Travel Demand Management for New Communities in Calgary

Final Report

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Executive Summary

This project developed a comprehensive approach for identifying important policy related variables for developing strategies to increase sustainable modes of transportation such as walking, cycling and public transport ridership. A survey was administered to 411 households in three community areas in the City of Calgary to gather information on their knowledge and perceptions of the various travel modes available as well as their self-reported choices under various policy scenarios.

The study used structural equation modeling (SEM) to simultaneously link attitudinal variables and respondents’ characteristics to their mode choices. The mode choices considered include walk, cycle; bus rapid transit, bus, bus plus train, train, train plus car, and car. The effects on mode choice of changes in eleven variables were considered. These policy related variables included transit fare, fuel price, transit travel time, walking and cycling distance, bus stop distance, modal knowledge, transit frequency satisfaction, comfort satisfaction, safety characteristics, cycling preferences, and carpooling characteristics.

The SEM identified six important policy variable or groups of manifest variables: (1) travelers attitude towards fare increase; (2) travelers attitude towards gas price increase; (3) travelers attitude towards travel time increase; (4) travelers attitude towards trip distance increase; (5) travelers attitude towards transit stop distance increase; and (6) travelers attitude towards transit arrival frequency.
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1.0 INTRODUCTION

1.1 Background

The provision of a safe, efficient and sustainable transportation system is the mission of any transportation engineering agency today. In the past, most of the emphasis has been placed on increasing the efficiency and reliability of the system but now safety and sustainability has increasingly been seen as equally important goals.

Although private vehicular travel is one of the least sustainable modes, the car is often the first choice in daily travel. Changing travel culture means influencing people towards the use of realistic alternatives, to share travel and, on shorter journeys, to walk or cycle. Over time, this will contribute to reducing congestion, improving air quality and positively influencing our health.

The rapid urban expansion in the City of has been putting a heavier burden on the already congested transportation system with the need for further extension of available road infrastructure, and if we fail to respond to these traffic issues in timely manner, we may expect adverse social and environmental consequences in the near future that larger cities of the world are tackling with today.

This project is about taking responsibility for our future. It is about the planning of Calgary's new residential suburbs where most of its population growth is expected to occur (City of Calgary, 2007). The rapid urban expansion in the City of Calgary has brought up the need to develop strategies to manage the demand for transportation in the city. New suburban communities are currently under development, and more are being planned. Transportation demand management is a tool that is critical to reduce traffic congestion, air and noise pollution, transportation land use and energy consumption, ensuring a sustainable community.
At first glance there may not seem to be a problem with the way the suburbs are planned now. But, unless ways are found of significantly reducing the costs of development, the ongoing withdrawal of provincial funding and the increasing share of revenues that have to be spent on building and maintaining infrastructure to support growth may well become a serious financial burden for us and for future generations. Further, if we fail to respond adequately to social needs and put off dealing with difficult environmental issues, we should expect many of the social and environmental health problems that larger cities now contend with. Then the quality of life that Calgarians enjoy and value so much will be threatened (City of Calgary, 2007).

This study is intended to facilitate the design of new residential communities that start to address these fiscal, social and environmental issues. It is not just a report about land use planning. A wide choice of housing is provided, catering to a broad cross-section of the population. Because more of people's daily needs are provided within the community and transit is more accessible, the need for many car trips is reduced and less roads and other infrastructure have to be built and maintained by the City (and ultimately tax payers). The design of communities and buildings, and the facilities and services provided, combine to encourage people to adopt more sustainable lifestyles (City of Calgary, 2007).

1.2 Objectives of Research

The long term goal of this program is to develop strategies to change urban travel behavior by reducing single-occupant vehicle trips and increasing usage of more sustainable transportation modes such as carpooling, public transit, cycling and walking.

This project will take the first step towards the development of a sustainable transportation system for Calgary. In this first phase, the goal is to survey travel patterns and mode choices of the residents in a new suburban community in Calgary. Based on this evidence, appropriate strategies can be developed to encourage change to more sustainable travel behavior.
Many cities throughout North America are reconsidering how they plan their suburbs. The recommendations of this project are unlikely to be the complete answer, but they are a very significant start. Given the will to work together, experiment and take some risks, we can build more liveable communities that enable present and future generations to maintain a high quality of life (City of Calgary, 2007)

This study aims to identify the important policy related variables for developing strategies to increase sustainable modes of transportation such as walking, cycling and public transport ridership that are important for the design of new residential communities in the City of Calgary.

The research expects to answer the following research questions:

1. What is the overall trend in transportation mode choices in Calgary?
2. How residents in different districts (such as city centers, mixed used centers and auto oriented corridors) select their modes of transportation and what are the commonalities among them?
3. What policies or variables can affect travelers’ mode choices in different districts of Calgary?
4. How can these policies or variables influence the travelers to adopt sustainable modes of transportation such as walking, cycling and public transport?

1.3 Significance and Scope of the study

Calgary is the largest city in the province of Alberta. It is the third largest civic municipality by population in Canada. Alberta’s recent booming economy attracted a large number of people and the rapid growth has placed the city's transportation under strain. This has brought up the need to develop strategies to manage the demand for transportation and the sustainability of its transportation system.

A sustainable transportation system is one which is affordable, operates efficiently, offers choice of transport mode i.e. reduce car dependency by promoting the use of walking, cycling, ridesharing, carpooling and transit for access to work, entertainment, educational and public
facilities in a safe and consistent manner with human and ecosystem within and between generation.

In the City of Calgary, many new suburban communities are currently under development, and more are being planned. It is crucial to adopt measures that will encourage sustainable transportation modes and will reduce car dependency. In general, now-a-days people are more conscious and interested in using transit system, cycling, walking, ridesharing and carpooling. These alternatives will not be sustainable unless they become attractive as compared to non-sustainable modes of transportation.

This research study will develop mode choice model, incorporating policy related variables such as fare, frequency, comfort, security, safety, parking facility, cycling pathways and other facilities, and determine their effects on sustainable modes of transportation which include walking, cycling and ridesharing and public transport, and studying the effects of these policy variables on car use.
2.0 BACKGROUND AND LITERATURE REVIEW

2.1 Introduction

An efficient transport system is indispensable for the society with continued economic development and social welfare. Thus, it has become a necessary and integral part of our modern life. Vehicular transport is highly appreciated because of its benefits. A major portion of our population spends large amounts of their income on vehicular purchase. This has resulted in a sharp increase of vehicles on our roads and the same trend is forecasted in the future.

The growth in transportation energy demand is closely linked to economic development. Increase in gross domestic product (GDP) per capita also increases the distance that people are able to travel, as they use their income to switch from slower to faster and more expensive modes of transportation (Schafer and Victor, 1997). As economic growth occurs in developing countries, demand for petroleum increases and people change their modes from walking and bicycles in favour of motorbikes and automobiles. In developed countries, on the other hand, travelers are more likely to adopt transition from automobiles to high-speed rail and aircraft.

Each of these developments will increase the total energy demand for transportation, since the faster modes of transport require increasing amounts of energy to reach the higher speeds. The transition to faster modes of transportation is also likely to impact the level of urban sprawl around cities, since the commuting distance can increase without a proportional increase in a person’s travel time.

The widespread use of road transportation is responsible for many negative externalities such as serious health and environmental problems and depletion of finite fossil fuels resources. The increase in environmental externalities has been accelerated by the regular trend of modal shift in favour of the private car, which is the most damaging form of motorized transport (Rienstra et al., 1996).
One of the most widely recognized effects of road transportation is air pollution worldwide. Air pollution problem has drastically aggravated in the last few decades, especially increase in the traffic emissions of sulphur dioxide, carbon dioxide, carbon monoxide, oxides of nitrogen, volatile organic carbons, polycyclic aromatic hydrocarbons, particulate matter, ozone and other gases. Air pollution caused by these gases is the result of the combustion of sulphur-containing fossil fuels such as coal for domestic, vehicular and industrial purposes.

The major threat to clean air is now posed by traffic emissions which have an increasing impact on urban air quality both indoors and outdoors. The quality of the air is closely related to morbidity and mortality from respiratory and cardiovascular diseases. Worldwide increase in the use of vehicular traffic within the urban centers has brought the problems of congestion and air pollution that not only impair human health but also have an impact on the economy, global warming, noise pollution and water pollution.

The nature and extent of these problems were summarized in a Blueprint for Quality Public Transport (Transport 2000 Trust, 1997). Some of these costs include road casualties, pollution, noise, congestion, social isolation, damage to wildlife and the countryside, and resource depletion. Hence, the argument for a sustainable transport policy has gained force and urgency as evidence of environmental damage and of people's concern has mounted (Transport 2000 Trust, 1997).

While technology plays a significant role in reducing the levels of pollution at the source, the benefits that technological improvements can offer are likely to be over-shadowed by the predicted worldwide growth in transportation (WBCSD, 2001). In addition, the increasing noise and land use impacts of transportation combined with growing numbers of accidents and congestion represent a significant burden on society and adversely affect sustainable development.
2.2 Sustainable Development

The World Commission on Environment and Development (the Brundtland Commission) in 1987 defined “sustainable development” which has since became the most accepted definition of sustainable development worldwide:

“Humanity has the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987).

The Brundtland definition of sustainable development provides a simple concept of identifying the current needs of the humanity and mitigating these needs without distressing environment for the coming generations. The concept of sustainability is based on two basic principles: 1) the protection of the needs of future generations; and 2) an integrated viewpoint on the three dimensions of all human activity (economic development, environmental protection, and social justice).

The concept of sustainability was further enhanced by the 1992 “Earth Summit” UN Conference on Environment and Development held in Rio de Janeiro in which a statement on sustainability called the Rio Declaration, and a 700 page action plan for sustainability called Agenda 21 was developed. The Rio Conference provided the groundwork for policy makers and planners to think about many issues the world is facing concerning sustainability. As a result, more than 2,000 local governments have implemented Local Agenda 21 Sustainability Plans since the 1992 Rio Conference.

2.3 Sustainable Transportation

One of the major issues surrounding sustainable development is the development of sustainable urban transportation systems. A sustainable transport system is one that meets the needs of the present without compromising the ability of future generations to meet their own transport needs (Cahill, 2007). Rienstra et al. (1996) defined sustainable transportation as “Transport demand (leading to mobility) is satisfied in such a way that, within accepted limits of quality of
environment and safety - now and in the future - the socio-economic function of mobility is maintained or enhanced as much as possible”.

The Centre for Sustainable Transportation in Canada, defines sustainable transportation as one that:

- allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations;
- is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy; and
- limits emissions and waste within the planet’s ability to absorb them, minimizes consumption of non-renewable resources, reuses and recycles its components, and minimizes the use of land and the production of noise.

The National Science and Technology Council (NSTC) initiative on Transportation and Sustainable Communities expresses the concept of a sustainable transportation system as “A transportation system that meets the needs for mobility and accessibility while balancing the current and long-term goals of economic growth, environmental quality, and social equity.” Both definitions make reference to the two concepts at the heart of the sustainability concept, namely: 1) the protection of the needs of future generations, and 2) the integrated perspective on the three dimensions of all human activity (Environment, Economy, and Equity).

Another definition of sustainable transportation put forward by the Organization for Economic Cooperation and Development (OECD) as part of their Environmentally Sustainable Transport (EST) project is as follows:

“A sustainable transport system is one that:

- provides for safe, economically viable, and socially acceptable access to people, places, goods, and service;
- meets generally accepted objectives for health and environmental quality;
- protects ecosystems by not exceeding critical loads and levels for ecosystem integrity;
• does not aggravate adverse phenomena such as climate change, stratospheric ozone depletion, and the spread of persistent organic pollutants” (Caid et al., 2002, p. 220).

The EST definition supports the Three E’s (Environment, Economy, and Equity) of sustainable transportation; however, the definition is transportation-centric. It stops short of connecting the transportation sector to the problems that occur as a result of its “use,” such as over consumption and the rapid global use of natural resources. One reason to exclude the stocks and flows of freight and people from the definition is that these factors are controlled mainly by the world market. One can argue, therefore, that it is not the transportation sector’s responsibility. This suggests that a system boundary is drawn at the very point where the problem becomes too difficult to be addressed by the transportation community.

The system boundary is constructed by the structures/institutions developed to manage our physical and social systems. Hence, excluding important concepts of sustainable development from sector specific definitions as a result of ‘enforced system boundaries may result in a series of solutions which - while robust within the boundary – may undermine the overarching goal of sustainable development.

It is interesting to note that the principles of sustainable transportation are sufficiently general to enable the above measures to be incorporated or linked to the definition of sustainable transportation. However, if we consider the EST definition and look deeper into the text supporting the definition, it can be argued that this has not occurred in practice.

To address this problem, an additional element is presented that could be added to the EST definition to state, explicitly, the importance of the link between transportation and other sectors. It also provides an avenue through which institutional principles - such as integration of decision-making, long-term planning, transparency and accountability etc. - can be considered in a direct and legitimate way.
To augment this deficiency an additional element to be added to the above definition: “Supports, reinforces, and facilitates national policies that aim to reduce the throughput of natural and manmade resources to rates within the carrying capacity of the environment”. The new element changes the focus of transportation system development to incorporate the wider implications of enhanced mobility. Therefore, it follows that a well founded sustainable transportation policy would form part of a much larger national policy architecture directed towards the ultimate objective of sustainable development. Coordinating the development of the transportation sector with other sectors will play a major role in making sustainable development a reality.

2.4 Responsibility of Transportation Sector

Over consumption of resources is a major challenge to sustainability that needs to be addressed within transportation sector and outside the transportation sector. This will require system changes across problem areas, sectors, government departments and missions (Ashford et al., 2002). Therefore, improvements in the transportation sector alone will be insufficient to bring transportation sectors towards a sustainable state. To accomplish goals of sustainable transportation, far-reaching improvement in both the social and environmental spheres without compromising the economy - i.e., a system innovation is required (Berchicci, 2002).

The present industrial capitalist system of incentives and disincentives - what we consider progress - is invariably directed toward increasing levels of consumption, which in turn increases the level of freight transportation (Manno, 2002). The environmental problems associated with increasing freight transportation are further compounded by the fact that as commodity chains grow in length, become more complex, and more international, the spatial and social distance between production and consumption is widened (Princen, 2002; Conca 2002). Transportation sector acts as facilitator in a growing economy. Market forces dictates the transportation sector in facilitating the growing economy and thus transportation professionals are protected from the implications of their decisions, whether addition of new transportation facilities support the sustainability or not.
The present segregation of governmental departments and a growing confidence in the market economy means that in the case of the transportation sector, the transportation community is, in effect, shielded from the implications of their decisions. For example, relying on the market to dictate how transportation systems are used means that the transportation sector is acting as a facilitating mechanism and does not need to question whether its actions might be either socially objectionable or good for society.

“Conscience is the broadest category of all. It raises the distinction between professional and personal ethics. In situations where lawyers may, but are not required to act, discretion must be exercised; and discretion is to be guided by conscience. Conscience imposes a duty to improve the law and the legal system, not only for the benefit of clients, but for the general welfare and the public good” (Ashford, 1999, p618)

The above discussion takes an alternative look at the traditional way of thinking about the transportation sector and sustainable development. We need to nurture the development of effective sustainable transportation strategies which enable transportation professionals to consider the wider implications of the conveyance systems they develop. Knowledge of the potential impacts of new transportation system on the general welfare and public good will enable transportation planners and engineers to make more informed decisions and contribute towards achieving sustainable development.

2.5 Sustainable Modes of Transportation

An assumption in most transport policies for decades is that an effective transportation system is essential for a growing economy. More recently, however, the damaging outcomes of unchecked increases in transportation, especially car dependence, have forced policy makers and transportation planners to amend their strategies. The early 21st century has seen a revival of interest in public space sometimes referred to as the public realm and a delayed recognition by many local authorities that out-of-town shopping, privatized malls, and multi-story car parks, while catering for the car, have squeezed the life out of many urban environments.
The planned cities of the last 50 years, which have accommodated the car, have created many zoned areas that become ‘‘dead space’’, places where people are often afraid to venture after the shops shut for the evening. Providing walking routes through cities and pedestrian friendly precincts and squares offer a way of revitalizing the public spaces of our cities. Copenhagen, for example, made a conscious decision from the early 1960s to gradually introduce car-free areas.

There is a growing literature on how to put life back into our cities, and cycling and walking are central to this effort. Both cycling and walking have the advantage of not producing carbon emissions and are also an excellent way to maintain physical fitness. The decline in cycling and walking among the common masses is one of the reasons for the alarming rise in obesity levels, along with poor diet and sedentary leisure activities. If current trends continue, a large population of adults and children will be obese. When one bears in mind that most journeys are less than five miles, the case for walking and cycling is strong. Yet this is not reflected in the spending priorities of the highways authorities which continue to spend the bulk of their budgets on road construction and maintenance.

2.5.1 Walking

Growth of motorization in industrialized world as well as in developing countries has caused a sharp decrease in walking as a mode of transportation. As the urban areas sprawl, trips to various destinations lengthen which discourage walking which becomes inefficient for such longer journeys and other swift modes of transportation becomes more attractive as compared to walking. Over the decades, such changes in urban development have changed the perception of the masses about walking as an inferior mode of transportation. Walking is no longer treated as a mode of transportation. Rather, it is considered as healthy-living and exercising activity. Utilitarian walking as a mode of transportation is only for those who cannot afford motorized alternatives (Lamsdon and Mitchell, 1999).

The decline in walking as a mode of transportation can be attributed to: increases in car ownership and usage; changes in demographics, employment, patterns, social structure and
location of facilities; increases in the level of disposable income; and a range of specific deterrants (Banister, 1995). Despite its decrease, walking is still considered as a healthy and sustainable mode of transportation, with a huge potential for further expansion if the neighbourhoods are properly planned to promote walking as a mode of transportation. In Britain at least 28% of all journeys are less than 1 mile and 80% of these are made on foot. Walking accounts for a major portion of short journeys, and is three and half times more than all public transport journeys (Hillman, 1997).

Walking as a form of transport and an essential part of daily life is an area which is becoming a more significant aspect of transportation policy for the planners than ever before. The significance of walking is its health benefits and walking have been described as ‘the nearest activity to perfect exercise’ (Morris and Hardman, 1997). More walking can result in a significant reduction in health problems such as cardiovascular diseases, obesity, diabetes, osteoporosis, premature death, anxiety, depression, and colon cancer (Cavil 2001).

Another aspect of walking is reducing the amount of car use which is likely to result in significant reduction in environmental impacts, such as reductions in noise pollution, greenhouse gases and other air pollution (Cavil 2001). These environmental impacts will, in turn, have a significant effect on our health and quality of life.

Walking also promotes social life in streets which is difficult to achieve in a motorized world. These streets become desolate, resulting in a growing trend of fear from strangers and accidents threats, and hence, a reduction in the amount of children walking to school (Hillman et al, 1990). Busy streets with motorized transport mean that children can no longer play outside and are discouraged from walking and cycling to schools. They not only diminish walking and cycling trends in children but also decrease children’s abilities to interact with their surroundings and environment (Cavill, 2001).
2.5.2 Factors affecting Walking

Since a significant amount of literature regarding the factors that influence walking as a mode of transportation is available, only some recent studies which are relevant to this study will be included in this section.

Ann et al (2008) found that walking and total physical activity were affected by street pattern, ‘pedestrian-oriented’ infrastructure and amenities, mixed land use, destinations-in shorthand, neighbourhood design and trip destinations. Like earlier studies, the authors found that walking for specific purposes (e.g. leisure) varies in relation to the physical characteristics of places.

McDonald (2008) showed that walking time is the most policy-relevant factor affecting the decision to walk to school. He concluded that increases in walking rates are not only dependent on policies such as “Safe Routes to School” but would require significant changes in the current land use, school, and transportation planning practices.

Kim et al (2006) studied the physical environment and potential factors associated with a pedestrian friendly environment. He found that factors that determine a pedestrian friendly environment are width of sidewalk, street furniture, plantings, and other activities.

Canepa (2007) found that Transit-Oriented Developments (TOD) in the United States have been modeled almost exclusively with a half-mile radius as a reliable limit for pedestrian walkability from and to a light rail station. New research has emerged to challenge this standard, with data indicating that transit users might walk greater distances than previously estimated. Variables such as housing density, employment density, and urban design had a significant effect walking patterns. These factors were considered as expanders or contractors of the TOD radius, with implications on the future of urban growth.

Gallin (2001) conducted a study which aimed to develop guidelines for assessing the Level of Service (LOS) for pedestrian facilities in Western Australia. Pedestrian LOS was defined as an overall measure of walking conditions on a route, path, or facility. This measure was linked
directly to factors that affected mobility, comfort, and safety, reflecting pedestrians' perceptions of the degree to which the facility was perceived as 'pedestrian friendly'.

Overall, the review of previous studies suggested that factors determining walking as a mode of transportation included traffic, weather, distance, time, footways, personal safety and attitudes towards walking. Many authors demonstrated that the cultural dominance of car travel in relation to all other modes of transportation provided private vehicular travelers with a sense of superiority in terms of status, comfort, convenience, safety and privacy (Goodman and Tolly, 1999)

2.5.3 Cycling

Britain and other European countries had rapidly adopted the car as the main mode of transportation by 1960s, and consequently, other modes of transportation were being marginalized (Horton, 2006). Even then, Debord (1959) warned against the negative side-effects of the modernization and motorization such as increasing speed, distance, and the dispersal of local community. During 1960s and 1970s, as motorization continued to increase, thereby increasing the level of congestion, traffic, accidents and reshaping of urban environments to accommodate automobiles, more concerns were raised by various environmentalists (Buchanan 1964; Thompson, 1969, Dave Horton, 2006).

As a result, during the last two decades of the twentieth century, non-motorised travel had increased in some European countries. In 1990s a popular slogan ‘two wheels good, four wheels bad’ had emerged which encouraged sustainability and a social shift from the car to other modes of mobility: public transport, foot and bike (McLaren et al., 1998; Christensen, 2004; Hillman, 2004, Dave Horton, 2006).

However, the bicycle is the only vehicle that addresses all the environmental liabilities of the oil dependent car (John Ryan 1999). Hence, the website of one of Europe’s leading eco-centres, the Centre for Alternative Technology in Wales, urges its reader to use their bicycles in its list of “25 ways to save the planet”. As a consequent, in Germany, for example, urban cycling trips rose
from 8% to 12% between 1972 and 1995 (Pucher 1997). By 1990, Netherlands (30%), Denmark (20%) and Switzerland (10%) had significant cycling shares of urban trips compared to 0.9% in the United States (Pucher 1997).

2.5.4 Factors Affecting Cycling

Krizek et al (2007) demonstrated that a cogent distance decay pattern existed and that the decay function varied by trip purpose. They also found that bicyclists traveled, on average, 67% longer in order to include bike trail facilities on their routes. They also explained how distance decayed and discussed how shortest path versus taken path analysis could aid in the planning and analysis of new trail systems.

Jennifer et al (2007) studied the levels of bicycling in the United State among adults for non recreation purposes. They found that about 1% of the trips that people made were on bicycles, and less than 5% of trips less than half mile were made on bicycles. Factors influencing the rates of cycling include demographics and environmental factors (number of miles of bike lanes, average temperature, and street connectivity) and people's ratings or perceptions of the bicycling environment. People's attitudes about travel and mobility also played a role in choice of commute mode.

Wardman et al. (2007) showed that financial incentives, good parking and shower facilities at work could contribute to cycling becoming a much more significant mode and hence had an appreciable impact on car share.

Pucher and Buehler (2006) showed that while Canadian cities had been more successful than American cities at promoting cycling as a mode of transport, they fell far short of European cities for the two reasons: European cities had more compact land-use patterns leading to shorter trip distances and a wide range of policies discouraging car use by making it more expensive or more difficult to travel by car.
Stinson et al (2004) studied factors that affected the frequency of bicycle use for a person's commute to and from work. They found that the availability of showers or clothing lockers at the workplace did not appear to inspire bicycle commuters to commute by bicycle more frequently but using a bicycle for non work trips increased an individual's frequency of commuting by bicycle to work. Their results also indicated that non bicycle commuters either had misconceptions about the dangers of bicycling or lacked convenient, safe route options for bicycling to work.

In another study, Stinson et al (2003) examined factors affecting commuter bicyclists' route choices using data from a stated preference survey. Their models indicated that, for commuter bicyclists, travel time was the most important factor in choosing a route. Presence of a bicycle facility (especially a bike lane or separate path), the level of automobile traffic, pavement or riding surface quality, and presence of a bicycle facility on a bridge were also very important determinants.

Hirotaka et al (2002) found that transportation systems in cities and different population sizes influenced the perceptions and preferences for bicycles, which in turn affected bicycle use level. They found four factors that affected the modal shift from bicycle user to automobile user during the college-age period: physical environment, financial aspects, past experience, and favouritism toward bicycle use.

Nankervis (1999) examined the effects of short term weather conditions and longer term seasonal or climatic changes on cyclists’ decision to ride a bicycle using a sample of commuters in Melbourne, Australia. The results for non-students were similar to the student commuters, and indicated that weather conditions had relatively little effect on ridership. In brief, those who rode a bicycle did so consistently and under most conditions. The results suggested that an understanding of these factors could encourage a greater use of bicycles for commuting.

Noland (1995) showed that two courses of action were possible to both increase the level of bicycle commuting while simultaneously reducing automobile commuting: (1) providing infrastructures such as convenient bicycle lanes on city and suburban streets by enlarging the
roadway shoulder and ensuring that a safe and efficient network of bicycle routes, bicycle parking facilities at places of employment; (2) decreasing the relative convenience of automobile commuting; for examples, on-street bicycle lanes can replace on-street parking and traffic signals can be timed to reflect the average speeds of bicycles rather than automobiles. These adjustments would also tend to slow automobile traffic, which would create a safer environment for bicyclists.

Roelof (2003) showed that safety is often presented as a conflicting aim with cycling mobility since the risk of being killed as a car driver would typically be lower than the risk of being killed as a cyclist. However, a significant increase in cycling might result in an improvement in the safety of cyclists by encouraging transportation engineers and planners to adopt better design practices and integrating cycling with other modes of travel by the road users.

2.5.5 Car Pooling or Ride Sharing

Car-pooling is the sharing of rides in a private vehicle among two or more individuals. It involves the use of one person’s private or company vehicle to carry one or more fellow passengers. Carpooling is the easiest and most common ridesharing arrangement. It usually consists of two to four persons commuting in a vehicle. Sometimes carpoolers share driving, and other responsibilities. In other cases, one person does all the driving and is reimbursed for mileage by his or her riders. The carpool driver may pick up passengers from their home or the passenger may find a way to get to the driver’s home at a specified time or they may meet at a particular location.

Car-pooling defined as an effort by drivers of motor cars who agree to take turn to share rides from places of residence to places of employment. As the definition implies, carpooling therefore refers only to the exercises carried out by the owners and drivers of private motor cars. Although car sharing mode of transportation requires the use of car, it is still regarded as sustainable mode of transportation as it helps in reducing the use of private car. Car sharing (the concept of being able to use a car but not owning one) is a strategy with strong potential of achieving sustainable transportation.
Moreover, several studies in Germany, Switzerland and the USA (Krietemeyer, 1997, 2003; Muheim, 1998; Franke, 2001; Cervero and Tsai, 2004; Shaheen et al., 2004) found that more modal shifts from personal vehicle usage towards the environmental sustainable transportation (walking, cycling and public transport) would take place when people joined a car-sharing organization. Therefore, the importance of the integrated transport system has been increasing. In densely populated areas, car sharing would be more likely to facilitate a sustainable transport. Within Germany, for example, Hamburg and Berlin were the pioneers of car sharing programmes.

2.5.6 Factors Affecting Car Pooling

Brunso et al. (1979) surveyed 901 employees of New York State government to test for causal relationships between demographics, attitudes and ride-sharing behavior. Four market segments based on distance and travel time to work were identified. The incidence of carpooling was greatest (54%) in long-distance (over 10 miles) commuters traveling over slow routes. Middle-distance commuters (3-10 miles) and long-distance commuters traveling over fast routes carpooled at slightly lower incidence: 32% and 40% respectively. Short-distance (less than 3 miles) commuters carpooled at only 14% incidence.

Trayford et al. (1996) developed a procedure for predicting membership in a car pooling scheme. Based on a mathematical model using an 80% car pooling matching success rate, they found the expected membership to be about 150,000 for a city the size of Melbourne, Australia. Using psychological survey techniques, the factors determining future success were ease of use, reliability and convenience of door to door travel. Car pooling was found to be almost as good as the private car in terms of low perceived personal risk. The household survey also found that 44% of Melbourne drivers surveyed expressed a desire to join the scheme.

Greenwood (1992) conducted a survey to determine attitudes to car pooling, travel behaviour, mode and other factors. This research helped to formulate the car pooling program and to determine the best ways to encourage employees to car pool. Incentives were established, such as
preferential parking and a guaranteed ride home in case of emergency, to encourage staff to car pool. The paper discussed the attitudinal survey, publications developed, car pooling scheme, its success, costs and benefits, and lessons for other employers.

Ferguson (1995) conducted a survey and found that automobile availability within households and the level of education of individual commuters might be more significant factors in carpool formation. The research showed that (a) family income had little direct effect on carpool formation other than at the lowest income levels, (b) family income did affected automobile ownership, which partially determined auto availability, (c) gender had little direct effect on the formation of non-household carpools, and (d) women were more likely to form house-hold-based carpools in families with children, particularly very young children.

Li (2007) studied why people choose their mode of travel by examining characteristics of carpoolers and single-occupancy vehicles, reasons for their travel mode choice, and carpool formation, on the basis of a survey of travelers in Dallas-Fort Worth and Houston in Texas. Carpool users rated the ability to use HOV lanes as the most important factor in their decision to form a carpool. Enjoying traveling with others ranked second, followed by reasons such as saving time, helping the environment and society, and sharing vehicle costs. Carpool partner matching programs, employer carpool incentives, and preferred parking at work were not very important factors in travelers' consideration of carpooling. The importance of various factors changed significantly if the respondent was on a work or commute trip versus other trip modes. Travelers on work or commute trips ranked travel time savings and cost sharing much higher, as expected, because of their frequent travel during peak hours.

2.5.7 Public Transport

Urban passenger transportation has gone through several innovations, from horse-drawn street railways in the middle of the nineteen century to modern modes like transit buses, bus rapid transit and light rail transit. In an effort to motivate and facilitate more users of public transport, subsidy of transit services has increased dramatically in recent years, with little effect on overall ridership. Quite obviously, a clear understanding of the factors influencing transit ridership is
central to decisions on investments in and the pricing and deployment of transit services. Yet the literature about the influences of transit use is quite spotty; most previous aggregate analyses of transit ridership have examined just one or a few systems, have not included many of the external, control variables thought to influence transit use, and have not addressed the simultaneous relationship between transit service supply and consumption.

Estimating transit demand functions is complex because the perceived utility and disutility of transit trips varies significantly from person to person and from trip to trip (even for the same person). First, the utility of a transit trip is to a large extent a function of the utility of the activity from which the demand for a transit trip is derived. While the utility, and hence, demand for a particular good, service, or activity can be ascertained, transit is likely just one of many possible ways to access the desired good, service, or activity.

Second, the perceived disutility of a transit trip cost varies dramatically. Numerous studies have found that travelers perceive out-of-vehicle time (walking to and from transit stops, transferring, and waiting at transit stops) as more onerous (and therefore more costly) than in-vehicle time. Therefore, someone who lives and works near transit stops on a particular line will likely perceive lower costs for a peak-hour, peak-direction transit trip than will a person traveling between the same two stops, but who lives and works farther from the stops and/or who is traveling at night or weekends when service is less frequent.

Third, while some people do not have practical substitutes for transit trips, most do. Relatively fast, flexible private vehicles dominate metropolitan travel and even walking now far exceeds the number of trips made on public transit in the US. Thus, most travelers find the relative utility of traveling by other modes (particularly private vehicles) to be greater than that of public transit for most trips.

The characteristics of transit service obviously affect the perceived costs of transit travel. Put simply, in the absence of transit service, no service will be consumed, regardless of demand. On the other hand, increasing the network density, reducing headways, and/or lowering fares all lower the perceived cost of transit travel, and move the demand and supply equilibrium point to
increase transit patronage. Further, if buses and trains are packed full and service supply is insufficient to accommodate demand; increased service supply will lead to increased consumption of transit trips by accommodating demand previously suppressed due to inadequate supply.

Thus, we can think of the aggregate consumption of public transit service as a function of the collective characteristics of travelers, the physical and economic characteristics of metropolitan areas, the availability of substitute modes for travel, and the price, quantity, and quality of transit services. While automobiles and all-weather roads brought unprecedented freedom in our lifestyle, they also brought about serious adverse consequences, particularly in terms of safety and the environment. In fact, trends around the world indicate that urban areas are becoming increasingly automobile-dependent with a precipitous decline in public transit use. The deleterious effect of rapid motorization and attendant urbanization raise serious concern about the sustainability of our transportation systems..

2.5.8 Factors affecting Public Transport

Grotenhuis et al. (2007) conducted a research study to identify customers’ desired quality of integrated multimodal travel information (IMTI) in public transport. The main determinants were time savings (travel and search time) and effort savings (physical, cognitive, and affective effort).

Espino et al. (2006) showed that the subjective value of time decreases as comfort is improved; it is higher for men than for women and for workers than for non-workers. Increments in service frequency appear to be more valued for men than for women as well as for people older than 35. They also found bus demand to be inelastic, meaning that attribute changes are met by less than proportionate changes in the probability of choosing bus. They also examined the effects of different policy variables and found that demand seemed to be most sensitive for scenarios that penalise the private car – raising parking costs and implementing road pricing policies – than those improving public transport.
Friman et al. (2001) analyzed the effects of negative critical incidents on the overall satisfaction of the service. They found that overall satisfaction was affected by satisfaction with reliability of service and the simplicity of information provided but not affected by customer treatment by employee or system design. In the model, overall cumulative satisfaction was positively related to attribute-specific cumulative satisfaction which in turn was negatively related to the remembered frequency of negative critical incidents. In addition, both attribute-specific satisfaction and the frequency of negative critical incidents were related to treatment by employee, reliability of service, simplicity of information, and system design.

Matas (2004) found that bus users were sensitive to price and quality variables and also to the underground network, implying a substitution effect between these modes of transport. He also found that the price of petrol should not be ignored as an element of the pricing policy given its statistically significant but small impact on bus demand. He suggested that there was enough scope to develop a more efficient non-uniform pricing policy with positive effects on revenue while minimizing the negative effects on demand. He argued that the declining trend in public transport ridership could be reversed through an active public transport policy based on low cost travel passes and improvements in the quality of services.

Paulley (2005) studied the factors affecting the demand for public transport. While a wide range of factors was examined in the study, the paper concentrated on the findings regarding the influence of fares, quality of service and income and car ownership. Income had a positive impact on public transport demand, but with an offsetting negative impact, particularly in the bus market, through its positive effects on car ownership. As car ownership growth slowed and reached saturation, these negative effects would diminish. There was also sizeable evidence on the importance of key attributes such as walk time, wait time, IVT and some aspects of information provision. However, there was little evidence on the impacts of reliability, vehicle characteristics, waiting environment, interchange, personal security, and awareness campaigns.

Casper et al. (2007) found that there was a strong positive relationship between destination familiarity and perceived resourcefulness (operationalized as one’s perceived awareness of alternative routes for a given mode and destination). Level of experience with a given mode was
found to be of far lesser importance. Destination familiarity also appeared to play an important role on the perceived reliability of estimates for all sorts of trip characteristics (such as travel times and costs). For travel time estimates, the occurrence of non normal trip circumstances was found to be a crucial factor. Incidental circumstances such as the occurrence of deviations or accidents appeared to induce a more negative influence than does the occurrence of more “recurrent” circumstances such as peak hour conditions. Regarding types of information, they found that there was a demand for basic time and cost-related information, especially for destinations never visited before as well as information that promised to make traveling easier (such as early warning functions), rather than information that facilitate advanced search possibilities (such as multimodal information).

Cervero (2002) found that residential location and commute choice were jointly related decisions among station-area residents. A comparison of odds ratios among those living near and away from transit, controlling for the influences of other factors, found that residential self-selection accounts for approximately 40 percent of the rail-commute decision. These findings suggested that supportive zoning should be introduced and barriers to residential mobility should be eliminated to allow the self-selection process to occur naturally through the marketplace.

2.6 Effects of Neighbourhood on Mode choice

In response to suburban sprawl, several cities in USA and Europe adopted the principles of new urbanism (Calthrope 1993; Katz 1994). This new concept provides intensive retail, commercial (as well as office) land use with sufficient pedestrian and as well as vehicular orientation and transit access. Neo-traditional urban designs reduce car dependency and promote sustainable modes of transportation which increase walking, cycling and public transport usage, as well as shortens trip distances and times. The academic literature is, however, ambiguous about the effect of neighbourhood characteristics and land use on reducing car use and commute behaviour. Although physical characteristics of the neighbourhood affect commute mode choice or commute length (Cervero, 1996a, 2002), many studies found socio-demographic factors such
as gender, household composition, and income and travel-related attitudes or lifestyle variables to be more important.

For example, Kitamura et al. (1997) found that personal attitudes were more strongly associated with travel than were land use characteristics. Recently, a number of authors have claimed that residential location choice was not exogenous to the association between land use variables and travel behaviour (Boarnet and Crane, 2001; Cervero and Duncan, 2002; Handy, 1996; Sermons and Seredich, 2001; Srinivasan and Ferreira, 2002; Van Wee et al., 2003). They argued that a household with a tendency towards a certain type of travel self-selects a residential location enabling the search of that preferred type of travel. For example, those who preferred to travel by car would likely choose to live in suburban or auto oriented corridors. However, those who would like to travel by public transport would choose to reside in a location providing easy access to transit infrastructure.

Mode choice for commute trips is probably the dimension of travel behaviour that has been studied most thoroughly. Conventional wisdom holds that workers act as rational consumers and choose the mode providing the highest utility. These utilities are typically a function of objective price or level of service factors such as travel time, travel cost and taste variables that are usually represented by socioeconomic and demographic characteristics of households and sometimes supplemented by locational variables (Ben-Akiva and Lerman, 1985; Cervero, 2002). While most existing work has left at least one set of variables out of consideration (typically the locational and/or the price factors), basically all disaggregate studies have utilized socio-demographic taste variables, such as income, gender and household composition.

A number of studies have shown that the share of driving a private vehicle to work decreases, and the proportions of trips by public transit and bicycling and walking increase, as the intensity of land uses is higher; the mixing of land uses is higher; the neighbourhood is more pedestrian-friendly; and/or transit service quality is better (Cervero, 1996 a,b, 2002; Cervero and Kockelman, 1997; Cervero and Radisch, 1996; Frank and Pivo, 1994). At least three reservations can be made with regard to this purported effect of the physical structure of neighbourhoods on commute mode choice.
First, it is generally accepted that neighbourhood structure variables exert a stronger influence on mode choices for non-work trips (Cervero and Radisch, 1996; Van and Senior, 2000).

Second, while such an impact has been found for the average neighbourhood resident, it is unclear to what extent it holds for all segments of the neighbourhood population. The impact of urban form may differ across men and women, household types and socioeconomic groups (Badoe and Miller, 2000).

Third, residential location choice may not be independent of commute mode choice. This implies that it is not clear that residential location choice is exogenous to the relationship between land use configuration and commute mode choice. Households with a predisposition toward a certain type of travel may choose to locate in a neighbourhood enabling the pursuit of the preferred type of travel. This phenomenon is referred to as residential self-selection in the literature on travel behaviour and urban form (Boarnet and Crane, 2001; Cervero and Duncan, 2002; Handy, 1996; Sermons and Seredich, 2001; Van Wee et al., 2003).

Therefore, it is important that residents living in auto oriented communities and those living in mixed use centres will be surveyed with same set of questions. In this research project, the travel behaviour of residents of the two different neighbourhoods will be studied. In addition, how the residents of these two different neighbourhoods respond to various policy related variables will be analyzed. Hopefully, this study will provide useful insights for the policy makers and planners to re-evaluate their priorities and policies to enhance sustainable transportation in the City of Calgary, which will add to the sustainability of our environment.

2.7 Transportation Demand Management

Development of any society is dependent on the system of transportation it provides and the demand of transportation will increase with an increasing population and rising standard of living. Traffic congestions in many developed and developing countries are mounting, putting
tremendous pressure on the capacity of the networks. Therefore, transportation policies of most
developed nations, like Canada, have evolved over time to accommodate the design of new
urban centers and supplying all citizens with mobility through a multi-modal transportation
system that also includes the re-evaluation and management of existing transportation systems
and their impacts.

2.7.1 Defining Transportation Demand Management.

The need for Transportation Demand Management (TDM) emerged in 1970s and aimed at
increasing the efficiency of existing transportation infrastructure instead of expanding the
existing infrastructure that was the target of transportation planning up until 1960s. Broadly
transportation demand management can be defined as strategies and actions that improve the
existing infrastructure and providing viable transportation alternatives that will satisfy
transportation needs and at the same time relieve transportation congestion on existing
transportation network, thus achieving “specific objectives such as reduced traffic congestion,
road and parking cost savings, increased safety, improved mobility for non-drivers, energy
conservation and pollution emission reductions” (VTPI, 2009).

Since TDM includes an action or set of actions aimed at influencing people's travel behaviour in
such a way that alternative mobility options are presented and/or congestion is reduced (Meyer,
1997), it is a useful tool to achieve a more sustainable transportation system. As a result, TDM
strategies to manage the increasing demand are being adopted more frequently as components of
transportation planning in order to alleviate transportation/congestion problems and assist in
creating and maintaining sustainable communities (May et al., 2000).

2.7.2 Transportation Demand Management Strategies

Several strategies coping congestion, with their benefits and impacts, are identified in Salomon
& Mokhtarian (1997), VTPI (2009) and Meyer (1999). TDM strategies could be classified into
four categories: (1) improvement in transport options; (2) incentives; (3) land use management;
and (4) policies and programs (VTPI, 2009). A wide and growing range of different TDM
measures that can be used to achieve the vision and the objectives of a TDM strategy have also been identified in the literature. These measures include land-use, infrastructure, management, information provision and pricing measures.

In England, for example, the joint Department of the Environment (DOE) and Department of Transport (DOT) Planning Policy Guidelines on Transport (PPG13, DOE/DOT, 1994) list three key aims for local authorities’ land-use and transportation planning policies. These are: to reduce growth in the length and number of motorized journeys; to encourage alternative means of travel which have less environmental impact (that is walking, cycling and public transport); and to reduce reliance in future on the use of private cars (IHT, 1997).

2.7.2.1 Land-use Planning Measures

Land-use planning measures are not generally focused on a particular mode of transport. The main role of such measures is to improve the integration of land-use and transportation planning, particularly by reducing the need to travel both in terms of shorter journeys and less frequent travel. Eight land-use measures have been identified by IHT (1997):

- Concentrating dense developments within transport corridors where public transport can provide a viable alternative to the use of cars.
- Increasing development densities, thereby encouraging shorter journeys and thus the use of walking and cycling, and may help to make public transport more viable.
- Altering the development to form a better mix of use - improved accessibility can reduce the need to travel.
- Reducing the parking standards offers the single most direct impact on the level of car use and can be used in trip-end restraint.
- Increasing developers contributions for transport infrastructure and public transport can be required as part of the process of obtaining planning for new developments.
- Promotion of free parking facility like park-and-ride schemes.
- Promoting travel reduction plans, specifying ways in which they will reduce car use in specific communities.
• Encouraging flexible working hours as a form of land use measure designed to reduce peak-period demand for travel and the resulting congestion.

2.7.2.2 Infrastructure Measures

Twelve infrastructure measures have been identified by IHT (1997):

• Promoting travel reduction plans, specifying ways in which they will reduce car use in specific communities.
• Pedestrian facilities provide a dramatic improvement in the environment for pedestrians and have proven to be successful in enhancing trade in many town and city centers.
• Cycle routes provide dedicated infrastructure for cyclists and thus extend the range of opportunities for safer cycling.
• Guided buses provide a lower cost alternative to light rail and can provide greater flexibility in that the buses are able to operate on normal roads in suburban areas.
• Conventional (heavy) systems are now largely limited to the re-opening of closed railway lines and provision of new stations.
• Terminals and interchanges provide a means of extending converge of public transport services by reducing the time and discomfort involved in achieving interchange between services.
• Park-and-ride stations extend the catchment of fixed track public transport into lower density areas, by enabling car drivers to drive to stations on the main line. Bus park–and–ride can also enhance access to town centers.
• New off-street car parks are best combined with a reduction in on-street parking to act as a restraint on car-use.
• New road that bypass sensitive areas can achieve environmental improvements. It has been shown that the effects of by pass can be enhanced, if that is part of a wider package of measures.
• Lorry (trucks) parks provide a means of reducing the environmental impact of on-street overnight parking of lorries/trucks.
• Trans-shipment facilities provide a means of transferring goods from larger to smaller less environmentally intrusive vehicles for distribution in congested town and city centers.

• Encouragement of other modes for freight focusing primarily on rail-borne freight but can be extended to the use of water-borne freight and pipeline.

2.7.2.3 Management Measures

Seventeen management measures have been identified by IHT (1997):

• Conventional traffic management which includes a wide range of measures normally aimed at increasing the efficiency of the road network. A major practical consideration with all traffic management is that of enforcement. Unless measures are self-enforcing, the costs of the enforcement action need to be included in any appraisal.

• Traffic calming and speed reduction measures that are designed to reduce the adverse environmental and safety impacts of vehicle traffic.

• Urban traffic control systems are a special form of traffic management which aims to coordinate traffic signal control over a wide area.

• Accident remedial measures cover a wide range of measures to reduce accidents.

• Parking control can provide an effective way of controlling car-use in terms of trip-end restraint. Controls can include reducing the supply of spaces, restricting the duration or opening hours, and regulating use through permits or charging.

• Intelligent transport systems include a wide range of information and communication technology applied to transport.

• Physical restrictions on car use and the reallocation of road space to other traffic can reduce car use. Measures can include extensive pedestrian areas, traffic calming and the use of bus only lanes (Vincent et al, 1978; IHT, 1992).

• Regulatory restrictions on car-use regulations, including the use of bans and permits, have been used in several European cities, as a way of reducing car-use (GLC, 1997).

• Car sharing offers a means of reducing car traffic, while retaining many of the advantages of private car travel.
- Bus priorities that enable buses to bypass congested traffic and thus offer bus users reduced and more reliable journey times.
- High occupancy lanes can extend the use of bus-only lanes to other vehicles to make more effective use of scarce road space
- Bus and rail service schedules can be modified to increase patronage and hence lead to a modal shift away from cars.
- Bus service management measures can be designed to improve the reliability of bus services to enhance their quality of service or to reduce operating costs.
- Cycle lanes and priorities can serve the same function as cycle-routes and provide safer and more convenient facilities for cyclists.
- Secure cycle parking can assist in a modal shift to cycling by providing secure and accessible facilities. Some local authorities have also set cycle-parking standards for new developments in UK in the same way as they set car-parking standards.
- Pedestrian crossing facilities not only enhance safety but may also reduce travel time for pedestrians.
- Lorry routes and bus lanes that are primarily designed to reduce the environmental intrusion of heavy Lorries.

2.7.2.4 Information Measures

Ten information measures have been identified by DOE (1994):
- Conventional directional-signing can provide benefits to all road users by reducing journey lengths and travel times.
- Variable message signs that enable drivers to be diverted away from currently known, but unpredictable, areas of congestion. They can also be used to set speed-limits during congested time periods, thus maintaining overall throughput.
- Real time driver information systems and route guidance are rapidly developing forms of Intelligent Transport Systems (ITS) applications. Information is used to provide in-vehicle radio or display messages or to indicate preferred routes to avoid congestion.
Dynamic route guidance systems can provide recommended routes depending on the vehicle’s destination and prevailing traffic conditions.

- Parking information systems are another ITS application designed to reduce the high levels of traffic searching for parking spaces in urban areas.
- Travel awareness campaigns have recently been developed by several local authorities.
- Real-time passenger information is now being provided at some major terminals, individual stations, bus stops and on-vehicle. The main purpose is to reduce the uncertainty and stress associated with the late-running of services.
- Public transport operational information systems use ITS based fleet management facilities to identify the locations of buses and to reschedule services to reduce the impact of unreliability (Keen, 1992)
- Fleet management systems have been widely introduced for freight vehicle, enabling them to respond more rapidly to the changing demands of ‘just-in-time’ delivery schedules (Keen, 1992).
- Telecommunications services are increasingly provided as an alternative to travel through teleworking, on-line shopping and teleconferencing.

2.7.2.5 Pricing Measures

Eight pricing measures have been identified by DOE (1994):

- Parking charges are one of the more widely used forms of parking control and enable demand to be kept at a level below the supply of spaces.
- Congestion charging has been proposed in a number of forms, including screen-line or cordon charging, differential licences, toll-rings or fully automated electronic charging. The key barriers to the implementation of congestion charging are concerns about public acceptance and the fact that primary legislation would be needed to permit its introduction.
- Fare levels can be adjusted to alter patronage and influence modal shift from car use. Fares are to a large extent outside local authority control but less so where Passenger Transport Authorities exist (Webster et al, 1980).
• Fare structures that include the introduction of flat or zonal fares, lower off-peak fares, travel cards and season tickets (Gilbert et al, 1991).

• Concessionary fares provide lower fares, or free travel, for passengers with special needs, such as school children, elderly people and people with disabilities (Goodwin et al, 1988).

• Vehicle ownership taxes including annual vehicle excise duty on road vehicles but are the responsibility of central government. As a fixed tax, their main impact is on car-ownership, with little or no effect on car use.

• Fuel taxes have a more direct effect on car-use but in a non-selective way. Again they are the responsibility of central government (RCEP, 1994).

• Company car taxation is also the responsibility of central government (Lex, 1995) and the general approach is that benefits in kind should be treated in line with payments of income. The system is not intended to substitute private cars or to provide incentives to drive further but often has these effects.

2.7.2.6 Integrating Measures

Three integrating measures have been identified:

• First measures can be brought together which will complement one another. For example, encouragement of new developments in association with rail investment.

• Second, some measures make other elements of the strategy financially feasible. For example, fares revenue can provide finance for new infrastructure; and

• Third, some measures are likely to be more publicly acceptable, if combined with others.

2.7.3 Effectiveness of TDM strategies

TDM strategies are most appropriately adopted with respect to the travel needs of specific communities. The success and efficiency of TDM strategies will depend upon the relationship between the “travel changing” incentives and/or disincentives of the TDM action and the propensity of travelers in a particular market to respond. The effective incentives and
disincentives required to change travel behaviour at levels to make a difference would be problematic given the current reliance on the automobile for personal travel (Meyer, 1999).

2.8 Role of Policy Variables in Selection of Transportation Modes.

The transportation problem in urban and suburban areas is the combination of small intercity problems that are interrelated. These problems can be classified into three major categories: congestion, mobility and externalities (Black, 1995). Congestion in the city increases travellers’ costs both in terms of time and money, which is the direct and indirect costs of intercity economic, leisure, and job related activities.

It is a general trend among the people now-a-days that they seldom live in places where they work or where most of the leisure facilities are available. Consequently, people need mobility and access to these places. Mobility refers to the ability to move between different activity sites while accessibility refers to the number of opportunities available within a certain distance or travel time. Both measures are typically greater if one uses the private car (Espino et al, 2007). Now, the need for mobility is a direct consequence of the spatial separation between different types of land uses in a city, which requires moving at a certain time of day, during certain days of the week and to certain places, ultimately causing congestion which is mostly due to private car use.

The third category considers the negative impacts of transportation system such as accidents, air and water pollution, global warming and noise, which are the end results of car use. Public transport on the other hand is considered to be slow and generally used by the low income groups in the communities although it is low cost and environment friendly (Raquel Espino et al, 2007).

In order to encourage walking, cycling and public transport use, TDM measures will be required. In the past, many policies such as higher fuel taxes, strict land-use control or high parking costs were not effective in limiting the use of car and park-and-ride schemes have not proved effective to alleviate congestion in urban areas (Ortuzar, 1983). However, neo-traditional neighbourhood
designs have shown some signs of success (Khattak and Rodriguez, 2005) and road pricing has proven to be effective (Brownstone et al., 2003).
3.0 RESEARCH METHODOLOGY

3.1. Introduction

The entire design process in traffic engineering from the initial recognition of a problem to the final solution requires data to assist the resolution of the problem at every stage. This process can be divided into three stages:

- Analyzing information about the status of transport system and how it is changing over the time, with the advent of new technologies and economic conditions, and how these changes result in a change the behaviour of people.
- Evaluating the impacts and benefits of each transport development plan on the existing network against its objectives.
- Assessing the overall impacts of such improvements on each community specifically and surrounding environment generally.

One common method of collecting the needed data is to conduct surveys. Different types of surveys are available for different purposes and data collection method differs widely according to the type of survey to be conducted (Richardson et al, 1995).

The need of traffic component assessment (in this case mode choice) can usually be determined by observational techniques (observed or revealed preferences) or questionnaire surveys (self-reported or stated preferences) which disclose personal attitude towards specific changes. Household travel survey is convenient and widely used method to collect a broad range of data on personal preferences in selecting mode choice. The task of selecting the appropriate survey method is important to the overall efficiency of the survey effort. The choice of survey method will usually be the result of optimizing the objectives of the survey subject to the resources available for it. The decisions and choices are shown in Figure 3.1.
A trade-off often occurs because it is impossible to maximize all of the major elements in the Figure 3.1 with finite resources. Given a fixed budget and time frame, the selection of the survey method with an associated degree of quality control will automatically determine the quantity of data which can be collected. Alternately, within a fixed time and budget, specification of the quantity of data to be collected will immediately dictate the quality of data which can be collected (Richardson et al, 1995).

### 3.2 Procedure

In this study, self-completion questionnaire survey technique is chosen because it is the most widely used technique in transportation studies. Self-administered surveys are defined as those in which the respondent completes a questionnaire without the assistance of the interviewer. Several types of basic survey format can be described, depending on the methods used for collection and distribution of the questionnaire forms. These include:

- Mail out / mail back surveys;
- Delivered to respondent / mail back;
- Delivered to respondent / collected from respondent.
Due to the higher response rates (Stopher et al, 1992), the latter two methods are chosen in this study for data collection.

The survey conducted in this study was approved by the Conjoint Research Ethics Board of the University of Calgary. A self administered questionnaire, consisting of 69 questions, was developed in collaboration with City of Calgary Transportation Demand Management (TMD) section. The survey will be administered door-to-door in three community areas selected in consultation with the City of Calgary. The data collected will be analyzed using the standard descriptive statistical analyses and then applied to more advanced statistical methods like discrete choice models and structural equation models.

3.3 Survey Questionnaire

A simple household travel survey was developed using similar research found in the literature. It was modified after consulting with the major stakeholders in the City of Calgary. It was then pilot tested using a sample of students in transportation engineering at the University of Calgary. The survey was approved by the university’s Conjoint Faculty Research Ethics Board before it as administered publicly to households in Calgary.

In addition to the usual socio-demographic data, the survey collected information on the travel modes that were regularly used by the respondents as well as modes that were the most frequently used for different types of trips including work, school and other trips (See Appendix A for a copy of the survey). It also asked the respondents about their knowledge of the various travel modes. The survey also asked the respondents about their perceptions of the attributes of the various travel modes such as comfort, travel time, frequency of service, cost, etc. Finally, it asked the respondent whether they would switch their travel modes under scenarios like changes in transit fares, gas prices, travel time, travel distance.
### 3.4 Data Collection

The survey area comprised of the community of McKenzie Towne (auto oriented corridor), community of Glamorgan (mixed use centre) and community of Huntington Hills (urban centre). Details of the communities are:

**Glamorgan**
- Total population (2008): 6493 Persons
- Growth Rate since 2004: 0.9%
- Median Household Income: CAD 59,369
- Total occupied private dwellings: 2780
- Distance from city centre: 10

**McKenzie Towne**
- Total population (2008): 13118 Persons
- Growth Rate since 2004: 89.1%
- Median Household Income (2005): CAD 76,353
- Total occupied private dwellings: 4560
- Distance from city centre: 19 km

**Huntington Hills**
- Total population (2008): 13621 Persons
- Growth Rate since 2004: -1.4%
- Median Household Income (2005): CAD 56,505
- Total occupied private dwellings: 5525
- Distance from city centre: 8 km

The first step in data collection was deciding on the time frame. To minimize external influences, it was decided that survey will be completed within a two week period. The survey was distributed by hand to households in the three different communities. It included a cover letter and the questionnaire. Respondents who agreed to participate completed the questionnaire and returned it to the researcher either the same day or they could mail it back to the researcher using a prepaid return envelope. Participants could also choose to complete the survey online.
The following tables summarize the distribution of the number of questionnaires delivered in each community and the number of responses from the participants:

<table>
<thead>
<tr>
<th>Community</th>
<th>Glamorgan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>14/3/2009 to 19/3/2009</td>
</tr>
<tr>
<td>Mail Back Surveys Delivered</td>
<td>200</td>
</tr>
<tr>
<td>Mail Back Surveys Received</td>
<td>34 (17%)</td>
</tr>
<tr>
<td>On-the-Spot Surveys Delivered</td>
<td>120</td>
</tr>
<tr>
<td>On-the-Spot Surveys Collected</td>
<td>102 (85% Response rate)</td>
</tr>
<tr>
<td>Total Surveys Delivered</td>
<td>320</td>
</tr>
<tr>
<td>Total Received</td>
<td>136 (42.5%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Community</th>
<th>McKenzie Towne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>20/3/2009 to 24/3/2009</td>
</tr>
<tr>
<td>Mail Back Surveys Delivered</td>
<td>76</td>
</tr>
<tr>
<td>Mail Back Surveys Received</td>
<td>11 (14.4% Response rate)</td>
</tr>
<tr>
<td>On-the-Spot Surveys Delivered</td>
<td>174</td>
</tr>
<tr>
<td>On-the-Spot Surveys Collected</td>
<td>139 (79.8% Response rate)</td>
</tr>
<tr>
<td>Total Surveys Delivered</td>
<td>250</td>
</tr>
<tr>
<td>Total Received</td>
<td>150 (60%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Community</th>
<th>Huntington Hills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>25/3/2009 to 29/3/2009</td>
</tr>
<tr>
<td>Mail Back Surveys Delivered</td>
<td>64</td>
</tr>
<tr>
<td>Mail Back Surveys Received</td>
<td>8 (12.5% Response rate)</td>
</tr>
<tr>
<td>On-the-Spot Surveys Delivered</td>
<td>141</td>
</tr>
<tr>
<td>On-the-Spot Surveys Collected</td>
<td>117 (82.9% Response rate)</td>
</tr>
<tr>
<td>Total Surveys Delivered</td>
<td>205</td>
</tr>
<tr>
<td>Total Received</td>
<td>125 (61%)</td>
</tr>
</tbody>
</table>
3.5 Sample Size Determination

The method to calculate the sample size needed in a survey can be found in most textbooks on statistics or marketing research (Smith and Albaum, 2005; Berenson and Levine, 1992). For a fixed level of confidence, one way to obtain a narrower confidence interval is to increase the sample size. Thus, researchers will often fix in advance the desired width of the confidence interval and then choose a sample size that is big enough to obtain the desired confidence interval and level of confidence. Consider an individual who is interested in estimating the mean of a population (μ) with a known variance σ². How large a sample must be taken if the investigator wants the probability to be (1-α) that the sampling error |\bar{x} - \mu| is less than some amount D (in percentage).

The confidence interval is centered at the sample mean \(\bar{x}\) and extends a distance

\[
D = \pm z_{\alpha/2} \frac{\sigma}{\sqrt{n}}
\]

(3.1)

The investigator wants to fix D in advance and need to have a large enough sample size to guarantee that the confidence interval does not extend more than D units from sample mean. If we solve this equation for n, we obtain

\[
n = z_{\alpha/2}^2 \sigma^2 / D^2
\]

(3.2)

If the variance of population is unknown, it may be necessary to estimate its value by taking a small sample called a pilot sample.

For fixed choice survey questions, we can proceed in the same way if we want to determine the sample size (n) needed to estimate a proportion (p) of the respondents who would choose a certain choice with a specified margin of error (D) at a certain level of confidence (1-α).
The minimum sample size required is

\[ n = z_{\alpha/2}^2 \frac{p(1-p)}{D^2} \]  

(3.3)

Again, this equation cannot be used directly because requires a known value for the sample proportion p. If we have an initial estimate of p, we can substitute this value for p in the equation. If there is no such estimate available, we can substitute 0.5 (worst case scenario) for p in the formula because the product p(1-p) cannot exceed 0.25 (maximum value for \(0 \leq p \leq 1\)). Hence, the upper limit of the minimum sample size n is

\[ n = z_{\alpha/2}^2 \frac{0.25}{D^2} \]  

(3.4)

In this research, the widely used confidence level of 95\% \((z_{0.025} = 1.96)\) and margin of error of 5\% \((D = 0.05)\) were chosen. Therefore, sample size needed would be

\[ N = 0.25(1.96)^2 / (0.05)^2 \]
\[ = 384 \]

The number of surveys collected in this study was 411 which is above the minimum number required. Hence, the margin of error at 95\% confidence level would be less than ±5\% for the worst case scenario \((p=0.5)\) and would be very much smaller if \(|p| < 0.5\).

### 3.6 Structural Equation Model

Structural equation modeling (SEM) is a statistical methodology used by sociologists and psychologists as well as transportation engineers, biologists, economists and medical researchers. There are many reasons to use SEM for various research purposes. One of the reasons is the ease of handling and measuring unobservable or latent variables and observable variables, which are also called exogenous and endogenous variables in econometric analysis to provide researchers with a comprehensive method for the quantification and testing of substantive theories. It also
take into account measurement error that is ever-present in most disciplines, and typically contain hidden variables which is one of the major characteristics of structural equation models.

SEM is designed to deal with several difficult modeling challenges, including many transportation engineering problems. For example, in a study of transit ridership, a researcher may be interested in analyzing the impact of a latent variable such as attitude towards transit on transit ridership. As attitude towards transit ridership cannot be observed directly, one method the researcher can use is to ask a question or a number of questions with the intent to indirectly measure this variable. These observed variables reflect the latent variables such as perception towards travel time, comfort, wait time, walk time, mode availability, social status, etc. In addition, social status, demographics, community of residence and experiences with riding transit might influence attitudes toward transit, and attitudes toward transit might influence their experiences.

These latent variables are theoretical or imaginary constructs of major importance in many sciences, or alternatively can be viewed as variables that do not have observed realizations in a sample from a focused population. Hence, latent are such variables for which there are no available observations in a given study. Typically, there is no direct operational method for measuring a latent variable or a precise method for its evaluation. Nevertheless, manifestations of a latent construct can be observed by recording or measuring specific features of the behaviour of studied subjects in a particular environment and/or situation.

Measurement of behaviour is usually carried out using pertinent instrumentation, for example tests, scales, self reports, inventories, or questionnaires. Once studied constructs have been assessed, SEM can be used to quantify and test plausibility of hypothetical assertions about potential interrelationships among the constructs as well as their relationships to measures assessing them.

Due to the mathematical complexities of estimating and testing these relationships and assertions, computer software is a must in applications of SEM. To date, numerous programs are available for conducting SEM analyses. Software such as AMOS, LISREL, Mplus, SAS PROC CALIS, SEPATH, and RAMONA are likely to contribute in the coming years to yet a further
increase in applications of this methodology. Although these programs have somewhat similar capabilities, LISREL and EQS seem to have historically dominated the field for a number of years. In this research study LISREL 8.80 has been used to construct SEM for the mode choice considering various policy variables (Latent Variables) and their impact on traveler mode choice. Before we proceed further explanation of some common terminologies is important:

3.6.1 Characteristics and Use of SEM

The following are some characteristics of structural equation models.

1. The models are usually conceived in terms of not directly measurable, and possibly not (very) well-defined, theoretical or hypothetical constructs. For example, anxiety, attitudes, goals, intelligence, motivation, personality, reading and writing abilities, aggression, and socioeconomic status can be considered representative of such constructs.

2. The models usually take into account potential errors of measurement in all observed variables, in particular in the independent (predictor, explanatory) variables. This is achieved by including an error term for each fallible measure, whether it is an explanatory or predicted variable. The variances of the error terms are, in general, parameters that are estimated when model is fit to data. Tests of hypotheses about them can also be carried out when they represent substantively meaningful assertions about error variables or their relationships to other parameters.

3. The models are usually fit to matrices of interrelationship indices— that is, covariance or correlation matrices—between all pairs of observed variables, and sometimes also to variable means.

A lot of research is being conducted in the field of travel-behaviour analysis. SEM, a flexible linear-in-parameters multivariate statistical modeling technique that best fits this type of analysis, has been used for various travel-behaviour studies since the 1980s. Golob (2003) provided a good review of the method, as well as more recent applications in the field of travel demand.
An early example is Allaman et al. (1982) who used it to determine attitudes toward travel, as well as travel behavior. Recent applications include Axhausen et al. (2001) who tested a hypothesis linking car ownership, transit season-ticket ownership, and modal usage; Simma and Axhausen (2003) who investigated the interactions among travel behavior, accessibility, and personal characteristics; Choo and Mokhtarian (2007) who studied the relationships between telecommunications and travel; and Fuji and Kitamura (2000) who used it to represent the effects of transportation-control measures on commuters’ daily activity patterns after working hours.

Examples of SEM to study the relationships between attitudes and travel include Golob and Hensher (1998) who developed models in which changes in travel times, attitudes toward carpooling, mode choice, and the use of an exclusive freeway lane for carpoolers were examined; and Garling et al. (2001) who tested the link between attitude toward driving and frequency of choosing whether to drive. SEM has also increasingly been used for travel demand modeling in engineering recently (Molenaar et al, 2000; Wong & Cheung, 2005; Dulaimi et al, 2005; Islam & Faniran, 2005).

### 3.6.2 Theory of Structural Equation Model

SEM consists of measurement and structural components (Byrne, 1994). In Figure 3.6.2, the measurement component is a characterized model that measures exogenous variables (Fare Increase, Gas Price Increase, Transit Frequency Satisfaction) with a set of observed variables (X7, X8, ..., X31). The structural component is a characterized model of the causal relationship between the six exogenous and five endogenous variables (Walk, Bus, ..., Car). Observed variables have data that a researcher can directly measure (i.e., numeric responses to a rating scale item) while latent variables are variables that are of interest to a researcher but are not directly observable (Islam & Faniran, 2005).
In general, the overall structure of SEM can be expressed by the following equation:

\[ \eta = B \eta + \Gamma \xi + \zeta \]  

(1)

where $\eta$ is a vector for endogenous variables
\[ \xi \] is a vector for exogenous variables
$B$ and $\Gamma$ are coefficient matrices
\[ \zeta \] is a vector that expresses latent errors in the equations.
Note that \( \eta \) and \( \xi \) are, in fact, variables that are not measured but are related to the measured variables \( y \) (observed indicators of \( \eta \)) and \( x \) (observed indicators of \( \xi \)) by the following equations:

\[
Y = \Lambda \eta + \varepsilon \\
x = \Lambda \xi + \delta
\]

where \( \Lambda \) is the coefficient vector relating \( y \) to \( \eta \) or \( x \) to \( \xi \)

\( \varepsilon \) and \( \delta \) are error terms associated with the observed \( x \) or \( y \) variables.

These equations are multivariate regression equations associated with variables that are easily observed, and with latent variables that are not observed (Bollen, 1989; Haire et al., 2006). \( B \) and \( \Gamma \) in Eq. (1) represent the coefficient matrix for \( \eta \) and \( \xi \) respectively. Also, \( \Lambda \) in Eq. (2) is the coefficient relating \( y \) to \( \eta \) whereas \( \Lambda \) in Eq. (3) is the coefficient relating \( x \) to \( \xi \). Therefore, \( B \) is a matrix consisting of \( \Lambda_y \), and \( \Gamma \) is a matrix consisting of \( \Lambda_x \), which can be expressed in the following equation:

\[
z = \begin{bmatrix} A_y & 0 \\ 0 & A_x \end{bmatrix} \begin{bmatrix} \eta \\ \xi \end{bmatrix} + \begin{bmatrix} \varepsilon \\ \delta \end{bmatrix}
\]

where \( Z \) = observed polychotomous vector

\( A_y \) = coefficient rating \( y \) to \( \eta \)

\( A_x \) = coefficient rating \( x \) to \( \xi \)

SEM differs from other types of multivariate analysis models not in terms of how it analyzes variance but in terms of the covariance analysis method it uses. Consequently, SEM deals with the covariance among the measured variables or observed sample covariance matrices. Although the use of a covariance matrix or a correlation matrix among the variants measured with SEM is not always clear, SEM programs can use one of these two matrices as their input (Haire et al., 2006).
SEM is usually developed in three stages. The first stage is to define the structural and measurement components (measured variables, latent variables, etc.). The second stage is to set up a hypothetical model. The third stage is to assess the validity of the structural model. SEM is a developmental process of determining a hypothetical model based on the structural and measurement components defined in the first stage, of validating the appropriateness of the hypothetical model, and of showing the optimum causal relationship. Generally, a SEM is verified by evaluating its appropriateness. Various Goodness of Fit (GOF) measures are used to evaluate the appropriateness of SEM.

3.7 Model Development

The main goal of this study is to recognize the causal relationship between policy variables (such as transit fare increase, transit arrival frequency etc.) and transportation mode choice by conducting a quantitative data analysis that was obtained from self-completion questionnaire survey technique in three different communities. Model development of SEM was in accomplished in five steps/stages as shown in Figure 3.7.

In the first step, policy variables (latent variables) affecting mode choice of the travelers were identified. The different policy variables affecting mode choice of the travelers were selected and identified through extensive literature review and discussions with the city of Calgary Transportation Demand Management (TDM) specialists. A questionnaire was designed that collected data on the observed variables used to capture the latent or exogenous variables as well those used to represent the endogenous variables (see section 3.3).

In the second step, data was collected by administering the questionnaire survey to households in three different communities in Calgary (see section 34). A total 411 observations were recorded.
In the third step, SEM was established by defining the constructs for the input data such as observed variables, latent variables in model. Based on the data set collected from the 411 cases, the observed variables, exogenous variables, and endogenous variables comprising the SEM were described as follows:

(i) Observed variables: characteristics that affected the mode choices of the respondents.
(ii) Exogenous variables: latent variables that were deduced from a factor analysis, that represent the observed variables, and that are associated with endogenous variables;
(iii) Endogenous variables: the dependent variables such as car, bus, cycle and train.
As shown in questionnaire (see Appendix) and discussed in section 3.3, eleven policy variables (latent variables or exogenous variables) were selected:

1. transit fare increase (questions 7-9);
2. fuel price increase (questions 10-13);
3. transit travel time increase (questions 14-15);
4. walking and cycling destination distance increase (questions 16-17);
5. bus stop distance increase (questions 18-23);
6. mode knowledge (questions 24-29);
7. transit frequency satisfaction (questions 30-32);
8. comfort satisfaction (questions 33-35);
9. safety characteristics (questions 39-44);
10. cycling preferences (questions 45-50 and 57-58);
11. carpooling characteristics (questions 55-56 and 59-60).

In the fourth step, factor analysis of the observed variables was conducted to verify the underlying exogenous variables or factors with which the pattern of correlations among various observed variables could be explained (see the Measurement Component in Figure 3.6.2). The general purpose of the factor analysis was to find a method of simplifying the information from the many initial variables into smaller new variables. In other words, the factor analysis that was conducted discovered the fundamental constructs that underlay the measured variables (Haire et al., 2007).

Therefore, this study deduced the exogenous variables that represent the characteristics (measured variables) affecting mode choice by conducting factor analysis. Model estimation and validation was accomplished through the maximum likelihood method (MLM). In this study, the LISREL 8.8 software was used to calculate the formation of the causal relationship among the concepts that comprise the hypothetical model, and to analyze the level of influence among the causal relationships. As described above, this study confirmed the SEM by verifying its appropriateness from the results of the covariance structural analysis. Various GOF measures were used for this purpose. Generally, the ratio for \( \frac{\chi^2}{df} \) (degree of freedom), the goodness-of-fit
index (GFI), the comparative index (CFI), the root mean square error of approximation (RMSEA), and the normal-fit index (NFI) have been used to verify the appropriateness of SEM.

In the final step, the results of the SEM model would be interpreted and discussed. Based on the results obtained, suitable recommendations would be provided to encourage Calgarians to shift from the private vehicular travel to more sustainable modes.
4.0 RESULTS AND DISCUSSIONS

4.1 Respondent Profile

The shares of male respondents in different communities are shown in Figure 4.1a. Of the 411 respondents who completed the survey, 52.6% are male. This percentage compared relatively well to the city-wide proportional of 54% (Calgary Snapshots, 2009). Hence, there should be no substantial gender bias in the overall sample. Among the three communities, the share of male respondents in McKenzie Towne was slightly higher than Glamorgan and Huntington Hills. These differences were found to be statistically significant by the chi-square test. The higher share of males at McKenzie Towne may be a result of a large number of males returning from work as the survey in this community was conducted mostly after 5 PM in the evening.

Figure 4.1a: Gender Composition (%)

The age distribution of the respondents is shown in Figure 4.1b. Note that this survey targeted adults with driving license who have wider choices in their travel modes. The purpose of the research was to understand the factors that influence travellers’ mode shift from private vehicles to more sustainable modes of travel. Hence, residents under the age of 16 years old will be under-represented in the sample compared to the population of the city.
There are no statistically significant difference in the age groups of Glamorgan and Huntington Hills. However, McKenzie Towne had higher percentages of respondents in age groups between 26 to 35 and 36 to 45 as compared to other two communities. Again, this result may due to the time of the survey when the young working adults return home from work.

The distribution of household income is shown in Figure 4.1c. The median income of the sample (about $60,000) is lower than the median income of the city ($83,000). The mean income of McKenzie Towne is higher than the other two communities and this difference is statistically significant.
The distribution of household vehicle ownership is shown in Figure 4.1d. Only 1.9% of the household surveyed did not own any vehicle and most household have more than one vehicle. Hence, the car mode is available to most all the respondents.

![Figure 4.1d: Household Vehicle Ownership (%)](image)

### 4.2 Knowledge about Travel Modes

Before reporting on respondents’ mode choices, it is important to get some idea about their knowledge of the other modes of travel besides driving to provide some information on their set of choices. The likelihood of a traveler choosing to take a bus will be low if he or she has little or no knowledge of how the bus operates, even though the option is available to him or her.

Respondents’ knowledge of the public transit is reported in Figure 4.2a. More than two-third of the respondent rated their knowledge of the train services as good or very good but only about one-third rated their knowledge of the bus rapid transit as good or very good. The latter result is not surprising since BRT is only available in some communities but not others.
Respondents’ knowledge of other travel options is reported in Figure 4.3b. About 60% of the respondent rated their knowledge of the walking path as good or very good and about 40% rated their knowledge of cycling route as good or very good. However, only about a quarter rated their knowledge of carpool as good or very good.
4.3 Mode Choice

4.3.1 Regularly Used Modes

The travel modes used regularly by respondents for commuting trips are shown in Figure 4.3.1a. As shown in the figure, the share of private car as the mode of choice is very much larger than any other mode, especially for the McKenzie Towne, which has a significantly higher share because of the lack of LRT service.

Figure 4.3.1a: Commuting Travel Mode (% Regularly Used)

The travel modes used regularly by respondents for non-commuting trips are shown in Figure 4.3.1b. As shown in the figure, the share of private car as the mode of choice is substantially larger than any other mode. Again, the share of car trips for the McKenzie Towne is a significantly higher than the other two community areas because of the lack of LRT service.
Comparing the mode choice of commuting and non commuting trips, the share of trips made in private cars is much lower for commuting trips. One reason for this difference is the concentration of jobs in the downtown area whereas parking is a problem. Moreover, public transportation services are relatively good during the morning and afternoon peaks during work days. Hence, commuters are more willing to use public transportation for commuting.

### 4.3.2 Travel Time and Public Transit Choice

To gauge the effect of travel time on public transit usage, the respondents are asked to indicate the travel time limit within which they will consider using public transit. Their responses are shown in Figure 4.3.2. About 35% of the respondents indicated that they will not use public transportation regardless of how short the travel time is while around 25% indicated that they will consider using public transportation if the travel time less than 30 minutes. As expected, the longer the travel time, the fewer the number of people who will consider using public transportation.
4.3.3 Travel Distance and Non Motorized Modes

To gauge the limit of travel by human power, respondents are asked to indicate the distance within which they will consider walking or cycling. As shown in Figure 4.3.3, 40% of the respondents indicated that they will not consider cycling regardless of the distance and will be consider walking even for trips of less than 0.5 km. It is safe to conclude that the latter group of people are very attached to their cars and will hop into them whenever they have to go anywhere.

It is interesting to note that the effects of travel distance on non motorized modes are not linear or monotonic. Cycling appears to be the preferred choice of a small group of people (less than 20%) even for distances of above 5 km whereas around half that amount will consider cycling if the trip is less 0.5 km.
4.4 Transit Satisfaction

4.4.1 Satisfaction with Transit Frequency

Respondents’ ratings of their satisfaction with the frequency of transit services are shown in Figure 4.4.1. About half of the sample indicates that they do not know about the frequency of the BRT services. Among the other half, about 30% indicates that they are satisfied or very satisfied with BRT frequency whereas the other 20% indicates that they are dissatisfied or very dissatisfied with it. Overall, respondents reported a slightly favourable opinion of the BRT frequency.

Overall, respondents’ ratings of the frequency of bus services are slightly better than BRT. Besides the one quarter who do not know about the frequency of bus services, 42.4% of the respondents indicate that they are satisfied or very satisfied whereas 32.3% indicates that they are dissatisfied or very dissatisfied.
As expected, the train system experiences the lowest share (22.9%) of people who do not know about its frequency of service. It also has the highest share of respondents who are satisfied (45.3%) or very satisfied (6.8%). Overall, respondents are relatively happy with the frequency of the train service. However, about one quarter of the respondents is still dissatisfied (15.6%) or very dissatisfied (9.5%) with the frequency of the train service.

4.4.2 Satisfaction with Transit Comfort

Respondents’ ratings of their satisfaction with the comfort of transit services are shown in Figure 4.4.2. Again, the respondents rate the train system very well in terms of comfort. The majority (54.5%) of the respondents rate the comfort level of the train as satisfactory or very satisfactory compared to 25.8% who rates it as dissatisfactory or very dissatisfactory. Similar but slightly lower ratings are given by the respondents for the comfort of the transit buses.
4.5 Sensitivity to Price Increases

4.5.1 Responses to Fare Increase

Participants’ responses to transit fare increases are shown in Figure 4.5.1. Only about one third of the respondents will not switch to driving, with C-Train riders being the least sensitive to fare increases and bus riders being the most sensitive to fare increases. About one quarter of the respondents will switch to driving if the fare increases by $0.75 or less while only 10% will consider switching when the fare increases by $2.00 or more. In general, Calgary residents are fairly sensitive to transit fare increases and are willing to switch to driving when fare increases.
Participants’ responses to transit fare increases are shown in Figure 4.5.2. More than half of the respondents in the survey will not switch to other modes besides driving even if the gas price increases by more than $2.00 per litre. It is interesting to note that more people are willing to switch from driving to riding the train than to car-pooling.

In general, Calgary residents are not sensitive to changes in gasoline prices in terms of their travel mode choices. Note that the price elasticity of substitution of between car and transit is not symmetric. It is easier to get people out of public transit into private cars than to get drivers to use public transit.
4.6 Confirmatory Factor Analyses

Before performing structural equation modelling, it is customary to perform confirmatory factor analyses (CFA) to classify attitudinal variables in such a way as to reduce the number of these variables and to detect structural relationships among them, while retaining the explanatory power of each manifest attitudinal statement. In the survey, 29 attitudinal variables were used to measure respondents’ sensitivity to a broad range of experiences that they might encounter due to changes in policy variables of the different travel modes that they might consider for their journey. The choice of the various attitudinal questions was based on the literature review and experience from previous studies conducted by the authors, as well as inputs from the City of Calgary.

Eleven factors were tested by CFA to determine the right group of factors that explained all the attitudinal questions. Factors that were significant and all of whose loadings had the correct sign were chosen. These seven factors are shown in Table 4.6a and Figures 4.6a and 4.6b. In general, the results of the factor analysis are very good, with very large t-statistics, indicating that the data fitted very well. Moreover, the items in the survey loaded into latent variables as expected.
<table>
<thead>
<tr>
<th>Latent Variable 1: desire to change mode due increase in fare price</th>
<th>Coefficient</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>I will switch from C-train to car if train fares are increased by</td>
<td>1.10</td>
<td>19.54</td>
</tr>
<tr>
<td>I will switch from bus rapid transit to car if bus fares are increased by</td>
<td>1.28</td>
<td>26.09</td>
</tr>
<tr>
<td>I will switch from bus to car if bus fares are increased by</td>
<td>1.22</td>
<td>25.37</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Latent Variable 2: desire to change mode due gas price increase</th>
<th>Coefficient</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>I will switch from car to C-train if gasoline price is ___$ per liter.</td>
<td>1.27</td>
<td>23.62</td>
</tr>
<tr>
<td>I will switch from car to bus if gasoline price is ___$ per liter.</td>
<td>1.33</td>
<td>23.79</td>
</tr>
<tr>
<td>I will switch from car to carpool if gasoline price is ___$ per liter.</td>
<td>1.18</td>
<td>19.21</td>
</tr>
<tr>
<td>I will switch from car to walk/bicycle if gasoline price is ___$ per liter.</td>
<td>1.18</td>
<td>9.90</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Latent Variable 3: desire to use mode depending upon travel time</th>
<th>Coefficient</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>I will use bus service when total travel time is not more than</td>
<td>1.19</td>
<td>20.55</td>
</tr>
<tr>
<td>I will use C-train service when total travel time is not more than</td>
<td>1.06</td>
<td>18.82</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Latent Variable 4: desire to use mode depending upon destination distance</th>
<th>Coefficient</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>I will cycle when my destination is less than ___ blocks away from my origin.</td>
<td>0.98</td>
<td>9.48</td>
</tr>
<tr>
<td>I will walk when my destination is less than ___ blocks away from my origin.</td>
<td>1.01</td>
<td>11.07</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Latent Variable 5: desire to use mode depending upon transit stop distance</th>
<th>Coefficient</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>I will use C-train when C-train station is less than ___ blocks away from my origin.</td>
<td>1.05</td>
<td>20.11</td>
</tr>
<tr>
<td>I will use bus service when bus stop is less than ___ blocks away from my destination.</td>
<td>0.67</td>
<td>12.32</td>
</tr>
<tr>
<td>I will use C-train when C-train station is less than ___ blocks away from my destination.</td>
<td>0.99</td>
<td>18.90</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Latent Variable 6: satisfaction with frequency of transit mode</th>
<th>Coefficient</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus Rapid Transit</td>
<td>1.03</td>
<td>16.28</td>
</tr>
<tr>
<td>C-train</td>
<td>0.86</td>
<td>15.08</td>
</tr>
</tbody>
</table>
Figure 4.6a: Coefficients in Confirmatory Factor Analysis

Chi-Square=108.66, df=104, P-value=0.00000, RMSEA=0.043
Figure 4.6b: t-values in Confirmatory Factor Analysis
### 4.7 Structural Equation Models

After the factor analyses confirmed the factor structure, the next step involved linking the traveler attitudes to demographic characteristics. This step employed SEM, simultaneously estimating the relationships between the latent (attitudinal factors) and dependent variables (in this case mode choice), and between the manifest (attitudinal statements) and the latent variables. SEM enables testing of a set of linear models to identify the structural attitudes of travel behaviours and quantification of the causal relationships between travelers’ socioeconomic status or demographic profile and their attitudes.

Both manifest and latent variables are used in the SEM. There are six main groups of manifest variables: (1) travelers attitude towards fare increase (2) travelers attitude towards gas price increase (3) travelers attitude towards travel time increase travelers (4) attitude towards destination distance increase (5) travelers attitude towards Bus Stop Distance increase (6) travelers attitude towards transit arrival frequency increase. The structure of the SEM estimated is shown in Figure 4.7a through Figure 4.7f.

The SEM is constructed in Lisrel 8.80, which uses path diagrams to represent relationships among manifest and latent variables. Ovals or circles represent latent variables, while rectangles or squares represent manifest variables. Single-headed arrows in the path diagram represent causal effects. The SEM process results in a final set of traveler factors, which are estimated by these three sets of equations simultaneously. Using the estimated SEM, attitudinal factor scores can be calculated using the estimated coefficients for functions between attitudinal factors and mode choice. The factor scores are then used as inputs to a cluster analysis of market segmentation.
Figure 4.7a: Coefficients in the SEM. (Mode of Transportation to Work)
Figure 4.7b: $t$-values in the SEM (Mode of Transportation to Work)
Figure 4.7c: Coefficients in the SEM. (Mode of Transportation to School)
Figure 4.7d: $t$-values in the SEM. (Mode of Transportation to School)
Figure 4.7e: Coefficients in the SEM. (Mode of Transportation for Other Trips)
Figure 4.7f: $t$-values in the SEM. (Mode of Transportation for Other Trips)
4.8 Effect of Policy Related Variables on Mode Choice

4.8.1 Public Transport Fare and Mode Choice

As shown in Table 4.8.1, public transport fare increases with respect to the structural components did not influence respondents’ choices of mode for work trip, except the Car option. The positive coefficient estimated (coefficient = 0.11, \(t=2.28\)) implied that as transit fares increased, likelihood of choosing the car option increased and vice versa. Coefficients for other modes (walk, cycle, BRT, bus, bus+train, train and train+car) were negative but statistically insignificant. One probable reason might be the mode shift towards the car option would be distributed among various modes.

<table>
<thead>
<tr>
<th>Work Mode</th>
<th>Structural Component</th>
<th>Measurement component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exogenous Variable</td>
<td>Public Transport Fare Increase</td>
<td>Public Transport Fare Increase</td>
</tr>
<tr>
<td>Endogenous variable</td>
<td>Walk</td>
<td>Cycle</td>
</tr>
<tr>
<td>Observed variable</td>
<td>-0.13</td>
<td>-0.06</td>
</tr>
<tr>
<td>Standard coefficient</td>
<td>0.08</td>
<td>0.07</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>t-value</td>
<td>1.57</td>
<td>0.84</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>School Mode</th>
<th>Structural Component</th>
<th>Measurement component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard coefficient</td>
<td>-0.05</td>
<td>-0.02</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>t-value</td>
<td>0.81</td>
<td>0.28</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other Mode</th>
<th>Structural Component</th>
<th>Measurement component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard coefficient</td>
<td>-0.05</td>
<td>-0.06</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>t-value</td>
<td>0.68</td>
<td>0.90</td>
</tr>
</tbody>
</table>

Public transport fare increase with respect to the structural components did not influence mode choice for school trips. Although the coefficients estimated were negative, none of them were
statistically significant. One reason for this finding might be because student and university passes at uniform rates and availability of school buses for school going children made public transportation modes independent of fare increases for trips taken to and from schools.

It can also be seen in Table 4.8.1 that fare affected non-work trips more negatively than work trips and results were statistically significant. Transit fare increases would negatively affect Bus+Train mode \((\text{coefficient} = -0.14, \ t=2.07)\) and Train model \((\text{coefficient} = -0.15, \ t=1.99)\) but not car mode for non-work trips. When transit fare increases, travellers would simply reduce the number of non work trips instead of switching to driving. Alternatively, they might incorporate some of their non work trips into their work trips as additional stops along the way.

Overall, our results suggested that public transit use for both work and non work trips were moderately sensitive to transit fare changes. Hence, transit fare could be a useful tool to management travel demand. A study conducted by Dissanayake et al (2002), using the Bangkok metropolitan region as a case study, showed that fare reductions in public transportation could be used as an efficient tool in congestion-reduction policy in the central business district.

4.8.2 Gas Price and Mode Choice

Gasoline prices have risen substantially over the last few years worldwide, before the economic downturn and many transit agencies have pointed to fuel price growth as a major impetus to increased transit ridership. Supporting these claims, Haire et al (2007) found a high correlation between fuel price and transit ridership in several historically auto-based US metropolises. They also sought to discern whether a similar pattern of fuel cost-driven mode choice could be observed in Canadian cities. Three Canadian cities, Calgary, Ottawa, and Vancouver, were selected based on their relative levels of auto-orientation and the extent and variety of transit services offered. Their study found that although ridership and fuel prices grew in all three cities, the rates of growth do not correspond with the correlation estimated.

As shown in Table 4.3.1.2, gas price increases had no statistically significant overall effect on any of the mode choices available to a traveler. Since Alberta’s economy in general and
Calgary’s economy in particular are heavily dependent on the oil and gas sector, the insensitivity of Calgary drivers to gasoline price increases was expected. Perhaps, the insensitivity of Calgary drivers to gasoline prices had contributed to the lower than expected increase in ridership found in the study by Haire et al (2007).

Table 4.8.2: Gasoline Price and Mode Choice

<table>
<thead>
<tr>
<th>Work Mode</th>
<th>Structural Component</th>
<th>Measurement component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exogenous Variable</td>
<td>Fuel Price Increase</td>
<td>Fuel Price Increase</td>
</tr>
<tr>
<td>Endogenous variable</td>
<td>Walk</td>
<td>Cycle</td>
</tr>
<tr>
<td>Observed variable</td>
<td>Standard coefficient</td>
<td>-0.06</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>t-value</td>
<td>0.66</td>
<td>0.57</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>School Mode</th>
<th>Structural Component</th>
<th>Measurement component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard coefficient</td>
<td>0.02</td>
<td>-0.06</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>t-value</td>
<td>0.23</td>
<td>0.86</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other Mode</th>
<th>Structural Component</th>
<th>Measurement component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard coefficient</td>
<td>-0.06</td>
<td>-0.03</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>t-value</td>
<td>0.78</td>
<td>0.37</td>
</tr>
</tbody>
</table>

4.8.3 Travel Time and Mode Choice

As shown in Table 4.8.3, public transport travel time increases with respect to the structural components were found to negatively influence ‘mode choice for work, school and other trips. Among the three travel activities, work trips were influenced the most and other trips were least influenced by travel time. Among the different modes, train travel was affected the most by increases in travel time, followed by the Bus+Train option whereas the least sensitive option was the private car mode. These results were consistent with the results of study by Limtanakool et al (2006) who found that travellers seemed to be more sensitive to the travel time by train than car.
A key challenge facing policymakers is how short, medium and longer distance trips can be made more sustainable. These results suggest that physical planning may assist in reducing private car use and the associated short negative external effects. The results imply that higher-density developments with all possible urban activities and services with minimum short travel times to access can play an important role in promoting the use of public transport. If the density and degree of land use mix around railway stations are increased as planned in Calgary, the train and bus will become more attractive transport modes of transportation.

### 4.8.4 Travel Distance and Non Motorized Mode Choice.

As shown in Table 4.8.4, the coefficients of walk, cycle, BRT, bus, bus+train, train and train+car were positive and were statistically significant. Also, travel distance increases (walking and cycling) with respect to the structural components were found to positively influence mode choice.

<table>
<thead>
<tr>
<th>Work Mode</th>
<th>Structural Component</th>
<th>Measurement component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exogenous Variable</td>
<td>Travel Time Increase</td>
<td>Travel Time Increase</td>
</tr>
<tr>
<td>Endogenous variable</td>
<td>Walk</td>
<td>Cycle</td>
</tr>
<tr>
<td>Observed variable</td>
<td>X14</td>
<td>X15</td>
</tr>
<tr>
<td>Standard coefficient</td>
<td>-0.57</td>
<td>-0.47</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.2</td>
<td>0.18</td>
</tr>
<tr>
<td>t-value</td>
<td>2.83</td>
<td>2.59</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>School Mode</th>
<th>Structural Component</th>
<th>Measurement component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard coefficient</td>
<td>-0.39</td>
<td>-0.31</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.13</td>
<td>0.13</td>
</tr>
<tr>
<td>t-value</td>
<td>2.98</td>
<td>2.45</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other Mode</th>
<th>Structural Component</th>
<th>Measurement component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard coefficient</td>
<td>-0.5</td>
<td>-0.57</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.13</td>
<td>0.13</td>
</tr>
<tr>
<td>t-value</td>
<td>3.88</td>
<td>4.44</td>
</tr>
</tbody>
</table>
choice for work, school and other trips. These results suggested that an increase in travel distance for travellers already using sustainable modes of transportation, such as walking and cycling, would induce them to use other sustainable modes of transportation. Users of these sustainable modes of transportation, walking and cycling, would likely not switch to private car use, especially for work trips (work mode “car”; coefficient = 0.04, t=0.31). However we might see some increases in the use of the private car for school (school mode “car”; coefficient = 0.42, t=3.55) and other trips (other mode “car”; coefficient = 0.27, t=3.11).

Table 4.8.4: Trip Distance and Mode Choice.

<table>
<thead>
<tr>
<th>Structural Component</th>
<th>Measurement component</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Work Mode</strong></td>
<td></td>
</tr>
<tr>
<td>Exogenous Variable</td>
<td>Destination Distance Increase</td>
</tr>
<tr>
<td>Endogenous variable</td>
<td>Walk</td>
</tr>
<tr>
<td>Observed variable</td>
<td></td>
</tr>
<tr>
<td>Standard coefficient</td>
<td>0.77</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.19</td>
</tr>
<tr>
<td>t-value</td>
<td>3.99</td>
</tr>
<tr>
<td><strong>School Mode</strong></td>
<td></td>
</tr>
<tr>
<td>Standard coefficient</td>
<td>0.58</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.13</td>
</tr>
<tr>
<td>t-value</td>
<td>4.52</td>
</tr>
<tr>
<td><strong>Other Mode</strong></td>
<td></td>
</tr>
<tr>
<td>Standard coefficient</td>
<td>0.90</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.11</td>
</tr>
<tr>
<td>t-value</td>
<td>8.36</td>
</tr>
</tbody>
</table>

Mokhtarian and Salomon (2001) suggested that travel might have a positive utility of its own which was not necessarily related to reaching a destination. The phenomenon of taking the car out for a spin would be an example of this utility. Even when travel was related to a destination, people did not necessarily minimize their travel time or always choose the most cost efficient mode or route. Other utility factors, such as health benefits, flexibility and independence, associated with walking and cycling might make them more attractive. However, studies of
travel behaviour often concentrated on car travel and limited any comparisons to those between cars and public transport but very few comparisons had been made with walking and cycling.

The results of our study were also consistent with the study conducted by Anable and Gatersleben (2005) who found that travel experiences differed between respondents depending on their travel modes. For example, for work trips, users of non-motorised modes appeared to rate these modes as performing the best overall for the journey to work because there were many attributes measured in this study for which they scored very highly. When evaluating one’s own mode, walking and cycling were perceived by these respondents to satisfy both instrumental and affective requirements equally well if not better than the car. The scores revealed that the non-motorised modes were perceived to score highly on factors such as flexibility, cost and freedom. On the other hand, car users only rated their mode marginally higher on one of the most important instrumental attributes, flexibility, but it scored lower on the most important affective attribute, no stress.

Attempts to develop sustainable transport policies need to be based on a diagnosis of the main motives for car use and the factors discouraging the uptake of alternative modes. For any non-car mode to increase its competitiveness, it must be able to adapt to meet travellers ever rising requirements. Affective journey attributes and its utilities have been found to be measurable in most cases in addition to practical, instrumental factors. By using this approach, policy makers are then better informed to make targeted choices about where to make physical improvements as well as on which characteristics to attempt to influence perceptions of alternative modes. Journey itself is considered an activity based on certain functions and affective states that the traveller wishes to satisfy. If functions and states are satisfied the journey will remain sustainable otherwise travelers will switch to other modes that satisfy their needs based on the utility of other modes that satisfy their needs.

4.8.5 Transit Stop Distance and Mode Choice

As shown in Table 4.8.5, increase in transit stop distance had no statistically significant effect on any of the mode choices available to a traveler. As discussed earlier, travel experiences differed
between respondents depending on the travel modes that they used themselves. Most travelers using non-motorized modes of transportation by choice would score walking to the bus stop as a utility associated with that mode and an increase in bus stop distance might not affect their choice of that mode, rather increasing bus stop distance might positively influence the selection of that mode (Biggiero et al, 1998).

Table 4.8.5: Transit Stop Distance and Mode Choice.

<table>
<thead>
<tr>
<th>Work Mode</th>
<th>Structural Component</th>
<th>Measurement component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exogenous Variable</td>
<td>Bus Stop Distance Increase</td>
<td>Bus Stop Distance Increase</td>
</tr>
<tr>
<td>Endogenous variable</td>
<td>Walk</td>
<td>Cycle</td>
</tr>
<tr>
<td>Observed variable</td>
<td>0.03</td>
<td>-0.02</td>
</tr>
<tr>
<td>Standard coefficient</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>t-value</td>
<td>0.36</td>
<td>0.26</td>
</tr>
<tr>
<td>Standard coefficient</td>
<td>-0.02</td>
<td>-0.03</td>
</tr>
<tr>
<td>School Mode</td>
<td>Standard error</td>
<td>0.07</td>
</tr>
<tr>
<td>t-value</td>
<td>0.25</td>
<td>0.41</td>
</tr>
<tr>
<td>Standard coefficient</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.01</td>
<td>0.07</td>
</tr>
<tr>
<td>t-value</td>
<td>0.08</td>
<td>0.90</td>
</tr>
</tbody>
</table>

4.8.6 Transit Frequency Satisfaction and Mode Choice

As shown in Table 4.8.6, increase in transit frequency satisfaction had no statistically significant effect on any of the mode choices available to a traveler. Further, frequency played its expected positive role but it was much less significant with respect to the travel time and cost attributes.

As discussed earlier, most respondents from the three communities using Bus/BRT/Ctrain as a mode of transportation of expressed their level of satisfaction between good and very good. Moreover, traveler would be more likely to choose a transit mode if an available transit trip was
sufficiently compatible with his/her desired arrival time rather than relying on the frequency of transit services.

Table 4.8.6: Transit Frequency and Mode Choice.

<table>
<thead>
<tr>
<th></th>
<th>Structural Component</th>
<th>Measurement component</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Work Mode</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exogenous Variable</td>
<td>Public Transport Arrival Frequency (Satisfaction)</td>
<td>Public Transport Arrival Frequency (Satisfaction)</td>
</tr>
<tr>
<td>Endogenous variable</td>
<td>Walk</td>
<td>Cycle</td>
</tr>
<tr>
<td>Observed variable</td>
<td>Standard coefficient</td>
<td>-0.07</td>
</tr>
<tr>
<td></td>
<td>Standard error</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>t-value</td>
<td>0.84</td>
</tr>
<tr>
<td><strong>School Mode</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard coefficient</td>
<td>-0.05</td>
<td>0.00</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>t-value</td>
<td>0.72</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Other Mode</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard coefficient</td>
<td>0.09</td>
<td>0.03</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>t-value</td>
<td>1.27</td>
<td>0.37</td>
</tr>
</tbody>
</table>
5.0 CONCLUSIONS AND RECOMMENDATIONS

Sustainable modes of transportation must compete with the private car to get a larger market share in much the same way as other products and services compete for customers. In the field of business administration, professionals refine their strategies to understand the market trends as well as customer attitudes and choices toward different products and services in order to attract more clients. Similarly, transportation professionals have also examined many transportation and travel related problems using complex methodologies to dig deeper into the traveler’s attitudes and their preferences regarding different modes of transportation.

This research study was among one of many such studies that aimed to promote sustainable modes of transportation in the City Calgary. This study also demonstrated the use of the SEM approach as a powerful tool to improve the understanding of travel behaviour and to enhance sustainable modes of transportation. Six groups of latent variables representing traveler’s behaviour in selecting the preferred mode of transportation and shaping the SEM model were examined. They included travel time, fare increase, gas price increase, destination distance by walking and cycling, bus stop distance increase and transit frequency.

Our research found that public transport fare increase had a significant affect in restricting car use as a mode of transportation to work but had an insignificant affect on other modes of transportation, such as walk, cycle, BRT, bus, bus+train, train and train+car. Fare increase effects on mode of transportation to school and on non-work trips were found to be insignificant. Bus+Train and Train modes were significantly affected by transit fare increase but we did not see any significant changes in car use for non-work trips.

The second policy related variable examined in our model was fuel price increase. Although observed variables significantly influenced the model, its impact on endogenous variables (mode of transportation) was insignificant. This finding suggested that although observed variables positively influenced the exogenous or attitudinal variables, it did not necessary follow that this attitude would influence travelers in their mode selections.
The third policy related variable analyzed in our model was transit time. Transit travel time was found to influence mode choice for work, school and other trips. Among the three types of trips, work trip was influenced the most, followed by school trip while other trip was the least influenced by travel time.

The fourth policy related variable investigated in our model was travel distance. Travel distance increase (walking and cycling) was found to influence mode choice for work, school and other trips. These results suggested that an increase in travelling distance for travellers already using sustainable modes of transportation, such as walking and cycling, would induce them to use other sustainable modes of transportation, such as train and bus.

The fifth policy related variable included in our model is transit stop distance. Increases in transit stop distances had no statistically significant effect on any of the mode choices available to a traveler. This result suggested that travelers using non motorized modes of transportation by choice would score walking to the bus stop as a positive utility associated with that mode and an increase in bus stop distance might not affect their choosing of that mode; rather increasing bus stop distance might positively influence their selection of that mode.

The last policy related variable studied in our model was transit frequency satisfaction. Again, our study found no statistically significant effect on any of the mode choices available to a traveler. As discussed earlier, respondents from the three communities using Bus/BRT/Ctrain as a mode of transportation rated their level of satisfaction between good and very good. Moreover, traveler would be more likely to choose a transit mode if a trip option provided a sufficiently close time with his/her desired arrival time rather than relying on the frequency of transit services to make his or her choice.
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Figure 7: Survey

Dear Sir/Madam,

RE: Household Travel Survey

In an effort to better manage the transportation systems in the city, the City of Calgary and the University of Calgary is conducting a survey to understand residents' choice of different travel modes and how they may be affected by different factors. This research is being conducted as a partial fulfillment of a Master of Science degree at the University of Calgary.

I like to invite you to participate in the survey. The survey can also be done online through website [http://www.schulich.ucalgary.ca/survey](http://www.schulich.ucalgary.ca/survey). It will take only 15 minutes. There are no correct answers and I assure you that your answers will remain completely anonymous, so please respond as honestly as possible. The data collected will be treated with strict confidentiality and only my supervisor and I will have access to the data provided. A copy of final report of this study will also be provided to the City of Calgary but only the results of the statistical analysis will be presented.

Participation in the survey is completely voluntary, so please feel free to withdraw from the survey at any time should you feel disinclined to continue. Consent to participate will be assumed from the voluntary completion and return of the survey.

Thank you for participating in the survey. If you have any questions regarding this survey, please feel free to contact my supervisor, Professor Richard Tay, at 403-220-4725 or rtay@ucalgary.ca.

This project has been approved by the Conjoint Faculties Research Ethics Board of the University of Calgary. If you have any questions of the way you have been treated, please contact Mr. Russell Burrows at 403-220-3782 or rburrows@ucalgary.ca.

Yours truly,

Mr. Amjad Khan
Tel: (403) 2026270
Email: amkhan@ucalgary.ca
I will use the following mode of transportation regularly (assuming all modes are available)
Please check all that apply

<table>
<thead>
<tr>
<th></th>
<th>Car</th>
<th>Carpool</th>
<th>Car+C-train</th>
<th>C-train</th>
<th>Bus+C-train</th>
<th>Bus</th>
<th>Bus Rapid Transit (BRT)</th>
<th>Bicycle</th>
<th>Walk</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Work trips</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2 School trips</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3 Other trips</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
| The one mode that I use the most frequently now is (please check one):
<p>|                      | Car | Carpool | Car+C-train | C-train | Bus+C-train | Bus | Bus Rapid Transit (BRT) | Bicycle | Walk | Other |
| 4 Work trips         | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| 5 School trips       | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| 6 Other trips        | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| Please check one     |     |         |             |         |             |     |                         |         |      |       |
| 7 I will switch from C-train to car if train fares are increased by | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| 8 I will switch from bus rapid transit to car if bus fares are increased by | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| 9 I will switch from bus to car if bus fares are increased by | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| Please check one     |     |         |             |         |             |     |                         |         |      |       |
| 10 I will switch from car to C-train if gasoline price is __$ per liter. | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| 11 I will switch from car to bus if gasoline price is __$ per liter. | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| 12 I will switch from car to carpool if gasoline price is __$ per liter. | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| 13 I will switch from car to walk/bicycle if gasoline price is __$ per liter. | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| Please check one     |     |         |             |         |             |     |                         |         |      |       |
| 14 I will use bus service when total travel time is not more than | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| 15 I will use C-train service when total travel time is not more than | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| Please check one     |     |         |             |         |             |     |                         |         |      |       |
| 16 I will cycle when my destination is less than ___ blocks away from my origin. | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| 17 I will walk when my destination is less than ___ blocks away from my origin. | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| Please check one     |     |         |             |         |             |     |                         |         |      |       |
| 18 Distance from my home to bus stop | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| 19 Distance from my home to C-train station | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| 20 I will use bus service when bus stop is less than ___ blocks away from my origin. | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| 21 I will use C-train when C-train station is less than ___ blocks away from my origin. | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| 22 I will use bus service when bus stop is less than ___ blocks away from my destination. | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| 23 I will use C-train when C-train station is less than ___ blocks away from my destination. | ☐   | ☐       | ☐           | ☐       | ☐           | ☐   | ☐                       | ☐       | ☐    | ☐     |
| My knowledge of the following travel mode is: | Very Poor | Poor | Good | Very Good | Don't Know |
| 24 Bus | ☐   | ☐       | ☐           | ☐       | ☐           |
| 25 Bus Rapid Transit | ☐   | ☐       | ☐           | ☐       | ☐           |
| 26 C-train | ☐   | ☐       | ☐           | ☐       | ☐           |
| 27 Bicycle routes | ☐   | ☐       | ☐           | ☐       | ☐           |
| 28 Walking routes | ☐   | ☐       | ☐           | ☐       | ☐           |
| 29 Carpooling | ☐   | ☐       | ☐           | ☐       | ☐           |
| My level of satisfaction with frequency of the following travel mode is: | Very Dissatisfied | Dissatisfied | Satisfied | Very Satisfied | Don't Know |
| 30 Bus | ☐   | ☐       | ☐           | ☐       | ☐           |
| 31 Bus Rapid Transit | ☐   | ☐       | ☐           | ☐       | ☐           |
| 32 C-train | ☐   | ☐       | ☐           | ☐       | ☐           |
| My level of satisfaction with comfort of the following travel mode is: | Very Dissatisfied | Dissatisfied | Satisfied | Very Satisfied | Don't Know |
| 33 Bus | ☐   | ☐       | ☐           | ☐       | ☐           |
| 34 Bus Rapid Transit | ☐   | ☐       | ☐           | ☐       | ☐           |
| 35 C-train | ☐   | ☐       | ☐           | ☐       | ☐           |</p>
<table>
<thead>
<tr>
<th>Please indicate whether you agree or disagree with the following statements</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
<th>Don’t Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>36 C-train is more reliable than car in moving me from my origin to destination</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>37 Extending C-train service to other parts of the Calgary will reduce congestion, air pollution and car use</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>38 I want real time bus arrival information available at bus stops</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>39</td>
<td>I feel safe while cycling</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>40 I feel safe while walking</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>41 I feel safe while traveling in car</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>42 I feel safe while traveling in bus</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>43 I feel safe while traveling in C-train</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>44 I will use train if I live near train station</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>45 Shower facility at my destination will increase my cycling trips</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>46 Secure bicycle parking at my destination will increase my cycling trips</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>47 Better cycling pathways will increase my cycling trips</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>48 I prefer roads with lanes shared by cyclists and vehicles</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>49 I prefer roads that have separate cycling lanes</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>50</td>
<td>I prefer cycling lanes to be separated from roads</td>
<td>cycle park</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>51 I will switch from car to train only if park and ride facility is available</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>52</td>
<td>I would like more space availability at park and ride facility</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>53 I will reduce car use if car insurance premium is based on vehicle mileage</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>54 I am aware of the City’s online ride match service for carpools</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>55 I have used the City’s website for ride match service and have found ride matches for carpools</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>56 I have used City’s website for ride match service and have not found any ride match for carpools</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

Please check one

<table>
<thead>
<tr>
<th>57 I use existing walking and cycling pathways for</th>
<th>Do not use</th>
<th>Work trips</th>
<th>Leisure</th>
<th>Exercise</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>58 I want walking and cycling pathways to have</th>
<th>Lightings</th>
<th>Pavement</th>
<th>Safe Crossings</th>
<th>Rest rooms</th>
<th>Well connected</th>
<th>Signs and Information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>59 Number of adults that participate in my carpoo on a typical day</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>More than 3</th>
<th>Do not carpool</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>60 I would be encouraged to carpoo to work more often if following is available</th>
<th>Reserved Parking</th>
<th>Lanes for Vehicles having more than one person</th>
<th>Flexible working arrangements</th>
<th>Help in finding people to carpool with</th>
<th>Do not carpool</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>61 I hold a valid driving license</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>62 My gender</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>63 My education</th>
<th>No degree, certificate</th>
<th>High School</th>
<th>College Diploma</th>
<th>University Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>64 My income</th>
<th>less than $40000</th>
<th>$41000-$60000</th>
<th>$61000-$80000</th>
<th>$81000-$100000</th>
<th>More than $100000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>65 Number of vehicles in my house</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>More</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>66 My employment status</th>
<th>Full Employed</th>
<th>Part-time Employed</th>
<th>Unemployed</th>
<th>Student</th>
<th>Retired</th>
<th>Home Maker</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>67 Type of residence I live in</th>
<th>Single-detached</th>
<th>Ground Access (Semi-detached, Row house)</th>
<th>Low rise (Up to 4 storey)</th>
<th>Apartment (5 stories or more)</th>
<th>Other dwellings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>68 My age</th>
<th>Under 16</th>
<th>16-25</th>
<th>26-35</th>
<th>36-45</th>
<th>46-55</th>
<th>56-65</th>
<th>Over 65</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>69 My location in Calgary (community name)</th>
<th>McKenzie Towne</th>
<th>glitch</th>
<th>Huntington Hills</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>