Newtown**	58	18	27	0	0	4	0	0	6	4	
17	**Wilsonton**	29	7	20	0	0	3	0	0	39	4	
18	**East Toowoomba**	0	14	10	0	0	16	12	0	0	0	
19	**Outer Northern Areas**	28	23	32	8	0	41	2	0	11	4	
20	**Outer Southern Areas**	23	18	33	23	0	8	0	10	0	0	
21	**Outer Eastern Areas**	18	50	21	5	0	10	0	10	6	0	
22	**Outer Western Areas**	14	18	35	3	0	6	0	2	0	3	
SUM of Attraction		588	1149	933	137	112	239	152	136	180	43	3669

Table 5.6: Trips attraction to each shopping centre

No	Shopping Centre	Sum of trips attracted (from sample)	Trip attracted used in modelling
1	Clifford Gardens Shopping Centre	588	3764
2	Kearneys Spring Shopping Centre	1149	7354
3	Grand Central Shopping Centre	933	5972
4	Drayton Shopping Centre	137	877
5	High Street Shopping Centre	112	717
6	Northpoint Shopping Centre	239	1530
7	The Range Shopping Centre	152	973
8	Westridge Shopping Centre	136	871
9	Wilsonton Shopping Centre	180	1152
10	Betros Bros Shopping Centre	43	275
Sum		3669	23484

Table 5.7 provides details of the shopping trip generation (productions and attractions) and shows that the Grand Central shopping centre has a high number of trips attracted. The attraction of trips changed according to the answers of shoppers surveyed about how a congestion charge for entering the CBD might affect their shopping in the CBD.

The new trip attraction was calculated for the cases of road pricing and increasing parking pricing. In the case of increasing parking pricing the survey question was:

" If the cost of all parking in the CBD, including parking meters and previously free parking at shopping centre parking, were to increase by below prices, at which price would affect the number of times you travel to do shopping in the CBD?"

The number of the respondents from each direction, who chose the price that affects them on the number of times for shopping at the CBD were divided by the total sample of the direction. This represented the percentage of people who would shift at this price from this direction. This percentage was applied to shopping trips of the CBD shopping centres in the matrix of the shopping trips. In this matrix, the shifted shopping trips were subtracted from the original trips of the CBD shopping centres to produce the new trips to the shopping centres at the CBD. The shifted shopping trips from the CBD shopping centres added to the original shopping trips of the other shopping centres out of the CBD to produce the new trips to shopping centres out of the CBD.

In the case of road pricing the survey question was:

“If a congestion charge were introduced for entering the CBD, would this affect your shopping in the CBD?”

The number of people from each direction who chose the “yes” option were divided by the total sample number in this direction. This represented the percentage of people who would shift from this direction when applying road pricing. The process of calculation the new trip attraction has been done as on the previous method for the case of increasing parking pricing.

The method used in this study had some limitations in that it did not have specific questions on how many trips that the respondent would reduce from CBD shopping centres and how many trips that the respondent would increase to other shopping centres. This would require many choices in the survey for each case (cases of road pricing and parking pricing). This study ensured realism without building a complex survey to reduce the mental effort required to answer questions. The study took into account the quality of responses by reducing the high burden on participants who are supposed to process on a limited time.

Table 5.7 also shows the surveyed number of shopping trips after (i) the possible introduction of road pricing and (ii) a $1 increase in parking pricing. The same number of production trips resulted in new attraction figures in both cases. The table shows that CBD shopping trips (to Grand Central and Betros Bros trips areas) reduce while increases occur in the trips to other shopping centres, as would be expected. The effect of this is to reduce congestion on roads of the CBD and achieve one of the study’s aims namely to reduce the traffic around the CBD by introducing road pricing. Appendix I shows the new trip attractions which occur for $2, $3, and $4 increased parking fees. In each case, the shopping traffic to the CBD is decreased by increasing the parking pricing, and this satisfies another aim of the study which is to decrease the congestion by using parking pricing.

Table 5.7: Shopping trips generation for studied area before and after pricing

Zone number	Trip Production		Shopping Centre number	Shopping Centres	Trip Attraction		
	Zone	Trips production			Trip attraction without pricing	Trip Attraction with Pricing	
					Original	Road pricing	Parking pricing (with $1 increased parking pricing)
1	Harlaxton	811	1	Clifford Gardens Shopping Centre	3764	4534	3871
2	North Toowoomba	1025	2	Kearneys Spring Shopping Centre	7354	8861	7563
3	Rockville	843	3	Grand Central Shopping Centre	5972	2595	5502
4	Wilsonton Heights	470	4	Drayton Shopping Centre	877	1056	902
5	Darling Heights	869	5	High Street Shopping Centre	717	864	737
6	Kearneys Spring	1940	6	Northpoint Shopping Centre	1530	1843	1573
7	Middle Ridge	1382	7	The Range Shopping Centre	973	1172	1001
8	South Toowoomba	1016	8	Westridge Shopping Centre	871	1049	895
9	Centenary Heights	1299	9	Wilsonton Shopping Centre	1152	1388	1185
10	Mount Lofty	550	10	Betros Bros Shopping Centre	275	122	255
11	Rangeville	1860					
12	Redwood	31					
13	Drayton	433					
14	Glenvale	1441					
15	Harristown	2035					
16	Newtown	2385					
17	Wilsonton	1717					
18	East Toowoomba	1243					
19	Outer Northern Areas	1302					
20	Outer Southern Areas	236					
21	Outer Eastern Areas	409					
22	Outer Western Areas	191					
	Total Trips	**23484**					

5.4 Trip Distribution

After computing the total shopping trip production from each zone and the total attraction to each shopping centre zone, the trips were distributed between production and attraction zones using a gravity model. It was assumed that the shopping trips produced at a zone and attracted to a shopping centre is directly proportional to the total shopping trip production at the zone and total attraction at the shopping centres, and inversely proportional to the square of the distance between zones.

Before the gravity model was used for prediction of shopping trips, it was calibrated. Calibration of the gravity model involved calculation of the friction factor (F), which represents the impedance of shoppers to make shopping trips between various zones, and the selection of appropriate socio-economic adjustment factors (k).

The friction factor (F) is an impedance between zones, with the longer the distance between zones, the greater being the impedance. This study used distance between zones to generate the friction factors. A distances matrix is generated by calculating the distance between each zone and each shopping centre. This was done for all of the 22 production zones and the 10 shopping centre attractions as is shown in the Table J.1in appendix J. Table J.2a in the same appendix shows the friction factor (F) matrix which is calculated using the equation:

Friction Factor (F) Matrix = 1/ (distance) ^2

The friction factor indicates that as distance increases, shoppers are increasingly less likely to make shopping trips of such lengths.

The adjustment factor **K** for individual trip interchanges is known as the socioeconomic adjustment factor. This factor is assumed equal to 1.0 in using the gravity model analysis in this study because socioeconomic adjustment between zones does not appear to be warranted in the Toowoomba area. Toowoomba does not have pronounced differences in the land use characteristics between zones, and social and economic conditions are also reasonably consistent between zones.

The form of the Gravity Model used in this study was:

$$t_{ij} = \frac{P_i A_j F_{ij} K_{ij}}{\sum_{j=1}^{n} A_j F_{ij} K_{ij}}$$

$$= \frac{(Productions)(Attractions)(Friction\ Factor)}{Sum\ of\ the\ (Attractions * Friction\ Factors)\ of\ the\ Zones}$$

Where

t_{ij}= trips from zone i to zone j

P_i =trips produced from zone i

A_j =trips attracted to zone j

F_{ij}=friction factor

K_{ij} = zone to zone adjustment factor known as an adjustment factor

n = number of zones in the study area

The matrices of Fij, kij, and Fij kij are available in Table J.2b, Table (J.3a), and Table (J.3B) respectively in Appendix J. The Gravity Model uses an iterative process which compares the productions and attractions calculated in an iteration with the target values, with iterations occurring until a suitable level of convergence is achieved. It is important to look for adequate convergence for numbers to terminate the iterations. Mladenovic (2017) states that since the predicted trips are within 0.95 to 1.05 of the observed trips, the iteration process is terminated on the third iteration. In this research, the ratio of predicted shopping trips to the surveyed trips was between 0.99 and 1.00 on iteration number ten. The research used this accuracy because the calculations involved applying pricing comparisons where the trip differences after pricing could be small in some cases, so a high degree of accuracy was utilised in the calculations. In other words, the adequate numbers convergence for this study were obtained after ten iterations, which are shown in Table J.4 and in Appendix J. It can be seen from the matrix of the 10th iteration (original modelling) in Table 5.8 that high numbers of shopping trips go to the CBD from different zones especially those zones close to the CBD. The trip numbers to the CBD decrease when road pricing is increased and increase to other shopping centres out of the CBD as shown in the same matrix in the same table. Parking pricing also affects the trips from different zones to the CBD. The shopping centres out of the CBD received an increase in trips as a result of increased parking pricing. This increase becomes greater when the prices of parking are increased from $1 to $4. Table 5.8 outlines the reduction in trips for each shopping centre by a $1 increase in parking fees while Table L.1, Table L.2, and Table L.3 in appendix L show respectively the trip distribution matrix for $2, $3, and $4 increases

in parking fees. Thus, reducing the number of trips by distributing them to other shopping centres leads to reductions in the traffic in the city centre which is an important aim of this study.

Regularization, Early-Stopping and Expansion of the training data are from the strategies used to reduce Overfitting effects (Ying 2019). A form of regularization is an Early-Stopping which is based on choosing when to stop running an iterative algorithm. In the Toowoomba shopping trips model the accuracy was noticed in estimating shopping trips through the iteration. The iterations stop when there are no differences between estimated attraction shopping trips and the original attraction shopping trips to each shopping centre, where the model achieved a strategy to reduce the overfitting effects.

Collecting more data and ensuring the used data are clean and relevant, are ways of increasing the model accuracy. Cleaning data was an essential step to prepare data for analysis in this research. This has been done for the Toowoomba shopping trips model by removing noisy, incorrect, and unreasonable data using SPSS. So, this was another strategy to reduce the overfitting effects. In regard to the regularization strategy, the model becomes complicated if the number of features increases (Ying 2019). The Toowoomba shopping trips model achieved the solution of the regularization strategy to reduce the overfitting effects because it has relevant and accurate features for shopping trips.

5.5 Trip Assignment Analysis

After determining the number of shopping trips between each zone and each shopping centre, the next stage was to identify the particular routes for trips. This process is a traffic assignment which involves determining the amount of traffic allocated to each road. In this study, the traffic allocation is based on finding the minimum distance for each pathway.

All or Nothing

The process of assigning trips between two zonesis based on the minimum travel time between the centroids of the two zones and uses the technique known as all-or-nothing assignment.

The study dealt with shopping trips between centroids of zones and the centroids of shopping centres which are located around Toowoomba.

The survey asked people in Toowoomba to rate their preference in selecting roads when traveling to shop. Most people in Toowoomba preferred to choose a travel route close to the shortest distance. So, based on the answers, the minimum path for this study represents the route most likely to be selected between the residential zone centroid and the shopping centre centroid. For example, by using Emme software the zone of (Glenvale), with centroid number (46) and the High Street shopping centre with centroid number (190) are connected by many possible paths. The roads shown in the Figure 5.6 indicate the shortest distance path which means that, the shopping trips from Glenvale to High Street shopping centre use this shortest path. Extending this concept, Figure 5.7 represents the shortest distance paths from various centroids of zones of study to the High Street Shopping Centre. This technique was applied for the trips from all studied zones to all studied shopping centres. Each cell of the matrix in Table 5.8 shows the number of trips assigned between zones for the three cases of (i) existing flow, (ii) after implementation of road pricing, and (iii) after implementation of increased parking pricing.

Table 5.8: Shopping trips distribution for studied area

Des. / Orig.	1			2			3			4			5			6			7			8			9			10			Total prod.
	*O	**RP	***PP	O	RP	PP	O	RP	PP	O	RP	PP	O	RP	PP	O	RP	PP	O	RP	PP	O	RP	PP	O	RP	PP	O	RP	PP	
1	62	85	65	77	116	82	267	122	248	6	10	7	3	4	3	333	403	343	23	31	24	10	14	10	15	20	16	15	7	14	**811**
2	54	76	57	57	89	61	349	165	325	4	6	4	2	3	2	501	626	518	18	25	19	7	11	7	9	12	9	24	12	23	**1025**
3	122	166	127	117	179	125	327	151	304	8	13	9	2	3	2	133	163	138	16	22	16	12	18	13	89	120	93	16	8	15	**843**
4	76	100	80	64	94	68	164	72	151	7	11	8	1	2	2	47	55	48	10	14	11	9	13	9	83	107	86	8	4	7	**470**
5	47	46	47	497	535	504	76	25	67	78	88	79	2	2	2	5	4	4	8	8	8	151	158	152	3	3	3	3	1	3	**869**
6	67	64	67	1493	1583	1508	139	44	122	84	93	85	7	7	7	10	8	9	22	21	22	109	113	110	5	5	5	5	2	5	**1940**
7	27	25	27	1196	1250	1205	75	24	66	14	15	14	8	8	8	3	2	3	18	17	18	36	37	36	2	2	2	3	1	3	**1382**
8	92	124	96	347	523	370	448	203	417	9	15	10	6	9	6	12	15	13	40	54	42	41	61	44	4	6	4	16	7	15	**1016**
9	57	58	57	812	939	832	218	76	195	13	15	13	43	51	44	12	11	12	91	94	91	42	48	43	4	4	4	8	3	8	**1299**
10	44	67	47	77	132	83	279	144	263	5	8	5	3	6	4	68	94	72	44	68	47	9	14	9	6	9	6	16	8	15	**550**
11	68	69	69	488	555	499	269	92	240	16	19	16	596	702	612	21	19	21	348	354	350	35	39	36	6	6	6	12	4	11	**1860**
12	3	3	3	10	15	10	14	6	13	0	1	0	1	2	1	1	1	1	1	2	1	1	1	1	0	0	0	1	0	1	**31**
13	13	12	13	54	54	54	19	6	16	331	347	334	0	0	0	1	1	1	2	2	2	10	10	10	1	1	1	1	0	1	**433**
14	370	435	380	371	488	387	403	160	368	96	132	101	5	7	5	38	40	38	28	33	29	64	82	66	49	57	51	17	7	15	**1441**
15	601	673	612	618	774	641	464	175	421	71	93	74	5	6	5	22	22	22	26	29	27	195	238	201	16	18	16	17	6	15	**2035**
16	1400	1684	1440	170	228	178	614	249	562	18	26	19	3	4	3	41	44	41	18	22	19	30	39	31	67	79	69	25	10	23	**2385**
17	306	362	314	161	213	168	399	159	364	20	28	22	3	4	3	58	62	59	20	23	20	25	32	26	707	826	724	18	7	16	**1717**
18	83	139	89	164	305	178	743	418	708	8	15	8	7	14	8	45	66	47	131	219	141	18	33	20	7	12	8	38	21	36	**1243**
19	187	249	195	259	385	275	498	224	462	28	43	29	7	11	7	153	182	157	48	63	50	32	47	34	66	87	69	24	11	23	**1302**
20	18	19	18	115	130	118	35	12	31	41	49	42	1	2	1	3	3	3	5	5	5	13	14	13	2	2	2	1	1	1	**236**
21	34	39	34	149	196	156	117	47	107	9	12	9	11	15	11	15	16	15	51	61	53	13	17	14	4	5	4	5	2	5	**409**
22	33	39	34	58	77	60	57	23	52	12	16	12	1	1	1	8	8	8	6	7	6	8	10	8	7	8	7	2	1	2	**191**
Sum	**3764**	**4535**	**3871**	**7354**	**8860**	**7563**	**5972**	**2595**	**5503**	**877**	**1056**	**902**	**717**	**864**	**737**	**1530**	**1843**	**1573**	**973**	**1172**	**1001**	**870**	**1049**	**895**	**1152**	**1388**	**1185**	**275**	**122**	**255**	**23484**

* Original

** Road pricing

*** Parking pricing

The number of trips in each cell is allocated to each link along the shortest path between zones. For instance, Figure 5.8 contains the number of daily shopping trips from Glenvale to the High Street Shopping Centre along the shortest path on each link.

Calculation of traffic assignment in this study was performed using an Excel worksheet.

The process started with allocating the shopping trips from each zone to a particular shopping centre for all links on the shortest path to that particular centre and then summing all trips on each link. Appendix K shows the detail of the process of traffic assignment, starting by linking the excel spreadsheet of the estimated volumes in the iteration number ten that resulted from the Gravity model (Table k.1in Appendix k) by the sheet of the shortest path as shown in Table k.2 in Appendix k. For example, each shortest path in Table k.2 in Appendix k contains the value of shopping trips from each zone to the Clifford Gardens shopping centre. This operation was done for each shopping centre. Then, the summation of all the shopping trips on each link on the shortest path was calculated in one column as shown in the example in Table k.3 in Appendix K. The results are shown in Figure 5.9 and Figure 5.10. These figures show the modelled distributed shopping trips on assigned paths on Toowoomba and CBD of Toowoomba. Shopping trips on particular roads varied from a few trips up to several thousand trips on major roads.

Figure 5.6: The shortest path from Glenvale to the High Street Shopping Centre

Figure 5.7: The shortest paths from whole zones to the High Street Shopping Centre

Figure 5.8: Allocating the shopping trips on the shortest path from Glenvale to the High Street Shopping Centre

The all-or-nothing assignment approach used in this study had some limitations in that the approach assumes that all trips will start at zone centroid. So, this could result in some error that would affect accuracy.

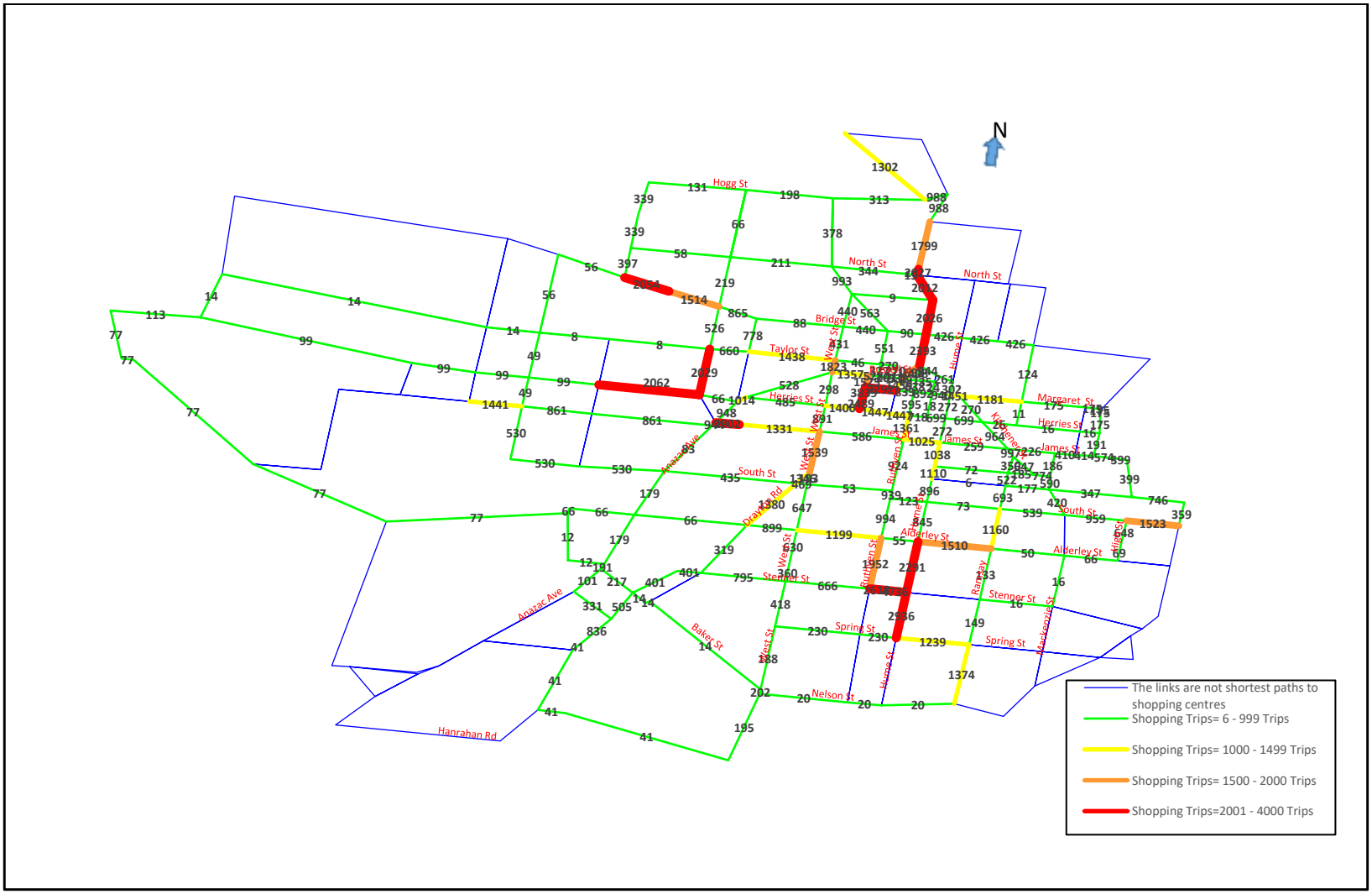


Figure 5.9: Shopping trips on roads of Toowoomba

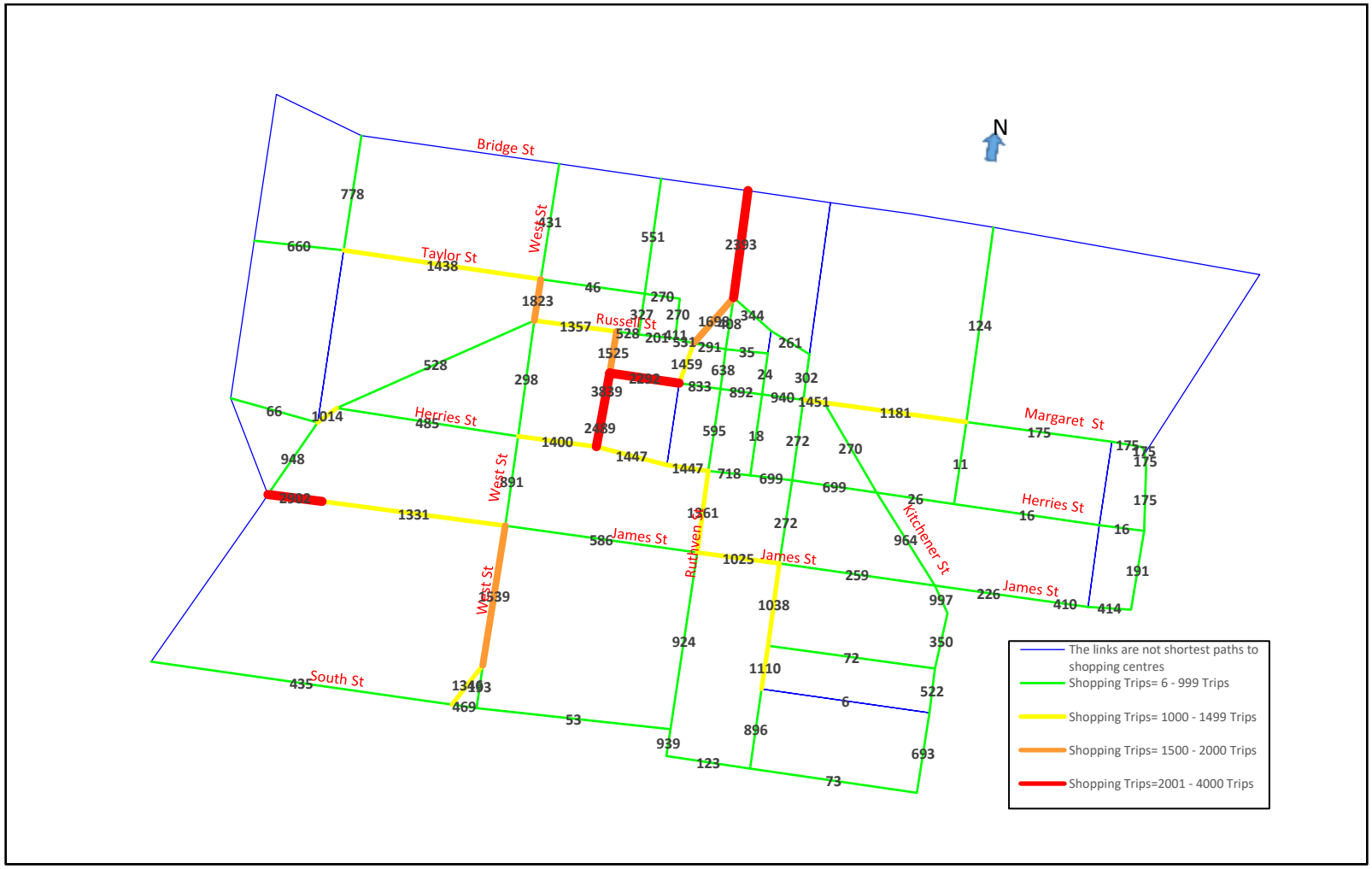


Figure 5.10: Shopping trips on roads of Toowoomba CBD

5.6 Model Validation

The model was validated by checking its ability to replicate actual trip patterns. This process required a comparison of shopping trips estimated by the model with observed shopping trips on the roads. A model is evaluated in terms of the acceptable level of error (Wegmann 2008). The proposed error presented by Federal Highway Administration (FHWA) for regionwide validation shows that the acceptable error for principal arterial roads is +/- 10 percent, minor arterials is +/- 15 percent, and collectors and frontage roads are +/- 25 percent (Wegmann 2008). Tolouei, Abellan, and Alvarez (2016) showed in their research using data from the FHWA criteria for CBD, urban, suburban, and rural of +/-25% and preferably +/-15%.

The aim of the Toowoomba shopping model validation is to compare the observed shopping trips with the model outputs to verify that the modelled trips are representing the observed trips. Table 5.9 represents the values of estimated assigned shopping trips, and the observed shopping trips for six shopping centres for twelve hours a day in weekdays and nine hours in weekends.

The shopping trips entering a specific shopping centre is a part of the total shopping trips represented on the links. The validation was done on the same set of days and times that the survey results showed was the preferred time to shop at each shopping centre, as shown in the Table M.1 in Appendix M. The table of comparisons shows that the differences between the output of the model and the observed data range between -10% and +10% and are within acceptable limits. Hidas and Milthorpe (2009) demonstrate in their study of NSW transport that there can be significant differences between the output of the model and the observed data for any given time period even from the same input data. They explain that this is due to the static traffic assignment method used in the strategic models. They show in their study that the differences vary between +/-10 %, and that those variations were for a few trips up to several thousand trips. They clarify what can be expected between any strategic model outputs and collected observed data in a given time period. In addition, the same research states that any of the model validation guidelines do not provide information on how convergence between observed and estimated trips can be obtained (Hidas & Milthorpe 2009). Thus, for the Toowoomba shopping study, the errors that were obtained are within the acceptable tolerance of errors, as accepted by previous

researchers. The model is considered validated as the variation between modelled and observed data is acceptable.

Table 5.9: Validation survey comparison with model results

Shopping Centre	Total observed Turning Trips	Modelled Total Turning to each shopping centre	Diff of all	% Difference
Westridge	950	870	80	8
The Range	897	973	-76	-8
High Street	795	717	78	10
Wilsonton	1052	1152	-100	-10
Drayton	957	877	80	8
Betros Brose	304	275	29	9

5.7 Conclusion

This chapter has presented the different steps that were used at each stage in the traditional four-step model for forecasting Toowoomba shopping trips. The modelling was undertaken sequentially and is based upon the answers to a series of questions about shopping decisions obtained from the survey. The sequence involved five tasks. It started with the division of the Toowoomba area into study zones. The sequence then calculated the number of shopping trips starting from each zone by a trip production technique. For this study, trip production incorporated mode choice. Mode choice allocates the shopping trips among the Toowoomba available modes of car, bus, walking, bicycle, motor bike, and truck. Next, trip distribution analysis prepared a trip matrix starting in each zone and ending in a shopping centre at each destination. Then the shortest path that is selected by the shopper was used to perform a trip assignment analysis. Validation of the final modelling results was performed by ensuring that the variation between modelled and observed results was within an acceptable range. The explanation of the opinions of Toowoomba people and their likely behaviour of shopping after pricing are discussed in chapter six.

Chapter Six

Impact of Pricing on Shopping Trips

6.1 Introduction

This chapter reviews the outcomes of the survey with respect to: the general opinions of survey respondents on road pricing, the impact of road pricing on shopping trips, the impact of increasing parking pricing on shopping trips and shopping trips in Toowoomba after pricing. It concludes with a study of the possibility of transferring the findings from the Toowoomba research to other Australian Regional Cities.

6.2 The General Opinion of Toowoomba People on Presumptive Road Pricing

6.2.1 The overall Opinion of Survey Respondents

A total of 304 respondents answered the survey question about what they thought of proposed congestion charges if one was introduced. The two alternatives for levels of charge in the survey were $1-$2 per visit and $3-$4 per visit. Table 6.1 shows the survey results. A small number of people selected the choice "other" when answering the survey question and wrote comments but did not suggest prices.

Table 6.1: Counts and percentages of the whole respondents who agreed on the level of charging

Pricing	Direction	Survey Results	
		People who shop in CBD (% of total survey)	People who agree on level of pricing (% of total survey)
$1-$2	N	51 (88%)	42 (72%)
	S	96 (82%)	84 (71%)
	E	59 (92%)	50 (78%)
	W	51 (79%)	46 (72%)
	Average	85%	73%
$3-$4	N	51 (88%)	11 (19%)
	S	96 (82%)	25 (21%)
	E	59 (92%)	10 (16%)
	W	51 (79%)	13 (20%)
	Average	85%	19%
Other	N	51 (88%)	5 (9%)
	S	96 (82%)	9 (8%)
	E	59 (92%)	4 (6%)
	W	51 (79%)	5 (8%)
	Average	85%	8%

As would be expected the above table shows that a higher percentage of respondents from all areas chose the lower price range of $1-$2, and a low percentage of respondents chose the price range of $3-$4.

The outcome indicates that overall the respondents to the survey would best tolerate a pricing charge of $1 - $2 with a few respondents indicating no charge in the “other charge” option.

6.2.2 The Opinions of Different Population Genders

The opinion of females was considered very important because of their significantly higher level of CBD shopping (Table 3.10). While both male and female chose the price $1-$2 from the four directions of travel (Table 6.2), percentages of choosing the preferred price was smaller for males than for females from each of the four directions. The percentages of females was approximately twice that of males.

To conclude there were significant differences between the opinions of males and females. The percentages of opinions on level of pricing for the four directions do not change very much according to the respondent’s gender.

6.2.3 The Opinions of Different Population Age Groups

The differences in opinion of various age groups toward road pricing was important as there are differing percentages across the various age groups in Toowoomba who prefer shopping in the CBD. The five age groups from the four areas of Toowoomba have different opinions about charging. Table 3.11 shows that the groups of age 30 to 44 years, 45 to 59 years and 60 to 74 years were the most frequent CBD shoppers from the sample. Table 6.3 shows that those age groups also preferred the pricing level of $1-$2.

The level of charging $3-$4 was the choice of a small percentage from each group. In conclusion, the most frequent shoppers in the Toowoomba CBD were aged 30 years to 74 years and they preferred a charge of $1-$2 per visit compared to a charge of $3-$4.

Table 6.2: Counts and percentages of agreed gender on the level of charging

Pricing	Direction	Male	Female
$1-$2	**N**	13 (22%)	29 (50%)
	S	23 (19%)	61(52%)
	E	15 (23%)	35 (55%)
	W	12 (19%)	34 (53%)
	Total	63(21%)	159(52%)
$3-$4	**N**	7 (12%)	4 (7%)
	S	11 (9%)	14 (12%)
	E	3 (5%)	7 (11%)
	W	4 (6%)	9 (14%)
	Total	25(8%)	34(11%)
Other	**N**	2 (3%)	3 (5%)
	S	3 (3%)	6 (5%)
	E	1 (1%)	3 (5%)
	W	2 (3%)	3 (5%)
	Total	8(3%)	15(5%)

Table 6.3: Counts and percentages of agreed age groups on the level of charging

Pricing	Direction	15-29 years	30-44 years	45-59 years	60-74 years	75 years and over
$1-$2	**N**	7 (12%)	12 (21%)	7 (12%)	7 (12%)	9 (16%)
	S	8 (7%)	26(22%)	23 (19%)	20 (17%)	7 (6%)
	E	4 (6%)	9 (14%)	18 (28%)	15 (23%)	4 (6%)
	W	4 (6%)	12 (19%)	12 (19%)	14 (22%)	4 (6%)
	Total	23(8%)	59(19%)	60(20%)	56(18%)	24(8%)
$3-$4	**N**	2 (3%)	4 (7%)	4 (7%)	1 (2%)	0 (0%)
	S	2 (2%)	7 (6%)	5 (4%)	10 (8%)	1 (1%)
	E	2 (3%)	2(3%)	3 (5%)	3 (5%)	0 (0%)
	W	1(2%)	2 (3%)	5 (8%)	4 (6%)	1 (2%)
	Total	7(2%)	15(5%)	17(6%)	18(6%)	2(0)
Other	**N**	0 (0%)	1(2%)	2 (3%)	1 (2%)	1 (2%)
	S	1 (1%)	2(2%)	1 (1%)	4 (3%)	1 (1%)
	E	0 (0%)	1 (2%)	2 (3%)	1 (2%)	0 (0%)
	W	1 (2%)	2 (3%)	2 (3%)	0 (0%)	0 (0%)
	Total	2(0)	6(2%)	7(2%)	6(2%)	2(0)

6.3 Opinions on Road Pricing

Other Cities

Community attitudes to road pricing are influenced by its perceived benefit to areas, such as its direct influence on other taxes. A major mechanism for increasing support for congestion charging is through the strategic use of the revenue raised. People's positive attitudes to pricing are affected if the pricing is linked to improvements in the transport system. For instance, the revenue raised in London is allocated to public transport, and the pricing charge is not paid by buses. Thus, the bus services have been considerably improved in London as a result of relieved congestion and using congestion revenues to improve the bus system. The charge in London was £5 in 2003 and it increased in 2005 to £8 for some vehicles with high CO2 emissions and was increased again to £10 in 2008. The increase in pricing has been generally acceptable in the longer term although the pricing initially was viewed negatively in London because it was regarded as a tax. The pricing system is generally regarded as successful in California although the mode-shift aims were not achieved by the service. Singapore and Norway used revenue for road maintenance purposes (Bureau of Infrastructure 2008), which improved the community attitude's positively. The greater the visible investment gain from the pricing, arising from a significant behavioural charge, the more likely that the pricing was acceptable to the community.

Toowoomba

The study was able to ascertain the reaction of Toowoomba people to two possible levels of charge for visits to the CBD. As would be expected with a plan to introduce monetary charges, the majority opinion of the community was for the lower price. The lower price was supported by most groups when the survey population data was examined in subgroups according to gender and age group.

While this initial response was positive, there would be more investigative work required to gain the Toowoomba community's acceptance before implementation of any road pricing. For example, the community could be informed that revenue would be dedicated to making improvements in public transport such as bus services improvements (similar to that which occurred in London charging projects and in California) to make road pricing more acceptable. It would also be stressed that with

road pricing travel to shop at the CBD would be both faster and safer due to lower congestion levels (Banister 2003 p.261).

6.4 Impact of Road Pricing on Shopping Trips

This section addresses the impact of road pricing on shopping trips with regard to the effects on shopping in the CBD and the likelihood of increased public transport use if road pricing was introduced.

Survey respondents were asked if a congestion charge would affect their shopping in the CBD. It was queried of respondents if they would shop less in the CBD, more at other shopping centres, or still shop in the CBD but use public transport. Respondents also had the opportunity to choose both shopping less in the CBD and using public transport.

6.4.1 The Effect of Road Pricing on Shopping Habits

There were 304 respondents that answered this question. Of these, 173 (57%) chose the option to shop less in the CBD if a congestion charge was introduced. Table 6.4 represents the details of the percentages of shifting shoppers from each direction and the percentages of shifting were fairly close for the four directions. The area with the most shifting percentage was the south. This is probably because of the availability of lots of alternate shopping centres in the south such as Kearneys Spring shopping centre and Westridge shopping centre. Approximately the same shifting percentage was indicated from the west, likely due to the people in this area being able to easily access the south Toowoomba shopping centres. The east has a small percentage of reduced shopping in the CBD when compared with other directions due to there not being a large alternate shopping centre in the east, and particularly in the north east.

Figure 6.1 represents the distribution of shopping trips in Toowoomba with an introduction of congestion charging (modelled on the results of the questionnaire data), while the distribution in the CBD area is represented in Figure 6.2. It was found that there was a reduction in trips in some roads inside and around the CBD of Toowoomba when compared with the trip distribution numbers for the current situation without pricing (Figure 5.10). Figures 6.3 and 6.4 show the differences from the original distribution. This change of shopping habits would reduce the number of vehicles on the roads of Toowoomba's CBD and would relieve traffic congestion.

Table 6.4: The effect of road pricing on shopping habits

Direction	Shoppers of CBD of sample	People who would shop less in CBD	Total sample
N	51 (88%)	30 (52%)*	58
S	96 (82%)	70 (59%)	118
E	59 (92%)	36 (56%)	64
W	51 (79%)	37 (58%)	64
Total	85%	57%	

*(30/58)*100=52%

6.4.2 The Effect of Road Pricing Based on Shopper's Gender

The effects of gender on shopping habits is shown in Table 6.5. This table shows that the differences between male and female behaviour in the case of implementation of road pricing is very small, and that two thirds of all CBD shoppers would be impacted. Both females and males have the same impact on traffic congestion reduction as a result of any introduction of road pricing.

6.4.3 The Effect of Road Pricing Based on Shopper's Age

Table 6.6 shows that the age groups 30-44 years, 45-59 years, and 60-74 years were those most influenced in their shopping habits by road pricing. Those age groups chose to shop at shopping centres out of the CBD and shop less in the CBD of Toowoomba as a result of road pricing. The age groups 15-29 years and 75 years and over had lower percentages of shifting than the other groups.

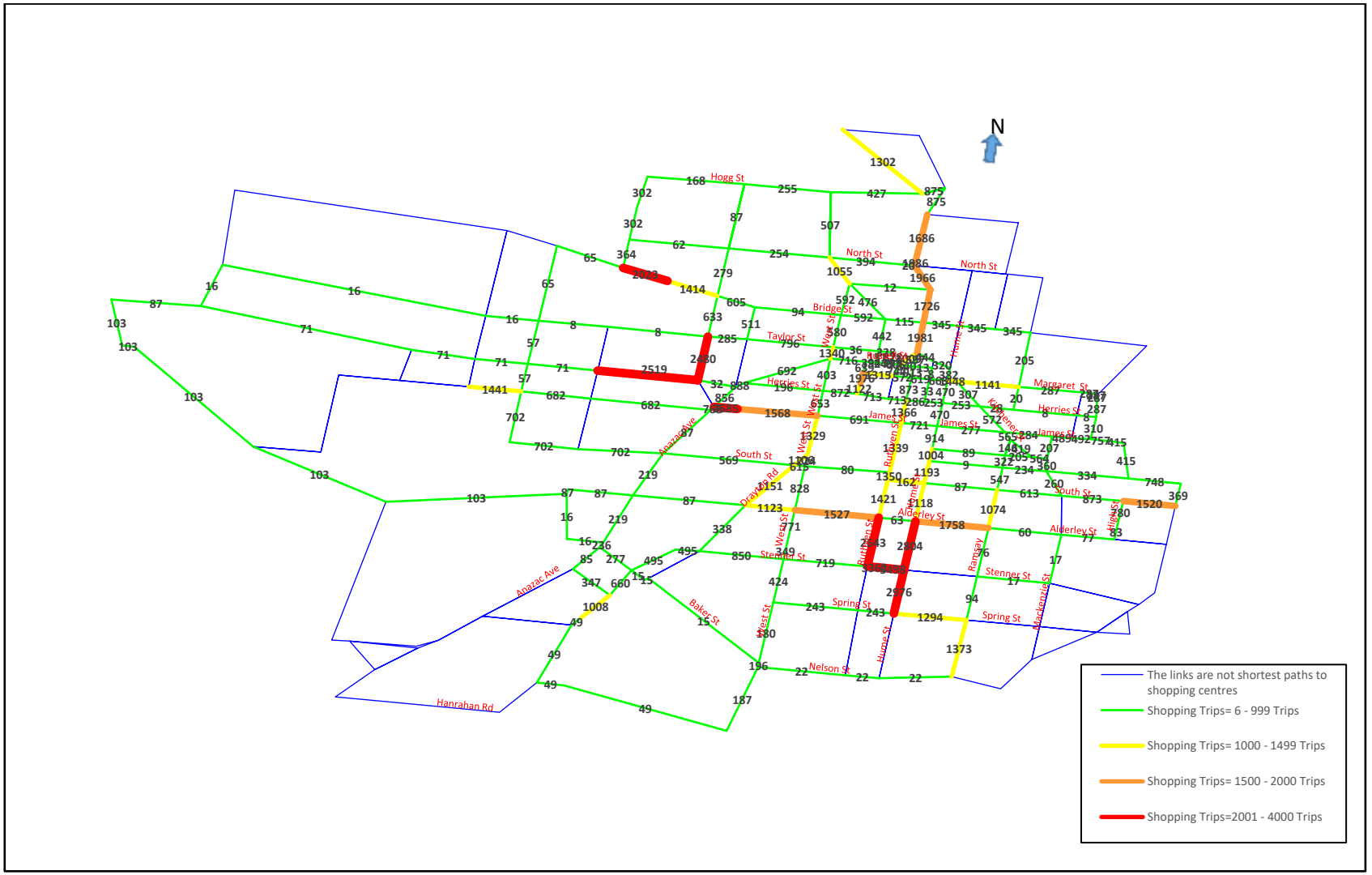


Figure 6.1: Distribution of shopping trips on Toowoomba by introducing congestion charge

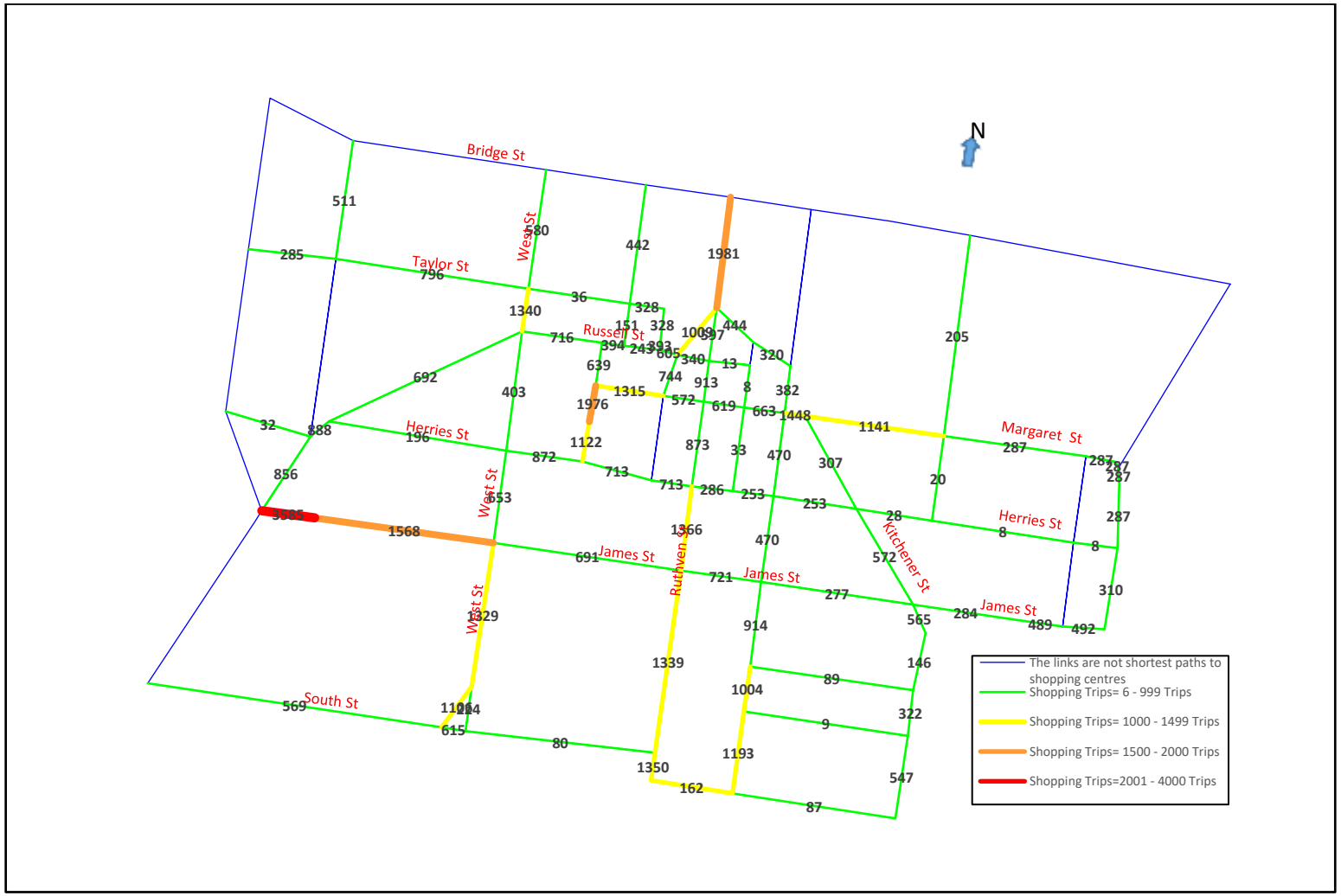


Figure 6.2: Distribution of shopping trips on CBD of Toowoomba by introducing congestion charge

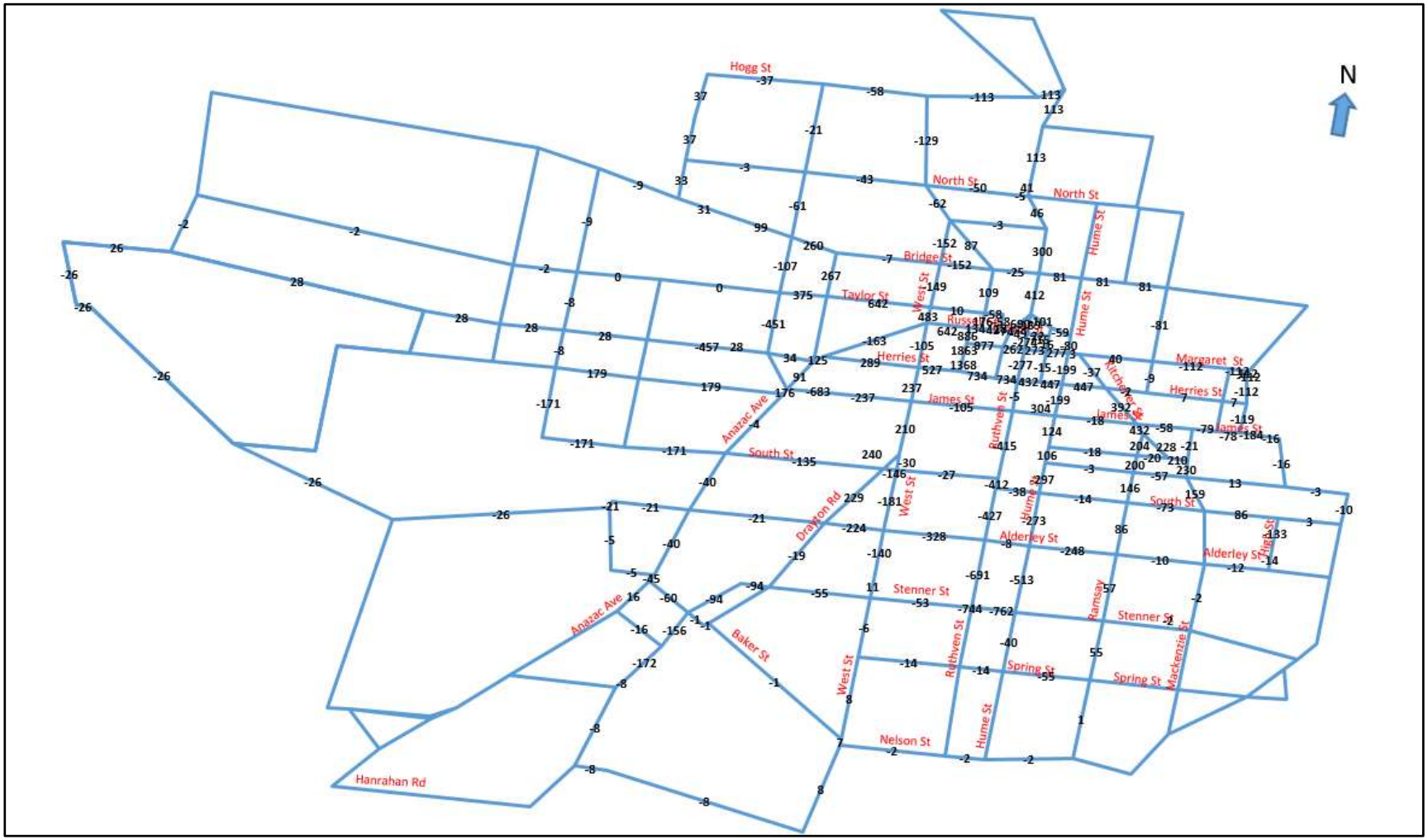


Figure 6.3: Differences between the original distribution of shopping trips on Toowoomba and the distribution after introducing congestion charge

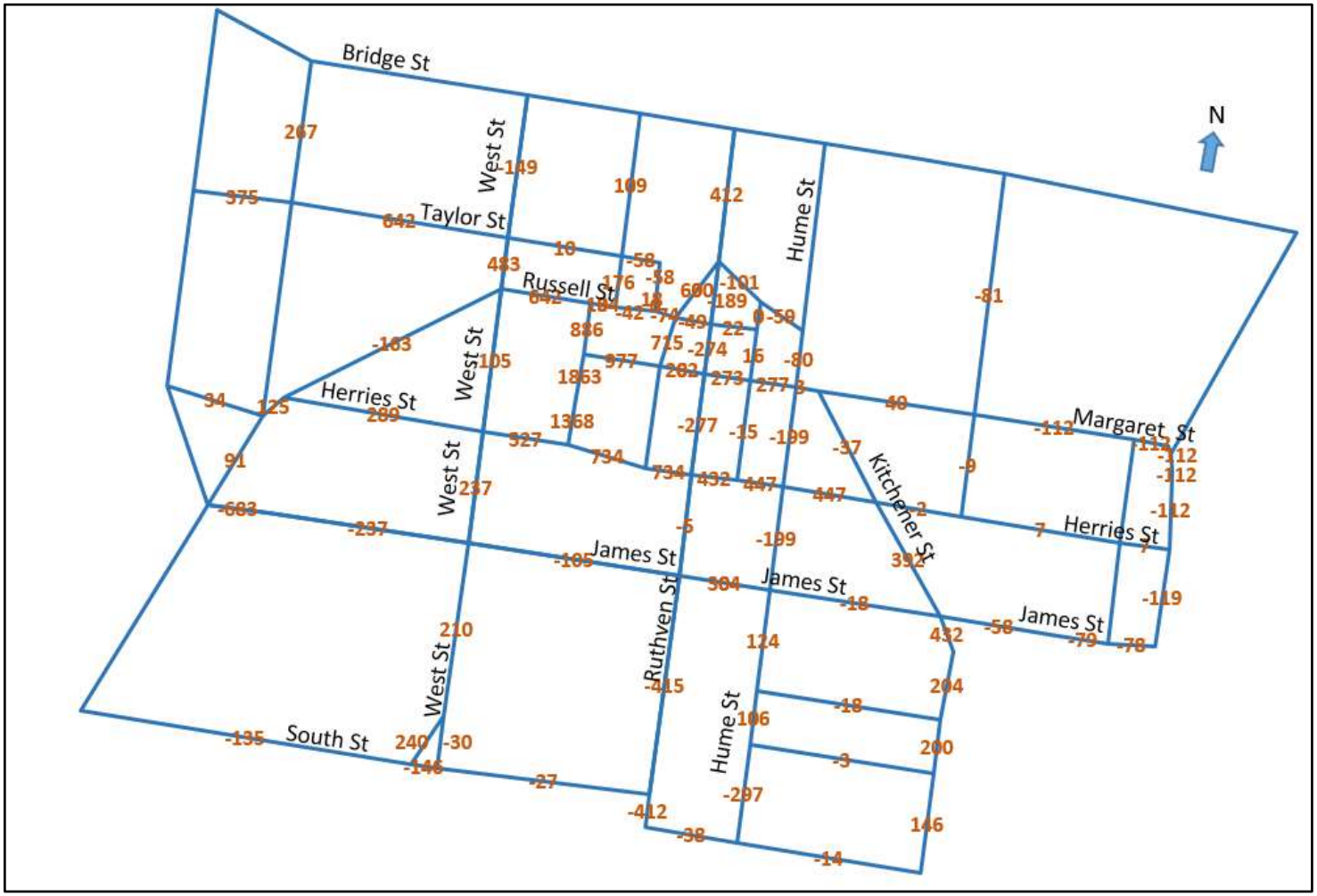


Figure 6.4: Differences between the original distribution of shopping trips on CBD of Toowoomba and the distribution after introducing congestion charge

Table 6.5: The effect of road pricing on shopping of genders in CBD

Direction	Males shoppers who would shift shopping	Females shoppers who would shift shopping
N	6 (32%) *	24 (75%)
S	25 (71%)	45(74%)
E	13 (72%)	23 (56%)
W	12 (80%)	25 (69%)
Total	56(64%)	117(69%)

*(6/19) *100=32%

Table 6.6: The effect of road pricing on shopping of age groups in CBD

Direction	15-29 years	30-44 years	45-59 years	60-74 years	75 years and over
N	2 (33%) *	9 (56%)	8 (73%)	8 (100%)	3 (30%)
S	3 (38%)	23(74%)	19 (86%)	21 (75%)	4 (57%)
E	3 (50%)	7 (64%)	18 (78%)	7 (44%)	1 (33%)
W	2 (50%)	13 (93%)	9 (64%)	12 (80%)	1 (25%)
Total	10(42%)	52(72%)	54(77%)	48(72%)	9 (38%)

*(2/6) *100=3%

6.5 Impact of Road Pricing on Public Transport Usage

6.5.1 The Effect of Road Pricing on Shopper's Travel Mode

Public transport in Toowoomba is limited to bus services. Responses to the survey indicated that the introduction of road pricing would cause 22% of respondents to change to public transport for travel to the CBD. Table 6.7 provides full details of percentages of shoppers shifting from cars to buses from each direction in Toowoomba. The change to public transport is the greatest for shoppers from the south and east. This is most likely because of the current good availability of buses that serve the south and east. It would appear that people from the east and south would keep shopping at the CBD but travel by a different mode. The change to public transport for shopping would reduce the number of cars in the streets and reduce congestion.

Table 6.7: The effect of road pricing on shopper's travel mode

Direction	Shoppers of CBD of sample	People who would use public transport	Total sample
N	51 (88%)	10 (17%)*	58
S	96 (82%)	30 (25%)	118
E	59 (92%)	15 (23%)	64
W	51 (79%)	13 (20%)	64
Total	85%	22%	

*(10/58)*100=17%

6.5.2 The Effect of Road Pricing Based on Shopper's Gender

Table 6.8 shows the details of genders who are moving to ride buses instead of cars. Both females and males are likely to change the mode of travel to the CBD. This means a reasonably large number of females and males would change their shopping mode from cars to buses, resulting in a decrease in shopping traffic on CBD roads.

Table 6.8: The effect of road pricing on using public transport of genders

Direction	Males shoppers who would use public transport	Females shoppers who would use Public Transport
N	3 (16%) *	7 (22%)
S	14 (40%)	16(26%)
E	5 (28%)	10 (24%)
W	5 (33%)	8 (22%)
Total	27(31%)	41(24%)

*(3/19) *100=16%

6.5.3 The Effect of Road Pricing Based on Shopper's Age

Table 6.9 shows that the groups of age 30 years to 74 years would be the most affected by introducing road pricing and that it would make them shift to public transport. The age group 15-29 years was lower affected than the age groups 30 to 74 years, and 75 years and over was not as reactive as other groups in moving to public transport. Accordingly, the shifting range of percentages of age groups of cars users to buses would help reduce traffic flows to the CBD.

Table 6.9: The effect of road pricing on using public transport of age groups

Direction	15-29 years	30-44 years	45-59 years	60-74 years	75 years and over
N	0 (0%)	3 (19%) *	3 (27%)	4 (50%)	0 (0%)
S	3 (38%)	10 (32%)	9 (41%)	7 (25%)	1 (14%)
E	1 (17%)	6 (55%)	4 (17%)	4 (25%)	0 (0%)
W	1 (25%)	5 (36%)	4 (29%)	2 (13%)	1 (25%)
Total	5 (21%)	24 (33%)	20 (29%)	17(25%)	2 (8%)

*(3/16) *100 = 19%

6.6 Road Pricing Outcomes in other Cities

Large cities, including Stockholm (Sweden), London (England), and Bergen, Oslo and Trondheim (Norway) had small percentages of people supporting road pricing when first introduced. The public support for pricing was found to increase after pricing introduction, when properly designed (Eliasson 2010; Levinson 2010). Eliasson (2010) identified the stages and reasons of acceptability in the Stockholm charging scheme. The reasons were many, such as the actual effects were more positive than anticipated and the patterns or travel costs were less than the public expected. The term of "accept the inevitable" summarised other reasons suggesting that the public are more accepting once changes are in place. Also, a trial period of seven months of Stockholm road pricing allowed the community to understand the effects on congestion levels and travel behaviour (Winslott-Hiselius et al. 2009).

Pridmore and Miola (2011) provided a table showing that in a short time there was an increasing positive community attitude toward charging. They show the increase in positive effects in Stockholm from 2001 to 2006 was 14% while reduction in negative acceptability through the two years was 5%. The negative effects in London was 40% in 2002 and reduced to 24 -28% in 2003 while the increase in acceptability was from 40% to 48 -57% through the two years. In the city of Bergen in Norway, the negative effect was 81% before road pricing and reduced to 42%, after pricing introduction. This city had a significant positive change in acceptability of charging. It was 19% of acceptance and raised to 58%. Oslo, the capital of Norway, had a decrease in negative effects from 70% to 59% after pricing introduction in 1990 while the positive effects were represented by a rise of percentages from 30% to 41%. The same positive direction was found in Trondheim, Norway in 1991. The positive attitude of the city to congestion charging was initially 9% and increased to 47%, and the negative attitude reduced from 91% to 53%. The higher benefits and lower disadvantages from charging schemes are the major reasons behind this phenomenon.

6.7 Impact of Increasing Parking Pricing on Shopping Trips

The survey asked respondents if an increase cost of parking in the CBD would cause a shift in their travel mode. Parking increases included parking meters, and previously free parking at shopping centre parking. The cost increase levels used increments used were $1, $2, $3 and $4 per hour. Respondents were asked at what price increase level

they would consider using public transport and the number of times per week that would occur. Respondents also were able to insert the price that would alter their behaviour, and to indicate if public transport was not available.

6.7.1 The Effect of Increasing Parking Pricing on Shopping Habits

The aim for this part was to investigate how many respondents in the whole survey people would choose each price for increasing parking price, and how this price would affect the number of times they visited the CBD to shop. A total of 170 people selected prices increases from the list. Respondents who answered "other", mostly indicated that pricing changes would have little influence on their current parking behaviour.

As expected more respondents indicated a greater impact on travel mode as the price level increased. Table 6.10 shows that the most influenced number of trips to shop at the CBD were from the directions of south and west Toowoomba for all levels of parking pricing. The north was the area where the smallest number of people indicated they would shift their trips, likely due to the highest average household size and car ownership (Table 3.8 and Table 3.9).

Table 6.11 shows the rise in the number of shifted trips from the CBD caused by increasing parking pricing, which would reduce traffic due to reduced shopping trips to the CBD. Figure 6.5 provides a graphical summary of how trips change as a function of increased parking fees.

Figures 6.6, 6.7, 6.8, and 6.9 show the sequential change in shopping trip distribution across the wider road network as parking pricing increases from by $1 to $4. For example the traffic on Drayton Road between Alderley and South Street reduced from 1334 to 1288 to 1225 to 1156 with the price increases.

Figures 6.10, 6.11, 6.12, and 6.13 provide similar information for the CBD for increases in parking pricing by $1, $2, $3, and $4. It can be seen from those figures that the reduction in shopping trips occurs mostly within the CBD while some limited increases occurred on the major arterial roads and perimeter roads that access other shopping centres. For example the traffic on the last segment for Margaret Street reduced from 2171 to 1967 to 1699 to 1342 with the above parking price increases.

Table 6.10: The effect of increasing parking pricing on shopping habits

Parking Price Increase	Direction	Survey Data		
		Total sample	People Who are shopping in CBD	People who would affect in number of times shopping at CBD
$1	N	58	51 (88%)	2 (3%)
	S	118	96 (82%)	12(10%)
	E	64	59 (92%)	4 (6%)
	W	64	51 (79%)	7 (11%)
	Average			8%
$2	N	58	51 (88%)	7 (16%*)
	S	118	96 (82%)	15 (23%)
	E	64	59 (92%)	8 (19%)
	W	64	51 (79%)	9 (25%)
	Average			21%
$3	N	58	51 (88%)	7 (28%)
	S	118	96 (82%)	20 (40%)
	E	64	59 (92%)	10 (34%)
	W	64	51 (79%)	11 (42%)
	Average			36%
$4	N	58	51 (88%)	10 (45%)
	S	118	96 (82%)	24 (60%)
	E	64	59 (92%)	12 (53%)
	W	64	51 (79%)	12 (61%)
	Average			55%

*((2+7)/58) *100=16%

Table 6.11: Number trips changed to CBD by price increase parking

Direction	$1	$2	$3	$4
N	52	235	418	680
S	216	486	846	1279
E	85	256	469	724
W	136	310	524	757

Figure 6.5: Shifted trips from the CBD under increasing parking pricing

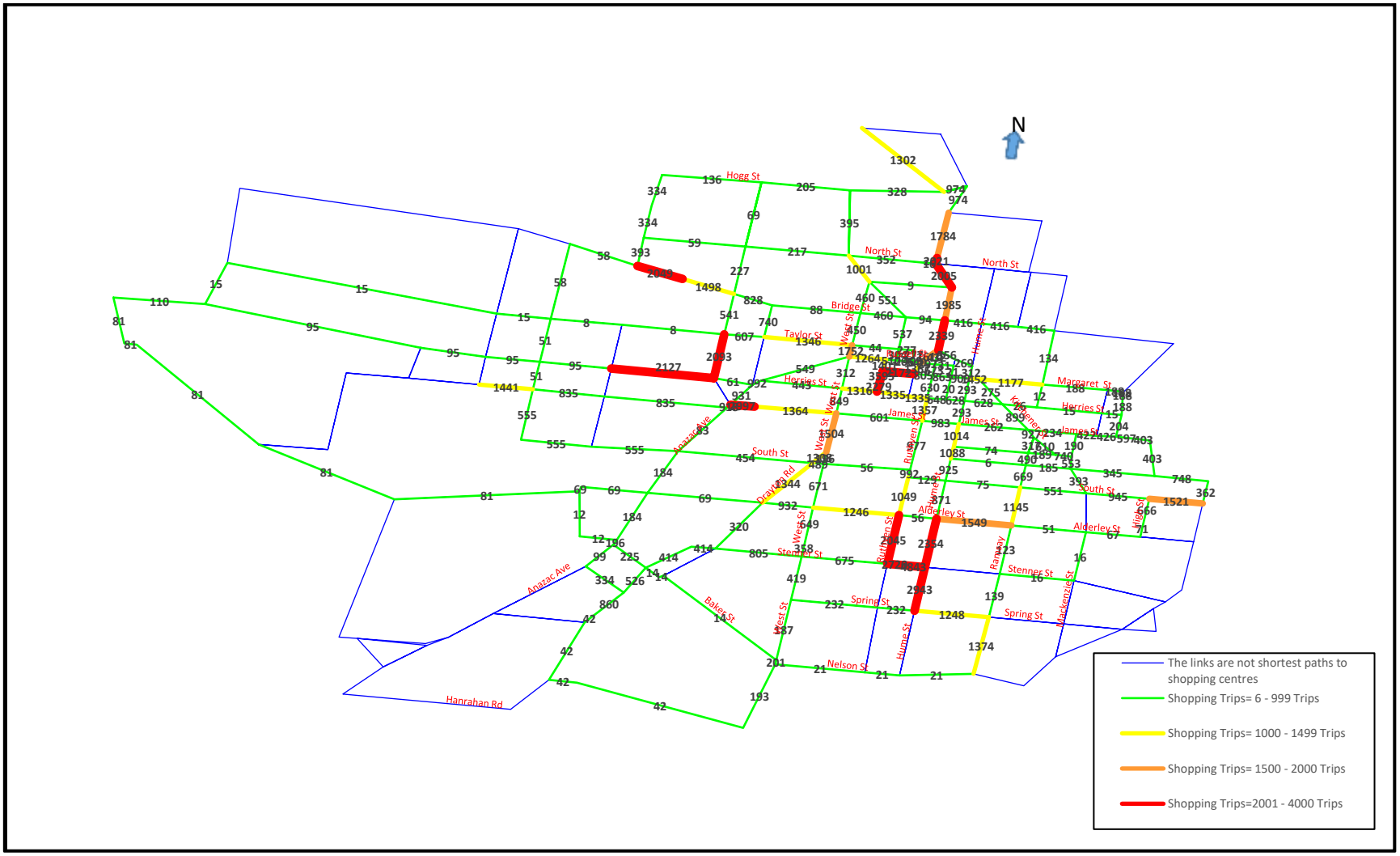


Figure 6.6: Distribution of shopping trips on Toowoomba by increasing $1 parking prices

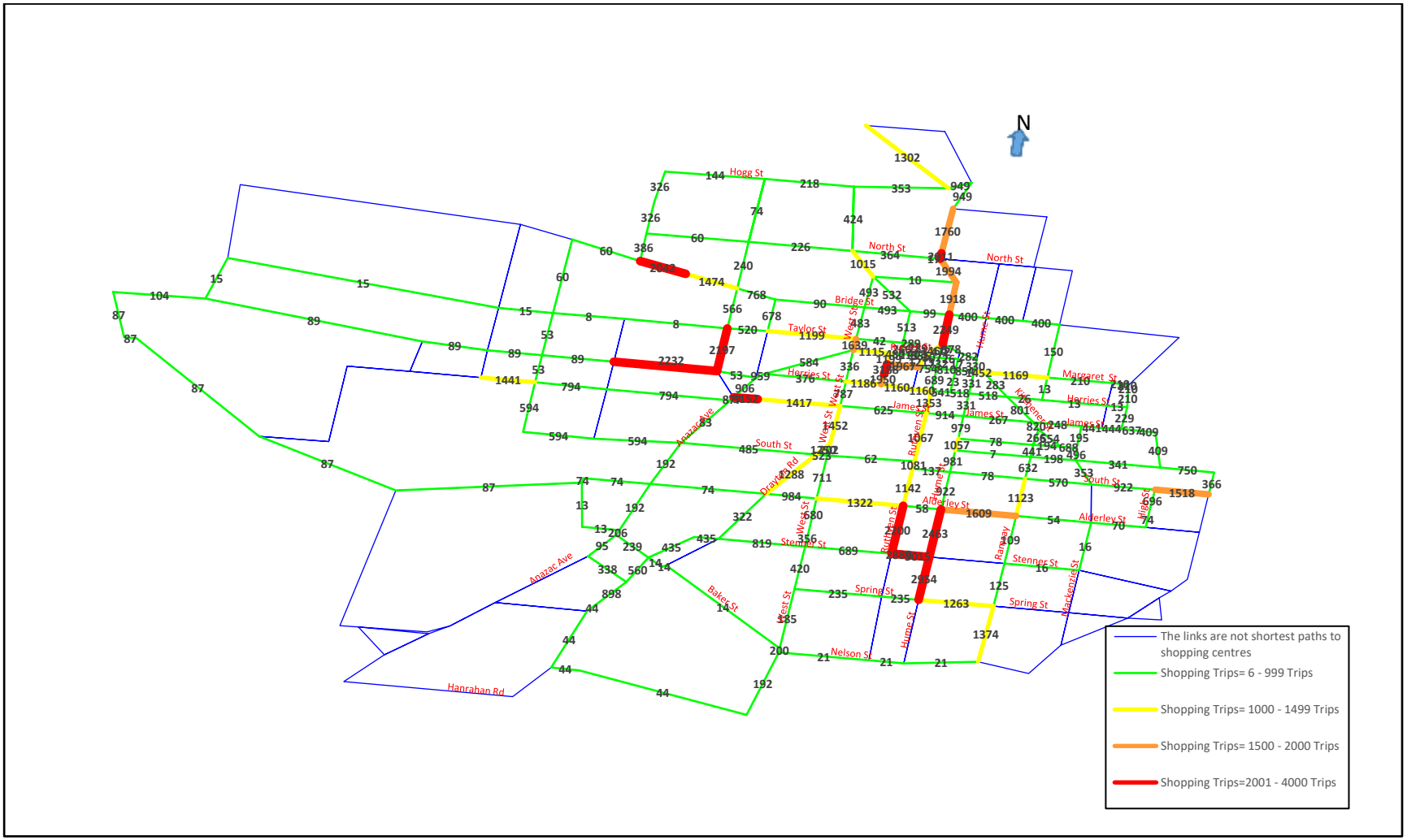


Figure 6.7: Distribution of shopping trips on Toowoomba by increasing $2 parking prices

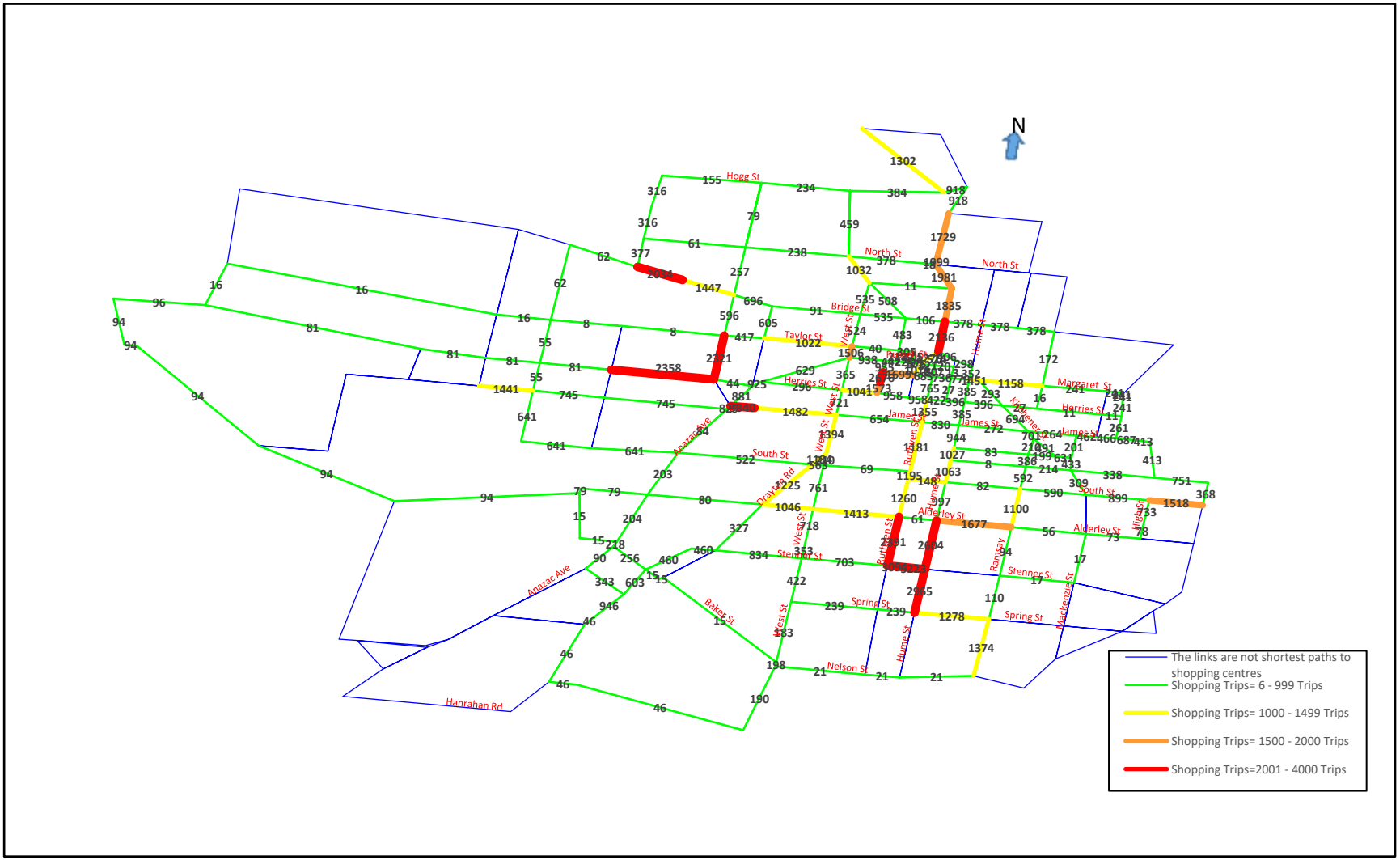


Figure 6.8: Distribution of shopping trips on Toowoomba by increasing $3 parking prices

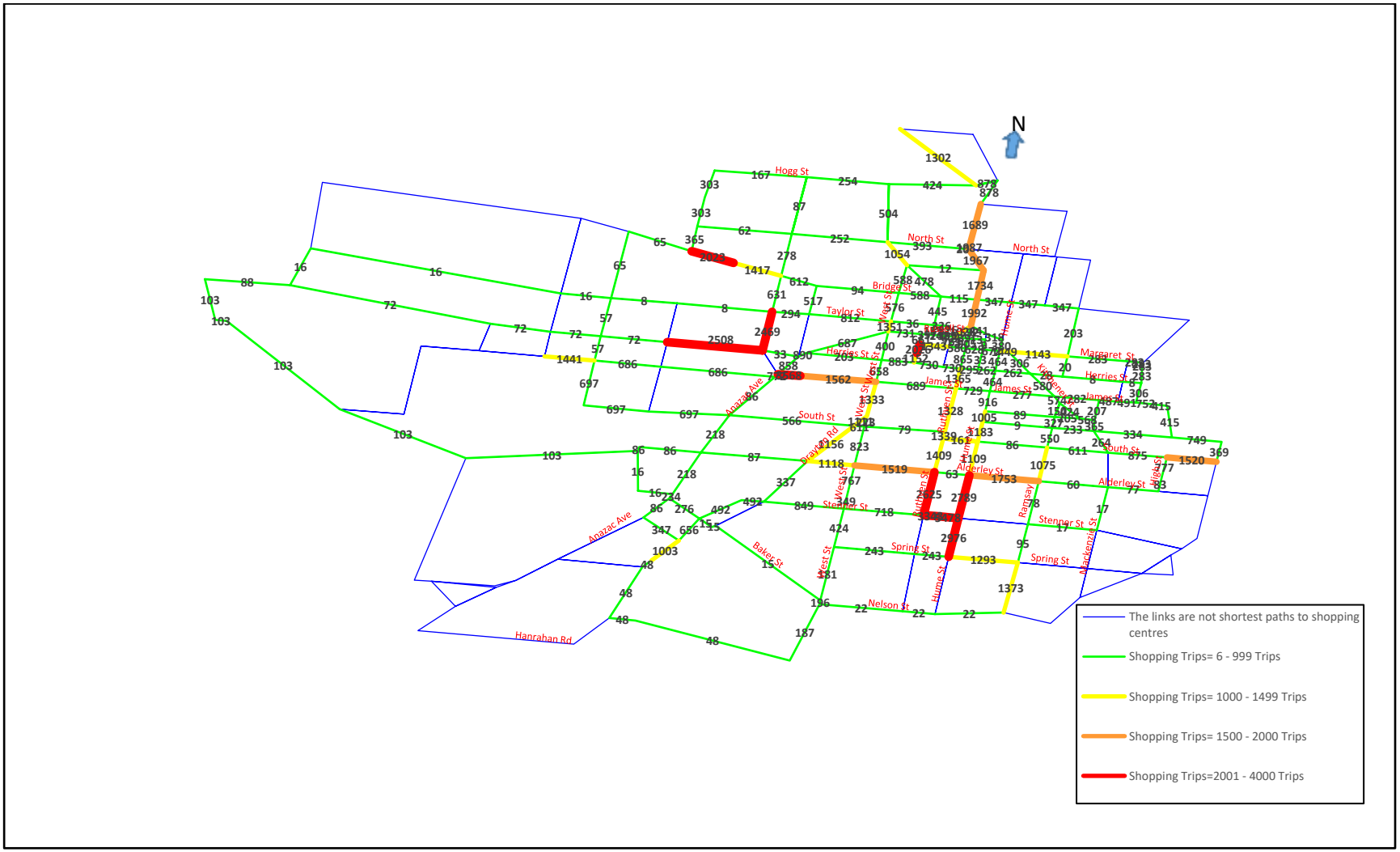


Figure 6.9: Distribution of shopping trips on Toowoomba by increasing $4 parking prices

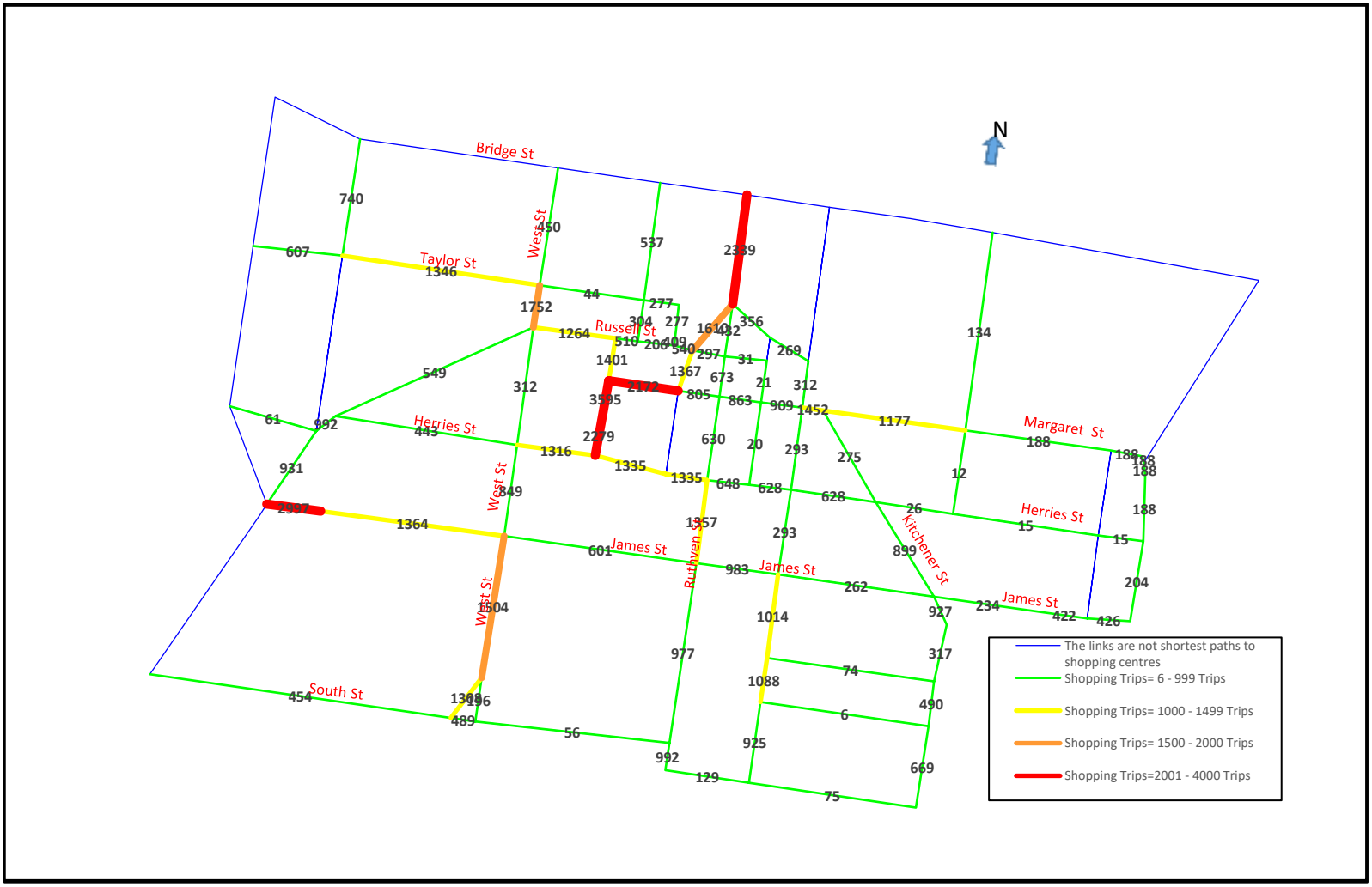


Figure 6.10: Distribution of shopping trips on CBD of Toowoomba by increasing $1 parking

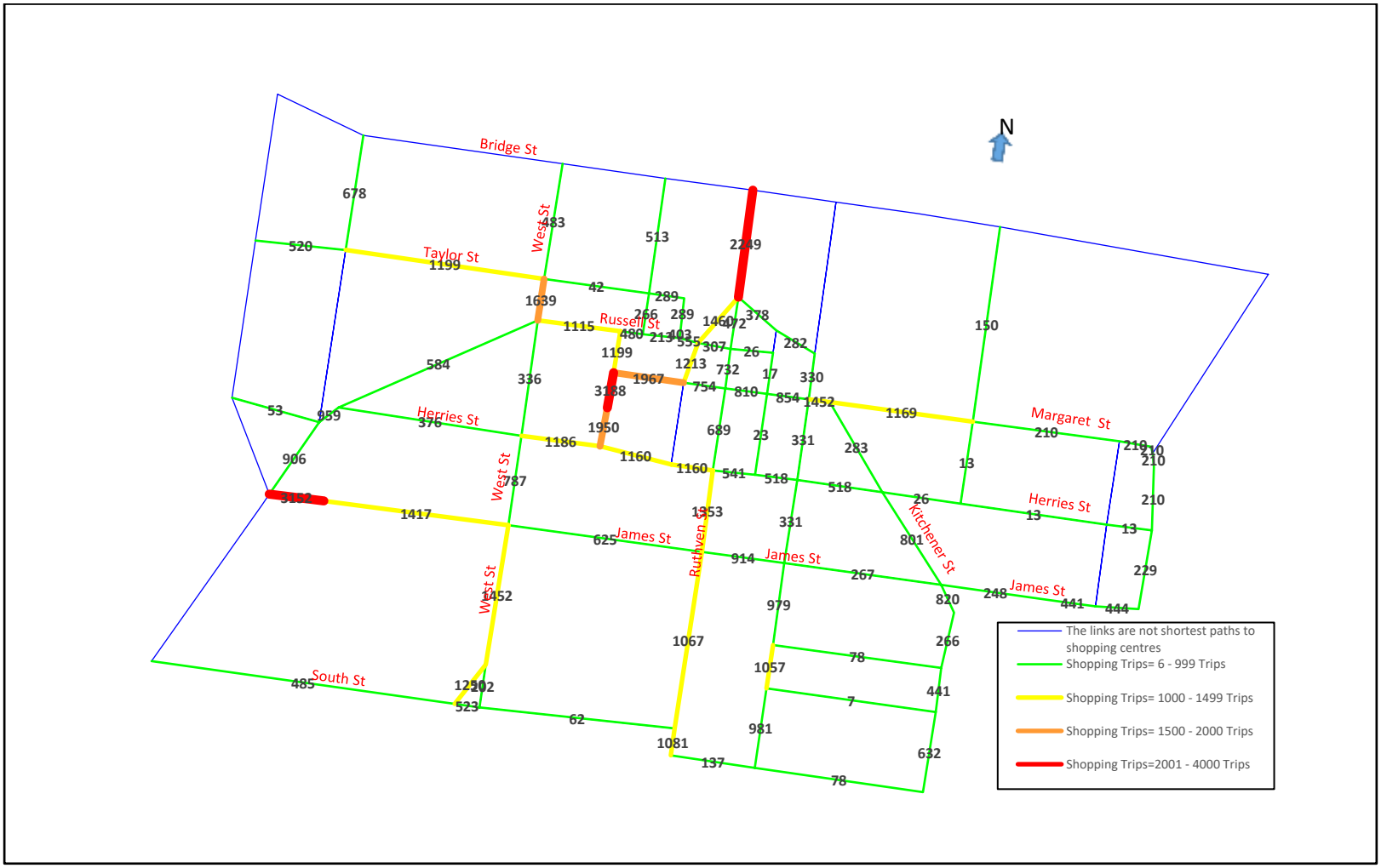


Figure 6.11: Distribution of shopping trips on CBD of Toowoomba by increasing $2 parking prices

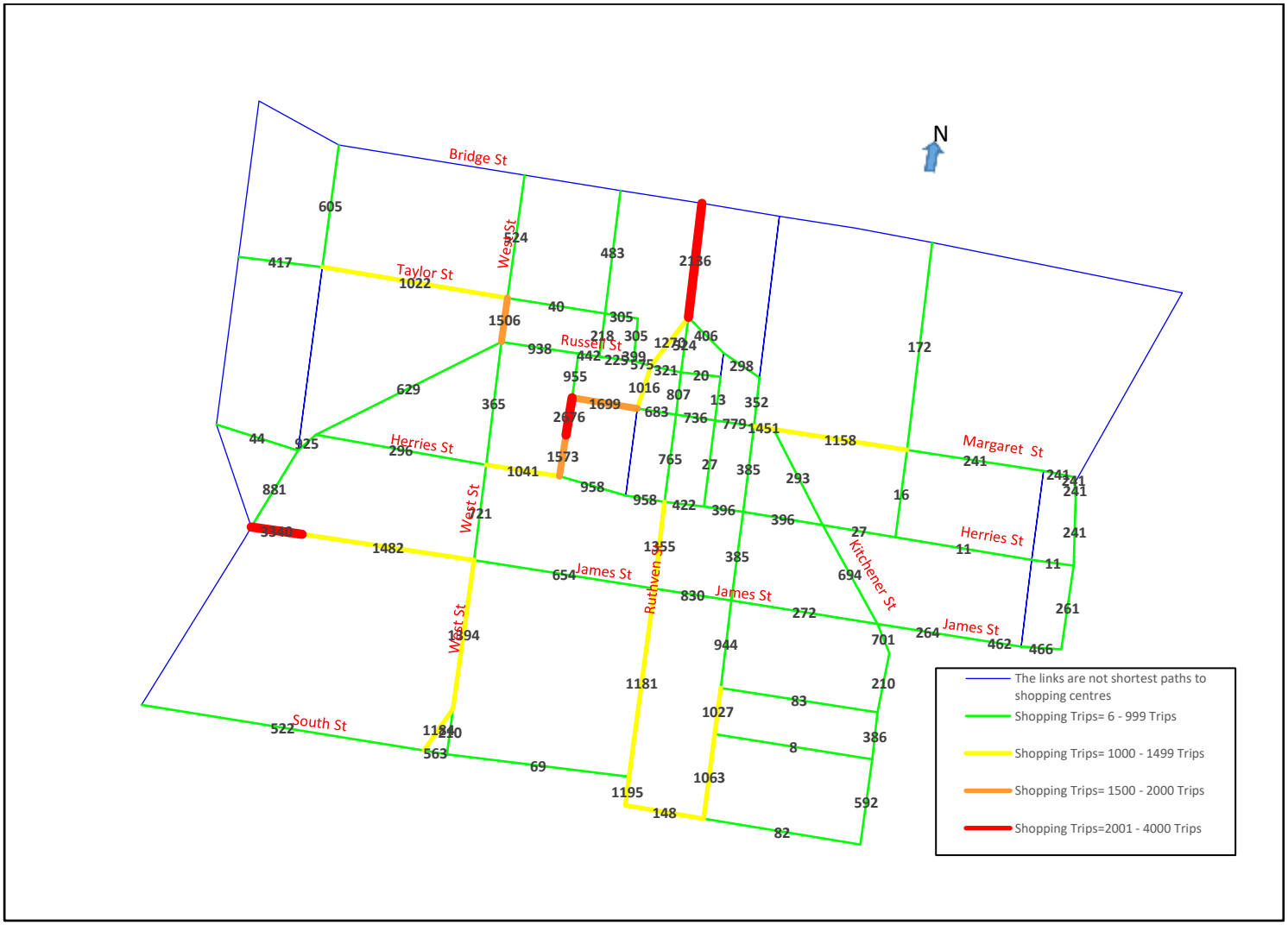


Figure 6.12: Distribution of shopping trips on CBD of Toowoomba by increasing $3 parking prices

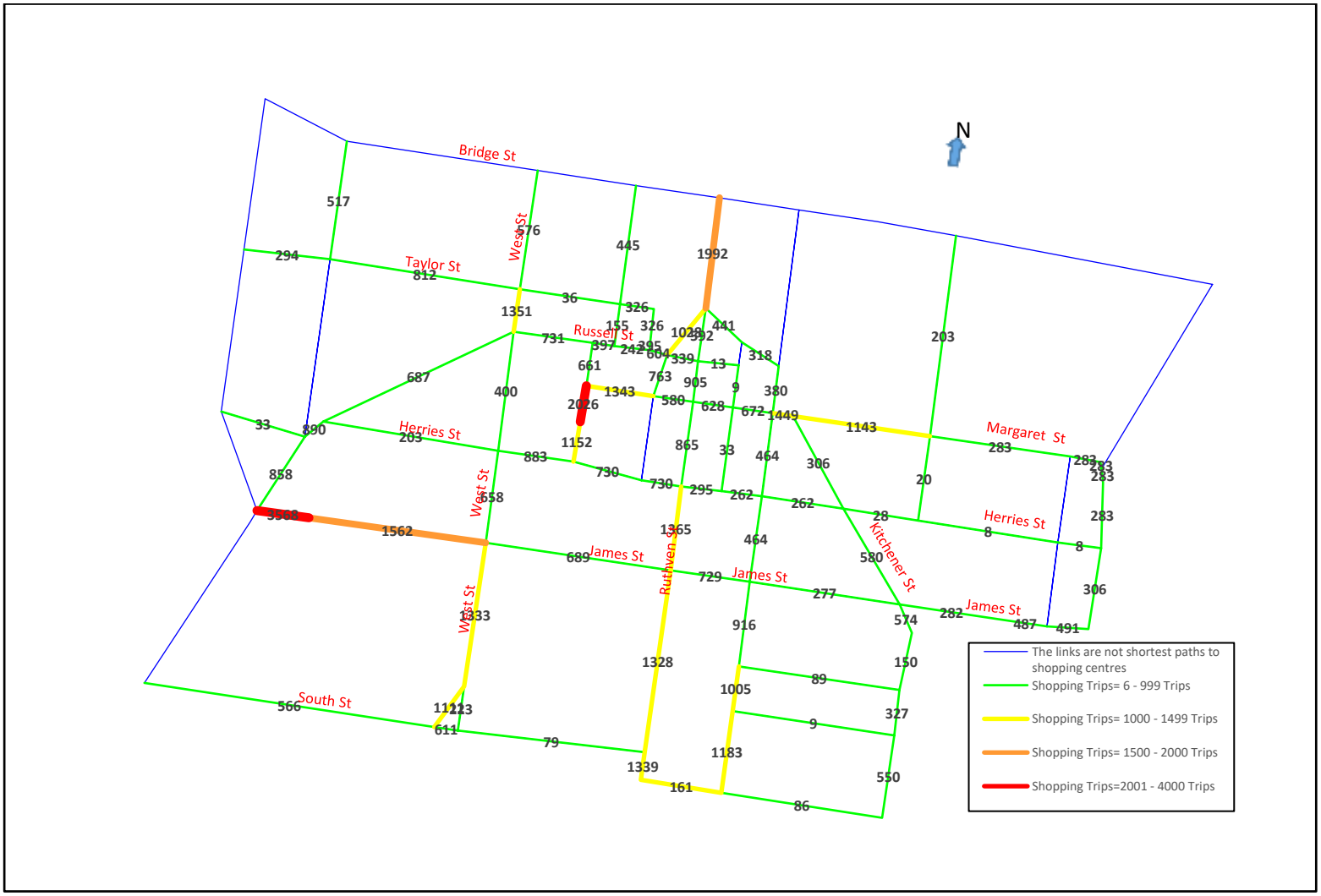


Figure 6.13: Distribution of shopping trips on CBD of Toowoomba by increasing $4 parking prices

6.7.2 The Effect of Increasing Parking Pricing Based on Shopper's Genders

Table 6.12 indicates that by increasing the prices of parking, the shifting percentages for both males and females were increased. The table also indicates that the shifted female and male percentages from the south and the west were predominant and that the movement of the two genders to other destinations was approximately similar when increasing parking pricing by $4.

6.7.3 The Effect of Increasing Parking Pricing Based on Shopper's Age

Table 6.13 shows that the age groups of 30-44 years and 45-59 years from the south would have the greatest shift as a result of increased parking pricing in the CBD area. It is apparent from Table 6.13 that the age groups in the 30-74 range from the north, south, east, and west would be the cohorts most likely to change travel habits.

Table 6.12: The effect of increasing parking pricing on shopping of genders in CBD

Pricing	Direction	Males shoppers who would affect in number of times shopping at CBD	Females shoppers who would affect in number of times shopping at CBD
$1	**N**	0 (0%)	2 (6%)
	S	3 (9%)	9(15%)
	E	2 (11%)	2 (5%)
	W	2 (13%)	5 (14%)
	Total	8%	11%
$2	**N**	2 (11%)	5 (22%)
	S	4 (20%)	11 (33%)
	E	2 (22%)	6 (20%)
	W	3 (33%)	6 (31%)
	Total	21%	27%
$3	**N**	2 (21%)	5 (38%)
	S	6 (37%)	14 (56%)
	E	3 (39%)	7 (37%)
	W	4 (60%)	7 (50%)
	Total	38%	46%
$4	**N**	3 (37%)*	7 (59%)
	S	9 (63%)	15 (80%)
	E	5 (67%)	7 (54%)
	W	5 (93%)	7 (69%)
	Total	63%	68%

*((0+2+2+3)/19)*100=37%

Table 6.13: The effect of increasing parking pricing on shopping of age groups in CBD

Pricing	Direction	15-29 Years	30-44 Years	45-59 Years	60-74 Years	75 Years and over
$1	N	0 (0%)	1 (6%)	1 (9%)	0 (0%)	0 (0%)
	S	1 (13%)	4 (13%)	4 (18%)	3 (11%)	0 (0%)
	E	1 (17%)	1 (9%)	1 (4%)	1 (6%)	0 (0%)
	W	0 (0%)	2 (14%)	2 (14%)	2 (13%)	1 (25%)
	Total	8%	11%	11%	9%	4%
$2	N	0 (0%)	3 (25%)	3 (36%)	1 (13%)	0 (0%)
	S	1 (25%)	6 (32%)	4 (36%)	4 (25%)	0 (0%)
	E	1 (33%)	2 (27%)	3 (17%)	2 (19%)	0 (50%)
	W	1 (25%)	3 (36%)	2 (29%)	2 (27%)	1 (3%)
	Total	21%	31%	29%	22%	8%
$3	N	0 (0%)	3 (44%)	2 (55%)	0 (13%)	2 (20%)
	S	1 (38%)	7 (55%)	6 (64%)	4 (39%)	2 (29%)
	E	1 (50%)	2 (45%)	3 (30%)	3 (38%)	1 (33%)
	W	1 (50%)	3 (57%)	3 (50%)	3 (47%)	1 (75%)
	Total	33%	51%	49%	37%	33%
$4	N	0 (0%)	3 (63%)	3 (82%)	2 (38%)	2 (40%)
	S	1 (50%)	7 (77%)	7 (95%)	6 (61%)	3 (71%)
	E	2 (83%)	3 (73%)	3 (43%)	4 (63%)	0 (33%)
	W	2 (100%)	4 (86%)	2 (64%)	4 (73%)	0 (75%)
	Total	54%	75%	70%	61%	54%

6.8 The Impact of Increased Parking Pricing on Public Transport Usage

It was found that increasing the parking pricing in the CBD Toowoomba encourages shoppers to use public transport when travelling to shop at the CBD.

The survey respondents used four increases in parking fees of $1, $2, $3, and $4 per hour as selection options for the price increase that would cause the respondent to consider changing to public transport for travel to shop in the CBD. The respondents also were able to suggest a price that would cause them to change travel mode. There was an option to indicate that they did not have public transport available where they live.

6.8.1 The Effect of Increasing Parking Pricing on Shopper's Travel Mode

Increasing parking pricing effects estimated for the full Toowoomba population are shown in Table 6.14 that shows the percentages of people shifting travel mode from cars to buses. Only small percentage rises were seen for a parking charge increase of $1 but rising significantly as parking charges rose by $4. The people who elect change of mode of travel for shopping would consider that riding buses would be cheaper than paying for car usage in the CBD after increasing parking charges.

Table 6.15 and Figure 6.14 provide details of the number of shifted trips from cars to buses for the four directions for the various increased parking pricing. The numbers of shifted trips were the highest in the west, decreasing for east, south, and lowest for north.

The overall shifting of trips to buses because of increasing parking cost would relieve car shopping trips, and reduce traffic congestion in the CBD.

Table 6.14: The effect of increasing parking pricing on shopper's travel mode

Parking Price Increase	Direction	Survey Data		
		Total Sample	People Who are Shopping in CBD	People Who Would Shift to Public Transport
$1	N	58	51 (88%)	1 (2%)
	S	118	96 (82%)	4(3%)
	E	64	59 (92%)	3 (5%)
	W	64	51 (79%)	5 (8%)
	Average			5%
$2	N	58	51 (88%)	3 (7%*)
	S	118	96 (82%)	5 (8%)
	E	64	59 (92%)	5 (13%)
	W	64	51 (79%)	5 (16%)
	Average			11%
$3	N	58	51 (88%)	5 (16%)
	S	118	96 (82%)	7 (14%)
	E	64	59 (92%)	7 (23%)
	W	64	51 (79%)	8 (28%)
	Average			20%
$4	N	58	51 (88%)	5 (24%)
	S	118	96 (82%)	9 (21%)
	E	64	59 (92%)	7 (34%)
	W	64	51 (79%)	7 (39%)
	Average			30%

*((1+3)/58) *100=7%

Table 6.15: Number trips changed to use buses to CBD by price increase parking

Direction	$1	$2	$3	$4
N	37	109	235	366
S	64	162	300	454
E	69	182	317	465
W	101	203	350	487

Figure 6.14: Shifted trips to use buses to the CBD under increasing parking pricing

6.8.2 The Effect of Increasing Parking Pricing Based on Shopper's Gender

W In the case of increasing parking pricing, it was noted that about one third of CBD shoppers from both male and female categories shifted to buses as shown in Table 6.16. Both genders have a similar percentage of shifting in each level of increasing charges for parking. The most shifted trips for the females and males were from the west. The shifted trips would help relieve traffic congestion in the CBD.

6.8.3 The Effect of Increasing Parking Pricing Based on Shopper's Age

It was expected that increasing the parking cost might result in different responses by different age groups. Table 6.17 shows that the age groups in the 15 years to 74 years range were the most likely to move to buses in the case of increased prices of CBD parking. The age groups 30 years to 74 years have a high percentage of shifting in the

four directions for each of the four levels of increased pricing. It can be seen that the age group (75 years and over) would still go to CBD with increasing parking prices.

Table 6.16: The effect of increasing parking pricing on using public transport of genders

Pricing	Direction	Males shoppers who would consider using public transport	Females shoppers who would consider using public transport
$1	N	0 (0%)	1 (3%)
	S	2 (6%)	2 (3%)
	E	1 (6%)	2 (5%)
	W	1 (7%)	4 (11%)
	Total	5%	5%
$2	N	1 (5%)	2 (9%)
	S	2 (11%)	3 (8%)
	E	1 (11%)	4 (15%)
	W	1 (13%)	4 (22%)
	Total	10%	13%
$3	N	2 (16%)	3 (19%)
	S	2 (17%)	5 (16%)
	E	3 (28%)	4 (24%)
	W	3 (33%)	5 (36%)
	Total	22%	23%
$4	N	2 (26%)	3(28%)
	S	3 (26%)	6 (26%)
	E	3 (44%)	4 (34%)
	W	2 (47%)	5 (50%)
	Total	33%	34%

Table 6.17: The effect of increasing parking pricing on using public transport of age groups

Pricing	Direction	15-29 Years	30-44 Years	45-59 Years	60-74 Years	75 Years and over
$1	N	0 (0%)	0 (0%)	1 (9%)	0 (0%)	0 (0%)
	S	0 (0%)	2 (6%)	1 (5%)	1 (4%)	0 (0%)
	E	0 (0%)	2 (18%)	1 (4%)	0 (0%)	0 (0%)
	W	1 (25%)	1 (7%)	1 (7%)	1 (7%)	1 (25%)
	Total	4%	7%	6%	3%	4%
$2	N	0 (0%)	1 (6%)	2 (27%)	0 (0%)	0 (0%)
	S	1 (13%)	2 (13%)	1 (9%)	1 (7%)	0 (0%)
	E	0 (0%)	2 (36%)	2 (13%)	1 (6%)	0 (0%)
	W	1 (50%)	1 (14%)	2 (21%)	1 (13%)	0 (25%)
	Total	13%	15%	16%	7%	4%
$3	N	0 (0%)	1 (13%)	2 (45%)	2 (25%)	0 (0%)
	S	1 (25%)	2 (19%)	3 (23%)	1 (11%)	0 (0%)
	E	1 (17%)	2 (55%)	2 (22%)	2 (19%)	0 (0%)
	W	0 (50%)	2 (29%)	2 (36%)	3 (33%)	1 (50%)
	Total	21%	25%	29%	19%	8%
$4	N	0 (0%)	2 (25%)	2 (64%)	1 (38%)	0 (0%)
	S	2 (50%)	3 (29%)	3 (36%)	1 (14%)	0 (0%)
	E	1 (33%)	2 (73%)	2 (30%)	1 (25%)	1 (33%)
	W	0 (50%)	2 (43%)	2 (50%)	2 (47%)	1 (75%)
	Total	33%	38%	41%	27%	17%

6.9 The Impact of Pricing on Shopping Trips

Overall the research has shown that increases in pricing would result in a reduction in shopping trips and a change of travel mode, which in turn would reduce car travel and congestion in the CBD. The impact would be most apparent on some sections of the main roads in the CBD, for example in sections of West St, Ruthven St, and Margaret St. There would also be reduced traffic on James St, Bridge St, Herries St, and Taylor St. All these streets, within and around the CBD are used by many shoppers as shown in Table 3.15.

Another consequence would be that at the same time shopping trips also increase in some sections of West St, Ruthven St, Margaret St, Kitchener St, and Spring St, as well as along Hume St, North St, Stenner St, and Alderley St. This is a result of residents using these streets to shop in shopping centres outside of the CBD. For example, traffic increases are predicted on James Street to shop at The Range Shopping Centre, on North Street to shop at North Point Shopping Centre, on Stenner Street to shop at Kearneys Spring Shopping Centre, and on Alderley Street to shop at The High Street Shopping Centre. The overall outcome of any pricing increases is that some shoppers change travel mode while others change their destination of shopping. This redistribution would cause traffic relief on some sections of roads in the CBD and a slight increase on other routes.

It has been seen that approximately 50% of Toowoomba people would change their destination of shopping in the case of charging for roads to the CBD with 22% of the respondents shifting to public transport. The percentages of females and males changing to public transport or changing the destination of shopping were similar. The age groups 30 years to 74 years were the higher percentages in changing habits of shopping by changing mode of travel to shop or the destination of shopping.

The research showed that increasing the CBD parking cost would cause a decrease in the number of people travelling to shop in the CBD. A $4 increase in parking pricing would reduce the percentage of CBD shoppers by more than half. The research also showed an increase in public transport use for CBD trips as a result of increasing the CBD parking cost. Approximately 30% of CBD shoppers would consider using the bus for CBD trips in the case of increasing parking pricing by $4.

The study also showed that the geographical directions of Toowoomba which have people with large household size and high percentages of motor vehicle ownership were not as influenced by pricing increases compared to directions which have lower household size and lower percentages of motor vehicle ownership.

6.10 Application of the Results to other Regional Cities

The possibility of transferring the results of the modelling of Toowoomba shopping trips to other regional cities in Australia has been investigated. Some regional cities in Australia have similar commercial and economic situations to Toowoomba. The commercial and economic situations of those regional cities were represented in this research by the percentages of retail trade and percentages of trade workers as shown in Table 2.1 in Chapter Two. Also, these regional cities have similar traffic congestion conditions to Toowoomba, as represented in the Table 2.1 by the Annual Average Daily Traffic (AADT).

This study of Toowoomba dealt with several variables impacting shopping activities in Toowoomba. These variables were gender, age, average household size and motor vehicle ownership. The regional cities shown in Table 6.18 have varying percentages of these variables. Hence, transferring the results of modelling Toowoomba shopping trips to those regional cities will vary depending on the level of similarity of those variables with Toowoomba's values.

The criterion of similarity of another regional city to Toowoomba was that all the statistical parameters of the regional city were close to the average value of the characteristics of 20 regional cities from across Australia. Closeness was taken to be within one standard deviation of the average value. It was then possible, with a reasonable level of confidence, to infer that the results of the Toowoomba model may be transferred to these other regional cities. From the initial list of 20 cities, the seven (7) cities most similar to Toowoomba (Ballarat, Cairns, Greater Bendigo, Mildura, Townsville, Wagga Wagga and Wodonga) were selected for further consideration. Again the average values of the parameters of these cities were calculated as well as the standard deviations for these parameters. All of Toowoomba’s parameters were within the one standard deviation range of these averages providing a high level of confidence for application of the Toowoomba results. The parameters for these cities and Toowoomba are shown in Table 6.20.

Table 6.18: Demographic characteristics for Toowoomba and other Australian regional cities

Regional City	Type of Regional City	Pop.	Registered Motor Vehicles (%)			Average Household Size	Gender (%)		Age Groups (%)				
			1 Motor Vehicle	2 Motor Vehicles	3 or more Vehicles		Male	Female	15-29 Years	30-44 Years	45-59 years	60-74 years	75 years and over
Albury, NSW	Inland	51,076	37.6	35.9	15.0	2.3	48.3	51.7	6.5	6.2	6.4	5.2	2.8
Ballarat, Vic	Inland	101,686	35.9	36.9	16.7	2.4	48.1	51.9	6.9	6.2	6.3	5.1	2.6
Ballina, NSW	Coastal	41,790	37.3	38.0	15.2	2.3	48.2	51.8	4.5	5.3	7.2	6.9	4.0
Bunbury, WA	Coastal	31,919	37.2	36.7	15.7	2.3	49.0	51.0	6.0	6.4	6.9	5.5	2.8
Burnie, Tas	Coastal	18,895	38.2	34.1	16.1	2.3	48.1	51.9	6.5	5.7	6.9	5.4	2.7
Cairns, Qld	Coastal	156,901	36.5	37.0	15.4	2.5	49.3	50.7	6.2	7.2	7.0	4.5	1.6
Coffs Harbour, NSW	Coastal	72,944	37.7	36.3	15.8	2.4	48.4	51.6	5.4	5.5	6.9	6.3	3.1
Greater Bendigo, Vic	Inland	110,477	32.8	37.9	19.8	2.4	48.5	51.5	6.5	6.0	6.5	5.3	2.7
Gympie, Qld	Inland	49,559	35.0	35.6	20.5	2.4	49.6	50.4	4.8	5.1	7.3	7.3	2.8
Horsham, Vic	Inland	19,642	33.0	36.2	20.7	2.3	48.8	51.2	5.8	5.6	6.6	5.6	3.3
Launceston, Tas	Inland	65,274	37.7	32.7	16.4	2.3	48.4	51.6	6.9	6.0	6.5	5.3	2.7
Mildura, Vic	Inland	53,878	32.8	35.7	19.9	2.4	49.1	50.9	6.2	5.7	6.7	5.5	2.8
Muswellbrook, NSW	Inland	16,086	33.1	37.7	18.2	2.5	51.3	48.7	6.3	6.7	6.7	4.3	1.7
Port Augusta, SA	Coastal	13,808	37.5	32.7	15.9	2.3	51.0	49.0	6.4	6.0	7.0	5.4	2.1
Port Hedland, WA	Coastal	14,469	27.2	39.2	23.5	2.7	53.4	46.6	7.3	9.4	6.5	1.9	0.3
Townsville, Qld	Coastal	186,757	33.7	39.5	18.1	2.6	50.0	50.0	7.7	6.9	6.4	4.1	1.5
Toowoomba, Qld	Inland	160,779	33.6	37.1	20.3	2.5	48.6	51.4	6.4	6.0	6.4	5.2	2.7
Wagga Wagga, NSW	Inland	62,385	34.1	37.8	18.4	2.5	48.9	51.1	7.4	6.3	6.1	4.6	2.3
Wentworth, NSW	Inland	6,794	27.7	39.3	21.2	2.4	51.6	48.4	5.1	5.4	7.3	6.6	2.6
Wodonga, Vic	Inland	39,351	33.4	40.4	17.5	2.5	49.0	51.0	6.9	6.3	6.3	4.8	2.1
Average			34.7	36.8	17.9	2.4	49.4	50.6	6.3	6.2	6.7	5.3	2.5
Standard Deviation			3.10	2.02	2.43	0.11	1.38	1.38	0.82	0.90	0.35	1.12	0.8

Source of Registered Motor Vehicles, Average Household Size, Gender, and Age Groups: ABS., 2016. Accessed date: 20/5/2019. Available at: https://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/317?opendocument

Small differences in the demographic characteristics of Toowoomba City and the other twelve (12) regional cities shown in Table 6.18 were taken into consideration when determining the level of transferring the results of the shopping trip modelling in Toowoomba to those cities. Nine (9) of the cities, as listed in Table 6.20, were classified in the moderate level of confidence when transferring the results of Toowoomba modelling because Toowoomba City has some differences with those cities in the demographic characteristics.

At low level of confidence, there is a lower chance of being able to transfer the results of modelling of shopping trips in Toowoomba to these other regional cities. This is because of some significant differences in the variables influencing shopping trips in Toowoomba and these regional cities. These cities were Wentworth, Muswellbrook, and Port Hedland and all had a relatively low population compared to Toowoomba. The level of transfer of the results might also be influenced by the low availability of public transport for these regional cities.

Table 6.19: Demographic characteristics for the regional cities which the Toowoomba study can be in high level of confidence transferred

Regional City	Type of Regional City	Pop.	Registered Motor Vehicles (%)			Average Household Size	Gender (%)		Age Groups (%)				
			1 Motor Vehicle	2 Motor Vehicles	3 or more Vehicles		Male	Female	15-29 Years	30-44 Years	45-59 years	60-74 years	75 years and over
Ballarat, Vic	Inland	101,686	35.9	36.9	16.7	2.4	48.1	51.9	6.9	6.2	6.3	5.1	2.6
Cairns, Qld	Coastal	156,901	36.5	37.0	15.4	2.5	49.3	50.7	6.2	7.2	7.0	4.5	1.6
Greater Bendigo, Vic	Inland	110,477	32.8	37.9	19.8	2.4	48.5	51.5	6.5	6	6.5	5.3	2.7
Mildura, Vic	Inland	53,878	32.8	35.7	19.9	2.4	49.1	50.9	6.2	5.7	6.7	5.5	2.8
Townsville, Qld	Coastal	186,757	33.7	39.5	18.1	2.6	50.0	50.0	7.7	6.9	6.4	4.1	1.5
Wagga Wagga, NSW	Inland	62,385	34.1	37.8	18.4	2.5	48.9	51.1	7.4	6.3	6.1	4.6	2.3
Wodonga, Vic	Inland	39,351	33.4	40.4	17.5	2.5	49	51	6.9	6.3	6.3	4.8	2.1
Average			**34.2**	**37.9**	**18.0**	**2.5**	**49.0**	**51.0**	**6.8**	**6.4**	**6.5**	**4.8**	**2.2**
Standard Deviation			**1.5**	**1.6**	**1.6**	**0.1**	**0.6**	**0.6**	**0.6**	**0.5**	**0.3**	**0.5**	**0.5**
Toowoomba, Qld	Inland	160,779	33.6	37.1	20.3	2.5	48.6	51.4	6.4	6	6.4	5.2	2.7

Table 6.20: Demographic characteristics for the regional cities which the Toowoomba study can be in moderate level of confidence transferred

Regional City	Type of Regional City	Pop.	Registered Motor Vehicles (%)			Average Household Size	Gender (%)		Age Groups (%)				
			1 Motor Vehicle	2 Motor Vehicles	3 or more Vehicles		Male	Female	15-29 Years	30-44 Years	45-59 years	60-74 years	75 years and over
Albury, NSW	Inland	51,076	37.6	35.9	15.0	2.3	48.3	51.7	6.5	6.2	6.4	5.2	2.8
Ballina, NSW	Coastal	41,790	37.3	38.0	15.2	2.3	48.2	51.8	4.5	5.3	7.2	6.9	4.0
Bunbury, WA	Coastal	31,919	37.2	36.7	15.7	2.3	49.0	51.0	6.0	6.4	6.9	5.5	2.8
Burnie, Tas	Coastal	18,895	38.2	34.1	16.1	2.3	48.1	51.9	6.5	5.7	6.9	5.4	2.7
Coffs Harbour, NSW	Coastal	72,944	37.7	36.3	15.8	2.4	48.4	51.6	5.4	5.5	6.9	6.3	3.1
Gympie, Qld	Inland	49,559	35.0	35.6	20.5	2.4	49.6	50.4	4.8	5.1	7.3	7.3	2.8
Horsham, Vic	Inland	19,642	33.0	36.2	20.7	2.3	48.8	51.2	5.8	5.6	6.6	5.6	3.3
Launceston, Tas	Inland	65,274	37.7	32.7	16.4	2.3	48.4	51.6	6.9	6.0	6.5	5.3	2.7
Port Augusta, SA	Coastal	13,808	37.5	32.7	15.9	2.3	51.0	49.0	6.4	6.0	7.0	5.4	2.1
Average			**36.8**	**35.4**	**16.8**	**2.3**	**48.9**	**51.1**	**5.9**	**5.8**	**6.9**	**5.9**	**2.9**
Standard Deviation			**1.7**	**1.8**	**2.2**	**0.0**	**0.9**	**0.9**	**0.8**	**0.4**	**0.3**	**0.8**	**0.5**
Toowoomba, Qld	Inland	160,779	33.6	37.1	20.3	2.5	48.6	51.4	6.4	6.0	6.4	5.2	2.7

Each of the Australian regional cities of Ballarat, Cairns, Greater Bendigo, Mildura, Townsville, Wagga Wagga and Wodonga, identified as being cities having a high level of confidence for the transfer of Toowoomba results, will now be considered in greater detail.

- **Ballarat**

Ballarat is located at the gateway to western Victoria and with 1.4% growth per year is one of the fastest growing inland cities in Australia. (City of Ballarat 2018). The city has quite similar demographic characteristics to Toowoomba (Table 6.19), with a population approximately one third the population of Toowoomba.

Ballarat is Victoria's third largest economy outside Melbourne. The council of the City of Ballarat is seeking to develop retail, business and residential sectors, as well as addressing the issues of pedestrian flow and traffic management through the CBD. With the expectation of continued growth, car parking demand will continue to rise in the CBD (City of Ballarat 2018). The traffic management through the Ballarat CBD would benefit by implementing road pricing at a modest level of charge similar to that proposed for Toowoomba. Increasing parking pricing by a minimal level would keep the balance between the demand and supply of parking as Ballarat traffic growth increases.

- **Cairns**

Cairns is a regional city in far north Queensland and is the major industrial, commercial, entertainment, retail, and education centre in Tropical North Queensland (Cairns Regional Council 2017). Table 6.19 shows that Cairns currently has a population slightly less than Toowoomba with demographic characteristics quite similar to Toowoomba's. However it can be noted that the percentage of older people (i.e. those 75 years and older) in Toowoomba is nearly double that of Cairns.

The road networks within Cairns and connecting Cairns to the surrounding regions are significant factors for the regional economy. One of the subjects linking to the 2050 vision for Cairns is focused on supporting growth by promoting connectivity for people and services across road transport and investing in the infrastructure that supports this mode of connectivity (Cairns Regional Council n.d.). Long-term transport strategy is a focus, including alternative transport modes (e.g. bus, rail, walking, and cycling), and new transport strategies (e.g. autonomous and electric

vehicles) (Cairns Regional Council 2019). The Cairns council seeks to develop transport and networks (Cairns Regional Council 2017). To improve safety for cyclists and pedestrians, vehicle speed limits were reduced in the city centre in early 2019 (Cairns Regional Council 2019).

Therefore, similar to Toowoomba, the introduction of road pricing would appear to be a suitable future strategy for Cairns. This would enable continued growth in the Cairns city centre while avoiding some of the adverse effects of increasing traffic.

- **Greater Bendigo**

The City of Greater Bendigo is one of Victoria's largest regional municipalities and is located in the geographic centre of Victoria. Greater Bendigo provides facilities for business and services for education, health, living, manufacturing and community services. Bendigo is the major retail centre in the region and the Bendigo CBD is the most significant employment area and activity centre in North Central Victoria (City of Greater Bendigo 2018).

The Integrated Transport and Land Use Strategy (ITLUS), 2015, aims to reduce the many short local trips that are unnecessary by the use of clever and innovative city design to support far greater levels of walking, cycling and improved public transport to better connect people and places. The Bendigo CBD Parking Strategy, 2018-2019, outlined introducing contemporary approaches to parking to ensure parking efficiency and accessibility for all visitors (City of Greater Bendigo 2018). The implementation of road pricing and increasing parking pricing at modest levels may be useful tools in assisting controlling congestion outcomes due to increasing population size, growth in the city and rapid transformation period for Bendigo's retail sector.

- **Mildura**

Mildura is the largest regional municipality in Victoria, covering 10% of the state (22,000 square kilometres). Mildura is located in the north-west corner of Victoria (Mildura Rural City Council 2019). Mildura is the principal and the largest service centre in the area. The CBD of Mildura, has long been an important business, service, and cultural centre for the Loddon Mallee Region (Mildura Rural City Council 2018). Similar to Toowoomba, Mildura's CBD area has changed significantly over the past 10 years (Mildura Rural City Council 2019). The population of Mildura is approximately one third of Toowoomba's.

Like several similar regional centres, Mildura has a high dependence on private vehicles. The local bus services are limited in terms of timing, duration, and frequency (Mildura Rural City Council 2019). The current active transport network is unsafe and disjointed (Mildura Rural City Council 2018). Another problem identified in Mildura CBD was a lack of parking (Mildura Rural City Council 2018). Allocation of funds for public transport and for improving bus services as well as for providing car parking would assist city progress. The benefits of revenue gains from the implementation of road pricing could be used as funding to support public transport development.

- **Townsville**

The Queensland city of Townsville is 1200 kilometres north of Brisbane. It is located approximately midway between Mackay and Cairns. Townsville has great potential for population growth and sustained economic development as it has an attractive lifestyle and diverse industry. Townsville's CBD location provides the opportunity for investors and business operators to harness the benefits of services, strong growth and lifestyle, such as superior commercial and social services, supportive planning initiatives, and development assistance and incentives (City of Townsville 2011).

Table 6.19 shows that Townsville has a larger population than Toowoomba and demographic characteristics quite similar to Toowoomba's. However it can be noted that the percentage of people in the age groups 60-74 years and 75 years and over in Toowoomba is approximately double that of Townsville. Townsville has transport problems similar to Toowoomba. Although the Townsville CBD is linked to surrounding suburbs by over 2,400 weekly bus services (City of Townsville 2011), this area has a lack of suitable public transport options to access the CBD. The provided bus services are inconsistent (City of Townsville 2017). Townsville council proposed means for improved transport that included the provision of small ferries (City of Townsville 2017). Lack of parking in the Townsville CBD and difficulties for pedestrians commuting around the CBD are other problems in the city (City of Townsville 2017).

The important location of the CBD and its future growth are likely to give rise to traffic congestion in this area. The suggestion of improving public transport to make it easier for pedestrians and commuters to access the CBD is one suitable solution to assist in

solving existing problems. Road pricing may also assist in relieving congestion in the CBD of Townsville.

- **Wagga Wagga**

Wagga Wagga is located within the heart of the Riverina - Murray region and is the largest regional city in inland New South Wales (City of Wagga Wagga 2017). The city is expected to attract investments which will lead to job creation in retail, business, education, health and government services (Sharley 2019). There is a retail growth strategy which aims to support the city's retail sector and build its capacity, focusing on the importance of the CBD. The strategy analyses the retail hierarchy in Wagga Wagga and provides the principles for promoting the retail sector for different existing retail characters (City of Wagga Wagga 2009). Implementation of the strategy would undoubtedly mean more traffic in the CBD.

There is a similarity between Toowoomba's demographic characteristics and Wagga Wagga's characteristics as shown in Table 6.19, except that the population of Toowoomba is about two and a half times greater than Wagga Wagga's population. There is similarity in the primary public transport choice (bus). A new Active Travel Plan (ATP) is being implemented in Wagga Wagga to address problems such as the limited designated street crossings, lack of dedicated cycling lanes and lack of infrastructure (Sharley 2019). The current plans for improving the transport situation in Wagga Wagga can work efficiently if they are supported by road pricing and increasing parking pricing. The variety of services in Wagga Wagga and the continuous improvements in the level of services are leading to increasing population growth. This contributes to increasing congestion in Wagga Wagga. Road pricing and/or increasing parking pricing in the CBD of Wagga Wagga could change drivers' behaviour, encourage walking, increases bus usage, and reduce CBD congestion.

- **Wondonga**

Wondonga is located in Victoria and is a growing city like Toowoomba. The total population is forecast to increase in Wodonga by 1.8% per year (City of Wodonga 2019). Table 6.19 shows that the city is similar to Toowoomba in its demographic characteristics but with a population of about a quarter of Toowoomba's. The expected growth of population and the proposed development of activities in Wodonga's growth areas is expected to create further opportunities for employment in the future. For example, the CBD of Wodonga recently undertook the Junction Place project which

will double the size of Wodonga's central business district (Drummond Real Estate 2018). The expansion and improvement in retail offerings in Wodonga are a result of new stores, new retailers and greater variety. A number of new developments in Wodonga are a result of strong competition in the supermarket industry (Drummond Real Estate 2018). The development in Wondonga resulting from the various opportunities of the economic activities and others could result in increased traffic congestion in this regional city. Any future introduction of road pricing and/or parking pricing could help ease congestion.

6.11 Summary

There is a similarity in the reasons for traffic congestion occurring in the CBDs of the listed regional cities in Tables 6.19 and 6.20. These cities have similar demographic characteristics with each other and with Toowoomba. The biggest reason for traffic congestion in CBDs of regional cities is rising car parking demand or the lack of parking in the CBDs as is noted in the cities of Ballarat, Greater Bendigo, Mildura, and Townsville. The other reason for traffic congestion in the CBDs was public transport problems, in case of unsuitability or lack of service, which was apparent in the cities of Ballarat, Mildura, Wagga Wagga, and Wodonga. The improvements and the developments in retail, business sectors and the expansion of the CBDs are causing more shopping trips to the CBDs of these cities. Those reasons for traffic congestion in the CBDs of the regional cities are the same as those for Toowoomba. This study showed that 85% of the respondents shopped in the CBD of Toowoomba. This investigation was required to understand the reasons of traffic congestion in selected regional cities (objective one of the study).

There are demographic similarities between Toowoomba and the other regional cities in this study. These are shown in Table 6.19 and Table 6.20. The percentages of gender and age groups of the listed regional cities were close to the percentages of the gender and age groups of Toowoomba. The study found that 57% of Toowoomba CBD shoppers identified as females and 23% to 21% are the rates of the age groups 30 years to 74 years who preferred to shop in the CBD. Given the similarity in the demographic characteristics of the listed regional cities with Toowoomba's characteristics, the key variables governing shopping activity in Toowoomba would be the same key variables

that governed congestion in other cities. This was required for objective two of this study.

Most of the regional cities' councils seek to manage traffic congestion resulting from the increase in additional trips to those cities. Investigation of road pricing and increasing parking pricing for Toowoomba, proved in this study to reduce shopping trips to the CBD and encourage the use of public transport. The study of road pricing in Toowoomba found 57% of CBD respondents would shop less in the CBD, including 38% from females and 16% to 18% for the age groups 30 years to 74 years. It also showed 22% of the research sample would choose to use public transport to the CBD including 13% from females and 6% to 8% from the age groups 30 years to 74 years. The study of increasing parking pricing in Toowoomba showed that 55% of the respondents indicated increasing parking pricing by $4 would affect them in the number of times shopping in the CBS, this included 37% of females and 13% to 17% from the age groups 30 years to 74 years. So, transferring these results of the Toowoomba study to other regional cities would reduce traffic congestion in the CBDs of the regional cities and achieve objective three of this study.

6.12 Conclusion

The purpose of this chapter was to study the impact of pricing on shopping trips in Toowoomba using situational modelling. This then enabled an examination of the possibility of transfer of the experience of the Toowoomba study to other regional cities in Australia.

The opinions of total population of Toowoomba, the opinion of different population genders, and the opinion of different population age groups were addressed early in this chapter to establish the general opinions of Toowoomba people regarding suitable road pricing. The second section dealt with modelling the survey results to represent the influence of road pricing on shopping trips in the behaviours of shopping, and using public transport after road pricing. The third section also dealt with the same previous cases but in the situation of increasing parking pricing. The last section addressed the capability of transferring the experiences from the case study (Toowoomba) to other regional cities.

Chapter Seven

Conclusions and Recommendations

Conclusions

7.1 Introduction

Australian regional cities have enjoyed growth, prosperity, and development in recent decades. This has been accompanied by increased car ownership which has in turn led to increased traffic and congestion. The research described in this thesis has shown that shopping trips dominated travel in the Central Business Districts (CBDs) of regional cities, contributing to congestion. The regional city of Toowoomba was selected as being representative of regional cities and was used to generate data and calibrate a new model.

Road pricing in major overseas cities has been shown to be effective in managing congestion and this research has extended that earlier research for use in helping to manage congestion in Australian regional cities through the introduction of road pricing and increasing parking pricing. The methodology applied in this research included a survey of residents and the construction of a numerical predictive model of shopping trips for the typical Australian regional city of Toowoomba. The survey results were used to investigate shopping in regional cities in terms of variables governing shopping and in terms of the habits of shopping and to build the model.

It was determined that the Toowoomba shopping trips model can be transferred with a high level of confidence to the Australian regional cities of Ballarat, Cairns, Greater Bendigo, Mildura, Townsville, and Wagga Wagga due to their similar demographic characteristics to Toowoomba. The Australian regional cities that the model can be transferred to with a reasonable level of confidence are Albury, Ballina, Bunbury, Burnie, Coffs Harbour, Gympie, Horsham, Launceston, and Port Augusta due to their slight differences in demographic characteristics.

7.2 Shopping Activity

Understanding the shopping habits of the population and the variables governing their travel behaviour provide an insight into their impact on the traffic congestion. The explored variables were population, gender, age group, household size, and car ownership. The study found there were specific gender and age groups that dominated shopping activity, and that most shoppers were from the geographic areas that have high average household size and motor vehicle ownership. It is expected that controlling shopping trips from areas that have such demographic characteristics would assist to reduce congestion resulting from shopping travel, especially to the CBD. Cars were identified as the preferred mode of transport for shopping trips.

This knowledge assisted the model construction, as mode choice was the third step in its construction. Any penalty on self-drive travel also helped to encourage other modes of transport for shopping and to reduce traffic. The peak hours and peak days of shopping were useful to determine the hours and days that have the most congestion. The study found that shoppers drive 1km to 5km to the shopping centre and that they preferred to shop locally with most CBD shopping trips derived from adjacent zones. The survey found that congestion in shopping centres carparks in the CBD results from the habit of shoppers parking and staying for a long time inside shopping centres without paying any parking penalty. The conclusions regarding shopping habits and variables of shopping were:

1. A total of 85% of respondents shopped in the CBD and 15% of the respondents indicated that their usual shopping was outside of the CBD.
2. The study found that females preferred to shop in the CBD more than males with 57% of the CBD shoppers identifying as female and 28% identifying as were male.
3. The main age groups that preferred to shop in the CBD were 30-44 years (23%), 45-59 years (24%), and 60-74 years (21.5%). Only 8% were in the 15-29 year band and 8.5% were above 75 years.
4. The geographic areas in the regional city that had the highest CBD shopping were the areas with the highest average household size and/or highest percentages of motor vehicle ownership.

5. The usual mode of travel for shopping in the regional city was by car. The frequency of shopping trips by car at an average of 84%was more than other modes of transport.
6. The peak period of shopping was between 10am and 6pm on weekdays (Monday to Thursday) and the busiest days for shopping were weekends, particularly Saturdays.
7. A distance between 1km and 5km was the preferred distances to travel for shopping.
8. The largest shopping centre in the CBD of the regional city attracted high number of shopping trips from different zones especially from the adjacent zones.
9. 42% of the research sample indicated that the time it usually took them to travel from home to the CBD by car was between 10 and 20 minutes.
10. 65% of the research sample indicated that they stay at shopping centres from 1 hour to 3 hours and that most of the shoppers choose to park at shopping centre car parks when shopping in the CBD.

7.3 Modelling shopping trips

The four steps method employed in most traditional transport planning studies was used to build the regional city shopping trip model. The constructed model was able to represent the current situation of shopping trips in the network of the city, and was able to represent the situation when road pricing and increasing parking pricing was applied. Representation of trip distribution was an important step to understand the current shopping trips distribution in the network, and understand and compare the situation of trip distribution when road pricing to the current situation. The representation was also important to compare the present distribution of shopping trips to the distribution when increasing parking pricing, and useful to compare the trip distribution in the network for various levels of parking charges. The key outcomes of the shopping trip study in the regional city were:

1. The average daily shopping trips per 1000 population varies from 102 to 394, reflecting the different behaviour of the population of various zones. The study also concluded that with road pricing and increasing parking pricing, shopping centres within the CBD would receive less trips, and shopping centres outside of the CBD would receive more trips.

2. There were high numbers of shopping trips to the CBD from different zones especially from adjacent zones. These numbers decrease when road pricing and increased parking pricing was introduced, whilst the shopping trips increased to other shopping centres outside of the CBD. Changing the destination of shopping increased when parking fees increased.
3. Shopping trips on assigned paths varied from a few trips up to several thousand trips in the network of the studied regional city. Traffic volume was reduced after pricing for most of the internal roads within the CBD while it increased on some of the major arterial roads and perimeter roads.

7.4 Impact of pricing on shopping trips

7.4.1 General opinion of Toowoomba people on road pricing

The conclusions from investigating the opinions of all respondents were:

1. The percentage of people who agreed on a level of pricing of $1-$2 was 73% of the total research sample.
2. The percentage of females who agreed on a level of pricing of $1-$2 was 52% of the total research sample.
3. The percentage of males who agreed on a level of pricing of $1-$2 was 21% of the total research sample.
4. The percentages of age groups 30-44 years, 45-59 years, and 60-74 years who agreed on a level of pricing of $1-$2 were 19%, 20% and 18% respectively.
5. The percentage of age groups 15-29 years, and 75 years and over who agreed on a level of pricing of $1-$2 was 8%.

7.4.2 Effect of road pricing on shopping trips

The study showed that congestion in the CBD road network of the regional city could be reduced by changing the destination of shopping for the most frequent shoppers. These people were shown to be both genders in the age groups 30-44 years, 45-59 years, and 60-74 years and people who have a large household size and car ownership. In addition, shifting those groups of people from cars to buses for shopping at the CBD would help to relieve congestion in the CBD.

- **Shopping at the CBD of studied regional city after road pricing**

In the case of introducing road pricing, the study found:

1. 57% of CBD shoppers would shop less at the CBD after the introduction of road pricing.
2. 369% and 64% of the CBD shoppers from female and male groups respectively indicated they would change their shopping destination if road pricing was introduced.
3. There were 72%, 77% and 72% of the CBD shoppers from the age groups 30-44 years, 45-59 years, and 60-74 years respectively would shop less in the CBD of the studied regional city and shop at shopping centres out of the CBD. 42% and 38% of the age groups 15-29 years and 75 years and over respectively would also change shopping destination if road pricing was introduced.
4. By comparing the distribution of shopping trips in the network of the regional city when road pricing with the current shopping trips distribution, the number of shopping trips to the CBD decreased and shopping trips to other shopping centres increased.

- **Using public transport to travel to the CBD after road pricing**

In the case of road pricing, the study demonstrated that:

1. By introducing road pricing, 22% of the research sample would choose to use public transport to the CBD.
2. The total percentage of female and male CBD shoppers who indicated they would use public transport if road pricing were introduced was24% and 31% respectively.
3. f road pricing were introduced, the total percentages of CBD shoppers from the age groups 15-29 years, 30-44 years, 45-59 years, 60-74 years, and 75 years and over who would shift to public transport for shopping in the CBD would be 21%, 33%,29%, 25%, and 8% respectively.

7.4.3 Impact of increasing parking pricing on shopping trips

The research has shown that increasing the cost of parking in the CBD of a regional city is likely to lead to reduced traffic congestion. It has shown a reduction in the number of shopping trips to the overall, reduced shopping activity of females and the age groups 30-44 years, 45-59 years and 60-74 years, and people from large households and with high car ownership. It has also shown that increased parking fees

will shift some people to buses to avoid the increased CBD parking fees. The modelling demonstrated a reduction in shopping trips by comparing the assigned current trips on the road network to the assigned trips after increasing parking pricing. It also concluded that shopping trips to the CBD continued to decrease with a gradual increase in parking pricing from $1 to $4.

- **Shopping in the CBD after increasing parking pricing**

The study found that an increasing number of people would be influenced as the parking price level rose from $1 to $4.

1. An average percentage of 55% of respondent's indicated increasing parking pricing by $4 would affect them in the number of times shopping in the CBD.
2. The modelling showed a maximum decrease in shopping trips to the CBD at an increased parking pricing of $4, resulted in the most increase in shopping trips to other shopping centres.
3. The modelling showed that staged increases in parking fees from $1 to $4 continuously reduced the number of shopping trips to the CBD and an increase in numbers of shopping trips to other shopping centres.
4. There was a total of 68% female and 63% male of the CBD shoppers of the research sample who indicated that the increasing parking pricing by $4 would cause them to reduce the number of times they shopped in the CBD.
5. A total of 54%, 75%, 70%, 61%, and 54% of the CBD shoppers were shoppers from age groups 15-29 years, 30-44 years, 45-59 years, 60-74 years, and 75 years and over respectively, who indicated that the increasing parking pricing by $4 would cause them to reduce their shopping in the CBD.

- **Using public transport to the CBD after increasing parking pricing**

By increasing parking pricing, the study found that the most significant shift from car to buses was when parking pricing increased by $4 as follows:

1. An average of 30% of respondents would consider riding buses to the CBD when parking pricing was increased by $4.

2. A total of 34% of females and 33% of males of the CBD shoppers would use buses in the case of increasing parking pricing by $4.
3. Of the age groups 15-29 years, 30-44 years, 45-59 years, 60-74 years, 75 years and over a total of 33%, 38%, 41%, 27%, and 17% respectively of the CBD shoppers would move to buses if parking pricing increased in cost by $4.

7.5 Discussions

The findings of the research address several gaps in the literature and add a significant contribution to knowledge. The survey of shopping activity in a typical regional city showed a total of 85% of respondents shop in the CBD. The dominant mode of shopping travel to the CBD is by car (an average of 84% respondents) in the 10am to 6pm peak shopping period. The survey and traffic volume data also identified that the major contributor to traffic congestion in regional cities was peak period shopping.

In the study of the introduction of road pricing and increasing parking pricing in the CBD of the selected regional city, the effect on shopping trips was that 57% of the CBD shoppers would shop less at the CBD. Similarly, 55% of respondent's indicated increasing parking pricing by $4 per hour would significantly affect their shopping in the CBD. These findings are useful because of the lack of studies on the shopping habits within the CBDs of regional cities after introducing road pricing or increasing parking pricing. So, managing the dominant trips in regional cities by pricing adds a significant contribution to the knowledge of how traffic congestion may be controlled.

The study also focused on investigating the influence of gender and age on shopping activity. The study found that 57% of the CBD shoppers identify as females, and the majority of shopping (69%) was from people in age groups between 30 and 74 years. This data addresses the gap in the literature on the controlling variables on shopping trips in regional cities. Additionally, the study found that introducing road pricing or increasing parking pricing by $4 will manage congestion in the CBDs of regional cities by reducing the trips of the dominate gender and age groups on shopping trips. .

In the case of shifting to use public transport for shopping in the CBD, it was noted that about 25% of the research sample would chose to transfer to the use of public transport to the CBD if road pricing or increased parking pricing ($4) were introduced. This means introducing road pricing or increasing parking pricing will significantly encourage the use of public transport in regional cities, even if the standard and frequency of service remained unchanged.

7.6 Limitations

The research limitations are as follows:

1. The questionnaire survey was the source of data for shopping trip information for the studied regional city. Additional information was not available from the Australian Bureau of Statistics and the Toowoomba Regional Council.
2. The regional shopping trips model was validated by comparing the shopping trip estimates from the model using limited traffic survey counts.
3. Application of the research outcomes is limited to other regional cities that have similar characteristics to Toowoomba.

7.7 Recommendations for Further Research

There is scope to extend the research using road pricing and increasing parking pricing in regional cities as follows:

- The relation between the demographic characteristics in regional cities could be studied for shopping trips and for other trip purposes. This would help to understand how these characteristics can affect shopping trips or trips for other purposes in regional cities and regional towns.
- The impact of new parking or roads being constructed could be studied. This would be useful to manage congestion in regional cities and regional towns with changes in road and parking infrastructure.
- The impact of growth in population, car ownership and household wealth on shopping trip behaviour could be investigated to determine any potential increase in CBD traffic congestion.
- A new origin-destination matrix could be investigated to reflect future changes in shopping due to changes in demographics, the road network, transportation systems or shopping centres.

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Appendix A

Questionnaire Survey and its Reliability

A.1 Questionnaire Survey

University of Southern Queensland

Questionnaire Regarding the Effect of Increased Shopping Trips on Traffic Congestion in Toowoomba

Dear Participant,

Toowoomba is a growing city and as growth occurs traffic congestion also increases. We are undertaking a study on the likely effects of increased shopping trips on traffic congestion in Toowoomba City, and particularly within the Central Business District (CBD) area. The study is being undertaken as a key part of doctoral research at the University of Southern Queensland but will ultimately provide useful information for traffic planning authorities in Toowoomba City and the region.

The questionnaire seeks some information on your current shopping trips, and the likely effect of any future price increases in either parking charges and /or road congestion charges. Responses to the questionnaire are confidential and will be used only for the purpose of the study. Aggregated summary data will however be made available to you upon request.

Yours sincerely

Mieaad Taha **(Principal Researcher)**

Research Supervisors

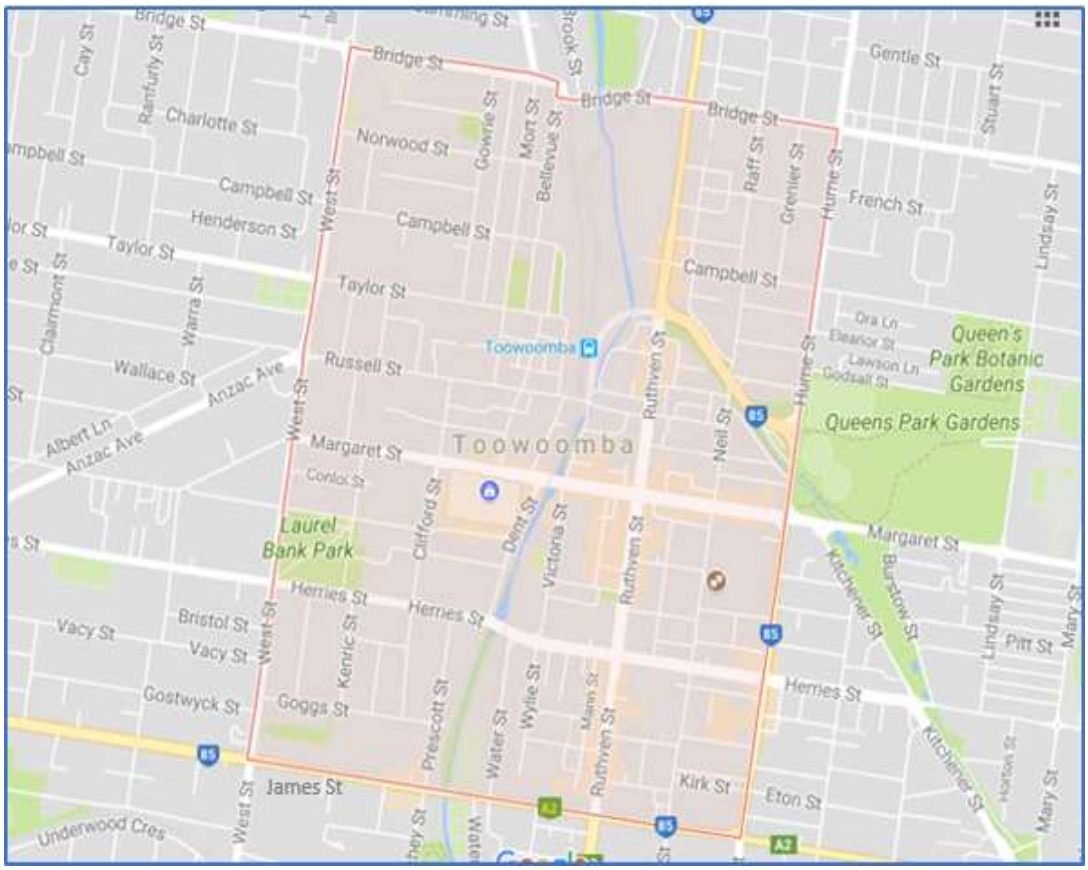
Professor Ron Ayers

Professor Frank Bullen

Dr. Soma Somasundaraswaran

CBD = Central Business Districts

For the purpose of this research and questionnaire the CBD is defined as the Toowoomba city area bounded by **James Street, West Street, Bridge Street, and Hume Street** as shown outlined in red in the map below.



General Information

1. *What gender do you identify as?* ***Circle your answer.***

   Male Female Other No answer

2. *Which of the following age groups describes your age?* ***Circle your answer***

   15 – 29 years
   30 – 44 years
   45 – 59 years
   60 – 74 years
   75 years and over

3. *Which direction from the city centre is the suburb where you live?* ***Tick the direction and circle the suburb (e.g.*** ☑ ***North*** *(…..* Harlaxton *,….)*

☐ **North** (Defined as. North Toowoomba, Harlaxton, Rockville, Wilsonton Heights)

☐ **South** (Defined as. Darling Heights, Kearney Springs, Middle Ridge, South Toowoomba)

☐ **East** (Defined as. Centenary Heights, Mount Lofty, Rangeville, Redwood, East Toowoomba)

☐ **West** (Defined as. Drayton, Glenvale, Harristown, Newtown, Wilsonton)

☐ **Other suburb or town**

Suburb or town…….

4. *How many people (including you) are there in your household in each of the following age groups? (e.g. …2…. Less than 17 years)*

…….. Less than 17 years
…….. 17 years or more

5. *How many vehicles (bicycles, motor bikes, cars, truck,…etc) do you have in your household? (e.g. ..2.. cars)*

…… Bicycle/s

…… Motor bike/s

…… Car/s

…… Truck/s

Other:

Type of vehicles	How many?

6. *On average, how many **trips** do **you or your family** make each week by various modes of transport for SHOPPING?*
(e.g. Walking …2…)

Walking …. Bicycle …. Motor bike …. Car …. Bus …. Taxi….Truck …. Other …..

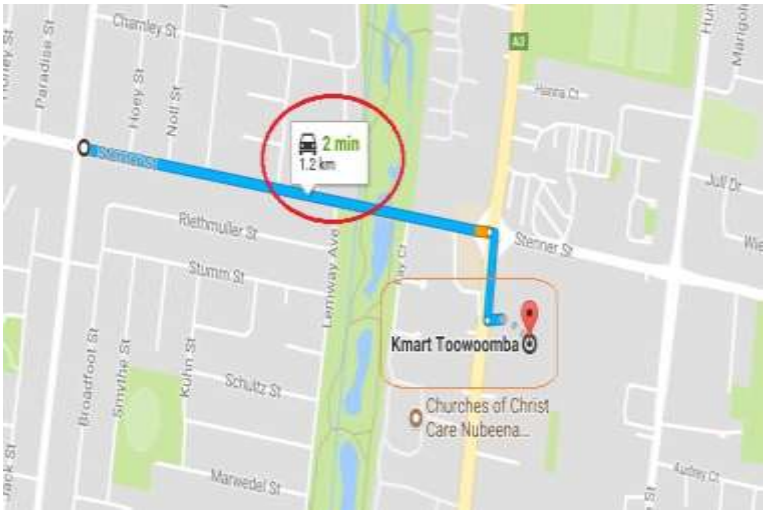
7. *What is the approximate distance from your home to the shopping centre you usually visit? **Tick your answer.***

Note: You could use the google map to check the distance from your home to the shopping centre you usually visit as shown in the red circle in the map below.

☐ Less than 1 Km

☐ 1 Km-5km

☐ More than 5 Km



Your Usual Habits for Shopping

8. *What are your usual habits for the first favourite shopping centre you go to most often?*

Questions	Answers
What is the first favourite shopping centre you go to most often? (e.g. Grand Central, Kearneys Spring, Clifford Garden)	
How often do you go to this shopping centre per month? (e.g. Three times)	
What is your usual mode of going to this shopping centre? (e.g. Private car, Taxi, Bus)	
What days and times you usually go to this shopping centre? (e.g. Monday 10 am - 12 noon)	

9. *What are your usual habits for the <u>second favourite</u> shopping centre you go to most often?*

What is the second favourite shopping centre you go to most often? (e.g. Grand Central, Kearneys Spring, Clifford Garden)	
How often do you go to this shopping centre per month? (e.g. Three times)	
What is your usual mode of going to this shopping centre? (e.g. Private car, Taxi, Bus)	
What days and times you usually go to this shopping centre? (e.g. Monday 10 am - 12 noon)	

10. *What are your usual habits for the <u>third favourite</u> shopping centre you go to most often?*

What is the third favourite shopping centre you go to most often? (e.g. Grand Central, Kearneys Spring, Clifford Garden)	
How often do you go to this shopping centre per month? (e.g. Three times)	
What is your usual mode of going to this shopping centre? (e.g. Private car, Taxi, Bus)	
What days and times you usually go to this shopping centre? (e.g. Monday 10 am - 12 noon)	

Central Business District Trips

11. *How long does it usually take to travel from your home to the Central Business District of Toowoomba as defined in this questionnaire (CBD) by car and by Bus? (**Tick your answer)***

A) By Car

☐ Less than 5 minutes ☐ 5-10 minutes ☐ Between 10 and 20 minutes

☐ 20 – 30 minutes ☐ More than 30 minutes

B) BY Bus

☐ Less than 5 minutes ☐ 5-10 minutes ☐ Between 10 and 20 minutes

☐ 20 – 30 minutes ☐ More than 30 minutes ☐ **Bus not available**

12. *How long do you normally spend when shopping in the CBD? **(Tick your answer)***

☐ Up to 20 minutes ☐ Between 20 minutes and 1 hour

☐ 1 hour - 3 hours ☐ More than 3 hours

13. *Which major road do you use when you are going shopping in the CBD? Why you use it?* ***(Tick more than one if necessary)***

Note: Please choose the main road/s from those around or through the CBD, as shown in the map below.

☐ West Street ☐ James Street ☐ Hume Street ☐ Bridge Street

☐ Ruthven Street ☐ Margaret Street ☐ Herries Street

☐ Taylor Street ☐ Campbell ☐ Kitchener Street

☐ *Other* *Name of road……*

The reason of using this\ these road\s is……

……

Parking in the CBD

14. Where do you normally park when shopping in the CBD?
(Tick more than one if necessary)

☐ Shopping centre carpark

☐ Kerbside parking on roads

☐ Off-street council carpark

☐ Other carpark
Please specify…….

15. *If the cost of all parking in the CBD, including parking meters and previously free parking at shopping centre parking, were to increase by below prices, at which price would affect the number of times you travel to do shopping in the CBD?*

☐ $1 per hour
☐ $2 per hour
☐ $3 per hour
☐ $4 per hour
☐ Other What price
……

16. If the cost of all parking in the CBD, including parking meters and previously free parking at shopping centre parking, were to increase by below prices, which price would you consider using public transport for CBD trips?

☐ $1 per hour
☐ $2 per hour
☐ $3 per hour
☐ $4 per hour
☐ Other What price
……

☐ I do not have public transport where I live

Road Pricing for the CBD

17. *Congestion charging is used in the CBDs of some major cities (e.g. London, Singapore) to ease traffic congestion. If CBD congestion in Toowoomba could be relieved by introducing a congestion charge (similar to automatically debited toll road charge) what do you think would be a reasonable congestion charge level?*

☐ $1 - $2 per visit
☐ $3 - $4 per visit
☐ Other What price
……

18. *If a congestion charge were introduced for entering the CBD, would this affect your shopping in the CBD?*

☐ Yes. *How?* (**Tick as many as appropriate)**
☐ I would shop less in the CBD and more at other shopping centres. Which centres?
.....

☐ I would use more public transport trips to the CBD.

☐ No

19. *If a CBD congestion charge of $3 per visit during 10:00 AM to 2:00 PM on weekdays existed, but did not exist during other times (including weekends), how would this affect your shopping habits? (**Tick as many as appropriate):***

☐ I would change the time/s I shop in the CBD to non-charged times.
What time/s change to?
.....

☐ I would change the day/s I shop in the CBD.
What day? .....
☐ I would spend less time shopping in the CBD.

A.2 Reliability of Questionnaire

Table A.1: Reliability of Questionnaire

Questions	Reliability Statistics\ Cronbach's Alpha
Q2 Age Groups	0.97
Q4 Less than 17	0.99
Q4 More than 17	0.97
Q5 Car	0.97
Q5 Bicycle	0.97
Q6 car trips	0.97
Q6 Bicycle trips	0.88
Q7 Distance	0.74
Q8 How often	0.90
Q9 How often	0.96
Q10 How often	0.84
Q13 Bridge street	0.85
Q13 Taylor street	0.80
Q14 Kerbside	0.97
Q15 Parking cost $2 affect going to shopping at CBD	0.92
Q16 Parking cost $4 using public transport	0.96
Q17 Resealable cost per visit $1-$2	0.94
Q18 I will use more public transport	0.82
Q19 I would spend less time in shopping	0.86

The Reliability was 1.0 for non-mention questions above

Appendix B

Comparison of the collected demographic data with ABS data

B.1 Comparison of ABS data and survey for household size

Table B.1: Comparison of ABS data and survey for household size

Dir.	Zone	Average Household Size (No. of Persons)						Diff. of percentages (%ABS-%Survey)
		ABS				Survey		
		Count of Households	Total Direction Households (A)	Total Population of Direction (B)	Average Household Size (no. of Persons) for Direction (B/A)	Average Household size		
						Zones	Directions	
N	Harlaxton	1107	7714	19537	2.5	4	3.0	-0.5
	North Toowoomba	1342				4		
	Rockville	1349				2		
	Wilsonton Heights	1112				2		
	Outer Northern Areas (Highfields)	2804				3		
S	Darling Heights	1854	10772	26961	2.5	4	2.6	-0.1
	Kearneys Spring	3718				2		
	Middle Ridge	2550				2		
	South Toowoomba	2375				2		
	Outer Southern Areas (Top camp)	275				3		
E	Centenary Heights	2526	10584	25408	2.4	5	2.7	-0.3
	Mount Lofty	1510				2		
	Rangeville	3463				3		
	Redwood	65				2		
	East Toowoomba	2384				2		
	Outer Eastern Areas (Withcott)	636				2		
W	Drayton	684	14543	34036	2.3	2	2.8	-0.5
	Glenvale	2353				3		
	Harristown	3889				3		
	Newtown	4362				3		
	Wilsonton	2589				3		
	Outer Western Areas (Kingsthorpe)	667				3		

B.2 Comparison of ABS data and survey for motor vehicles

Table B.2: Comparison of ABS data and survey for motor vehicles owning

Dir.	Zone	ABS								Survey								Diff.			
		None		1 Motor Vehicle		2 Motor Vehicle		3 or more Motor Vehicle		None		1 Motor Vehicle		2 Motor Vehicle		3 or more Motor Vehicle		None	1 Motor Vehicle	2 Motor Vehicle	3 or more Motor Vehicle
		Cou.	(%)	Cou.	(%)	Cou.	(%)	Cou.	(%)	Cou.	(%)	Cou.	(%)	Cou.	(%)	Cou.	(%)				
N	Harlaxton	78	8.0	421	43.2	288	29.5	141	14.5	1	12.5	4	50.0	2	25.0	1	12.5	-4.5	-6.8	+4.5	+2.0
	North Toowoomba	91	74.0	516	41.9	404	32.8	184	14.9	1	6.7	9	60.0	3	20.0	2	13.3	+67.3	-18.1	+12.8	+1.6
	Rockville	72	6.0	518	43.0	370	30.7	202	16.8	1	6.3	9	56.3	4	25.0	2	12.5	-0.3	-13.3	+5.7	+4.3
	Wilsonton Heights	61	6.0	436	43.0	347	34.3	124	2.2	1	11.1	4	44.4	3	33.3	1	11.1	-5.1	-1.4	+1.0	-8.9
	Outer Northern Areas (Highfields)	36	1.3	575	21.5	1219	45.5	788	29.4	1	10.0	5	50.0	2	20.0	2	20.0	-8.7	-28.5	+25.5	+9.4
Ave.			**19.1**		**38.5**		**34.6**		**15.6**	**5**	**9.3**	**31**	**52.1**	**14**	**24.7**	**8**	**13.9**	**+9.8**	**-13.6**	**+9.9**	**+1.7**
S	Darling Heights	64	4.2	590	38.4	592	38.6	244	15.9	2	10.0	8	40.0	7	35.0	3	15.0	-5.8	-1.6	+3.6	+0.9
	Kearneys Spring	304	8.9	1501	44.1	1049	30.8	353	10.4	1	4.5	11	50.0	6	27.3	4	18.2	4.4	-5.9	+3.5	-7.8
	Middle Ridge	40	1.7	608	26.4	1120	48.7	487	21.2	2	4.8	14	33.3	19	45.2	7	16.7	-3.1	-6.9	+3.5	+4.5
	South Toowoomba	0	0.0	20	8.0	113	45.4	113	45.4	1	4.5	2	9.1	5	22.7	4	18.2	-4.5	-1.1	+22.7	+27.2
	Outer Southern Areas (Top camp)	203	9.7	908	43.3	654	31.2	248	11.8	1	8.3	9	75.0	8	66.7	4	33.3	+1.4	-31.7	-35.5	-21.5
Ave.			**4.9**		**32.0**		**38.9**		**20.9**	**7**	**6.4**	**44**	**41.5**	**45**	**39.4**	**22**	**19**	**-1.5**	**-9.5**	**-0.5**	**+0.6**
E	Centenary Heights	144	5.9	1010	41.6	828	34.1	363	15.0	1	9.1	4	36.4	3	27.3	3	27.3	-3.2	+5.2	+6.8	-12.3
	Mount Lofty	39	2.8	487	34.9	608	43.6	231	16.6	2	20.0	4	40.0	3	30.0	1	10.0	-17.2	-5.1	+13.6	+6.6
	Rangeville	136	4.3	1263	39.6	1250	39.2	482	15.1	5	20.8	8	33.3	6	25.0	5	20.8	-16.5	+6.3	+14.2	-5.7
	Redwood	0	0.0	13	27.1	21	43.8	14	29.2	0	0.0	1	20.0	2	40.0	2	40.0	0.0	+7.1	+3.8	-10.8
	East Toowoomba	186	8.9	878	14.8	699	33.3	273	13.0	1	16.7	2	33.3	2	33.3	1	16.7	-7.8	-18.5	0.0	-3.7
	Outer Eastern Areas (Withcott)	0	0.0	104	17.4	268	44.7	214	35.7	0	0.0	1	12.5	4	50.0	3	37.5	0.0	+4.9	-5.3	-1.8
Ave.			**3.7**		**29.23**		**39.8**		**20.8**	**9**	**11.1**	**20**	**29.3**	**20**	**34.3**	**15**	**25.4**	**-7.4**	**-0.1**	**+5.5**	**-4.6**
W	Drayton	33	5.4	210	34.3	212	34.6	143	23.4	0	0.0	3	42.9	2	28.6	2	28.6	+5.4	-8.6	+6.0	-5.2
	Glenvale	135	6.2	593	27.2	882	40.5	511	23.5	1	7.1	3	21.4	7	50.0	3	21.4	-0.9	+5.8	-9.5	+2.1
	Harristown	442	12.8	1449	42.0	1010	29.3	394	11.4	2	13.3	5	33.3	5	33.3	3	20.0	-0.5	+8.7	-4.0	-8.6
	Newtown	455	11.7	1651	42.5	1147	29.6	471	12.1	2	20.0	4	40.0	2	20.0	2	20.0	-8.3	+2.5	+9.6	-7.9
	Wilsonton	205	8.3	1027	41.7	825	33.5	320	13.0	0	0.0	5	50.0	4	40.0	1	10.0	+8.3	-8.3	-6.5	+3.0
	Outer Western Areas (Kingsthorpe)	9	1.4	156	24.0	288	44.4	180	27.7	1	12.5	2	25.0	3	37.5	2	25.0	-11.1	-1.0	+6.9	+2.7
Ave.			**7.6**		**35.3**		**35.3**		**18.5**	**6**	**8.8**	**22**	**35.4**	**23**	**34.9**	**13**	**20.8**	**-1.2**	**-0.1**	**+0.4**	**-2.3**

Appendix C

Shopping trips by various mode in Toowoomba

C.1: Shopping trips by various mode in Toowoomba

Table C.1: Shopping trips by various mode in Toowoomba from the sample

Dir.	Zone	Total Shopping Trips			Walking	Bicycle	Motor Bike	Car	Bus	Truck	Taxi	Frequency of shoppers (B)	Average Weekly Shopping Trips Per Household (A/B)
		Count (Direction)	Count (Zone) (A)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)		
N	**Harlaxton**	253	41	16	0	0	0	100	0	0	0	8	5.13
	North Toowoomba		85	34	8	4	0	86	1	0	1	14	6.07
	Rockville		82	32	16	4	0	73	0	0	7	15	5.47
	Wilsonton Heights		32	13	23	3	6	56	3	0	9	8	4.00
	Outer Northern Areas (Highfields)		13	5	0	0	0	100	0	0	0	4	3.25
	Average		51	20	**9**	**2**	**1**	**83**	**1**	**0**	**3**		4.78
S	**Darling Heights**	455	80	18	15	3	6	65	8	0	3	20	4.00
	Kearneys Spring		98	22	13	5	1	74	6	0	0	22	4.45
	Middle Ridge		179	39	6	5	0	85	3	0	1	42	4.26
	South Toowoomba		74	16	9	2	2	85	3	0	0	22	3.36
	Outer Southern Areas (Top camp)		24	5	0	0	0	100	0	0	0	4	6.00
	Average		91	20	**9**	**3**	**2**	**82**	**4**	**0**	**1**		4.41
E	**Centenary Heights**	243	55	23	22	6	0	69	4	0	0	11	5.00
	Mount Lofty		34	14	19	6	3	71	0	0	3	10	3.40
	Rangeville		97	40	5	2	0	93	0	0	0	24	4.04
	Redwood		18	7	7	0	0	79	0	0	14	5	3.60
	East Toowoomba		30	12	14	13	0	69	4	0	0	6	5.00
	Outer Eastern Areas (Withcott)		9	4	0	0	0	100	0	0	0	2	4.50
	Average		41	17	**11**	**5**	**1**	**80**	**1**	**0**	**3**		4.26
W	**Drayton**	255	31	12	0	0	0	100	0	0	0	7	4.43
	Glenvale		60	24	0	0	0	100	0	0	0	14	2.29
	Harristown		67	26	15	3	2	77	3	0	0	15	4.47
	Newtown		44	17	13	0	0	84	2	0	0	10	4.40
	Wilsonton		51	20	9	0	0	86	4	0	0	10	5.10
	Outer Western Areas (Kingsthorpe)		4	1	0	0	0	100	0	0	0	2	2.00
	Average		43	17	**6**	**1**	**0**	**91**	**2**	**0**	**0**		3.78

Appendix D

Using the distance by each direction of Toowoomba

D.1 Using distance by each direction of Toowoomba

Table D.1: Count of people using the distance by each direction of Toowoomba

Direction	Less than 1 Km		1 Km - 5 Km		More than 5 Km	
	Count	(%)	Count	(%)	Count	(%)
North	4	6.9	32	55.2	22	37.9
South	8	6.8	91	77.1	19	16.1
East	6	9.4	42	65.6	16	25.0
West	5	7.8	44	68.8	15	23.4
Total	23	7.6	209	68.8	72	23.7

Appendix E

Shopping trips to the top three preferred shopping centres

E.1 Shopping trips to the first three preferred shopping centre to visit monthly

Table E.1: Shopping trips to the first preferred shopping centre to visit monthly

Zones \ Shopping Centre		Clifford Garden	Kearneays	Grand central	Drayton	High Street	North point	The range	Westridge	Wilsonton	Betros Bros
		1	2	3	4	5	6	7	8	9	10
1	Harlaxton	5	0	11	48	0	0	0	0	0	0
2	North Toowoomba	10	0	29	0	0	46	0	0	0	0
3	Rockville	8	0	10	0	0	14	0	0	51	0
4	Wilsonton Heights	0	0	35	0	0	10	0	0	16	0
5	Darling Heights	0	90	28	16	0	0	0	10	0	0
6	Kearneys Spring	6	110	16	0	12	0	15	10	0	0
7	Middle Ridge	2	193	45	0	20	0	14	25	0	0
8	South Toowoomba	9	64	35	0	0	0	16	0	0	0
9	Centenary Heights	0	25	47	0	0	0	0	30	0	0
10	Mount Lofty	0	0	19	0	0	48	11	0	0	0
11	Rangeville	0	92	32	0	32	0	36	0	0	0
12	Redwood	0	29	0	0	0	0	6	0	0	0
13	Drayton	16	26	0	14	0	0	0	0	0	0
14	Glenvale	79	4	5	0	0	0	0	0	0	0
15	Harristown	59	25	38	0	0	0	0	0	0	0
16	Newtown	46	0	14	0	0	4	0	0	0	0
17	Wilsonton	16	0	9	0	0	0	0	0	26	0
18	East Toowoomba	0	10	3	0	0	16	8	0	0	0
19	Other Northern Suburbs	5	10	18	0	0	38	0	0	11	4
20	Other Southern Suburbs Centroid	6	12	20	19	0	2	0	10	0	0
21	Other Eastern Suburbs	12	40	17	5	0	10	0	10	6	0
22	Other Western Suburbs	3	5	23	3	0	5	0	0	0	3

Table E.2: Shopping trips to the second preferred shopping centre to visit monthly

Zones \ Shopping centre		Clifford Garden	Kearneays	Grand central	Drayton	High Street	North point	The range	Westridge	Wilsonton	Betros Bros
		1	2	3	4	5	6	7	8	9	10
1	Harlaxton	9	0	11	0	0	0	0	0	0	0
2	North Toowoomba	3	6	31	0	0	1	0	0	0	0
3	Rockville	0	0	45	0	0	4	0	0	13	10
4	Wilsonton Heights	3	0	12	0	0	0	0	0	17	0
5	Darling Heights	12	21	18	0	0	0	0	0	0	0
6	Kearneys Spring	5	47	23	0	0	0	0	2	0	0
7	Middle Ridge	24	66	51	7	0	0	3	0	0	4
8	South Toowoomba	14	37	8	5	0	0	0	0	1	0
9	Centenary Heights	0	17	12	0	10	0	0	0	0	0
10	Mount Lofty	2	0	10	0	0	10	2	0	12	0
11	Rangeville	2	31	21	0	19	0	18	0	0	4
12	Redwood	0	0	10	0	0	0	0	0	0	0
13	Drayton	6	0	1	6	0	0	0	0	0	0
14	Glenvale	19	3	20	0	0	0	0	0	3	0
15	Harristown	10	24	24	0	0	0	0	0	0	0
16	Newtown	12	4	11	0	0	0	0	0	4	4
17	Wilsonton	11	0	5	0	0	3	0	0	12	4
18	East Toowoomba	0	0	5	0	0	0	3	0	0	0
19	Other Northern Suburbs	22	8	7	0	0	0	2	0	0	0
20	Other Southern Suburbs Centroid	12	6	9	0	0	0	0	0	0	0
21	Other Eastern Suburbs	4	10	1	0	0	0	0	0	0	0
22	Other Western Suburbs	11	9	7	0	0	0	0	0	0	0

Table E.3: Shopping trips to the third preferred shopping centre to visit monthly

Zone \ Shopping centre		Clifford Garden	Kearneays	Grand central	Drayton	High Street	North point	The range	Westridge	Wilsonton	Betros Bros
		1	2	3	4	5	6	7	8	9	10
1	Harlaxton	2	0	4	0	0	6	0	0	0	0
2	North Toowoomba	4	2	1	0	0	6	2	0	0	0
3	Rockville	32	3	0	0	0	0	0	0	5	0
4	Wilsonton Heights	7	0	2	0	0	2	0	0	0	0
5	Darling Heights	11	12	12	0	0	0	0	0	0	0
6	Kearneys Spring	15	8	14	0	0	0	0	0	0	0
7	Middle Ridge	13	34	27	0	0	4	0	17	0	4
8	South Toowoomba	4	8	14	1	0	0	0	15	0	0
9	Centenary Heights	2	2	3	0	9	0	7	0	0	6
10	Mount Lofty	0	1	3	0	0	0	2	0	0	0
11	Rangeville	5	10	14	0	10	0	6	0	0	0
12	Redwood	3	0	1	0	0	0	0	0	0	0
13	Drayton	2	1	6	0	0	0	0	0	0	0
14	Glenvale	14	4	0	1	0	0	0	0	0	0
15	Harristown	1	6	7	0	0	0	0	5	0	0
16	Newtown	0	14	2	0	0	0	0	0	2	0
17	Wilsonton	2	7	6	0	0	0	0	0	1	0
18	East Toowoomba	0	4	2	0	0	0	1	0	0	0
19	Other Northern Suburbs	1	5	7	8	0	3	0	0	0	0
20	Other Southern Suburbs Centroid	5	0	4	4	0	6	0	0	0	0
21	Other Eastern Suburbs	2	0	3	0	0	0	0	0	0	0
22	Other Western Suburbs	0	4	5	0	0	1	0	2	0	0

Appendix F

Details of demographic data and shopping habits

F.1 The demographic data and shopping habits

Table F.1: Counts and percentages of Toowoomba CBD shoppers who owning a motor vehicle

Dir.		None	1 Motor Vehicle	2 Motor Vehicle	3 or more Motor Vehicle	Total	Total sample
N	First Favorite	0	12	4	2	18	58
	Second Favorite	1	17	10	4	32	
	Third Favorite	0	1	0	0	1	
	Total shoppers at the CBD	1	30	14	6	51	
	Total people owning motor vehicle from the sample	5	31	14	8		
	Percentages of shoppers CBD from the motor vehicle owners (%)	*20	97	100	75		
	Percentages of shoppers CBD from the direction sample (%)	**2	52	24	10	88	
S	First Favorite	0	9	10	0	19	118
	Second Favorite	1	13	19	10	43	
	Third Favorite	1	9	12	12	34	
	Total shoppers at the CBD	2	31	41	22	96	
	Total people owning motor vehicle from the sample	7	44	45	22		
	Percentages of shoppers CBD from the motor vehicle owners (%)	29	70	91	100		
	Percentages of shoppers CBD from the direction sample (%)	2	26	35	19	82	
E	First Favorite	1	7	8	4	20	64
	Second Favorite	1	9	9	5	24	
	Third Favorite	2	4	3	6	15	
	Total shoppers at the CBD	4	20	20	15	59	
	Total people owning motor vehicle from the sample	9	20	20	15		
	Percentages of shoppers CBD from the motor vehicle owners (%)	45	100	100	100		
	Percentages of shoppers CBD from the direction sample (%)	6	31	31	23	92	
W	First Favorite	0	3	5	3	11	64
	Second Favorite	0	6	12	4	22	
	Third Favorite	2	6	6	4	18	
	Total shoppers at the CBD	2	15	23	11	51	
	Total people owning motor vehicle from the sample	6	22	23	13		
	Percentages of shoppers CBD from the motor vehicle owners (%)	34	68	100	85		
	Percentages of shoppers CBD from the direction sample (%)	3	23	36	17	79	

***Total shoppers at the CBD /Total people owning motor vehicle from the sample = (1/5) *100=20%, ** Total shoppers at the CBD / Total Sample = (1/58) *100=2%**

Table F.2: Gender counts and percentages on the sample visiting the first three preferred shopping centres

Dir.		Male	Female	Total	Total sample
N	First Favorite	9	9	18	58
	Second Favorite	10	22	32	
	Third Favorite	0	1	1	
	Total shoppers at the CBD	19	32	51	
	Total Gender of the sample	22	36		
	Percentages of shoppers CBD from the gender (%)	*86	89		
	Percentages of shoppers CBD from the direction sample (%)	**33	55	88%	
S	First Favorite	6	13	19	118
	Second Favorite	16	27	43	
	Third Favorite	13	21	34	
	Total shoppers at the CBD	35	61	96	
	Total Gender of the sample	37	81		
	Percentages of shoppers CBD from the gender (%)	95	75		
	Percentages of shoppers CBD from the direction sample (%)	30	52	82%	
E	First Favorite	3	17	20	64
	Second Favorite	10	14	24	
	Third Favorite	5	10	15	
	Total shoppers at the CBD	18	41	59	
	Total Gender of the sample	19	45		
	Percentages of shoppers CBD from the gender (%)	95	91		
	Percentages of shoppers CBD from the direction sample (%)	28	64	92%	
W	First Favorite	2	9	11	64
	Second Favorite	7	15	22	
	Third Favorite	6	12	18	
	Total shoppers at the CBD	15	36	51	
	Total Gender of the sample	18	46		
	Percentages of shoppers CBD from the gender (%)	83	78		
	Percentages of shoppers CBD from the direction sample (%)	23	56	79%	

***Total shoppers at the CBD / Total Gender of the sample = (19 /22) *100= 86%, ** Total shoppers at the CBD /Total Sample = (19/58) *100=33%**

Table F.3: Age groups counts and percentages on the sample visiting the first three preferred shopping centres

Dir.		15-29 Years	30-44 Years	45-59 years	60-74 years	75 years and over	Total	Total sample
N	First Favorite	2	7	3	3	3	18	58
	Second Favorite	4	9	8	5	6	32	
	Third Favorite	0	0	0	0	1	1	
	Total shoppers at the CBD	6	16	11	8	10	51	
	Total Age Groups of the sample	9	17	13	9	10		
	Percentages of shoppers CBD from the age groups (%)	*67	94	85	89	100		
	Percentages of shoppers CBD from the direction sample (%)	**10	28	19	14	17	88	
S	First Favorite	1	10	4	3	1	19	118
	Second Favorite	5	14	11	13	0	43	
	Third Favorite	2	7	7	12	6	34	
	Total shoppers at the CBD	8	31	22	28	7	96	
	Total Age Groups of the sample	11	35	29	34	9		
	Percentages of shoppers CBD from the age groups (%)	73	89	76	82	78		
	Percentages of shoppers CBD from the direction sample (%)	7	26	19	24	6	82	
E	First Favorite	3	4	7	6	0	20	64
	Second Favorite	2	4	8	8	2	24	
	Third Favorite	1	3	8	2	1	15	
	Total shoppers at the CBD	6	11	23	16	3	59	
	Total Age Groups of the sample	6	12	23	19	4		
	Percentages of shoppers CBD from the age groups (%)	100	92	100	84	75		
	Percentages of shoppers CBD from the direction sample (%)	9	17	36	25	5	92	
W	First Favorite	2	5	1	3	0	11	64
	Second Favorite	0	7	7	6	2	22	
	Third Favorite	2	2	6	6	2	18	
	Total shoppers at the CBD	4	14	14	15	4	51	
	Total Age Groups of the sample	6	16	19	18	5		
	Percentages of shoppers CBD from the age groups (%)	67	88	74	83	80		
	Percentages of shoppers CBD from the direction sample (%)	6	22	22	23	6	79	

***Total shoppers at the CBD / Total age groups of the sample = (6/9) *100=67%,**

**** Total shoppers at the CBD /Total Sample = (6/58) *100=10%**

Table F.4: Total shoppers at the CBD for both genders

Dir.	Total shoppers at the CBD		Total
	Male	Female	
N	19	32	51
S	35	61	96
E	18	41	59
W	15	36	51
Total CBD shoppers	87	170	257

Table F.5: Total shoppers at the CBD for all age groups

Dir.	Total shoppers at the CBD					Total
	15-29 Years	30-44 Years	45-59 years	60-74 years	75 years and over	
N	6	16	11	8	10	51
S	8	31	22	28	7	96
E	6	11	23	16	3	59
W	4	14	14	15	4	51
Total CBD shoppers	24	72	70	67	24	257

Appendix G

Shopping Days in Toowoomba

G.1 Days of shopping in Toowoomba

Table G.1: Frequent of people in the days usually go shopping for the first of the three preferred shopping centres

Dir.	Zone	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Other	Total
North	Harlaxton	0	1	3	0	0	2	1	1	8
	North Toowoomba	1	1	2	3	1	3	2	2	15
	Rockville	1	1	2	2	3	5	2	0	16
	Wilsonton Heights	2	1	1	0	0	3	2	0	9
	Outer Northern Areas (Highfields)	0	0	3	1	0	3	3	0	10
	Total	4	4	11	6	4	16	10	3	58
South	Darling Heights	5	0	1	2	1	6	3	2	20
	Kearneys Spring	2	2	2	2	5	6	2	1	22
	Middle Ridge	4	4	4	7	5	9	7	2	42
	South Toowoomba	2	2	3	3	2	5	2	3	22
	Outer Southern Areas (Top camp)	0	0	1	2	2	4	3	0	12
	Total	13	8	11	16	15	30	17	8	118
East	Centenary Heights	1	0	0	2	2	3	2	1	11
	Mount Lofty	0	1	1	0	1	4	3	0	10
	Rangeville	2	1	2	3	2	6	7	1	24
	Redwood	1	0	0	1	1	0	1	1	5
	East Toowoomba	0	0	0	1	0	3	2	0	6
	Outer Eastern Areas (Withcott)	0	0	1	1	1	3	2	0	8
	Total	4	2	4	8	7	19	17	3	64
West	Drayton	1	1	0	0	2	1	0	2	7
	Glenvale	0	1	2	2	2	4	2	1	14
	Harristown	1	2	1	2	1	4	3	1	15
	Newtown	0	1	1	1	1	3	3	0	10
	Wilsonton	1	1	0	2	0	3	3	0	10
	Outer Western Areas (Kingsthorpe)	0	0	0	1	1	4	2	0	8
	Total	3	6	4	8	7	19	13	4	64

Table G.2: Frequent of people in the days usually go shopping for the second of the three preferred shopping centres

Dir.	Zone	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Other	Total
N	Harlaxton	1	0	1	0	0	2	2	1	7
	North Toowoomba	0	1	3	1	1	5	4	0	15
	Rockville	0	2	2	2	1	5	3	0	15
	Wilsonton Heights	0	0	2	1	0	3	2	1	9
	Outer Northern Areas (Highfields)	0	0	2	0	1	4	3	0	10
	Total	1	3	10	4	3	19	14	2	56
S	Darling Heights	0	2	2	3	2	5	4	1	19
	Kearneys Spring	0	1	1	4	3	7	5	0	21
	Middle Ridge	3	3	4	6	5	9	7	3	40
	South Toowoomba	1	2	2	2	3	6	4	2	22
	Outer Southern Areas (Top camp)	0	0	0	2	2	3	3	0	10
	Total	4	8	9	17	15	30	23	6	112
E	Centenary Heights	0	0	1	2	2	4	2	0	11
	Mount Lofty	1	1	1	1	1	3	2	0	10
	Rangeville	1	1	3	5	2	6	4	2	24
	Redwood	0	0	1	0	0	2	2	0	5
	East Toowoomba	0	0	1	1	0	3	1	0	6
	Outer Eastern Areas (Withcott)	0	0	0	0	1	3	2	0	6
	Total	2	2	7	9	6	21	13	2	62
W	Drayton	0	0	0	1	1	3	1	0	6
	Glenvale	1	1	1	2	0	5	3	1	14
	Harristown	2	1	1	1	3	3	2	2	15
	Newtown	0	0	1	1	1	4	3	0	10
	Wilsonton	0	0	1	0	1	4	3	0	9
	Outer Western Areas (Kingsthorpe)	0	1	1	1	0	2	2	0	7
	Total	3	3	5	6	6	21	14	3	61

Table G.3: Frequent of people in the days usually go shopping for the third of the three preferred shopping centres

Dir.	Zone	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Other	Total
N	Harlaxton	0	0	0	1	0	3	1	0	5
	North Toowoomba	1	0	1	1	0	2	2	1	8
	Rockville	1	2	1	2	2	2	2	0	12
	Wilsonton Heights	1	0	0	0	0	1	1	1	4
	Outer Northern Areas (Highfields)	0	0	2	1	0	2	2	0	7
	Total	3	2	4	5	2	10	8	2	36
S	Darling Heights	1	1	2	2	2	5	3	1	17
	Kearneys Spring	1	1	1	3	3	6	3	2	20
	Middle Ridge	2	2	2	5	7	8	7	3	36
	South Toowoomba	1	1	2	2	2	5	4	1	18
	Outer Southern Areas(Top camp)	0	1	1	2	2	3	2	0	11
	Total	5	6	8	14	16	27	19	7	102
E	Centenary Heights	0	0	1	2	2	4	2	0	11
	Mount Lofty	0	0	0	0	0	3	2	0	5
	Rangeville	1	0	3	2	3	5	3	1	18
	Redwood	0	0	0	0	1	1	0	0	2
	East Toowoomba	0	1	1	0	0	2	1	0	5
	Outer Eastern Areas (Withcott)	0	0	1	1	1	2	2	0	7
	Total	1	1	6	5	7	17	10	1	48
W	Drayton	0	0	0	0	0	3	2	0	5
	Glenvale	0	1	1	1	1	3	3	2	12
	Harristown	1	1	3	3	3	2	2	0	15
	Newtown	1	1	1	1	1	1	1	0	7
	Wilsonton	1	1	1	1	1	2	1	1	9
	Outer Western Areas (Kingsthorpe)	0	0	0	1	1	3	2	0	7
	Total	3	4	6	7	7	14	11	3	55

Appendix H

Shopping time in Toowoomba

H.1 shopping time in Toowoomba

Table H.1: Frequent of people in the time usually go shopping for the first of the three preferred shopping centres

Dir.	Zone	Early Morning	Late Morning	Early Afternoon	Mid Afternoon	Late Afternoon	Early Evening	*Other	Total
N	Harlaxton	1	3	1	2	1	0	0	8
	North Toowoomba	1	7	3	1	1	1	1	15
	Rockville	1	4	3	2	4	1	1	16
	Wilsonton Heights	0	5	2	2	0	0	0	9
	Outer Northern Areas (Highfields)	0	1	3	4	1	1	0	10
	Total	3	20	12	11	7	3	2	58
S	Darling Heights	1	5	5	3	3	2	1	20
	Kearneys Spring	5	4	4	3	1	2	3	22
	Middle Ridge	6	13	5	7	5	3	3	42
	South Toowoomba	2	4	5	3	4	2	2	22
	Outer Southern Areas (Top camp)	0	0	3	3	3	1	2	12
	Total	14	26	22	19	16	10	11	118
E	Centenary Heights	1	3	2	2	2	1	0	11
	Mount Lofty	1	1	3	2	2	1	0	10
	Rangeville	2	6	4	4	4	3	1	24
	Redwood	1	1	1	1	1	0	0	5
	East Toowoomba	3	2	0	0	0	1	0	6
	Outer Eastern Areas (Withcott)	0	0	4	3	1	0	0	8
	Total	8	13	14	12	10	6	1	64
W	Drayton	1	1	2	1	2	0	0	7
	Glenvale	1	2	3	2	5	0	1	14
	Harristown	0	5	5	3	1	1	0	15
	Newtown	0	2	2	2	2	1	1	10
	Wilsonton	2	1	4	2	0	1	0	10
	Outer Western Areas(Kingsthorpe)	0	1	2	2	2	0	1	8
	Total	4	12	18	12	12	3	3	64

*Other: No specific time - Early Morning 8 Am-10 Am - Late Morning 10 Am-12 Noon - Early Afternoon 12 Noon-2 Pm - Mid Afternoon 2 Pm – 4 Pm

- Late Afternoon 4 Pm – 6 Pm - Early Evening 6 Pm -9 Pm

Table H.2: Frequent of people in the time usually go shopping for the second of the three preferred shopping centres

Dir.	Zone	Early Morning	Late Morning	Early Afternoon	Mid Afternoon	Late Afternoon	Early Evening	Other	Total
N	Harlaxton	1	4	1	0	0	1	0	7
	North Toowoomba	0	4	4	4	3	0	0	15
	Rockville	3	6	1	2	2	1	0	15
	Wilsonton Heights	0	4	2	2	1	0	0	9
	Outer Northern Areas (Highfields)	1	3	3	2	0	0	1	10
	Total	5	21	11	10	6	2	1	56
S	Darling Heights	0	4	6	4	4	1	0	19
	Kearneys Spring	3	5	6	2	2	2	1	21
	Middle Ridge	4	11	12	6	5	1	1	40
	South Toowoomba	4	4	5	3	3	1	2	22
	Outer Southern Areas (Top camp)	0	3	3	3	1	0	0	10
	Total	11	27	32	18	15	5	4	112
E	Centenary Heights	0	3	4	2	1	1	0	11
	Mount Lofty	0	2	4	2	1	1	0	10
	Rangeville	2	5	6	5	4	1	1	24
	Redwood	1	1	1	2	0	0	0	5
	East Toowoomba	1	1	3	1	0	0	0	6
	Outer Eastern Areas (Withcott)	0	4	2	0	0	0	0	6
	Total	4	16	20	12	6	3	1	62
W	Drayton	0	3	3	0	0	0	0	6
	Glenvale	0	4	4	3	3	0	0	14
	Harristown	1	3	3	3	4	1	0	15
	Newtown	1	5	1	2	1	0	0	10
	Wilsonton	0	3	3	1	1	1	0	9
	Outer Western Areas(Kingsthorpe)	0	3	3	1	0	0	0	7
	Total	2	21	17	10	9	2	0	61

Table H.3: Frequent of people in the time usually go shopping for the third of the three preferred shopping centres

Dir.	Zone	Early Morning	Late Morning	Early Afternoon	Mid Afternoon	Late Afternoon	Early Evening	Other	Total
N	Harlaxton	0	2	2	0	0	1	0	5
	North Toowoomba	1	0	3	2	1	1	0	8
	Rockville	3	2	2	2	1	1	1	12
	Wilsonton Heights	0	1	1	1	1	0	0	4
	Outer Northern Areas (Highfields)	0	1	3	3	0	0	0	7
	Total	4	6	11	8	3	3	1	36
S	Darling Heights	0	7	4	3	1	0	2	17
	Kearneys Spring	0	5	5	4	3	1	2	20
	Middle Ridge	3	14	6	3	3	3	4	36
	South Toowoomba	0	6	3	1	2	1	5	18
	Outer Southern Areas (Top camp)	0	2	4	3	1	1	0	11
	Total	3	34	22	14	10	6	13	102
E	Centenary Heights	1	1	2	2	2	1	2	11
	Mount Lofty	0	2	2	1	0	0	0	5
	Rangeville	1	5	4	3	4	1	0	18
	Redwood	1	0	0	1	0	0	0	2
	East Toowoomba	1	0	2	0	1	0	1	5
	Outer Eastern Areas (Withcott)	0	2	2	2	1	0	0	7
	Total	4	10	12	9	8	2	3	48
W	Drayton	0	1	2	0	1	0	1	5
	Glenvale	0	3	3	2	3	0	1	12
	Harristown	0	4	3	3	4	1	0	15
	Newtown	0	1	1	2	1	1	1	7
	Wilsonton	0	2	2	3	1	1	0	9
	Outer Western Areas (Kingsthorpe)	0	0	2	2	2	1	0	7
	Total	0	11	13	12	12	4	3	55

Table H.4: The time it usually takes to travel from home to the CBD by car

Dir.	Less than 5 minutes		5 - 10 minutes		Between 10 and 20 minutes		20 - 30 minutes		More than 30 minutes		Total Sample
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	
North	8	*13.8	10	17.2	27	46.6	10	17.2	3	5.2	58
South	5	4.2	45	38.1	60	50.8	6	5.1	2	1.7	118
East	11	17.2	31	48.4	17	26.6	4	6.3	1	1.6	64
West	8	12.5	25	39.1	28	43.8	3	4.7	0	0.0	64
Average	32	11.9	111	35.7	132	42.0	23	8.3	6	2.1	304

*(8/58) *100=13.8%

Table H.5: Time spend inside shopping centres when shopping at the CBD

Direction	Up to 20 minutes		Between 20 minute and 1 hour		1 hour - 3 hour		More than 3 hour		Total Sample
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	
North	3	*5.2	17	29.3	36	62.1	2	3.4	58
South	3	2.5	35	29.7	77	65.3	3	2.5	118
East	2	3.1	20	31.3	41	64.1	1	1.6	64
West	2	3.1	16	25.0	43	67.2	3	4.7	64
Average	10	3.5	88	28.8	197	64.7	9	3.1	304

*(3/58) =5.2%

Appendix I

Trip generation after increasing parking pricing

I.1 Trip Generation after increasing parking pricing

Table I.1: Shopping trips generation for studied area after increasing parking pricing by $2

Suburb number	Suburb	Trips Production	Shopping Centre Number	Shopping Centres	Trips Attraction
1	Harlaxton	811	1	Clifford Gardens Shopping Centre	4045
2	North Toowoomba	1025	2	Kearneys Spring Shopping Centre	7904
3	Rockville	843	3	Grand Central Shopping Centre	4739
4	Wilsonton Heights	470	4	Drayton Shopping Centre	942
5	Darling Heights	869	5	High Street Shopping Centre	770
6	Kearneys Spring	1940	6	Northpoint Shopping Centre	1644
7	Middle Ridge	1382	7	The Range Shopping Centre	1046
8	South Toowoomba	1016	8	Westridge Shopping Centre	936
9	Centenary Heights	1299	9	Wilsonton Shopping Centre	1238
10	Mount Lofty	550	10	Betros Bros Shopping Centre	220
11	Rangeville	1860			
12	Redwood	31			
13	Drayton	433			
14	Glenvale	1441			
15	Harristown	2035			
16	Newtown	2385			
17	Wilsonton	1717			
18	East Toowoomba	1243			
19	Other Northern Suburbs	1302			
20	Other Southern Suburbs	236			
21	Other Eastern Suburbs	409			
22	Other Western Suburbs	191		**Total Trips**	23484

Table I.2: Shopping trips generation for studied area after increasing parking pricing by $3

Suburb number	Suburb	Trips Production	Shopping Centre Number	Shopping Centres	Trips Attraction
1	Harlaxton	811	1	Clifford Gardens Shopping Centre	4257
2	North Toowoomba	1025	2	Kearneys Spring Shopping Centre	8318
3	Rockville	843	3	Grand Central Shopping Centre	3811
4	Wilsonton Heights	470	4	Drayton Shopping Centre	992
5	Darling Heights	869	5	High Street Shopping Centre	811
6	Kearneys Spring	1940	6	Northpoint Shopping Centre	1730
7	Middle Ridge	1382	7	The Range Shopping Centre	1100
8	South Toowoomba	1016	8	Westridge Shopping Centre	985
9	Centenary Heights	1299	9	Wilsonton Shopping Centre	1303
10	Mount Lofty	550	10	Betros Bros Shopping Centre	178
11	Rangeville	1860			
12	Redwood	31			
13	Drayton	433			
14	Glenvale	1441			
15	Harristown	2035			
16	Newtown	2385			
17	Wilsonton	1717			
18	East Toowoomba	1243			
19	Other Northern Suburbs	1302			
20	Other Southern Suburbs	236			
21	Other Eastern Suburbs	409			
22	Other Western Suburbs	191		**Total Trips**	23484

Table I.3: Shopping trips generation for studied area after increasing parking pricing by $4

Suburb number	Suburb	Trips Production	Shopping Centre Number	Shopping Centres	Trips Attraction
1	Harlaxton	811	1	Clifford Gardens Shopping Centre	4515
2	North Toowoomba	1025	2	Kearneys Spring Shopping Centre	8822
3	Rockville	843	3	Grand Central Shopping Centre	2680
4	Wilsonton Heights	470	4	Drayton Shopping Centre	1052
5	Darling Heights	869	5	High Street Shopping Centre	860
6	Kearneys Spring	1940	6	Northpoint Shopping Centre	1835
7	Middle Ridge	1382	7	The Range Shopping Centre	1167
8	South Toowoomba	1016	8	Westridge Shopping Centre	1044
9	Centenary Heights	1299	9	Wilsonton Shopping Centre	1382
10	Mount Lofty	550	10	Betros Bros Shopping Centre	127
11	Rangeville	1860			
12	Redwood	31			
13	Drayton	433			
14	Glenvale	1441			
15	Harristown	2035			
16	Newtown	2385			
17	Wilsonton	1717			
18	East Toowoomba	1243			
19	Other Northern Suburbs	1302			
20	Other Southern Suburbs	236			
21	Other Eastern Suburbs	409			
22	Other Western Suburbs	191		**Total Trips**	23484

Appendix J

Details of Gravity Model

J.1 Parameters of Gravity Model equation: Distance matrix

Table J.1: Distance matrix

Study Zones	D / O	Shopping Centres									
		1	2	3	4	5	6	7	8	9	10
	1	4.4	6.99	3.29	8.86	6.18	1.1	4.58	6.55	3.61	2.93
	2	3.24	5.57	1.97	7.65	5.06	0.614	3.53	5.23	3.18	1.58
	3	3.12	5.6	2.94	7.65	6.85	1.72	5.44	5.83	1.46	2.79
	4	3.9	7.5	4.12	8.14	8.07	2.87	6.65	6.7	1.5	3.94
	5	3.55	1.93	4.33	1.76	4.9	6.58	5.35	1.16	5.93	4.7
	6	5.08	1.9	5.46	2.89	4.55	7.74	5.56	2.32	7.58	5.85
	7	5.07	1.35	4.73	4.5	2.69	8.86	3.9	2.56	7.47	5
	8	2.46	2.23	1.72	4.92	2.79	3.86	2.34	2.14	4.59	1.94
	9	4.04	1.88	3.18	5.41	1.32	5.1	2	2.72	6.24	3.43
	10	4.17	5.56	2.56	8.15	4.29	1.93	2.61	5.49	4.57	2.29
	11	5.37	3.54	4.18	7.09	0.515	5.56	1.49	4.36	7.28	4.24
	12	4.41	3.94	2.93	7.21	1.94	3.86	4.15	4.33	5.88	2.82
	13	4.21	3.69	5.46	0.535	6.69	7.58	6.96	2.8	6.27	5.8
	14	3.41	6.01	5.05	4.26	8.28	6.17	7.75	4.79	3.74	5.25
	15	1.61	2.8	2.83	2.98	5.06	4.88	4.83	1.65	3.93	3.18
	16	0.926	4.69	2.16	5.13	5.92	3.14	5.06	3.69	1.7	2.29
	17	2.6	6.33	3.52	6.39	7.52	3.44	6.45	5.32	0.686	3.52
	18	3.31	4.16	1.71	6.91	3.16	2.61	1.65	4.11	4.51	1.61
	19	6.68	10.03	6.33	11.07	9.86	4.27	8.31	9.37	4.5	6.06
	20	7.68	5.41	8.58	3.27	8.21	10.82	9.13	5.3	9.88	8.91
	21	8.97	7.5	7.41	11.14	4.49	7.78	4.54	8.38	10.28	7.28
	22	8.62	11.48	10.14	9.21	13.78	10.36	13.01	10.27	7.57	10.31

J.2 Parameters of Gravity Model equation: Friction Factor

Table J.2a: Friction Factor (F), Friction Factor (F) Matrix= 1/ (distance) ^2

D / O		Shopping Centres									
		1	2	3	4	5	6	7	8	9	10
Study zones	1	0.052	0.020	0.092	0.013	0.026	0.826	0.048	0.023	0.077	0.116
	2	0.095	0.032	0.258	0.017	0.039	2.653	0.080	0.037	0.099	0.401
	3	0.103	0.032	0.116	0.017	0.021	0.338	0.034	0.029	0.469	0.128
	4	0.066	0.018	0.059	0.015	0.015	0.121	0.023	0.022	0.444	0.064
	5	0.079	0.268	0.053	0.323	0.042	0.023	0.035	0.743	0.028	0.045
	6	0.039	0.277	0.034	0.120	0.048	0.017	0.032	0.186	0.017	0.029
	7	0.039	0.549	0.045	0.049	0.138	0.013	0.066	0.153	0.018	0.040
	8	0.165	0.201	0.338	0.041	0.128	0.067	0.183	0.218	0.047	0.266
	9	0.061	0.283	0.099	0.034	0.574	0.038	0.250	0.135	0.026	0.085
	10	0.058	0.032	0.153	0.015	0.054	0.268	0.147	0.033	0.048	0.191
	11	0.035	0.080	0.057	0.020	3.770	0.032	0.450	0.053	0.019	0.056
	12	0.051	0.064	0.116	0.019	0.266	0.067	0.058	0.053	0.029	0.126
	13	0.056	0.073	0.034	3.494	0.022	0.017	0.021	0.128	0.025	0.030
	14	0.086	0.028	0.039	0.055	0.015	0.026	0.017	0.044	0.071	0.036
	15	0.386	0.128	0.125	0.113	0.039	0.042	0.043	0.367	0.065	0.099
	16	1.166	0.045	0.214	0.038	0.029	0.101	0.039	0.073	0.346	0.191
	17	0.148	0.025	0.081	0.024	0.018	0.085	0.024	0.035	2.125	0.081
	18	0.091	0.058	0.342	0.021	0.100	0.147	0.367	0.059	0.049	0.386
	19	0.022	0.010	0.025	0.008	0.010	0.055	0.014	0.011	0.049	0.027
	20	0.017	0.034	0.014	0.094	0.015	0.009	0.012	0.036	0.010	0.013
	21	0.012	0.018	0.018	0.008	0.050	0.017	0.049	0.014	0.009	0.019
	22	0.013	0.008	0.010	0.012	0.005	0.009	0.006	0.009	0.017	0.009

Table J.2b: Friction Factor (F), Friction Factor (F) Matrix =F*1000

Study Zones	D / O	Shopping Centres									
		1	2	3	4	5	6	7	8	9	10
	1	51.65289	20.4666	92.38643	12.73892	26.18322	826.4463	47.67262	23.30866	76.7336	116.4836
	2	95.260	32.232	257.672	17.087	39.057	2652.548	80.251	36.559	98.888	400.577
	3	102.728	31.888	115.693	17.087	21.312	338.021	33.791	29.421	469.131	128.467
	4	65.746	17.778	58.912	15.092	15.355	121.405	22.613	22.277	444.444	64.418
	5	79.349	268.464	53.336	322.831	41.649	23.097	34.938	743.163	28.437	45.269
	6	38.750	277.008	33.544	119.730	48.303	16.692	32.348	185.791	17.405	29.221
	7	38.903	548.697	44.697	49.383	138.196	12.739	65.746	152.588	17.921	40.000
	8	165.246	201.090	338.021	41.311	128.467	67.116	182.628	218.360	47.465	265.703
	9	61.269	282.933	98.888	34.167	573.921	38.447	250.000	135.164	25.682	84.999
	10	57.508	32.348	152.588	15.055	54.336	268.464	146.798	33.178	47.881	190.690
	11	34.678	79.798	57.233	19.893	3770.384	32.348	450.430	52.605	18.868	55.625
	12	51.419	64.418	116.484	19.237	265.703	67.116	58.064	53.336	28.923	125.748
	13	56.420	73.442	33.544	3493.755	22.343	17.405	20.643	127.551	25.437	29.727
	14	85.999	27.685	39.212	55.104	14.586	26.268	16.649	43.584	71.492	36.281
	15	385.788	127.551	124.861	112.608	39.057	41.991	42.865	367.309	64.746	98.888
	16	1166.213	45.463	214.335	37.998	28.534	101.424	39.057	73.442	346.021	190.690
	17	147.929	24.957	80.708	24.491	17.683	84.505	24.037	35.333	2124.965	80.708
	18	91.273	57.785	341.986	20.943	100.144	146.798	367.309	59.199	49.164	385.788
	19	22.410	9.940	24.957	8.160	10.286	54.846	14.481	11.390	49.383	27.230
	20	16.954	34.167	13.584	93.520	14.836	8.542	11.997	35.600	10.244	12.596
	21	12.428	17.778	18.212	8.058	49.603	16.521	48.516	14.240	9.463	18.868
	22	13.458	7.588	9.726	11.789	5.266	9.317	5.908	9.481	17.451	9.408

J.3 Parameters of Gravity Model equation: Adjustment Factor

Table J.3a: Adjustment Factor (K) matrix

Kij	Dest.	1	2	3	4	5	6	7	8	9	10
Origin	1	1	1	1	1	1	1	1	1	1	1
	2	1	1	1	1	1	1	1	1	1	1
	3	1	1	1	1	1	1	1	1	1	1
	4	1	1	1	1	1	1	1	1	1	1
	5	1	1	1	1	1	1	1	1	1	1
	6	1	1	1	1	1	1	1	1	1	1
	7	1	1	1	1	1	1	1	1	1	1
	8	1	1	1	1	1	1	1	1	1	1
	9	1	1	1	1	1	1	1	1	1	1
	10	1	1	1	1	1	1	1	1	1	1
	11	1	1	1	1	1	1	1	1	1	1
	12	1	1	1	1	1	1	1	1	1	1
	13	1	1	1	1	1	1	1	1	1	1
	14	1	1	1	1	1	1	1	1	1	1
	15	1	1	1	1	1	1	1	1	1	1
	16	1	1	1	1	1	1	1	1	1	1
	17	1	1	1	1	1	1	1	1	1	1
	18	1	1	1	1	1	1	1	1	1	1
	19	1	1	1	1	1	1	1	1	1	1
	20	1	1	1	1	1	1	1	1	1	1
	21	1	1	1	1	1	1	1	1	1	1
	22	1	1	1	1	1	1	1	1	1	1

Table J.3b: Matrix of Friction Factor (F) by Adjustment Factor (k)

FijKij	Dest.	1	2	3	4	5	6	7	8	9	10
Origin	1	52	20	92	13	26	826	48	23	77	116
	2	95	32	258	17	39	2653	80	37	99	401
	3	103	32	116	17	21	338	34	29	469	128
	4	66	18	59	15	15	121	23	22	444	64
	5	79	268	53	323	42	23	35	743	28	45
	6	39	277	34	120	48	17	32	186	17	29
	7	39	549	45	49	138	13	66	153	18	40
	8	165	201	338	41	128	67	183	218	47	266
	9	61	283	99	34	574	38	250	135	26	85
	10	58	32	153	15	54	268	147	33	48	191
	11	35	80	57	20	3770	32	450	53	19	56
	12	51	64	116	19	266	67	58	53	29	126
	13	56	73	34	3494	22	17	21	128	25	30
	14	86	28	39	55	15	26	17	44	71	36
	15	386	128	125	113	39	42	43	367	65	99
	16	1166	45	214	38	29	101	39	73	346	191
	17	148	25	81	24	18	85	24	35	2125	81
	18	91	58	342	21	100	147	367	59	49	386
	19	22	10	25	8	10	55	14	11	49	27
	20	17	34	14	94	15	9	12	36	10	13
	21	12	18	18	8	50	17	49	14	9	19
	22	13	8	10	12	5	9	6	9	17	9

J.4 Gravity Model: Iterations

Table J.4: Gravity Model: (Iterations)

1st. Iter.	DEST.	1	2	3	4	5	6	7	8	9	10
	1	66	51	188	4	6	431	16	7	30	11
ORIGIN	**2**	56	37	240	2	4	633	12	5	18	17
	3	131	79	233	5	5	175	11	9	183	12
	4	77	41	109	4	3	58	7	6	159	6
	5	71	468	75	67	7	8	8	153	8	3
	6	102	1427	140	74	24	18	22	113	14	6
	7	42	1152	76	12	28	6	18	38	6	3
	8	130	310	423	8	19	22	37	40	11	15
	9	79	708	201	10	140	20	83	40	10	8
	10	56	62	238	3	10	107	37	8	14	14
	11	56	251	146	7	1156	21	187	20	9	7
	12	3	8	12	0	3	2	1	1	1	1
	13	22	55	21	314	2	3	2	11	3	1
	14	463	291	335	69	15	57	23	54	118	14
	15	780	504	400	53	15	34	22	172	40	15
	16	1547	118	451	12	7	55	13	23	141	19
	17	244	81	212	9	6	57	10	14	1075	10
	18	115	143	687	6	24	75	120	17	19	36
	19	223	193	393	19	19	221	37	26	150	20
	20	27	106	34	35	4	5	5	13	5	1
	21	44	124	103	7	34	24	45	12	10	5
	22	42	46	48	9	3	12	5	7	17	2
	Sum=	4377	6256	4767	729	1537	2044	723	787	2041	223
	Diff.	-613	1099	1205	148	-820	-514	250	83	-889	52
	New Aij	3237	8646	7481	1055	334	1145	1309	962	650	339

2nd. Iter.	DEST.	1	2	3	4	5	6	7	8	9	10
	1	62	66	257	5	3	352	23	8	19	15
ORIGIN	**2**	53	48	333	3	2	525	18	6	11	23
	3	121	101	316	7	3	141	16	10	111	16
	4	75	54	156	6	2	49	10	8	102	8
	5	54	486	83	71	3	6	10	150	4	3
	6	77	1463	153	77	10	12	26	109	7	6
	7	31	1176	83	13	11	4	21	36	3	3
	8	98	319	464	8	8	14	44	39	6	17
	9	62	764	231	11	60	14	102	41	5	9
	10	45	68	277	4	4	75	47	8	8	16
	11	65	398	247	12	728	21	340	29	7	11
	12	3	9	14	0	1	1	1	1	0	1
	13	16	55	22	322	1	2	2	11	1	1
	14	391	336	412	82	7	42	31	59	65	17
	15	643	568	481	61	7	25	29	182	22	17
	16	1418	148	602	15	4	44	19	27	85	24
	17	283	128	357	15	3	57	19	20	818	16
	18	86	145	743	6	10	49	140	17	9	38
	19	192	228	495	23	9	166	50	29	85	24
	20	21	111	38	37	2	4	6	13	3	2
	21	35	135	120	7	15	17	56	12	5	6
	22	35	52	58	10	1	9	6	7	9	3
	sum=	3866	6859	5944	796	894	1627	1017	821	1385	275
	Diff.	-103	496	28	81	-177	-98	-44	50	-233	0
	New Aij	3150	9271	7516	1162	268	1076	1253	1021	541	339

3rd. Iter.	DEST.	1	2	3	4	5	6	7	8	9	10
	1	62	72	265	6	3	340	23	9	16	15
ORIGIN	2	53	53	345	4	2	509	18	7	10	24
	3	121	111	326	7	2	136	16	11	95	16
	4	76	61	163	6	2	48	10	8	88	8
	5	50	493	79	74	2	5	9	150	3	3
	6	70	1482	146	80	7	10	23	109	5	6
	7	29	1189	78	13	9	3	19	36	2	3
	8	94	335	457	9	6	13	41	40	5	16
	9	58	795	225	12	47	13	95	42	4	9
	10	44	73	279	4	4	70	45	8	6	16
	11	68	459	267	14	628	22	350	33	6	12
	12	3	9	14	0	1	1	1	1	0	1
	13	14	55	20	327	0	2	2	10	1	1
	14	377	357	410	89	5	39	29	62	54	17
	15	615	599	475	66	5	23	27	190	18	17
	16	1404	161	615	17	3	42	19	29	72	25
	17	299	149	390	18	3	58	19	23	739	18
	18	83	156	746	7	8	46	134	18	8	38
	19	189	246	501	25	7	158	48	31	71	25
	20	19	114	37	39	1	3	5	13	2	2
	21	34	144	120	8	12	16	53	13	4	6
	22	34	56	58	11	1	8	6	8	7	3
	sum=	3797	7168	6017	839	758	1564	993	852	1217	278
	Diff.	-34	186	-45	38	-42	-34	-20	19	-65	-3
	New Aij	3123	9512	7460	1215	254	1052	1227	1043	512	336

4th. Iter.	DEST.	1	2	3	4	5	6	7	8	9	10
	1	62	75	266	6	3	336	23	9	15	15
ORIGIN	2	54	55	347	4	2	504	18	7	9	24
	3	122	115	327	8	2	135	16	12	91	16
	4	76	63	163	7	1	48	10	9	85	8
	5	48	496	77	76	2	5	8	151	3	3
	6	68	1489	141	82	7	10	22	110	5	6
	7	28	1193	76	14	8	3	18	36	2	3
	8	92	343	452	9	6	13	40	41	4	16
	9	57	806	221	12	44	12	92	42	4	9
	10	44	75	279	4	3	69	44	8	6	16
	11	68	479	270	15	604	22	349	35	6	12
	12	3	10	14	0	1	1	1	1	0	1
	13	14	54	19	329	0	1	2	10	1	1
	14	373	366	406	93	5	38	28	63	51	17
	15	606	611	469	69	5	22	26	193	17	17
	16	1401	166	615	18	3	41	18	29	68	25
	17	304	156	397	20	3	59	19	24	717	18
	18	83	160	745	7	7	45	132	18	7	38
	19	188	254	500	27	7	155	48	32	68	25
	20	19	115	36	40	1	3	5	13	2	1
	21	34	147	118	9	11	15	52	13	4	6
	22	33	57	57	11	1	8	6	8	7	2
	sum=	3778	7286	5996	861	726	1545	979	864	1172	277
	Diff.	-15	68	-24	16	-10	-15	-6	7	-20	-1
	New Aij	3111	9601	7430	1238	250	1042	1220	1051	503	334

5th. Iter.	DEST.	1	2	3	4	5	6	7	8	9	10
	1	62	76	267	6	3	335	23	10	15	15
ORIGIN	2	54	56	348	4	2	503	18	7	9	24
	3	122	116	327	8	2	134	16	12	90	16
	4	76	64	164	7	1	47	10	9	84	8
	5	48	497	76	77	2	5	8	151	3	3
	6	68	1491	140	83	7	10	22	110	5	5
	7	27	1195	75	14	8	3	18	36	2	3
	8	92	346	449	9	6	13	40	41	4	16
	9	57	810	219	13	43	12	91	42	4	8
	10	44	76	279	5	3	69	44	9	6	16
	11	68	486	270	16	598	21	348	35	6	12
	12	3	10	14	0	1	1	1	1	0	1
	13	13	54	19	331	0	1	2	10	1	1
	14	371	369	404	95	5	38	28	64	50	17
	15	603	615	466	70	5	22	26	194	16	17
	16	1400	168	615	18	3	41	18	30	67	25
	17	306	159	398	20	3	58	19	25	710	18
	18	83	162	744	8	7	45	131	18	7	38
	19	188	257	499	27	7	154	48	32	67	24
	20	19	115	35	41	1	3	5	13	2	1
	21	34	149	118	9	11	15	52	13	4	5
	22	33	57	57	12	1	8	6	8	7	2
	sum=	3770	7329	5982	871	719	1536	974	868	1159	276
	Diff.	-6	25	-10	6	-2	-7	-1	2	-7	-1
	New Aij	3105	9634	7417	1247	249	1038	1218	1054	500	333

6th. Iter.	DEST.	1	2	3	4	5	6	7	8	9	10
	1	62	77	267	6	3	334	23	10	15	15
ORIGIN	2	54	57	348	4	2	502	18	7	9	24
	3	122	117	327	8	2	134	16	12	89	16
	4	76	64	164	7	1	47	10	9	83	8
	5	47	497	76	77	2	5	8	151	3	3
	6	67	1492	139	83	7	10	22	109	5	5
	7	27	1195	75	14	8	3	18	36	2	3
	8	92	347	449	9	6	12	40	41	4	16
	9	57	812	218	13	43	12	91	42	4	8
	10	44	77	279	5	3	69	44	9	6	16
	11	68	488	269	16	597	21	348	35	6	12
	12	3	10	14	0	1	1	1	1	0	1
	13	13	54	19	331	0	1	2	10	1	1
	14	371	370	404	95	5	38	28	64	50	17
	15	602	617	465	71	5	22	26	194	16	17
	16	1400	169	615	18	3	41	18	30	67	25
	17	306	160	399	20	3	58	19	25	708	18
	18	83	163	743	8	7	45	131	18	7	38
	19	187	258	498	27	7	153	47	32	67	24
	20	18	115	35	41	1	3	5	13	2	1
	21	34	149	118	9	11	15	51	13	4	5
	22	33	58	57	12	1	8	6	8	7	2
	sum=	3766	7345	5976	874	717	1533	973	870	1155	275
	Diff.	-3	10	-4	2	0	-3	0	1	-3	0
	New Aij	3103	9647	7412	1250	249	1036	1218	1055	499	333

7th. Iter.	DEST.	1	2	3	4	5	6	7	8	9	10
	1	62	77	267	6	3	334	23	10	15	15
ORIGIN	2	54	57	349	4	2	501	18	7	9	24
	3	122	117	327	8	2	133	16	12	89	16
	4	76	64	164	7	1	47	10	9	83	8
	5	47	497	76	78	2	5	8	151	3	3
	6	67	1492	139	84	7	10	22	109	5	5
	7	27	1196	75	14	8	3	18	36	2	3
	8	92	347	448	9	6	12	40	41	4	16
	9	57	812	218	13	43	12	91	42	4	8
	10	44	77	279	5	3	68	44	9	6	16
	11	68	488	269	16	596	21	348	35	6	12
	12	3	10	14	0	1	1	1	1	0	1
	13	13	54	19	331	0	1	2	10	1	1
	14	370	371	403	96	5	38	28	64	50	17
	15	601	618	465	71	5	22	26	195	16	17
	16	1400	170	614	18	3	41	18	30	67	25
	17	306	161	399	20	3	58	20	25	707	18
	18	83	163	743	8	7	45	131	18	7	38
	19	187	258	498	27	7	153	47	32	66	24
	20	18	115	35	41	1	3	5	13	2	1
	21	34	149	117	9	11	15	51	13	4	5
	22	33	58	57	12	1	8	6	8	7	2
	sum=	3765	7351	5974	876	717	1531	973	870	1153	275
	Diff.	-1	4	-2	1	0	-1	0	0	-1	0
	New Aij	3102	9651	7410	1252	249	1035	1218	1055	499	333

8th. Iter.	DEST.	1	2	3	4	5	6	7	8	9	10
	1	62	77	267	6	3	333	23	10	15	15
ORIGIN	2	54	57	349	4	2	501	18	7	9	24
	3	122	117	327	8	2	133	16	12	89	16
	4	76	64	164	7	1	47	10	9	83	8
	5	47	497	76	78	2	5	8	151	3	3
	6	67	1493	139	84	7	10	22	109	5	5
	7	27	1196	75	14	8	3	18	36	2	3
	8	92	347	448	9	6	12	40	41	4	16
	9	57	812	218	13	43	12	91	42	4	8
	10	44	77	279	5	3	68	44	9	6	16
	11	68	488	269	16	596	21	348	35	6	12
	12	3	10	14	0	1	1	1	1	0	1
	13	13	54	19	331	0	1	2	10	1	1
	14	370	371	403	96	5	38	28	64	49	17
	15	601	618	465	71	5	22	26	195	16	17
	16	1400	170	614	18	3	41	18	30	67	25
	17	306	161	399	20	3	58	20	25	707	18
	18	83	163	743	8	7	45	131	18	7	38
	19	187	258	498	28	7	153	47	32	66	24
	20	18	115	35	41	1	3	5	13	2	1
	21	34	149	117	9	11	15	51	13	4	5
	22	33	58	57	12	1	8	6	8	7	2
	sum=	3764	7353	5973	877	717	1530	973	870	1153	275
	Diff.	0	1	-1	0	0	0	0	0	0	0
	New Aij	3102	9653	7409	1252	249	1035	1218	1056	499	333

9th. Iter.	DEST.	1	2	3	4	5	6	7	8	9	10
	1	62	77	267	6	3	333	23	10	15	15
ORIGIN	2	54	57	349	4	2	501	18	7	9	24
	3	122	117	327	8	2	133	16	12	89	16
	4	76	64	164	7	1	47	10	9	83	8
	5	47	497	76	78	2	5	8	151	3	3
	6	67	1493	139	84	7	10	22	109	5	5
	7	27	1196	75	14	8	3	18	36	2	3
	8	92	347	448	9	6	12	40	41	4	16
	9	57	812	218	13	43	12	91	42	4	8
	10	44	77	279	5	3	68	44	9	6	16
	11	68	488	269	16	596	21	348	35	6	12
	12	3	10	14	0	1	1	1	1	0	1
	13	13	54	19	331	0	1	2	10	1	1
	14	370	371	403	96	5	38	28	64	49	17
	15	601	618	464	71	5	22	26	195	16	17
	16	1400	170	614	18	3	41	18	30	67	25
	17	306	161	399	20	3	58	20	25	707	18
	18	83	164	743	8	7	45	131	18	7	38
	19	187	258	498	28	7	153	47	32	66	24
	20	18	115	35	41	1	3	5	13	2	1
	21	34	149	117	9	11	15	51	13	4	5
	22	33	58	57	12	1	8	6	8	7	2
	sum=	3764	7354	5972	877	717	1530	973	870	1152	275
	Diff.	0	1	0	0	0	0	0	0	0	0
	New Aij	3102	9654	7408	1253	249	1034	1218	1056	498	333

						Shopping Centres						
10th. Iter.	DEST.	1	2	3	4	5	6	7	8	9	10	TOTAL P
	1	62	77	267	6	3	333	23	10	15	15	811
ORIGIN	2	54	57	349	4	2	501	18	7	9	24	1025
	3	122	117	327	8	2	133	16	12	89	16	843
	4	76	64	164	7	1	47	10	9	83	8	470
	5	47	497	76	78	2	5	8	151	3	3	869
Zones	6	67	1493	139	84	7	10	22	109	5	5	1940
	7	27	1196	75	14	8	3	18	36	2	3	1382
	8	92	347	448	9	6	12	40	41	4	16	1016
	9	57	812	218	13	43	12	91	42	4	8	1299
	10	44	77	279	5	3	68	44	9	6	16	550
	11	68	488	269	16	596	21	348	35	6	12	1860
	12	3	10	14	0	1	1	1	1	0	1	31
	13	13	54	19	331	0	1	2	10	1	1	433
	14	370	371	403	96	5	38	28	64	49	17	1441
	15	601	618	464	71	5	22	26	195	16	17	2035
	16	1400	170	614	18	3	41	18	30	67	25	2385
	17	306	161	399	20	3	58	20	25	707	18	1717
	18	83	164	743	8	7	45	131	18	7	38	1243
	19	187	259	498	28	7	153	48	32	66	24	1302
	20	18	115	35	41	1	3	5	13	2	1	236
	21	34	149	117	9	11	15	51	13	4	5	409
	22	33	58	57	12	1	8	6	8	7	2	191
	sum=	3764	7354	5972	877	717	1530	973	870	1152	275	23484
	Diff.	0	0	0	0	0	0	0	0	0	0	
	New Aij	3102	9654	7408	1253	249	1034	1218	1056	498	333	

Appendix k

Traffic assignment

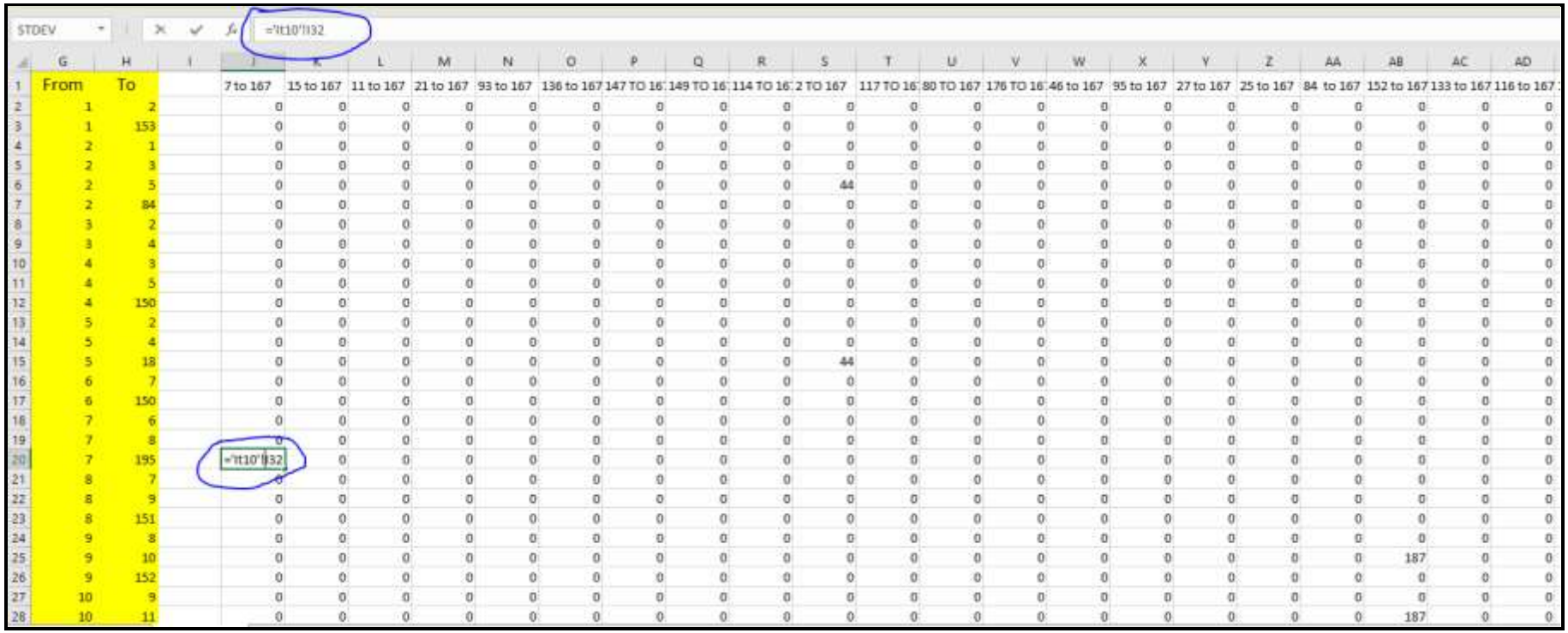
K.1 Traffic Assignment

Table k.1: Traffic Assignment Excel Worksheet formulas: Iteration No. 10

I32 =(Z3*P25*C3)/U32

	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
29														
30							Shopping Centres							
31		10th. Iter.	DEST.	1	2	3	4	5	6	7	8	9	10	TOTAL P
32			1	62	77	267	6	3	333	23	10	15	15	811
33		ORIGIN	2	54	57	349	4	2	501	18	7	9	24	1025
34			3	122	117	327	8	2	133	16	12	89	16	843
35			4	76	64	164	7	1	47	10	9	83	8	470
36			5	47	497	76	78	2	5	8	151	3	3	869
37			6	67	1493	139	84	7	10	22	109	5	5	1940
38			7	27	1196	75	14	8	3	18	36	2	3	1382
39			8	92	347	448	9	6	12	40	41	4	16	1016
40		Zones	9	57	812	218	13	43	12	91	42	4	8	1299
41			10	44	77	279	5	3	68	44	9	6	16	550
42			11	68	488	269	16	596	21	348	35	6	12	1860
43			12	3	10	14	0	1	1	1	1	0	1	31
44			13	13	54	19	331	0	1	2	10	1	1	433
45			14	370	371	403	96	5	38	28	64	49	17	1441
46			15	601	618	464	71	5	22	26	195	16	17	2035
47			16	1400	170	614	18	3	41	18	30	67	25	2385
48			17	306	161	399	20	3	58	20	25	707	18	1717
49			18	83	164	743	8	7	45	131	18	7	38	1243
50			19	187	259	498	28	7	153	48	32	66	24	1302
51			20	18	115	35	41	1	3	5	13	2	1	236
52			21	34	149	117	9	11	15	51	13	4	5	409
53			22	33	58	57	12	1	8	6	8	7	2	191
54			sum=	3764	7354	5972	877	717	1530	973	870	1152	275	23484
55			Diff.	0	0	0	0	0	0	0	0	0	0	

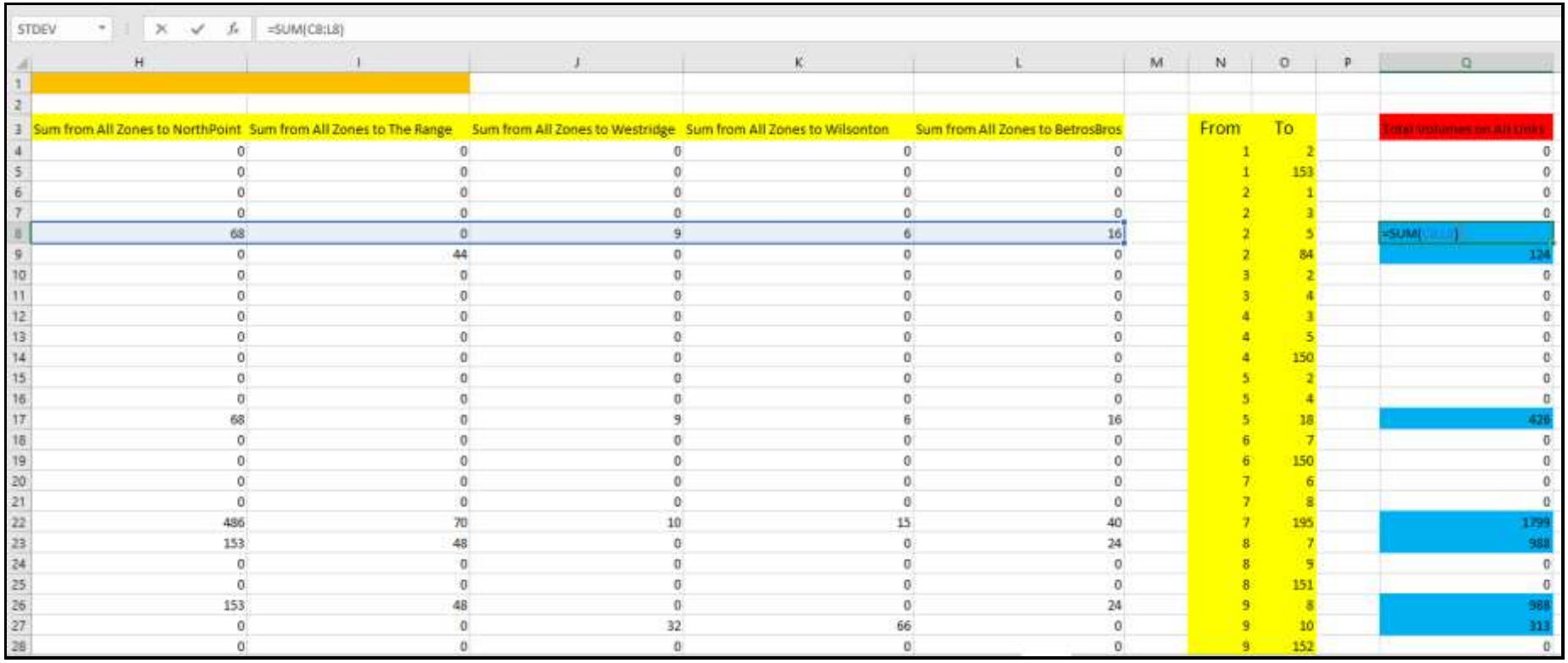
Table k.2: Traffic Assignment Excel Worksheet formulas: Representation shopping trips on the shortest path to Clifford Garden Shopping centre



STDEV | ='It10'!I32

	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
1	From	To		7 to 167	15 to 167	11 to 167	21 to 167	93 to 167	136 to 167	147 TO 16	149 TO 16	114 TO 16	2 TO 167	117 TO 16	80 TO 167	176 TO 16	46 to 167	95 to 167	27 to 167	25 to 167	84 to 167	152 to 167	133 to 167	116 to 167
2	1	2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1	153		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	2	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	2	3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	2	5		0	0	0	0	0	0	0	0	0	44	0	0	0	0	0	0	0	0	0	0	0
7	2	84		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	3	2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	3	4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	4	3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	4	5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	4	150		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	5	2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	5	4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	5	18		0	0	0	0	0	0	0	0	0	44	0	0	0	0	0	0	0	0	0	0	0
16	6	7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	6	150		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	7	6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	7	8		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	7	195		='It10'!I32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	8	7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	8	9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	8	151		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	9	8		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	9	10		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	187	0	0
26	9	152		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	10	9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	10	11		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	187	0	0

Table k.3: Traffic Assignment Excel Worksheet formulas: Summation of the volumes on each link on the shortest path to each shopping centre



STDEV | =SUM(C8:L8)

	H	I	J	K	L	M	N	O	P	Q
1										
2										
3	Sum from All Zones to NorthPoint	Sum from All Zones to The Range	Sum from All Zones to Westridge	Sum from All Zones to Wilsonton	Sum from All Zones to BetrosBros		From	To		Total volumes on All Links
4	0	0	0	0	0		1	2		0
5	0	0	0	0	0		1	153		0
6	0	0	0	0	0		2	1		0
7	0	0	0	0	0		2	3		0
8	68	0	9	6	16		2	5		=SUM( )
9	0	44	0	0	0		2	84		124
10	0	0	0	0	0		3	2		0
11	0	0	0	0	0		3	4		0
12	0	0	0	0	0		4	3		0
13	0	0	0	0	0		4	5		0
14	0	0	0	0	0		4	150		0
15	0	0	0	0	0		5	2		0
16	0	0	0	0	0		5	4		0
17	68	0	9	6	16		5	18		426
18	0	0	0	0	0		6	7		0
19	0	0	0	0	0		6	150		0
20	0	0	0	0	0		7	6		0
21	0	0	0	0	0		7	8		0
22	486	70	10	15	40		7	195		1799
23	153	48	0	0	24		8	7		988
24	0	0	0	0	0		8	9		0
25	0	0	0	0	0		8	151		0
26	153	48	0	0	24		9	8		988
27	0	0	32	66	0		9	10		313
28	0	0	0	0	0		9	152		0

Appendix L

Trip distribution after increasing parking pricing

L.1 Trip distribution after increasing parking pricing

Table L.1: Trip distribution matrix for a $2 increase in parking fees

Suburb Number	Shopping Centre / Suburb	1 Clifford Gardens	2 Kearneys Spring	3 Grand Central	4 Drayton	5 High Street	6 Northpoint	7 The Range	8 Westridge	9 Wilsonton	10 Betros Bros
1	**Harlaxton**	70	90	216	7	3	359	25	11	17	12
2	**North Toowoomba**	61	67	285	5	2	545	20	8	10	20
3	**Rockville**	137	138	266	10	2	144	18	14	100	13
4	**Wilsonton Heights**	85	75	131	8	2	50	12	10	92	6
5	**Darling Heights**	47	513	54	82	2	4	8	154	3	2
6	**Kearneys Spring**	66	1531	98	87	7	9	22	111	5	4
7	**Middle Ridge**	27	1219	53	14	8	3	18	37	2	2
8	**South Toowoomba**	103	408	363	11	7	13	45	48	5	13
9	**Centenary Heights**	57	863	160	14	46	12	93	45	4	6
10	**Mount Lofty**	51	94	235	6	4	77	52	10	7	13
11	**Rangeville**	69	516	196	17	636	21	353	37	6	9
12	**Redwood**	3	11	11	0	1	1	1	1	0	1
13	**Drayton**	13	54	13	338	0	1	2	10	1	1
14	**Glenvale**	395	414	311	109	6	39	30	71	53	13
15	**Harristown**	630	678	352	79	5	22	28	211	17	13
16	**Newtown**	1506	191	478	21	3	42	20	33	71	19
17	**Wilsonton**	327	180	308	23	3	60	21	28	752	14
18	**East Toowoomba**	100	205	645	10	9	51	158	23	9	33
19	**Outer Northern Areas**	209	302	402	33	8	164	53	37	74	20
20	**Outer Southern Areas**	19	121	26	44	1	3	5	14	2	1
21	**Outer Eastern Areas**	36	167	91	10	12	15	55	14	4	4
22	**Outer Western Areas**	35	65	44	13	1	8	6	9	7	2

Table L.2: Trip distribution matrix for a $3 increase in parking fees

Suburb Number	Shopping Centre / Suburb	1	2	3	4	5	6	7	8	9	10
		Clifford Gardens	Kearneys Spring	Grand Central	Drayton	High Street	Northpoint	The Range	Westridge	Wilsonton	Betros Bros
1	Harlaxton	76	101	176	8	3	378	28	12	18	10
2	North Toowoomba	67	76	235	5	2	580	22	9	11	16
3	Rockville	149	155	218	11	3	153	19	15	108	11
4	Wilsonton Heights	91	83	106	9	2	52	12	11	98	5
5	Darling Heights	46	524	40	84	2	4	8	156	3	2
6	Kearneys Spring	65	1556	73	90	7	9	21	112	5	3
7	Middle Ridge	26	1234	39	15	8	3	17	37	2	2
8	South Toowoomba	112	456	296	13	8	14	49	53	5	11
9	Centenary Heights	58	898	121	15	48	11	93	46	4	5
10	Mount Lofty	58	109	199	7	5	84	58	12	8	11
11	Rangeville	69	534	148	18	665	20	355	38	6	6
12	Redwood	3	13	9	1	1	1	1	1	0	0
13	Drayton	12	54	9	343	0	1	2	10	1	0
14	Glenvale	413	447	244	119	6	39	32	76	55	10
15	Harristown	650	721	272	85	6	22	29	223	17	10
16	Newtown	1584	207	377	23	3	43	21	36	75	15
17	Wilsonton	343	194	242	26	4	61	22	30	784	11
18	East Toowoomba	115	244	557	12	11	57	182	27	10	28
19	Outer Northern Areas	226	337	326	37	9	172	58	41	79	16
20	Outer Southern Areas	19	126	19	46	1	3	5	14	2	1
21	Outer Eastern Areas	37	180	71	11	13	15	58	15	5	3
22	Outer Western Areas	37	70	35	15	1	8	6	9	8	2

Table L.3: Trip distribution matrix for a $4 increase in parking fees

Suburb Number	Shopping Centre / Suburb	1	2	3	4	5	6	7	8	9	10
		Clifford Gardens	Kearneys Spring	Grand Central	Drayton	High Street	Northpoint	The Range	Westridge	Wilsonton	Betros Bros
1	Harlaxton	84	115	126	10	4	401	30	14	20	7
2	North Toowoomba	75	88	170	6	3	623	25	11	12	12
3	Rockville	165	178	155	13	3	162	21	17	120	8
4	Wilsonton Heights	99	93	74	11	2	55	13	12	106	4
5	Darling Heights	46	535	26	87	2	4	8	158	3	1
6	Kearneys Spring	64	1581	46	93	7	8	21	113	5	2
7	Middle Ridge	26	1249	25	15	8	2	17	37	2	1
8	South Toowoomba	123	518	210	14	9	15	53	60	6	8
9	Centenary Heights	58	936	79	15	51	11	94	48	4	3
10	Mount Lofty	67	130	148	8	6	93	67	14	9	8
11	Rangeville	69	554	96	19	699	19	354	39	6	4
12	Redwood	3	15	6	1	2	1	1	1	0	0
13	Drayton	12	54	6	347	0	1	2	10	1	0
14	Glenvale	434	485	166	131	7	40	33	81	57	7
15	Harristown	671	770	182	93	6	22	29	237	18	7
16	Newtown	1677	227	258	26	4	44	22	39	79	10
17	Wilsonton	361	211	165	28	4	62	23	32	823	8
18	East Toowoomba	137	300	429	15	14	66	216	33	12	22
19	Outer Northern Areas	248	381	231	43	11	181	63	47	87	11
20	Outer Southern Areas	19	130	12	48	2	3	5	14	2	1
21	Outer Eastern Areas	39	195	48	12	15	16	60	17	5	2
22	Outer Western Areas	39	76	24	16	1	8	7	10	8	1

Appendix M

Model validation

M.1 Model validation

Table M.1: Validation Survey Comparison with Model Results

(Total shopping trips and turning trips to shopping centres (Observed- Model Comparison))

Shopping Centre	observed Turning Shopping Trips to specific centre	Total observed Turning Trips	Modelled shopping trips	link 1	link 2	Percent of shopping on street to particular centre from the Model	Modelled turning trips to each shopping centre	Modelled Total Turning to each shopping centre	Diff	Error %	Diff of all	% Difference
Westridge	355	950	360	320	0	0.89	320	870	*35	**10	***80	****8
	595		630	551	0	0.87	551		44	7		
The Range	525	897	574	574	0	1.00	574	973	-49	-9	-76	-8
	372		399	399	0	1.00	399		-27	-7		
High Street	75	795	69	69	0	1.00	69	717	6	8	78	10
	720		648	648	0	1.00	648		72	10		
Wilsonton	772	1052	2071	846	0	0.41	846	1152	-74	-10	-100	-10
	280		1514	306	0	0.20	306		-26	-9		
Drayton	45	957	41	41	0	1.00	41	877	4	9	80	8
	912		836	836	0	1.00	836		76	8		
Betros Brose	74	304	270	67	0	0.25	67	275	7	10	29	9
	230		411	208	0	0.51	208		22	9		

*355-320

** ((355-320)/355)*100

***950-870

**** ((950-870)/950)*100