Potential Demand for Public Transport in Riyadh City, Saudi Arabia

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DECLARATION

This work has not previously been accepted in substance for any degree and is not concurrently submitted in candidature for any degree.

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LIST OF PUBLICATIONS

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ABSTRACT

In Riyadh City, as an effort to reduce the excess dependency on private vehicles, in 2012 city's authorities have approved the construction of a public transport system and travel demand management strategies. On this basis, this study question is "what are the procedures and approaches that have to be undertaken to ensure public transport uptake in Riyadh City?"

To answer the study question, a relevant literature has been reviewed in order to identify major successes of public transport services around the world. In addition, two empirical studies were conducted in Riyadh during the study course include a series of semi-structured interviews with local stakeholders and a web-based-general-public survey.

The study findings were consolidated and discussed to provide concrete answers to the study question. The study found considerable support by stakeholders and the general-public for introducing public transport services and reshaping the existing travel strategies. It was also found that the future planning of the public transport system in Riyadh City has to pay considerable attention to social and cultural perspectives of its citizens; for safety and separate family carriages. The study also found that improving infrastructure to enhance accessibility to and from transit stations, selecting appropriate TOD sites, parking charges are effective strategies.

Finding from a stated preference experiment showed that the likelihood of shifting people from private cars to public transport in Riyadh City would increase by a reduction in public transport cost, number of changes, and increase in the service frequency. Most importantly, there are cultural aspects involving perceptions towards public transport that play an important role in people's intention to use public transport. For example, it found that highly qualified individuals were more likely to perceive public transport as a 'taking a step down into the World' and this is a point in which public transport authorities need to focus in order to ease this perception. Finally, this is the first time to derive estimates of the value of travel time savings for Riyadh City.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADA	**Ar Riyadh Development Authority**
ANOVA	Analysis of Variance
ECMT	The European Conference of Ministers of Transport
GCC	Gulf Cooperation Council
KSA	The kingdom of Saudi Arabia
KSU	King Saud University
MENA	Middle East and North Africa
MOT	The Ministry of transport
MOMRA	Ministry of Municipal and Rural Affairs
OECD	The Organisation for Economic Co-operation and Development
OPEC	Organisation of Petroleum Exporting Countries
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
TDM	Travel demand management
TRB	Transportation Research Board
RDS	Respondent-Driven Sampling method
SAPTCO	The Saudi Public Transport Company
SDOT	Seattle Department of Transportation
SR	Saudi Riyal
SPSS	Statistical Package for the Social Sciences
UAE	United Arab Emirates
UN	United Nations
USA	United States of America
USD	United States Dollar
VTPI	Victoria Transport Policy Institute
WHO	World Health Organization

CHAPTER ONE: INTRODUCTION

1.1 Introduction

Urban population has witnessed a significant growth in the 20th century from 220 million to 2.8 billion and that number is forecast to be 6.9 billion by 2050 (UN statistics 2010; May 2013). In 2008 the urban population has exceeded that of rural areas for the first time in human history (United Nations 2009).

The significant growth of urban areas has caused enormous challenges such as denser use of space, increasing automobile dominated and less sustainable motorisation (Aljoufie 2014; Global Mass Transit 2015; Pojani and Stead 2015). Experience of development in different cities indicates that population is the key indicator for travel in which growth in travel demand is usually consistent with population growth (Javid et al. 2013). Sperling and Gordon (2009) state that the one billion cars driven currently on the earth are expected to double worldwide over the next two decades. Despite the fact that the car is the preferred mode of transport for many reasons, the recent increase in car numbers has caused serious problems. Congestion, pollution and road accidents are major consequences of heavy traffic (WHO 2004; Santos et al. 2010a). May (2013) states that the scale of these problems is likely to grow even more rapidly than urban populations, as a result of growing motorisation and urban sprawl.

During the past fifty years, cities within the Kingdom of Saudi Arabia (KSA) and the capital city of Riyadh, in particular, have witnessed a dramatic growth in urban development and motorisation (Al-Hathloul 2017). The current public transport system in Riyadh involves buses run by the Saudi Public Transport Company (SAPTCO) and privately owned 25-seat minibuses (Al-Fouzan 2012). According to Al-Fouzan (2012) and Ar Riyadh Development Authority (ADA (2014a) the lack of effective public transport in Riyadh City is a result of very low car operating costs affordable to many of Riyadh's inhabitants, thus leading to excessive car use. The latter has been accompanied with a high reliance on private cars, thus causing problems such as congestion, fatal car accidents, economic, social, and environmental impacts (ADA 2015b). Against this background, in 2012, authorities in Riyadh City have commissioned the

construction of a new public transport system comprising a network of six metro lines linked with a bus network. The full project is expected to be operational by 2018 (ADA 2015b).

1.2 Urban Transport Problems

The urban transport problem is more complicated than it appeared a few decades ago, when the critical task was seen to be how to transport tidal flows of commuters to and from city centres, and the main issues were congestion and car parking (Pojani and Stead 2015). Travel is now more dispersed in terms of both space and time, and our understanding of environmental problems has improved. Observers talk of suburban gridlock and edge cities while an older concern like congestion is now allied to issues like the greenhouse effect and social justice.

Many cities today are faced with unaffordable challenges, particularly in urban mobility systems (Un-Habitat 2013). Generally, most of the transport problems emerge when the transport systems, for any reason, do not satisfy the demand of urban mobility (Global Mass Transit 2015). The following subsections review some notable urban transport problems:

1.2.1 Traffic congestion and parking difficulties

Traffic congestion is often seen as one of the widespread transport problems in large cities (Cervero 1986; Banister 2002), as identified in the 1960s (Zavitsas et al. 2010). One of the universal definitions of traffic congestion was provided by the forum of the European Conference of Ministers of Transport (ECMT) (ECMT 2007, p. 10):

> *"Congestion is a situation in which demand for road space exceeds supply".*
> *"Congestion is the impedance vehicles impose on each other, due to the speed-flow relationship, in conditions where the use of a transport system approaches capacity".*
> *"Congestion is essentially a relative phenomenon that is linked to the difference between the roadway system performance that users expect and how the system actually performs".*

The ECMT (2007) reports that one of the key reasons for the absence of agreement on the definition of traffic congestion is that it is both a *physical phenomenon* whereby movement of cars slows down once demand for limited

road space attains full capacity, and a relative event pertaining to user prospects with reference to road system performance. Congestion is mainly associated with motorisation and the proliferation of the car which has led to increasing demands for transport infrastructure (Pojani and Stead 2015). In Britain the road congestion issue reported by the national road traffic forecast in 1989, and expected an increase in traffic from 83% to 143% by 2025 (Haywood 2009). Constructing more infrastructure capacity would be expensive, bring more cars to the roads and not ease congestion (Rodrigue et al. 2013). In Riyadh City, according to Al-Fouzan (2012) and Global Mass Transit (2015) the unprecedented increase in vehicular trips from just approximately one million in 1987 to 6 million in 2010 exceeds supply in major arterials resulting in serious congestion.

Aderamo and Atomode (2012) argue that traffic congestion is a critical aggravation for metropolitan movements, as well as being an epidemic which has developed into an integral part of normal life in almost all cities worldwide. Traffic congestion brings a waste time every day in journey, as a consequence, forces urban areas commuters make them plan for such problems such as leaving home early just to avoid being late (Buchanan 2015).

Traffic congestion is also related to parking given that cars spend most of the time parked; hence, vehicle use has increased the demand for parking space (Rodrigue et al. 2013). Congestion and parking are also interconnected in view of the fact that trying to find a parking space, also referred to as “cruising”, gives rise to further delays and impairs local circulation. In central areas of large cities, cruising may comprise more than 10% of the local circulation, as motorists try to find parking spots (Rodrigue et al. 2013; Global Mass Transit 2015).

Furthermore, as reported by the ECMT (2007) congestion increases the amount of time of each trip and causes delays, accidents, noise and higher fuel consumption, given that vehicles need to engage in a number of energy-consuming re-accelerations. Studies by Klein (2001) and Santos et al. (2013) maintain that increased demand on motorways and road infrastructure not only increases congestion and related travel time and accidents, but also fuel consumption and air pollution as a consequence of consuming excess fuel

and increasing the number of instances of acceleration/deceleration. A study conducted by the Australian Government estimated congestion costs for all Australian cities as almost $10 billion per year which comprises operating cost, private time cost and business time cost (Ali et al. 2014).

Another potential negative impact of traffic congestion is stress, which was defined by the ECMT (2007, p. 154), as “a pattern of physiological, behavioural, emotional and cognitive responses to stressors.” Continued exposure to stressors is known to have negative impacts on both psychological and physical health, and in extreme cases, stress can result in significant psychic and physical trouble, including headache, depression, irritability, insomnia, and digestive problems (ECMT 2007). Drivers in congested conditions can develop various behavioural patterns as a result of stress, such as, tailgating, aggressive driving, horn sounding, accelerating and braking unexpectedly, not focusing on the road or talking to other drivers (Hennessy and Wiesenthal 1999; ECMT 2007).

1.2.2 Traffic accidents and safety

Internationally, road traffic accidents are becoming recognised as an area of concern which can never be entirely safe (Ansari et al. 2000). Mathers and Loncar (2006) project that deaths caused by traffic accidents would be the second highest cause of death for men by 2030. According to the World Health Organization (WHO) (2009, 2013b) annually road crashes cause more than 1.3 million deaths and many more individuals all over the world are permanently disabled. Motorisation and human errors are always associated with an element of danger and nuisance resulting in injuries, damage and even death (Rodrigue et al. 2013).

Private automobile cost is also another challenge facing households’ income. Newman (2012) maintains that up to 40% of households’ income in some USA and Australia car-dependent cities are spent on private transport.

In Saudi Arabia, as a result of a remarkable growth in motorisation since the oil boom in the mid-1970s, traffic accidents have increased dramatically and have become a major health and economic problem facing the country (Bener and Jadaan 1992; Al-Ghamdi 2002). According to reports by the WHO (2013a)

and the General Department of Traffic (2015) the rate of road traffic deaths in Saudi Arabia placed it among the worst 19 countries over the world, where nearly one person is killed and four are injured every hour on average.

Recently, it was also reported that road accidents in Saudi Arabia are resulting in losses of $3.6 billion each year (Ramisetty-Mikler and Almakadma 2016). The causes of car accidents in Saudi Arabia divide into general causes such as increased car ownership, increased numbers of expatiates from different countries with different driving behaviour and specific causes such as driver error, speed and road safety and car conditions (Ansari et al. 2000).

1.2.3 Environmental problems

Motor vehicle traffic is a major source of air pollution that has become a significant problem for many urban areas, as it harmfully affects the quality of life and the health of the citizens (Steg 2007; Zavitsas et al. 2010). Many studies also comment that the annual increase in private car ownership is a threat to the human environment (Garling and Schuitema 2007; Bamberg et al. 2011). It is commonly acknowledged that these problems cannot be effectively controlled by new technology alone, which is focused on mitigating the negative impacts per car; reducing the volume of car traffic is also essential (Mega 1996; Garling et al. 2002; Steg and Gifford 2007).

Personal transport is also a major contributor to local and regional air pollutants, and road traffic is the single key source of Nitrogen oxides (NO_x), benzene and Carbon monoxide (CO) in many countries, and emission of particulate matter (PM) is of mounting concern (ECMT 2007; OECD 2011). Secondary pollutants, for example NO_x and volatile organic matter, are also of concern as they lead to the formation of tropospheric ozone (O_3) (ECMT 2007; OECD 2011). Some of the health effects of personal transport are presented in Table 1.1.

The largest part of pollutant emissions is low at intermediate speeds; nonetheless, they tend to increase at low and high speeds (ECMT 2007). It is reported that low engine speeds result in imperfect combustion and an increase of hydrocarbons and CO emissions. NO_x emissions are directly linked

to engine temperature; hence, they increase at high speed and load (Ang-Olson and Ostria 2005).

Table 1.1: Short-term and long-term effects of personal transport

Pollutant	Short-term effects	Long-term effects
Particulate matter (PM)	• Increase in mortality • Increase in hospital admissions • Exacerbation of symptoms and increased use of therapy in asthma • Cardiovascular effects • Lung inflammatory reactions	• Increase in lower respiratory symptoms • Reduced in lung function in children and adults • Increase in chronic obstructive pulmonary disease • Increase in cardiopulmonary mortality and lung cancer • Diabetes effects • Increased risk of myocardial infraction • Endothelial and vascular dysfunction • Development of asthma • Reduced in life expectancy
Ozone ($O_{3)}$	• Increase in mortality • Increase in hospital admissions • System effects on pulmonary function • Lung inflammatory reactions • Respiratory symptoms • Cardiovascular system effects	• Reduced lung function • Development of atherosclerosis • Development of asthma • Reduced in life expectancy
Nitrogen dioxide (NO2)	• Effects on pulmonary structure and function (asthmatics) • Increase in allergic inflammatory reactions • Increase in hospital admissions • Increase in mortality	• Reduced in lung function • Increased probability of respiratory symptoms • Reproductive effects

Source: OECD (2011, p. 99).

The UK Climate Change Programme reported by Department for Environment Food and Rural Affairs (Defra 2011) indicates that energy consumption continues to increase in the UK, particularly from the transport sector. Defra (2011) shows that greenhouse-gas emission from the transport sector has increased since 1990 and is projected to increase further by 2020, especially in levels of carbon dioxide and nitrous oxide, whereas methane gas level has been predicted to fall (see Table 1.2).

Table 1.2: Greenhouse-gas emissions from transport, MtC*

Gas	1990	1995	2000	2004	2010	2015	2020
Carbon dioxide	39.2	39.8	40.9	43.1	44.8	45.7	45.3
Methane	0.6	0.6	0.4	0.3	0.1	0.1	0.1
Nitrous oxide	0.4	0.8	1.3	1.6	1.7	1.8	1.9
Total	40.2	41.2	42.6	45.0	46.5	47.5	47.2
Change from 1990 levels		2.3	5.8	11.8	15.6	18.0	17.4

Source: Defra (2011, p. 62).

In Riyadh City, pollution levels are over three times higher than the country's air quality limits (Alharbi et al. 2015). According to Al-Fouzan (2012) and ADA (2014a) the lack of effective public transport in Riyadh City is a result of very low car-operating costs affordable to many of Riyadh's inhabitants, thus leading to excessive car use and congestion.

1.3 Potential Solutions

Primary and secondary research was carried out to resolve certain transport-related problems in urban areas such as Rodrigue et al. (2013), Doi and Kii (2012) and Pan (2012). Re-planning of city roads and transport systems, rail-based public transport, support for non-motorised travel modes, travel demand management (TDM) strategies and control of land use were efforts adopted worldwide for more sustainable mobility (Rodrigue et al. 2013; Pojani and Stead 2015; Litman 2017).

For decades, urban transport policy has been a vexed issue worldwide. As a result, Australia and other governments have promoted some alternatives in an attempt to reduce the problems of environmentally unsustainable travel (Mees 2000). Universally, urban public transport is almost hailed as a preferred means of transport and is recommended by most people as a way of reducing pollution and traffic congestion, and of saving on the financial and environmental cost of roads and car parks. If public transport were better, our cities would also be more equitable and people without cars would be treated less like second-class citizens. However, it has proven very difficult to attract people to public transport in 'post-modern' societies with high car ownership. Mees and Dodson (2007) suggest that the individual is best suited to make decisions about how to maximise their 'utility' and governments facilitating this since the 1950s and 1980s in the shape of the car.

Most studies on the impacts of public transport systems on cities focused on heavy rail systems and the recent generation of rail systems built in US cities over the past half-century (Cervero and Kang 2011). Weisbrod et al. (2014a) revisit some of the advantages of investing in public transport, which include improved mobility, reduced congestion and carbon emissions, and air quality improvements. Public transport would also facilitate mixed land use, enable economic growth and increase property values and generate jobs (Litman 2015a).

The role of public transport in facilitating more sustainable urban environments has also been examined. Mackett and Edwards (1998) argue that if the most common reason for developing a public transport system is to reduce car use and traffic congestion, an improvement in the quality of the environment is also expected to be an outcome.

Car travel is appealing, faster and more flexible than the alternative public transport modes, so it is not expected that large numbers of car drivers would change to public transport merely by the service being available (Hensher 1998). Jensen (1999) argues that it is necessary to provide more market-oriented and competitive public transport systems and appropriate TDM strategies to make cars less attractive. In addition, Zavitsas et al. (2010) conclude that many authorities have placed fairly high priorities for Intelligent Transport Systems (ITS) as it offered potential solutions to many transport problems. ITS seems to play an important role in urban traffic management in terms of providing information to the public and facilitating traffic management (Zavitsas et al. (2010).

Bull (2003) states that one possibility for alleviating congestion is to restrict trips to city centre areas in peak hours and that would encourage people to switch to high-occupancy vehicles or to change their trips to off-peak hours.

Another solution that would reduce transport problems in urban areas is park and ride schemes. Park and ride is referred to as a system which provides parking spaces at a location generally a little distance away from city centre areas, with access to public transport for transport users to their preferred destination (Ashley 1994), or a large off-site parking space with a shuttle-bus

serving the workplace (Hole 2004). There are two key purposes of park and ride, to change the modal split towards public transport, and to minimise the requirements for parking spaces in urban centres (Simpson 2003), which will allow an access to urban centres with somewhat less environmental damage due to traffic (Khalid et al. 2013; Hamsa et al. 2014). Hole (2004) states that park and ride is especially effective in minimising car use if the workplace has limited parking space on-site.

Finally, Zavitsas et al. (2010) conclude that to reduce urban transport problems, cities' authorities would greatly benefit from strategies and policies implemented worldwide to identify best practice and modify it to their city-specific needs.

1.4 Research Question

According to the transport problems stated above and in the light of Riyadh's new public transport, the study's question is: "*what are the procedures and approaches that have to be undertaken to ensure public transport uptake in Riyadh City*?" This question was then associated with ten objectives.

1.5 Objectives

To address the study question, the following objectives were highlighted through theoretical and empirical approaches.

In the theoretical approach, the study aimed to accomplish the following objectives:

1. Review potentially effective procedures and approaches of developed and developing countries in shifting people's travel modes towards sustainable transport modes.
2. Explore changes in people's behaviour with respect to using public transport and identify the causes of this behavioural change.

The empirical approach employed qualitative and quantitative methods in order to address the following eight objectives, namely:

3. Investigate whether the existing TDM policies are adequate to encourage public transport use in Riyadh City.

4. Identify the potential effectiveness, acceptability and applicability of a set of proposed interventions that could influence people's travel behaviour.
5. Consider the wider impacts of the new public transport system in Riyadh City on urban form, economics, environment, social norms and culture.
6. Analyse individual perspectives and attitudes towards the current travel conditions in Riyadh City
7. Investigate considerations and behavioural intentions to use Riyadh's new public transport system
8. Identify the potential barriers and facilitators for using the metro and bus in Riyadh
9. Explore public reactions towards various TDM strategies in order to encourage car users to use public transport
10. Explore the relationships between participants' behavioural intentions and the various factors that affect travel choices

1.6 Outline of the Thesis

This thesis was carried out across eight chapters as outlined in the following key points:

Chapter One: Introduction

Chapter One is designed to introduce the problem being researched and provides brief potential solutions. Therefore, it reviews worldwide urbanization and the associated transport problems such as traffic congestion and related issues. This Chapter also provides brief potential solutions for transport problems, study question, aims and objectives, stages to achieve research objectives and the thesis structure.

Chapter Two: Literature Review

This Chapter is designed as a theoretical stage that reviews background and previous works related to the research domain. The issues being reviewed include urbanisation and related topics such as the importance of transport, changing people's behaviour, and theories such as the theory of planned behaviour. Transport policy measures for changing travel behaviour including

'soft' and 'hard' transport policy measures are highlighted. This Chapter also reviews and discusses issues relating to demand for public transport, and unique situations concerning public transport in Saudi Arabia.

Chapter Three: A Profile of Study Area

This Chapter provides a profile of Saudi Arabia with special reference to Riyadh City. It is concerned with the study area's geographical and socio-economic background to present the research with essential data for analysis. This Chapter also reviews the current transport situation, systems and the planned strategies.

Chapter Four: Study Design and Methodology

The primary aim of this chapter is to provide a brief background of the main methodology that underpins the study. It also reviews, justifies and discusses various features of adopting a mixed method approach using qualitative and quantitative methods.

Chapter Five: Semi-structured Interviews

This chapter aims to elicit local stakeholders' perspectives of relevant travel strategies to encourage a shift from private cars to public transport in Riyadh City. In this sense, semi-structured interviews have been conducted with local stakeholders including transport experts and representatives of Riyadh City authorities. In this Chapter, qualitative method findings are analysed and discussed in the light of the data and information generated in Chapter Two, Literature Review.

Chapter Six: General-Public Survey

This Chapter attempts to explore the public behavioural intentions towards a new public transport system in Riyadh. It investigated and analysed individual perspectives and attitudes about the current travel conditions in Riyadh, and considerations and behavioural intentions towards Riyadh's new public transport system. This stage of the study attempts also to explore public reactions towards the various transport policy measures.

Chapter Seven: Discrete Choice Experiment

This Chapter presents findings from applying a discrete choice experiment using a stated preference approach as part of the general public survey. It measures respondents' valuations of the influence of different attributes related to travel modes such as travel cost and journey time for cars and public transport.

Chapter Eight: Consolidation and Discussion of the Research Findings

The fundamental goal of this Chapter is to consolidate the research findings and discuss the associated evidence. It identifies a selection of strategies which appear to have been supported by the policymakers. It also presents the contribution to the body of knowledge, limitations that faced the researcher and some suggestions for future research work.

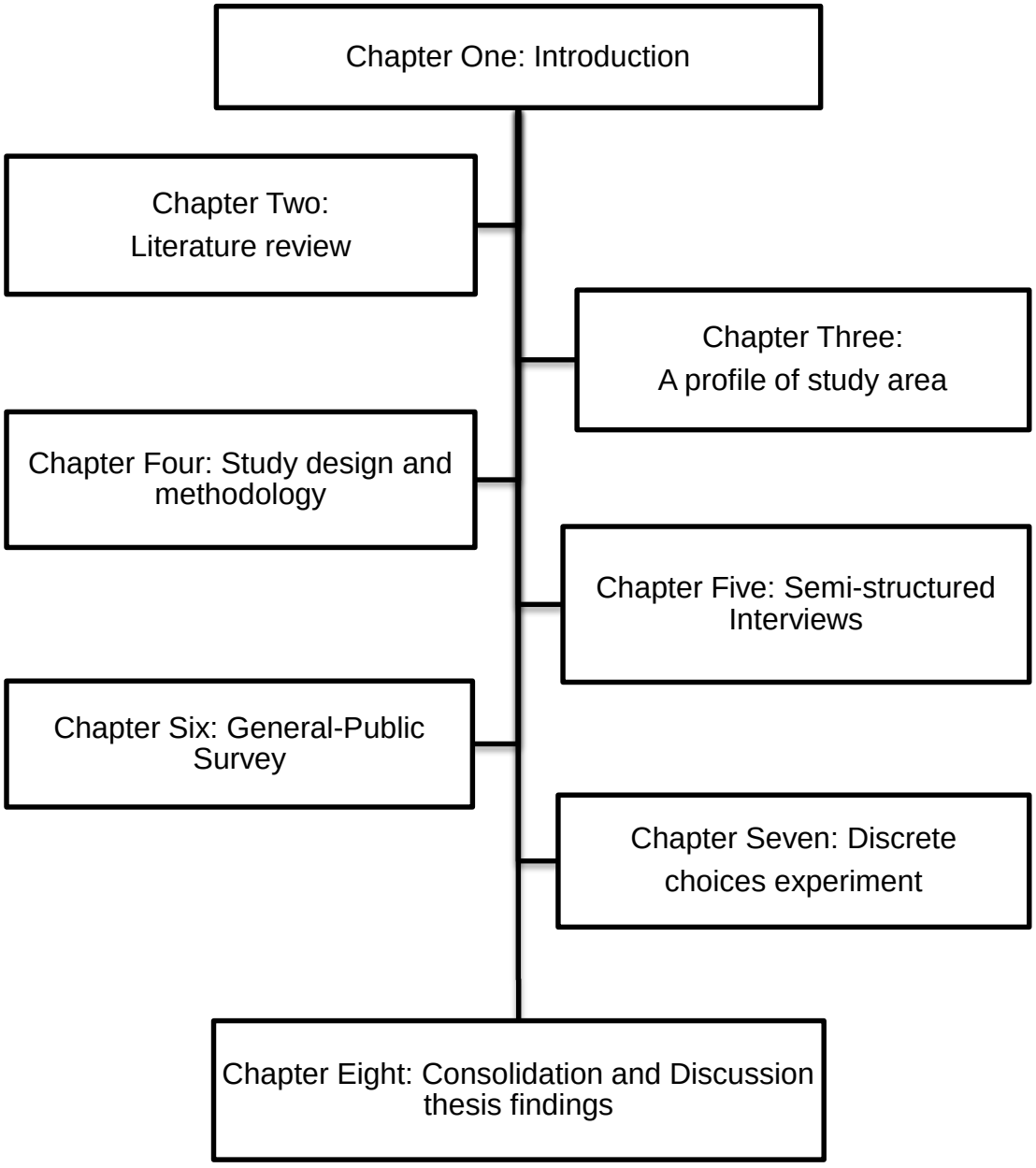


Figure 1.1: Thesis structure

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This Chapter is designed to address two of the research objectives, namely:

1. Review the successful procedures and approaches of developed and developing countries in shifting people's travel modes towards sustainable transport modes, mostly public transport.
2. Explore changes in people's behaviour with respect to using public transport and identify the causes of this behavioural change.

In this chapter, topics related to urbanisation, the importance of mobility and travel demand are reviewed and discussed. Types of public transport, the benefits of urban areas adopting public transport and attributes related to public transport are also reviewed in this Chapter. Moreover, theories of changing people's behaviour, academic research and real-life examples of TDM strategies in shifting people's travel choices towards more sustainable modes are reviewed in this Chapter. This Chapter also identifies the main themes followed in both practical stages of the research, namely: planning and physical changes, legal, economic, social and cultural and information and technological themes.

Finally, in the context of study area, the research explores issues relating to travel demand and challenges that would affect the use of Riyadh's public transport, such as the unique historical and cultural character forms of Saudis, economic and environmental aspects. Riyadh's society has not been exposed to any integrated public transport system before and the automobile is an integrated part of their life. Consequently, to make sure these challenges are not met with failure when introducing public transport, this Chapter examines possible strategies to increase the likelihood of success of the public transport system in Riyadh City.

2.2 Urbanisation and Travel Demand

Urban areas are places which are characterised by a high level of capital, accumulation and concentration of economic activity, as well as being multifaceted spatial structures supported by transport systems (Rodrigue et al.

2013). In 2008 the urban population has exceeded that of rural areas for the first time in human history (United Nations 2009). Donovan and Munro (2013) expect the population in urban areas to double over the next 40 years.

All people would use transport regardless of their demographic characteristics for a wide range of daily purposes and destinations (Balcombe et al. 2004). Litman (2017, p. 2) maintains that "travel demand refers to the amount and type of travel that people would choose in particular situations". It is characterised as qualitative, differentiated according to time of day, day of the week, purpose of the travel, and significance of speed and frequency (Litman 2017). It is therefore concluded that travel demand is rather difficult to analyse and forecast, that travel is a derived demand rather an end in itself. Travel demand, therefore, is profoundly controlled by space; hence, spaces should be considered in the majority of cases (de Dios Ortuzar and Willumsen 1994). However, travel demand also is argued to be needed a few hours daily especially in cities in which most of the congestion occurs during peak hours (Balcombe et al. 2004; Scheiner and Enoch 2013). Urbanisation is associated with an increase in travel demand and mobility allowing access for people and goods (Javid et al. 2013). Dealing with the constant increase in travel demand in urban areas is considered a dilemma faced by the majority of urban area authorities. This, according to Murray and Davis (2001), is why public transport has been identified as being a fundamental constituent in the administering and planning of urban areas, and also as sustaining essential human life in urban areas.

The basic signifier of mobility is the act of moving people and things between locations within one city or between cities, in towns or other places on the earth (Cresswell 2006). Mobility is a critical part of the development economy, facilitating and maintaining social bonds and relationships (Cresswell 2006). Mobility plays an important role between locations, as well as being an important human activity globally (Rodrigue et al. 2013). Vuchic (2007) argues that transport brings together a complex interaction of human forces which relate to human activity, as well as playing a key role in determining the location, size, form and structure of urban areas.

Between 1960 and 2010, the number of automobiles in urban areas increased from nearly 100 million to over 700 million (Davis et al. 2014; Rode et al. 2017). Previous studies (see Zhao 2010; WHO 2013a; Aljoufie 2016) indicate that a rapidly rising population, and urbanisation result in higher traffic volumes and increased vehicular use, leading to congestion and other negative impacts such as air pollution, greenhouse gas emissions and economic losses. The World Energy Council (2011, p. 4) summarised that "over the next four decades, the global transport sector will face unprecedented challenges related to demographics, urbanization, pressure to minimize and dislocate emissions outside urban centres, congestion of aging transport infrastructure and growth in fuel demand".

A study by Buehler and Pucher (2012) covering 16 cities in Europe, North America, and Australia, concludes that the increase in income makes cars more affordable with the effect that many public transport systems are struggling to compete with the private car in many urban areas' mobility. As regards citizens' preferences for car over rail, Garrett (2004) reports that cars offer people personal space and a sense of independence. Studies by (Jensen 1999; Hagman 2003; Anable 2005) state that the car is usually the most preferred method of transport, because of its convenience, speed, comfort and individual freedom.

People choose to pay petrol taxes, higher petrol prices, buy cars and take on repair and maintenance costs and car registration fees, instead of using public transport showing the value that people place on their cars. Hatwar and Gajghate (2014) argue that investment in public transport services is a compulsory quality leap for more liveable and accessible cities. Public transport plays a facilitating role in urban mobility (Banister 2001). In Asian and some Western developed cities, public transport accounts for more than 51% of daily trips while in car-orientated cities such as in the United States or the Gulf region it accounts for less than 10% (UN Habitat 2010). In Riyadh City for example, the current bus service shares less than 2% of 8 million daily trips (Al-Fouzan 2012; Alqahtani et al. 2012).

2.3 Public Transport

Public transport research indicates that the terms ‘transport’ and ‘transit’ are interchangeable when referring to providing buses, coaches, light and heavy trains, trams and ferries, as well as taxis and private car hire for public use (Parkan 2002; Balcombe et al. 2004). Public transport is a term mainly used in Europe, Japan and Australia, whereas terms such as mass transit and public transit are used more in North America and Southeast Asia, mainly China, Hong Kong and Singapore (Redman et al. 2013). Nonetheless, these terminological principles are not strict rules: there is some crossover, for example, in that the term ‘public transit’ has been used in Greece (Tyrinopoulos and Antoniou 2008), France (Dersin and Durand 1995), Germany (Flade 1990), and ‘public transport’ has been used in Hong Kong (Cullinane 2003).

Public transport has been defined in a number of ways. One of these definitions is that suggested by Walker (2012, p. 13) who indicates that public transport “consists of regularly scheduled vehicle trips, open to all paying passengers, with the capacity to carry multiple passengers whose trips may have different origins, destination, and purposes”. Walker (2012) explains this definition by taking its components apart. By *“regularly scheduled vehicle trips”*, Walker indicates that transport is delivered by a vehicle which runs on a regular schedule or pattern; however, there is a possibility for variation in routes and schedules. Public transport, in its essence, should be predictable in order that different people are able to plan around it without liaising directly with each other. Walker (2012) refers to this aspect as the key difference between transport and other means of sharing a ride.

As regards *“open to all paying passengers”*, the word *public* in *public transport* denotes being open to all people (Walker 2012). The phrase *“that can carry multiple passengers”* indicates that many passengers can be carried in a single vehicle, which is the feature of transport as well as being the most vital measure of its effectiveness (Walker 2012).

In terms of *"whose trips may have different origins, destinations, and purposes"*, (Walker 2012, p. 14) excludes in his definition the following means or transport:

- Carpools and vanpools, where several people with the same destination share a ride;
- School buses, where school is the only origin or destination served;
- A family in their minivan, or any other group that is intentionally travelling together;
- Taxis, which carry a small number of riders at the time, typically all with the same origin and destination.

Taxis have not been fully accepted as a means of public transport for two reasons; their higher charges mean that they do not serve the same markets as buses or trains, and in addition they are like private cars more than buses (Simpson 2003). In some countries, for example, South Africa, minibus taxis represent the prevalent mode of public transport; nevertheless, they do not operate according to timetables but operate according to the concept of full loads (Sebola 2014). The main features that distinguish public transport from other modes of travel is on the provision of vehicles, infrastructure and services such as timetables and tickets prices that operators have to publish (Jansson et al. 2016).

Public transport systems are seen mostly by urban planners as crucial to the liveability of urban areas for many social, environmental and economic benefits such as ensuring accessibility to activities and services, reducing traffic congestion, increasing productivity, and reducing carbon emissions (Daniels and Mulley 2013; Litman 2013; Tai et al. 2016). Walker (2012) states that public transport is an efficient user of energy and limited urban space, as well as being the most attractive alternative for journeys which are too long on foot or by cycle. As shown in Table 2.1, Litman (2013) provides some examples of the benefits urban areas would gain from public transport systems.

Table 2.1: Benefits to urban areas from adopting a public transit system

Type of Benefit	Benefit
Social and culture	• Would boost the community connections and socialism when people meet and travel together that are absent in private car use. • Improve people's lifestyle by encouraging daily activities such as walking and cycling to transit stops. • Helps in reducing car accidents and related health issues such as injuries and death. • Provides mobility for all social groups regardless of their demographical characteristics. • Public transport is less stressful compared to private car use, especially in congested cities and where there is limited parking.
Economic	• Public transport fare usually less than costs of owning and operating a car. • Reduces the space of land used to accommodate private cars, such as parking, roads and other infrastructures. • Reduces reliance on rapidly decreasing oil supplies.
Environmental	• Improves mobility and reduces pollution when more people switch from private cars to public transport. • Requires less land use than road infrastructure associated with private cars.

Source: Adapted from Litman (2013)

2.3.1 Public transport systems

Each of its components is designed to provide a specific array of services conferring mobility. Among the defining factors of public transport services are capacity, frequency, flexibility, costs and distance between stops. Based on these factors, public transport systems are divided into buses and coaches, taxis and private hire vehicles, tramways and light rail, heavy rail and metro. The following subsections give an overview of public transport types and services that each type would provide for urban areas.

2.3.1.1 Buses and coaches

Buses represent the prevalent component and the most universal mode of public transport (Balcombe et al. 2004). In general, the bus is the most universally used form of urban transit operating on streets and is designed to transport many passengers (Jansson et al. 2016). The range of bus vehicles by size includes a minibus (15-40 seats), a regular bus (30-50 seats and 60-20 standing spaces), and an articulated bus that has two axles and a capacity 50% more than a regular bus (Jansson et al. 2016). Bus services work throughout scheduled fixed routes and stops based on timetables published by the city's authority (Rodrigue et al. 2013). Bus services usually work as feeders by integrating with other public transport services, mainly metro and

heavy rail (Rodrigue et al. 2013). Buses have more advantages including changing routes based on cities' travel demands, they cost less to develop and maintain than other fixed transit systems such as heavy-rail systems and help in reducing air pollution (Vuchic 2002). On the other hand, buses are noisy, can get caught in congested routes and increase pollution and may lose money as they have to charge low fares to attract passengers (Miller et al. 2009, p. 601; Miller and Spoolman 2014, p. 285).

The studies of Beirão and Cabral (2007) and Clayton et al. (2016) reported that travel time is concurrently regarded as an advantage and a disadvantage of buses – as well as being a key reason for mode choice, maintaining that in areas with exclusive bus lanes, and also when travelling to the city centre, the bus was perceived by users of mainly public transport to be faster than the car. Nonetheless, for travel across the city or in areas with heavy traffic during peak traffic times, Beirão and Cabral (2007) report that using public transport is regarded as a waste of time by the majority of car users and not often by public transport users, and includes the waiting time, perceived as very long and a hindrance to public transport use.

Recently, a number of developments have been implemented with the aim of making bus services more attractive to passengers in terms of saving time, money and improving customer satisfaction. One example of such initiatives are bus priority schemes which were intended to reduce bus journey times and render services more reliable by means of isolating buses from general traffic congestion (Balcombe et al. 2004). Some of these schemes have been successful, whereas others have demonstrated few benefits (Daugherty 1999), often as a consequence of difficulties in evading physical impediments where priority measures are most needed (Balcombe et al. 2004).

Beirão and Cabral (2007) conducted 24 in-depth interviews (10 males and 14 females) with the general public in Porto, Portugal, to obtain a deeper understanding of travellers' attitudes towards transport. As summarised in Table 2.2, the study focused on buses and private cars, to allow for a comparative assessment between the modes and their perceived advantages and disadvantages.

Table 2.2: Perceived advantages and disadvantages of buses and private cars

Advantages	Disadvantages
Bus	
• Cost • Less stress • No need to drive • Opportunity/ability to relax • Opportunity/ability to rest or read • Travel time on bus lanes • Less pollution • Opportunity to talk to other people on the vehicle	• Waste of time • Too crowded • Lack of comfort • Time uncertainty • Lack of control • Unreliability • Long waiting time • Need for transfers • Traffic • Lack of flexibility • Long walk time
Private Car	
• Freedom/independence • Ability to go where desired • Convenience • Rapidity • Comfort • Flexibility • Knowing what to expect • Safety • Own private space • Opportunity to listen to music	• Cost • Difficulty of parking • Cost of parking • Stress of driving • Traffic • Waste of time in rush-hour traffic • Pollution • Possibility of accidents • Isolation

Source: Beirão and Cabral (2007, p. 482)

2.3.1.2 Tramways and light rail

Fixed rail divides into two major categories that are the tram rail system and the commuter rail system (Rodrigue et al. 2013). The tram rail system is mainly composed of streetcars (tramways) operating in central areas that can consist of up to four cars. The commuter rail system comprises passenger trains mainly developed to service peripheral/suburban areas through a heavy (faster and longer distances between stations) or light rail system (slower and shorter distances between stations). Frequency of services is strongly linked to peak hours and traffic tends to show an imbalance. Fares tend to be separate from the transit system and proportional to distance or service zones (Rodrigue et al. 2013).

Gunnarsson and Löfgren (2001) maintain that light rail vehicles, also referred to as modern tram, have become increasingly more common since the 1980s. Light rail is a “transit mode that typically is an electric railway with a light volume traffic capacity compared to heavy rail” (Hodges 2010, p. 17). Light rail systems have a number of benefits such as the absence of polluting

emissions, energy savings, and reduced noise pollution (Pratelli and Brebbia 2010). In Britain, there have been many efforts in recent years to develop light rail as a cheaper alternative to heavy rail in urban areas, including in Manchester, Sheffield, Newcastle, Birmingham and Nottingham (Haywood 2009).

2.3.1.3 Heavy rail and metro

Heavy rail is also a public transport mode that is referred to as rail rapid transit which is an electric railway with the capacity for a heavy volume of traffic (Steiner et al. 2012). Heavy rail is characterised by "high speed and rapid acceleration passenger rail cars operating singly or in multi-car trains on fixed rails, separate rights-of-way from which all other vehicular and foot traffic are excluded, sophisticated signalling, and high platform loading" (Hodges 2010, p. 17).

Heavy rail consists of underground and metro systems which are designed for high capacity as well as being fully isolated from surface traffic; examples of these systems are to be found in London, New York and Paris (Balcombe et al. 2004). Station spacing tends to be rather greater than for tramways or light rail, and use is inclined to be concentrated on radial work trips to/from city centres (Balcombe et al. 2004).

Metro have become increasingly more common since the 1980s. Its systems have a number of benefits, from an environmental perspective and contributing to a higher urban quality of life. Five main issues related to metro systems include job creation, citizens' preferences for car over rail, air pollution, traffic congestion, and cost efficiency and solvency.

Metro or subway systems exist in about 100 cities worldwide and have by far the highest performance with fixed routes, uniform frequency of service that would increase during peak hours, capacity, speed and reliability (Vuchic 2002). Metro stations are often underground in central areas and above ground at more peripheral locations and the system offers connected stations allowing passengers to transfer between lines or integration with other public transport systems such as buses (Wheeler and Beatley 2014).

2.4 Public Transport Demand

Earlier studies examined the relationship between socio-economic characteristics, environmental factors and the demand for public transport (see, Domencich and McFadden 1975; Webster and Bly 1982; Balcombe et al. 2004; Paulley et al. 2006). In 1980 a report called the demand for public transport was published by the Transport Research Laboratory (TRL) which became later known as 'The Black Book' (Balcombe et al. 2004). The TRL report included factors that influence the demand for public transport services and quantified their effects (Paulley et al. 2006). It proved to be invaluable to policymakers, public transport operators and transport planners (Paulley et al. 2006).

Twenty years on from the publication of 'The Black Book', there have been many organisational changes within the transport industry. Changes have included the legislative framework under which it operates, the lifestyle of passengers and policymakers' attitudes, all of which have reduced much of the relevance of 'The Black Book' to modern circumstances (Paulley et al. 2006). The report defined four key areas for public transport demand as stated below:

1. There is a positive relationship between car ownership and increasing income, and an increase in the use of public transport.
2. There is a negative relationship between car ownership and the demand for public transport.
3. The demand for public transport with respect to car availability and income is flexible and will vary according to levels of income.
4. There is a positive relationship between an individual's income and the length of journey undertaken.

Beirão and Cabral (2007) state that the journey type and time may affect the choice of transport mode in which travellers would make comparisons between public transport and private car. In order to encourage public transport use rather than private car, it is important that the reasons behind patterns of travel behaviour are understood.

There are frustrating examples of public transport system operations around the world (American Public Transportation Association 2010). In the 1960s, in the era just before the high prevalence of the automobile, the idea of making subsidies to public transport systems did not exist because operating costs were lesser than revenue (Lave 1991). However, studies in 15 different countries by Bly et al. (1980) found that between 1965 and 1976 subsidies in public transport systems increased rapidly. According to another study by Pucher (1982), in 1965 users' fares covered 99% of the operating costs of American's public transport systems, but this percentage declined to less than 42% in 1980. In the early 1970s, public transport ridership in North American cities declined to share less than 5% of daily trips due to increased income, the continuing decentralisation of cities and new patterns of trips that are difficult for public transport systems to serve (Buehler and Pucher 2012). Moreover, reasons such as high cost of public transport use, inappropriate locations of transit stations and lines, and preferring cars as travel mode over other transport modes discouraged public transport ridership (Neff and Dickens 2013). Riyadh City has some important local challenges that are also likely to lead to a possibility of failure when introducing public transport. For example, unfriendly pedestrian environments, the special traditions and cultural norms and the extreme summer heat, when temperatures frequently exceed 50°C (Alhedr 2016).

The public transport quality is defined by a number of attributes that can give comparative advantages to one mode of transport over another (Litman 2012; Rodrigue et al. 2013). These attributes can be categorised as physical or perceived. In physical attributes assumptions are made without involving public transport users, while in contrast, to measure perceived attributes public transport user responses must be observed, either directly (Friman et al. 2001) or indirectly (Balcombe et al. 2004; Paulley et al. 2006). Table 2.3 lists and defines the most commonly studied public transport quality attributes.

Table 2.3: Definitions of attributes for public transport service

	Attributes	Definition
Physical	Reliability	How closely the actual service matches the route timetable
	Frequency	How often the service operates during a given period
	Speed	The time spent travelling between specified points
	Accessibility	The degree to which public transport is reasonably available to as many people as possible
	Price	The monetary cost of travel
	Information provision	How much information is provided about routes and interchanges
	Ease of transfers/interchanges	How simple transport connections are, including time spent waiting
	Vehicle condition	The physical and mechanical condition of vehicles, including frequency of breakdown
Perceived	Comfort	How comfortable the journey is, with regard to access to seats, noise levels, driver handling, air conditioning
	Safety	How safe from traffic accidents passengers feel during the journey
	Convenience	How simple the public transport service is to use and how well it contributes to one's ease of mobility
	Aesthetics	Appeal of vehicles, stations and waiting areas to users' senses

Source: Redman et al. (2013, p. 121)

2.5 Factors Influencing Public Transport Demand

There are a number of factors that influence the demand for public transport including the quantity and quality of service provided, spatial factors, cost, the economy and others (Stover and McCormack 2012). Travel purpose and personal characteristics would affect travel demands so transport, specifically car travel, is predisposed to rise with employment and wealth (Litman 2013). Walking, cycling and public transport demand is likely to be higher among certain population groups, including the young, the elderly, the poor, people with disabilities, immigrants, those who enjoy exercise and those who reside in urban areas (Litman 2013; Holley-Moore and Creighton 2015). Spatial access, cost, information, physical accessibility and attitudes are also influences that contribute to people's ability and motivation to use public transport (Daniels and Mulley 2013). The following subsections separate demand factors into a number of groups:

2.5.1 Demographic and social factors

Demographic and social factors have been shown to be highly prevalent in relation to public transport demand (Polat 2012). Population increase, in terms of being a key factor (Papon 2002), population characteristics, such as age structure and the declining share of young people, have a negative effect on the use of public transport (Bresson et al. 2002), and exert substantial pressure on urban transport infrastructure (Polat 2012).

The influence of demographic factors for public transport demand were reported four decades ago by Hovell et al. (1975) to be slow to change and insignificant in facilitating key changes in order to influence the operational decisions, particularly in the short run (Polat 2012). Nonetheless, they have a profound bearing on public travel. Public transport demand is subject to change in relation to the changes in age structure and other related demographic factors, which probably bring about certain changes in travel patterns and traffic procedures (Balcombe et al. 2004; Nurdden et al. 2007).

The transport market is usually segmented by socio-demographic variables and transport use. However, Anable (2005) claims that few differences exist when only socio-demographic segmentation is taken into account, or when groups are determined according to transport use. It is therefore important that new segments of users, according to underlying psychological constraints, are identified, including attitudes and perceptions. A number of studies adopt different techniques, and have made interesting advances in the segmentation of the travel market (Jensen 1999; Outwater et al. 2003; Anable 2005). Bresson et al. (2002) studied the effect of age structure influences on the use of public transport services. Their study concludes that gender and the number of cars owned by the family unit were not highly influential factors for young people using public transport, but that they were deciding factors more for people of working age. They also found that differences between men and women in relation to public transport use were substantial.

Family size is one of those demographic factors that has an impact on the use of means of public transport. Kohn (1999) maintains that families with children may opt for private cars rather than urban transport because the monthly cost

of transport passes may be, or is thought to be, more expensive than using their own cars.

2.5.2 Travel cost

The literature reveals that the cost of travel is one of the key determinants of the demand for public transport (Albalate and Bel 2010), and that two structural factors stand out from the others: these are the user's cost of travelling by public transport and by private car (Souche 2010). The overall cost of a trip is the total cost of fares paid directly on each journey, as well as traveller-specific constituents, combined with the assessment of the traveller's own time (Horn 2004). Accordingly, as a public transport concept, the cost of travel comprises two key components: fares and time (Polat 2012).

Fares are argued to be vital to operating public transport, given that they are the key source of revenue for the operator (Paulley et al. 2006; Polat 2012). The influence of fares on public transport patronage is rather easy to observe, and usually if fares increase, public transport patronage decreases (Polat 2012).

The literature argues that changing fares represents the factor with the highest direct and strong influence on patronage (FitzRoy and Smith 1998; Bonnel and Chausse 2000; Bresson et al. 2002). Litman (2013) also indicates that increased prices for a certain kind of journey tend to reduce the use of that journey and at times this brings about a shift to alternative routes.

2.5.3 Travel time

Travel time is also one of the key factors that has an impact on using public transport and selecting transport mode, and the significance of time stems from its structural characteristics (Polat 2012). In contrast to price and other factors, time is an utter limitation given that people cannot increase the time spent on travelling infinitely (Golob et al. 1972; Polat 2012).

Travel time by public transport involves three main elements, including the time taken to walk to the nearest transit station or bus stop, waiting for the service and in-vehicle time (Polat 2012). Occasionally, transfer between vehicle or modes, which is connection time, is added to public transport travel time (Krygsman et al. 2004; Givoni and Banister 2010). Each one of these

elements has a different value for travellers; for example, the price for a typical public transport user includes many of these cost elements, involving access times to transit station or bus stop and final destinations, waiting times at stops, interchanges and travel times at means of transport (Horn 2004), which all have an effect on the travellers' evaluation of public transport services and demand (Polat 2012). McKnight (1982) indicates that access to public transport stations and waiting times were valued at somewhat less than twice in-vehicle time as they were the more distressing activities for an individual.

A research study by Wardman (2004) used evidence drawn from British studies conducted between 1980 and 1996 on mode choice behaviour. The research aimed to investigate the relative valuations of travel time by public transport including walk, wait and in-vehicle times to private car use. The research concluded that individuals would vary in terms of valuating walk and wait times according to their socio-economic and situational factors. Another study reviewing travel time valuation in the UK was by Abrantes and Wardman (2011) which concluded that travel time of walk, wait and headway were valued more highly by car users than public transport users. According to the mode in which the time is spent, the study reports that bus travel time was slightly more highly valued compared to other modes' travel time, and that would be due to differences in the comfort and conditions of travel.

2.5.4 Quality of service

Service quality is another determinant that influences the demand for public transport (Polat 2012; Redman et al. 2013); this is referred to as one of the transport aspects that has the most direct and strong impact on patronage (FitzRoy and Smith 1998). Bresson et al. (2002) argue that service quality is no less important than fare, and that fare increases can be recompensed by equivalent service improvements without having any impact on patronage. Service quality that really matter to users of public transport includes a number of key aspects, in addition to waiting times and service reliability, such as service frequency, cleanliness, operating speed and comfort (Joireman et al. 1997; Polat 2012; Hensher 2015).

The service quality measurement is an important area of research that has practical implications for service providers (Prioni and Hensher 2000). The perspective of consumers relating to quality of service issues for public transport is a highly important consideration for both operators and transport authorities (Hensher et al. 2003). Parasuraman et al. (1985) make the important point that consumers' evaluations of quality are difficult to measure, since they deal with abstract attributes such as comfort and safety. This complicates the development of accurate constructs of service quality. However, Prioni and Hensher (2000) argue that the most important factors relating to service quality, which are perceived by current and future transport users, should be clearly determined, although the specification of relevant attributes is complex. It is also important to identify their relative importance to users, such as reliability being a decisive factor (Bates et al. 2001; Hensher et al. 2003; Kou et al. 2017). Other attributes, such as frequency (Hensher et al. 2003), and comfort (Redman et al. 2013) are also valued highly by travellers and regarded as important factors within their satisfaction ratings. Travel time and level of fares may also have a major negative impact upon levels of consumer satisfaction (Hensher et al. 2003).

The integration of public transport systems is one of the factors which increases service quality and impacts the extent of demand, and encompass a number of issues, for example, coordination of service levels, paths and schedules as well as a common fare system (Matas 2004). Accordingly, it is argued that the further the public transport system is integrated, the better the service quality and the level of demand become in an urban area (Polat 2012).

Reliability represents the extent to which travellers are able to depend on and trust in a particular type of transport and public transport service, as well as encompassing other aspects, for instance, accessibility and confidence (Van Oort 2011; Polat 2012). A systematic review by Redman et al. (2013) found that public transport would attract car users if it offers over and above the basic level of attributes already offered by their cars, such as level of accessibility, reliability and competitive cost. The study concludes that it is important for policymakers and public transport suppliers to understand the targeted car users' perceptions of the quality of attributes and underlying motivations then

plan how these can be best achieved by implementing public transport improvements. Along this line, Ison (2000) concludes that travellers would prefer interventions such as the reliability of public transport and low fares.

Travellers must be capable of relying on public services and can perceive them as being accessible on a regular basis as well as being long term (Polat 2012). The number of seats available, longer waiting times as a result of bus or train late arrival and excessive in-vehicle-times because of traffic or system problems diminish reliability (Balcombe et al. 2004; Paulley et al. 2006). Balcombe et al. (2004) maintain that it is usual to express such forms of unreliability in terms of standard deviations in waiting or in-vehicle-times.

2.5.5 Weather conditions

Weather conditions (rainfall, snowfall and temperature) have emerged as an important issue in travel behaviour (Böcker et al. 2016), that can play a role in the demand for public transport and other travel modes (Guo et al. 2007). It is argued that weather conditions contribute up to 5% of travel time unreliability by affecting travel demand and supply (Zubir and Brebbia 2014). A study by one major bus operator group in Britain has suggested that weather conditions may affect passenger numbers. Like-for-like comparisons suggest little impact of temperature or sunshine, but heavy rainfall produces a reduction of about 3% in demand (Balcombe et al. 2004).

Transport users are exposed to direct physical impact from weather, both on their way to/from public transport as well as in the public transport vehicles. Rainfall and snowfall affect public transport demand for multiple reasons (Leard and Roth 2015). Krygsman et al. (2004) maintain that environmental conditions, for example, rainfall and wind affect accessibility to public transport, which is mostly done by walking or cycling. High temperature is another factor that would influence travel demand in some hot countries. Temperatures that are exceedingly high discourage passengers from using public transport, since rising (in-vehicle) temperatures may be associated with less travel comfort (Böcker et al. 2016).

However, rainfall and snowfall is not an issue in Saudi Arabia, given the fact that rainfall is low and completely absent in most of the months and snowfall

is almost lacking, except on higher grounds. Temperature is the factor that would be a major influence on the demand for public transport in Saudi Arabia (Alsalem 2016). A study by Law and Taylor (2001) in Los Angeles reported that placing shelters at transit stops as a weather protection would make waiting areas more comfortable and encourage transit ridership.

2.6 Changing People's Behaviour

All disciplines of social science offer theories and models of changing people's behaviour which help to define the types and contexts of behaviour change in which scholars are interested (Morris et al. 2012). (Bray 2008, p. 5) comments that "Behaviourism is a family of philosophies stating that behaviour is explained by external events, and that all things that organisms do, including actions, thoughts and feelings can be regarded as behaviours". The majority of public policies aim to shape and facilitate people's behaviour in a desirable manner (Dolan et al. 2012). Studies such as (Bray 2008; Morris et al. 2012) maintain that the production of a comprehensive review of theories of behaviour is not possible, but attempts have been made to isolate the key controlling factors and create a generalisable theory of human behaviour that ignore specific contexts.

Some research and theories focus on behaviour itself as agents of change, such as Disruptive Innovation Theories. Nevertheless, other research and theories on anthropological, geographical and sociological elements focus on behaviour as a result of complicated inter-relationships and shared social practice (Morris et al. 2012). Objects and environments are part of the production of behaviour and such theories rely heavily upon social thinking. The analysis of behaviour can also be viewed as highly political (Goodwin 2012), with such research reflecting the complexities and structures of the behaviour that it attempts to investigate (Shove 2010). Morris et al. (2012) state that individuals perform or reproduce behaviours from these perspectives, which are a result of relationships between the environment, people and the technology surrounding them. Morris et al. (2012) add that certain types of behaviour are easier to integrate with current theories of policy and policymaking than others.

Dolan et al. (2012) maintain that there are two ways of thinking about changing behaviour. The first way called the 'rational' or 'cognitive' model, which the most traditional interventions in public policy follow, being the standard model in economics. This way's presumption is based on influencing what people knowingly contemplate. For example, people analyse the various information and incentives and act in their best interests. The second way of thinking about behaviour change is called the 'context' model. Dolan et al. (2012) add that the context model focuses on the more automatic processes of judgment and influence, shift the focus of attention ahead of facts and information and towards changing the context within which people act.

2.7 Changing People's Travel Behaviour

At the end of the 20th century, and as a result of ongoing concern about improving mobility in urban areas and the increase of private car ownership, demands for implementing and developing transport policy measures towards more sustainable travel behaviour began to be proposed (Kitamura and Fujii 1998). The behaviour of travel is influenced by the service level standards of the transport system, which is not directly related to service level objectives, but influenced by psychological factors (Fujii and Kitamura 2003). Such factors include attitudes, habits and perceptions (Ajzen 1991; Fujii and Kitamura 2003). The mode of travel choice may therefore be changed by psychological factors, although the level of service quality is the same (Fujii and Kitamura 2003). In order to attract more users to the public transport system, it is important that psychological factors, which influence travel choice and measures needed to reduce dependency on cars, are understood.

Over the last ten years, two main theories have guided the psychological research that focuses upon understanding the process by which people's travel behaviour is modified to promote use of public transport instead of cars. These theories are the Theory of Planned Behaviour and the Norm-activation Theory, and are briefly described as follows:

2.7.1 Theory of planned behaviour

The theory of planned behaviour (TPB) is one of the commonly cited and applied behaviour theories and links beliefs and behaviour (Morris et al. 2012).

TPB is an extension of the Theory of Reasoned Action (TRA) which came into prominence in the 1970s (Ajzen and Fishbein 1977), and had an influence on theories related to travel behaviour (Koppelman and Lyon 1981; Garling et al. 1998). The successor to TRA was TPB, which is a theory of how intentions to perform behaviours are formed, and not a theory of discrete choice; it is also referred to as an expectancy value theory (Fishbein and Ajzen 1975). Its assumption is that an attitude towards behaviour is formed by considering the results of subjective probabilities, as well as the positive versus negative evaluations of all possible consequences of the behaviour.

Following this, a number of studies have proposed modification to TRA and TPB in an attempt to improve the predictive ability in specific contexts of the theory. In 1991, Ajzen considered all the modifications or additions and concluded that, “TPB in principle, is open to the inclusion of additional predictors if it can be shown that they capture a significant proportion of the variance in intention or behaviour after the theory’s current variables have been taken into account” (Ajzen 1991, p. 199).

TPB makes the assumption that should alternative behaviours exist, a choice is made based on relative merits (Bamberg et al. 2011). Discrete choice models differ in that intentions are determined by factors rather than attitudes towards the behaviours. The importance of situational constraints is emphasised in TPB; for example, when deciding whether to travel on a bus or in a car, people take into account their attitudes towards these two means of travel, as well as judging the difficulty of using them (Bamberg et al. 2011), which is referred to as perceived behavioural control. The authors add that another factor influencing intention is social norm; in TPB social norm is perceived as social pressure which will approve performance of the behaviour. Boschetti et al. (2014a) conclude that people will only change their behaviour if they have the opportunity, ability and motivation to do so.

An attitude is defined as a stable evaluative response (affective, cognitive or behavioural) to a particular object designated as the attitude object (Eagly and Chaiken 1993). An attitude object can be anything, intangible or tangible, which people prefer or keep in mind (Eagly and Chaiken 1993). According to Loukopoulos et al. (2005b, p. 6), using the car as an example, attitudes

towards car use comprise several components; including, “a cognitive component, reflecting knowledge of and reasoning about the positive and negative effects of car use (e.g. protection, status, congestion); an affective component, reflecting feelings towards car use; and a behavioural component, reflecting whether or not one intends to act in accord with his or her knowledge and feelings”.

2.7.2 Norm activation theory

The norm activation theory or model (NAM) developed in the 1970s attempts to explain pro-social behaviour (Schwartz 1977). It later developed into the Value Belief Norm (VBN) theory to take into account pro-environmental values, behaviour and attitudes (Stern 2000). As cited in (Han 2014, p. 463), according to Schwartz (1977), the norm activation theory that “poses three types of antecedents to predict pro-social behaviour include awareness of consequences, ascription of responsibility and personal norm”. The theory began with the awareness of action outcomes in which an individual would change the way he/she performs to prevent a harmful outcome (Cordano et al. 2011).

The idea that one is responsible for a type of behaviour that may cause harm to others often develops into feelings of guilt, which is a pro-social emotion as a result of an obligation which is felt to compensate for the damage that may be caused (Weiner 1995). Bamberg et al. (2011) assert that feelings of guilt and social norms inform people about what behavioural standards their social reference group views as being appropriate within a certain context. These norms become internalised and are referred to as personal norms.

A personal norm is defined as an obligation that is felt by the user to bring behaviour in line with internalised self-imposed standards (Biel and Thogersen 2007). Schwartz (1977) states that, personal norms result from the interplay of cognitive, emotional and social factors, with the awareness of a problem and perceived responsibility being cognitive preconditions for its development.

According to the norm activation theory, studies on travel behaviour argue that the use of cars depends upon evaluations of positive and negative outcomes for the use, and it depends more strongly on motives which are pro-social

(Garvill 1999; Nordlund and Garvill 2003). Garling et al. (2013) state that according to the norm activation theory, awareness of negative consequences of car use may make people change their travel behaviour. However, Beirão and Cabral (2007) consider that understanding the behaviour of travel and the reasons for choosing one mode of transport in favour of another, when different modes of transport are available, is important and complicated.

Tertoolen et al. (1998) note that when incompatibility between attitude (environmental awareness and behaviour, namely, car use) was mentioned to car drivers, the reaction was to change the attitude rather than change behaviour, for example, car use was not so adverse for the environment.

Accordingly, changing people's psychological factors may also change travel mode choice. Hence, to attract more users to the public transport system, it is imperative to know more about the psychological factors which have an effect on mode choice and the measures required to reduce car dependence (Prillwitz and Barr 2011). The authors add that one approach to increase that knowledge is through qualitative methods which can provide valuable insights into people's attitudes and perceptions towards transport.

Guiver (2007) conducted a study in the UK involving ten focus groups to discuss the various merits of car and bus travel and discovered that respondents used different criteria to evaluate each mode of transport. The study found that all groups viewed them differently depending on whether they were users or non-users. When referring to travel by bus, respondents focused on the worst-case scenarios, but these were not used to describe travel by car.

The users of cars, together with the perceived advantages and disadvantages of car use, were studied by Hagman (2003), revealing that advantages and disadvantages are presented differently. Perceived advantages such as flexibility, freedom and time savings are always personal, and as a result of personal experience, as are some of the disadvantages such as cost. Disadvantages relating to the negative impact upon the environment are usually presented with reference to public discussion and comment. However, respondents agreed that the use of cars should be reduced due to

environmental issues, yet they did not consider reducing their own car use. Semi-structured interviews were conducted by Gardner and Abraham (2007) in order to determine the reasons for driving to work. They identified five core motives including concerns about journey time, minimisation of effort, journey-based effect, concerns about personal space and monetary costs.

2.8 Travel Demand Management Strategies

Transport planners and policymakers around the world have realised the significance of changing individual travel behaviour from car use to a sustainable transport means, mostly in the form of public transport (Fujii and Taniguchi 2005). The conventional approach of 'predict and provide' for managing transport and traffic problems is no longer possible (Saleh and Sammer 2016). Saleh and Sammer (2016, p. 1) maintain that measures adopted to shift travellers from private car to other modes of transport should be accordingly changed "to 'predict and manage' or Travel Demand Management strategies".

The introduction and implementation of TDM strategies have been seen as a challenge many cities face around the world, especially in developing countries (Javid et al. 2013). TDM strategies or mobility management measures are a balance between demand and supply of traffic, and generally refer to reducing car use and encouraging other sustainable travel modes such as public transport (Garling et al. 2002; Loukopoulos et al. 2005b). TDM provides a sound, efficient transport measure that is expected to resolve transport and traffic problems (Tai et al. 2016). Litman (2003, p. 245) states that TDM is referred to as "a general term for strategies and programmes that encourage more efficient use of transport resources such as road and parking space, vehicle capacity, funding, energy, etc". It comprises, in general, an endeavour to change travel behaviour by communication, as well as aiming to manage transport and traffic systems (Fujii and Taniguchi 2005). TDM attempts to save energy, safety, improve air quality and reduce congestion in urban areas (Berman 2002). Saleh and Sammer (2016) state that TDM represents sets of strategies whose key objective is that of affecting people's travel behaviour by means of voluntary reduction or restricting private car use and ownership as well as providing travel alternatives.

TDM strategies introduced in the 1970s in the fields of urban and transport aimed to influence people's travel behaviour to restrain private vehicle use and encourage the use of other transport means (Ison and Rye 2008a; Grieco et al. 2012). Saleh and Sammer (2016) argue that such an extensive definition of TDM shows the historical development in TDM strategies from simply obliging people to reduce the use of their private cars through alternative modes of transport or by driving less often. More than a decade ago Taylor and Ampt (2003) argue that TDM strategies included any initiative having the objective of minimising the negative impacts of cars. This definition further indicates the wider evolutionary changes in policy procedures that have advanced from the 1960s, when attention focused on expanding infrastructure capacity to reduce traffic problems such as congestion, prevalent since the 1970s. At that time the focus was on improving the management of existing infrastructure; in the 1980s and onwards, strategies started to target changing travel behaviour (Bovy and Salomon 1998; Goodovitch 2016; Saleh and Sammer 2016). Rouphail (2008, p. 105) has summarised the objectives of TDM strategies in the following points:

- An overall reduction in demand for vehicular travel activities.
- A spatial shift in the current vehicular travel demand to less congested facilities.
- A temporal shift in the current vehicular travel demand to less congested periods of the day.
- A modal shift in the current vehicular travel demand to less polluting motorised or non-motorised alternatives.

TDM can be broadly be categorised as fiscal and non-fiscal (Saleh and Sammer 2016), hard and soft policy measures (Richter et al. 2009), coercive and non-coercive measures (Tertoolen et al. 1998) and push and pull measures (Garling and Fujii 2009).

Fiscal and non-fiscal measures include regulatory, pricing, planning or persuasive policies, and such policies endeavour to change travel temporal and spatial dimensions, mode choice and possibly even the decision to travel (Saleh and Sammer 2016).

Hard and soft transport policy measures refer to the older branches of TDM strategies (Grieco et al. 2012). Hard transport policy measures endeavour to change people's travel alternatives as an indirect consequence of pricing car use and physical changes in the city infrastructure (Garling et al. 2009; Grieco et al. 2012). However, it is argued that while hard measures may be necessary to bring about car use reduction, they are complicated to implement because of public opposition and political infeasibility (Jones and Sloman 2003; Garling and Schuitema 2007; Garling et al. 2009). It also argued that hard measures may not alone be successful in accomplishing car use reduction (Stopher 2004). As a result, interest has increased in soft measures which use techniques of information dissemination and persuasion to influence car users to switch voluntarily to sustainable travel modes (Rose and Ampt 2003; Taylor and Ampt 2003; Sloman and Jones 2007; Taniguchi et al. 2007; Taylor 2007; Garling and Fujii 2009). Soft transport policy measures are policy involvements, which aim at interfering directly in personal decision-making processes, in order to promote voluntary behavioural changes (Loukopoulos et al. 2005b; Bamberg et al. 2011; Meloni et al. 2012). Jones and Sloman (2003) and Taniguchi et al. (2007) state that the communicative measures pertaining to travel behaviour modification employed in mobility management are referred to as soft measures, or psychological and behavioural strategies.

Soft transport measures direct individuals to a review of their mobility approaches, as well as motivating them to attain a balance between various means of transport (Bamberg et al. 2011). The key idea is that the information and awareness about the consequences of car usage on personal and societal welfare are important for encouraging travel behaviour change (Meloni et al. 2012). In addition, Taylor (2007, p. 173) notes that "soft transport policy measures generally offer more of the carrot whereas in hard TDM measures the stick is perceived as more dominant". Cairns et al. (2004) and (Howarth and Ryley 2012) review classified soft transport policy measures into ten categories, including workplace travel plans, school travel plans, travel-awareness campaigns, personalised travel planning, public transport information marketing, car-sharing schemes, car clubs, teleworking, home shopping and teleconferencing.

Some studies support the belief that reduction in private car use can be accomplished by increasing the use of soft measures with the focus away from hard measures, including infrastructure or engineering changes and road space control (Anable et al. 2006; Howarth and Ryley 2012). Proponents of such strategies have pointed out that in one decade, national traffic levels have been reduced by up to 11% and in urban areas at peak hours by around 21% (Cairns et al. 2008). Howarth and Ryley (2012) maintain that soft measures which are intended for behavioural options focusing on reducing car use or promoting more sustainable car use have a high likelihood of encouraging the sustainability of transport. Overall, carrot and stick approaches that combine 'hard' and 'soft' TDM polices and measures are the way forward in reducing car use without facing strong public and political opposition (Thorpe et al. 2000; Garling and Schuitema 2007).

The Transit Cooperative Research Program conducted two interview studies in 1995 and 1998 aimed to explore strategies that can increase public transport ridership in America's cities. The studies targeted more than 50 public transport agency managers around the United States. Taylor et al. (2002) have placed the studies' results of TDM strategies into five major categories:

1. Strategies related to the current service: such as improving passenger facilities, adjusting the service routes and increasing the frequency.
2. Strategies related to pricing: such as a decrease in fare prices, special deals to reduce the cost of transit and discounts for students.
3. Strategies related to planning orientation: such as community based planning and strategic planning programmes.
4. Strategies related to awareness campaigns and marketing, such as creative and aggressive marketing to target specific groups.
5. Strategies related to service coordination, consolidation and market segmentation, such as integration of transport services provided by transport agencies and others such as universities transport services.

As illustrated in Table 2.4, Steg and Tertoolen (1999), Garling and Schuitema (2007) and Ison and Rye (2008b) identify four types of TDM measures that target different antecedents of travel demand, based on several postulations

of how behavioural changes may be drawn out: (1) physical change measures, (2) legal policies, (3) economic policies, and (4) information and education measures.

Table 2.4: TDM strategies

TDM Measure	Examples
Physical change measures	• Improving public transport • Improving infrastructure for walking and cycling • Park & ride schemes • Land use planning to encourage shorter travel times • Technical changes to make cars more energy efficient
Legal policies	• Prohibiting car traffic in city centres • Parking control • Reducing speed limits
Economic policies	• Taxation of cars and fuel • Road or congestion pricing • Kilometre charging • Reducing costs for public transport
Information and education measures	• Individualised marketing • Public-information campaigns • Giving feedback on consequences of behaviour • Social modelling

Source: Adapted from Garling and Schuitema (2007, p. 141), Steg (2003) and Ison and Rye (2008b).

In this section the main themes of the study are identified, namely: planning and physical changes, legal, economic, social and cultural and information and technological themes. These are consistent with the main themes emerging from the work of Steg and Tertoolen (1999), Garling and Schuitema (2007) and Ison and Rye (2008b). The following subsections give more details for each theme together with related strategies and worldwide examples.

2.8.1 Planning and physical changes

Planning and physical changes strategies are among the category of hard transport policy measures that focus on enhancing the relative appeal of alternative travel modes, such as improvement of infrastructure for public transport, improving accessibility for walking and cycling, removing parking places, or constructing speed ramps (Garling and Schuitema 2007, p. 141). The authors add that this type of TDM also indicates technical improvements which make cars more energy efficient, and the key postulation is that people will modify their car use in response to changes in physical settings. According to Wake (2016), strategies including prioritising public transport such as bus lane and park and ride schemes in Perth, Australia, resulted in a significant

increase in public transport ridership between 2000 and 2012. According to a study by The Victoria Transport Policy Institute (2014), a Transit Oriented Development (TOD) planning approach improving accessibility for walking and cycling and various other policies had significant cumulative effects which tripled Portland's public transport ridership between 1970 and 2002. In terms of the influence of walking distance, in California a research study by Cervero (1993) found that the propensity of passengers using public transport increased six times when the public transport stations and bus stop were situated within half a mile of their homes compared to a distance of more than three miles from public transport services. In Calgary, heavy investment in public transport infrastructure and improved space for accessibility attributed to a significant growth in public transport ridership between 1996 to 2013 (The Victoria Transport Policy Institute 2014).

2.8.2 Economic measures

Economic measures also involve hard transport measures that focus on making car use somewhat more costly compared to public transport, such as levying congestion or road pricing, parking charge, taxing fuels and cars and reducing costs for public transport. The key postulation is that people's travel choices are influenced by cost-benefit analyses of alternatives (Garling and Schuitema 2007). Shergold (2016) argues that lowering travel cost would maximise public transport ridership. Road pricing can be implemented as road tolls, congestion charge, cordon fees and Distance-based fees (VTPI, 2010).

Road pricing and congestion charging result in public dissatisfaction, especially at their commencement, when they have been implemented across several countries worldwide (Börjesson et al. 2012). For example, the United Kingdom, the United States, Singapore, and Sweden have implemented pricing policies to improve mobility and reduce negative environmental impacts (The Victoria Transport Policy Institute 2014). In Stockholm, Sweden, the national government introduced a congestion charge trial in 2006 as an effort to improve traffic efficiency and environmental quality (see Figure 2.1) (Eliasson et al. 2009). An analysis of the monitoring reports during and after the completed charge trial revealed that the scheme decreased the number of cars entering the zone by 22%, resulting in a 6% increase in public transport

ridership, improvement in congestion levels, more parking spaces and low pollution (Eliasson et al. 2009). Five years after the introduction of congestion charging in Stockholm, Börjesson et al. (2012) concluded that the substantial traffic reductions during the trial period were not at the same level over time. Increase in traffic could have been caused by the exemption of alternative fuel vehicles that was introduced in 2008. In London, measurable reductions in traffic and congestion after the introduction of the London Congestion Charge benefited public transport (see Figure 2.2) (Ison and Rye 2005; Banister 2008). Interestingly, a survey by Fiorio and Percoco (2007) in Trento, Italy, measured car users' willingness to switch to public transport and found that pricing car use had more influence on travellers than improving public transport speed.

Figure 2.1: ERP in operation indicates the toll is in effect in Stockholm.
Source: The Victoria Transport Policy Institute (2014)

Figure 2.2: The "C" symbol indicates the Congestion Pricing Area in London.
Source: The Victoria Transport Policy Institute (2014)

2.8.3 Legal measures

Legal measures are also a kind of hard transport policy measure that may be employed to reduce car use, such as prohibiting car traffic in city centres, reducing speed limits and introducing parking regulations. The postulation is that people will conform to these measures, as well as the hope that, in the longer term, legal policies will bring about changes in social norms (Garling and Schuitema 2007). A recent study from Bliss and Breen (2012) reported that legal strategies hoped to change social norms towards sustainability and increase road safety. Another study by Schlag and Teubel (1997) argues that prohibiting car traffic in city centres and congested locations, controlling parking and applying maximum parking regulations (Wake 2016) would be fairly effective but less acceptable compared with other legal measures.

2.8.4 Social and cultural policies and measures

Strategies related to social and cultural factors are deemed to be very important in influencing users to change travel behaviour to a more sustainable mode. These strategies include quality of service, security and privacy. Studies by Ison (2000) and Dell'Olio et al. (2011) examined the effectiveness of the quality and efficiency of public transport services in increasing the number of users. Their analysis showed that increases of public transport frequency, cleanliness and comfort were the most effective and acceptable strategies among the current and not current users of public transport. Another study by Andreassen (1995) states that different users evaluate the same service quality area differently, and their satisfaction will be affected by different service attributes.

Ison (2000); Balcombe et al. (2004); and Dell'Olio et al. (2011) found that high frequency of public transport, comfortable seats and cleanliness are highly effective and acceptable strategies to attract current and future public transport users. Surveys in cities throughout Europe state that developing safety and security measures across public transport facilities has raised passenger confidence to increase public transport use (Gaggi et al. 2013). Ison and Wall (2002) found that improved public transport and 'carrots' (incentives) such as safe walking and cycling routes are the most acceptable.

A study by Delbosc and Currie (2012) argued that even though the perception of the influence of safety measures on public transport ridership seems small, it affects more than household car ownership.

The strict gender segregation is an important aspect in Saudi society which is fully enforced by the country's rules and religious life (Ezzi et al. 2014; Alhazmi and Nyland 2015). Dunckel-Graglia and Brook (2013) describe separating women's carriages in public transport as a good idea to ensure their safety and modify their travel behaviour towards increased use of public transport.

As shown in Figure 2.3, another development in bus services is that buses with low floors are more common, which enable easier access to the elderly and disabled people and parents with young children, and wheelchair users (Balcombe et al. 2004). Other soft transport policy measures relate to altering car users' travel behaviour on a voluntary basis and motivating them to switch onto sustainable travel modes by, for example, implementing personalised travel plans and public transport marketing campaigns (Moser and Bamberg 2008; Richter et al. 2009; Bamberg et al. 2011).

Figure 2.3: Low floors and easier access for elderlies and disabled people.
Source: The Victoria Transport Policy Institute (2014)

2.8.5 Information and technology measures

Finally, information and technology policies are soft measures that focus on changing people's awareness, approaches, beliefs, values and personal norms in relation to car use, such as providing information about positive and negative aspects of car use, feedback about environmental impacts, social modelling and individualised marketing (Garling and Schuitema 2007). Early studies maintain that providers of public transport services should, for instance, provide clear and simple information for potential passengers

(Edvardsson 1998; Friman and Gärling 2001). A very recent use of the new technology development in London buses has been the introduction of a contactless or Oyster cards scheme and the rejection of cash to remove the delays associated with cash transactions (TfL 2014).

Measures that include providing specific information about public transport, travel campaigns and travel education are argued to be effective to shift people to use public transport (Fujii and Taniguchi 2005). Nevertheless, personalised communication is argued to be more effective for changing travel behaviour than non-personalised mass communications. Santos et al. (2010b) argue that information and education measures are necessary but not sufficient for travel behavioural change.

Soft measures employ systems of information dissemination and persuasion to prompt car users to switch voluntarily to sustainable travel means (Rose and Ampt 2003; Taylor and Ampt 2003; Sloman and Jones 2007; Taniguchi et al. 2007; Taylor 2007; Garling and Fujii 2009). These measures promote the reduction of single-occupancy car use and an increase in more benign and efficient alternatives by means of providing comprehensive travel information on public transport, using incentives and personalised feedback about travel behaviour, as well as marketing techniques which focus on personal travel behaviour (Taniguchi et al. 2007; Cairns et al. 2008). Bamberg et al. (2011) indicate that soft measures commonly employed to encourage more sustainable travel such as a workplace travel plan can be described as a set of soft measures put in place by an employer to discourage a single-occupancy car. School travel plans are also soft measures aiming to reduce the congestion caused by daily school trips by encouraging parents to use another sustainable alternative travel mode when they do their journey to school (Moser and Bamberg 2008). Personalised travel planning which encourages reduced car usage for all trip purposes include workplace travel plans, school travel plans, personalised travel planning, teleconferencing, home shopping, car-sharing schemes, car clubs, and marketing of public transport in terms of mass advertising campaigns, and travel-awareness campaigns (Moser and Bamberg 2008).

The study by Taylor et al. (2002) that explored 12 successful public transport systems in different places around the United States confirmed that public transport programmes targeting a high level of education, such as universities and colleges and employer-based programmes, are the most successful and effective strategies for their ridership growth. A study by Brown et al. (2001) of 35 university-based 'transit pass' schemes in America supports these conclusions, showing that these schemes were highly effective in increasing public transport ridership and reducing empty seats.

Nelson and Mulley (2013) conducted a comparative analysis of Intelligent Transport Systems policy in Europe and Australia. The study found that implementing a clear and accurate passenger information strategy using appropriate media would make public transport more attractive. Journeys would be simplified by using such methods as a smart ticketing system, mobile tickets app, journey planner app providing up-to-date information on public transport options and wireless internet. Grotenhuis et al. (2007, p. 28) state that "travel information is an important factor of public transport quality such as pre-trip, wayside and on-board information that helps people to plan and execute travel".

A number of programmes of Voluntary travel behaviour change (VTBC) have been implemented predominantly at an individual and community level through mass communication in different countries, particularly in Australia, the UK, Japan, Germany, and Austria among others (Richter et al. 2011). Brög and Ker (2009) refer to VTBC as one component of the eight management toolkit rather than a single 'silver bullet', and it is the face of demand management which is carried out without carrots (direct incentives), such as system improvements, or sticks (disincentives), for example, additional charges or regulations. Brög and Ker (2009) also indicate that, in the majority of cases, VTBC elicits awareness, improves availability of information and offers support for people to try alternatives to driving their cars, by operating through empowerment and motivation. VTBC represents a range of tools which work in the contexts of households, schools and the workplace; each context is a separate field of development (Brög and Ker 2009).

Marketing campaign programmes are increasingly used to encourage sustainable behaviour and include initiatives on energy saving, recycling, green products, and active trip campaigns among others directed at travel behaviour change (Meloni et al. 2012). Personalised communication is perceived as being more effective than social marketing (Fujii and Taniguchi 2006). Programmes which utilise personalised information and communication are referred to as personalised travel planning, aimed at providing individuals with travel-related information based specifically on their daily travel needs (Meloni et al. 2012).

2.9 Successful Examples of Adopting TDM Strategies

Following the review of the procedures and approaches used by developed and developing countries in shifting people's travel modes towards sustainable transport modes, this section of the research explores some promising real experiences from different parts of the world. Thus, consideration is given to some successful examples of increasing public transport ridership using different TDM strategies and incentives in some US cities and other parts of the world, such as in Canada, Australia and Europe.

For example, Buehler and Pucher (2012) analysis of public transport demand in Germany and America found that the decline in North American cities' public transport ridership followed by a notable increase in the mid-1970s was a result of the considerable expansion and improvement of public transport services. The study also shows that Germans are five times as likely as Americans to use public transport. The study concludes that the success of German public transport is due to a coordinated package of TDM strategies including a high quality of public transport services, convenient ticketing systems, attractive fares, full multimodal and regional integration, taxation and restriction of car use, and land use management.

According to The Victoria Transport Policy Institute (2014), the Portland region and Tallahassee, Florida became a national model for public transport due to its successful implementation of a number of TDM strategies. According to Ellis et al. (2005) and The Victoria Transport Policy Institute (2014), Portland's public transport ridership tripled between 1970 and 2002 due to a TOD

planning approach, improved accessibility for walking and cycling and various other pro-transit policies. Tallahassee city is another a successful case of increasing its public transport ridership by 11.7% in two years. The city has implemented a package of strategies that mainly include improved public transport services, partnerships with universities and state government (special passes), and marketing campaigns.

In New York City, in 1998 public transport ridership rose by 30% between 1997 and 1998 after introducing a smart card system called MetroCard that offers integrations between different public transport modes, companies and also other discounted payment options. The Seattle Department of Transportation (2008) conducted a study to discover the best TDM strategies to shift people from private car to other modes, mostly public transport. The study data was based on the lessons learned from the experience of other US and European cities. The city's study identified a number of hard and soft measures to support public transport ridership; however, it was primarily focused on external strategies which require much effort beyond the transit agency or the system itself.

Moving north of America, some Canadian cities such as "Vancouver Montreal, Toronto and Calgary" have provided bold examples in terms of boosting public transport success and increasing its share among other travel modes. In Vancouver TDM strategies have contributed to gaining a significant rise in public transport use by almost 25% between 2002 and 2004 (Litman 2015b). In Calgary, public transport ridership increased dramatically between 1996 and 2013 (The Victoria Transport Policy Institute 2014). According to Freemark (2014) TDM strategies have impressively boosted public transport success in Calgary. These schemes include new development in public transport systems, strict parking policies, restricting automobile access to congested areas, managing parking spaces, park and ride schemes and managing urban form through policies. Case studies by Cao et al. (2016) summarised Chicago and Ottawa experiences in the success of shifting trips from personal vehicles to public transport. The report concluded with the latest knowledge of 11 common TDM strategies adopted by both cities which are "public transport reliability and frequency, improved bus routing and coverage,

public transport fares, park and ride schemes, parking charges, parking management and supply, road pricing, land use and site design, TOD, walking and cycling infrastructures, employer and institutional TDM strategies".

Moving to another continent, Perth, Australia, which is similar to Riyadh City in the case of a sprawling and car-oriented city with a size of 80 km by 100 km. However, according to Wake (2016) the city is a successful example of increasing public transport ridership by 39% between 2000 and 2012 due to implementing TDM strategies. Policies used include prioritising public transport such as providing bus lanes, and park and ride schemes, applying parking policies such as controlled parking in the central business district and applying maximum parking regulations.

In Asia, five major Asian cities (Seoul, Tokyo, Hong Kong, Singapore, and Shanghai) provide successful examples of the implementation of TDM strategies; all have shown a reduction in car use and changes in travel time and route (Cheong and Nadiah 2013). Those strategies are characterised by developing high-quality public transport, integrating land use and transport planning, facilitating pedestrian-oriented development and restricting private car usage in urban areas. In Singapore, a congestion charge was a successful experience that optimises traffic flow, while in Shanghai controls on car growth optimises the use of existing road infrastructure. Tokyo restrained vehicle growth by adopting a unique set of parking policies such as minimum parking requirements that exempt small buildings with limited on-street parking available (Barter 2010; Cheong and Nadiah 2013).

A report by The Transit Cooperative Research Program (2007) has considered the experiences of 17 cities in Europe and other places to summarise the most successful TDM strategies for encouraging public transport ridership. The report labelled strategies as internal and external strategies. In terms of internal strategies, public transport features such as comfort, reliability and convenience were effective strategies. External strategies included in the study summery related to measures to decrease private car attractiveness such as parking limitations, high fuel prices and implementing policies in regard to urban planning.

The Seattle Department of Transportation (2008) conducted a study aimed to explore the best TDM strategies to shift travellers from private car to other modes, mostly public transport. The study was based on the lessons learned from the experience of other US and European cities. As shown in Table 2.5 the study summary and explained those strategies along with other examples of the best strategies adopted elsewhere in the world.

Table 2.5: Successful examples of TDM strategies to shift travellers from car to public transport

Strategy	Explanation	Region
Improve access to and from public transport services	Improve infrastructure for walking especially around public transport stations and bus stops.	New York city, Portland and Denver
Park & Ride scheme	Provides parking spaces at a location generally a little distance away from city centre areas, with access to public transport system.	Seattle
Road space allocation and the Complete Streets concept	Develop bus lane and reassigning a separate way to accommodate all users (cyclists, pedestrians and transit users).	New York City
Transit priority treatments	Travel management to optimise public transport frequency with the least possible negative impacts on other road users.	Ottawa, Richmond and Cleveland
Reduce fares and offer discounts	Such as discounts for family, students, special needs, and seniors.	
Land use management and transport land use linkages	Strict land use policies to support transport policies such as priorities for cycling, walking and transport.	Vancouver
Congestion charge	Economic incentives to reduce car attractiveness.	Singapore, London, and Stockholm
Parking charges and Road pricing	Increase private vehicle using cost such as parking charges and congestion charge.	San Francisco and Seattle
Parking management policies	More control for car parks such as waive the minimum parking requirement, parking cash-out, decrease public parking in residents' areas, and limited in duration and increase the cost of on-street parking.	Freiburg city, San Francisco and Seattle
Public transport pass programmes in coordination with employers and education such as universities	Open access to public transport provided through cooperation with residential neighbourhood, developers, employers and universities.	U-PASS for the University of Washington, Seattle; and Eco-Pass for employers and neighbourhood associations, Denver
Information and new technology services	Use new technology to provide passengers with services information and improve travel time such as multi-use contactless smart cards and mobile phone transit passes.	Los Angeles and San Francisco
Employers parking cash-out	Encouraging employees to stop commuting to work place by private car when they have a choice to get cash or bonus to give up their subsidised parking space.	State of California

Note: Adapted from Seattle Department of Transportation (2008)

2.10 Summary

The chapter gave an inclusive view of academic research, government studies and real-life examples of different cities worldwide to elicit the most effective TDM strategies to ensure the success of Riyadh's new public transport system.

This chapter explore the literature to identify a number of factors which influence the demand for public transport, including: demographic and social factors, cost of travel, fares, travel time, service quality, reliability, comfort, travel distance, economic factors, and weather conditions. These challenges, both the general and the specific, can lead to a fear of failure when introducing public transport.

This chapter concludes that the conventional approach of predict and provide for managing traffic congestion is an obsolete concept and should be replaced by predict and manage or TDM strategies include hard and soft transport policy measures.

Finally, the literature reviewed in this chapter were valuable sources for formulating and designing the research practical stages of the general public survey and the semi-structured interviews.

CHAPTER THREE: BACKGROUND OF STUDY AREA

3.1 Introduction

This chapter provides a profile of Saudi Arabia with special reference to Riyadh City. It presents the geographical and socio-economic background of the study area to furnish the research with essential data for analysis. In addition, it provides a general discussion and review of both the current situation and proposed plans for public transport in the city with a focus on sustainable practice. It describes the city region and provides a history of Riyadh's metropolitan strategic plans that have contributed extensively to automobile dependence and dispersed urban form, leaving the transit system lagging behind. Finally, this chapter demonstrates the need for an adequate urban public transport system in Riyadh City.

3.2 General Background

The Kingdom of Saudi Arabia is a country situated in Southwest Asia. It is the largest country in the Arabian Peninsula with a population exceeding 31 million and a land area of more than 2.15 million km^2 (ADA 2015b). From east to west it covers a distance of about 1,500 km, and 1,900 km from north to south (Ashwan 1990). It shares borders with Jordan, Iraq and Kuwait in the north, Yemen in the south, Oman, Qatar, the United Arab Emirates and the Arabian Gulf in the east, and the Red Sea and the Gulf of Aqaba in the west (Figure 3.1). Saudi Arabia is divided into five regions and these in turn are divided into districts and sub-districts. Riyadh, the state capital, is located in the central region. In the north and east there are several oases with a sedentary agricultural population. The western region includes Hijaz. It has some of the most important cities in the country, including Mecca and Medina, the two most sacred towns in the Muslim world (Ashwan 1990).

The geographical focus of this study is on the capital city of Saudi Arabia, Riyadh City. In an effort to guide the urban development and growth of Riyadh City, the first master plan for the city was approved by the Council of Ministers in 1972, prepared by Doxiadis Associates, a Greek consulting firm, who had designed a comprehensive master plan (Alqahtany 2014). The Doxiadis master plan divided Riyadh City into a number of districts, each with a total

area of 4 km^2. Also, in the plan, the car was considered the primary means of movement within the city and a comprehensive road network was designed (Al-Ahmadi et al. 2009). However, most studies indicated that the Doxiadis plan was more a technical document rather than a realistic program (Alqahtany 2014). The plan failed to address the expansion of the city due to unexpected growth in the population and expansion in urban areas that exceeded the proposed plan (Mubarak 2004).

The Ministry of Municipal and Rural Affairs decided to improve on the Doxiadis scheme, and in the early 1980s, the existing master plan was revised by another consulting firm, SCET International, in order to accommodate this enormous urban revolution up to the year 1992 (Alqahtany 2014). Rapid urban development in Riyadh continued during the 1990s and the beginning of the 21st century due to the increase in the country's economic growth (Alqahtany 2014). As a result of the expiry of the SCET scheme at the end of the 1990s, the Ministry of Municipal and Rural Affairs developed a new strategy known as the Metropolitan Development Strategy for Ar Riyadh (MEDSTAR) for managing the city's development over the next 50 years (Al-Ahmadi et al. 2009).

Figure 3.1: Map of the Kingdom of Saudi Arabia,
Source: GraphicMaps.com

3.3 Population Growth in Riyadh City

The increase in population is still the most prominent aspect of Riyadh City and is responsible for the growth of other sectors (Aldalbahi and Walker 2015). The most important feature of this growth is that the rate of increase has never been less than 4.5%, which is high compared to similar cities. In the 1980s, 1990s and the early decade of the recent century that rate increased to 16%. The other feature of Riyadh's population growth is characterised by qualitative elements in the standard of living of residents (Aldalbahi and Walker 2015). According to The General Authority of Statistics (2016) the population of the city grew from approximately 100,000 people in the early 1950s to

approximately 6,125,180 people at present, and forecasted to reach 10 million by 2020, including 50 different cultures, languages and interests (Al-Hathloul 2017). A total of 43.3% of the population are females, 37.3% are expatriates, and the population density is 2,379 inhabitants per square kilometre (ADA 2015b). Currently, the spatial area of Riyadh City is almost 3,000 km^2 with a 40-mile span, and includes 13 municipalities that accommodate 209 districts (ADA 2016). This development is driven by high rates of economic growth which attract migration from within Saudi Arabia and from foreign countries. The city is expected to continue growing at the same rate in the foreseeable future (Al-Dubikhi 2007).

Table 3.1: Population distribution in Riyadh City

Gender	Number	Grand Total	(%)
	Saudis		
Males	2,166,035	3,840,487	56.4
Females	1,674,451		43.6
	Non-Saudis		
Males	1,576,437	2,284,692	69
Females	708,254		31
	Total		
Males	3,613,856	6,125,180	59
Females	2,511,323		41
The total country population		32,709,112	

Source: ADA (2016)

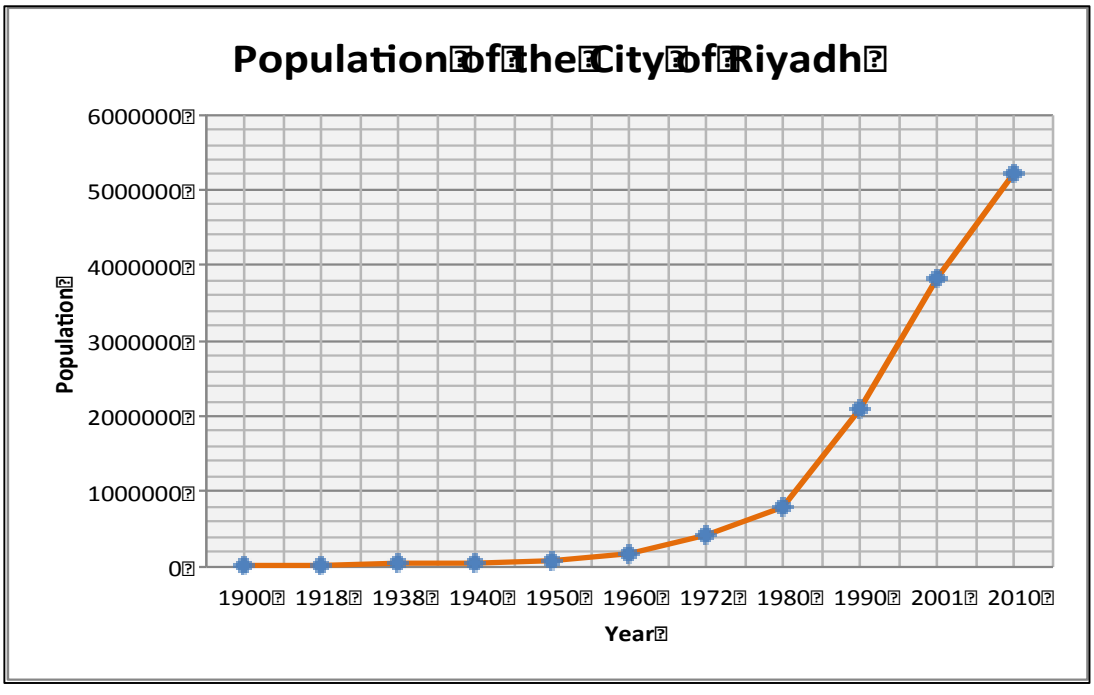


Figure 3.2: The growth of population in Riyadh City.
Source: Alqahtany (2014)

3.4 The Metropolitan Development Strategy for Riyadh Region

MEDSTAR regulates the future development of Riyadh City and factors affecting metropolitan development (ADA 2015b). The strategy's implementation plan provided a regulatory, structural, planning and executive framework for all authorities working in the city (ADA 2015b). As regards transport in Riyadh City, MEDSTAR has identified six key transport strategies, including the following (ADA 2009, p. 1):

1. The need to develop effective public transport in the city;
2. Progressive introduction of demand management measures including road pricing and congestion charging;
3. The alignment of higher density residential and commercial development along major public transport spines;
4. The development of the ring road system to take the pressure off congested central arterial roads;
5. Improving traffic management practices; and
6. Development of an integrated corridor management programme to upgrade major corridors in the city to ensure that they serve the proposed public transport network and qualify them for advanced traffic management schemes (ADA 2009, p. 1).

These achievements are substantial and have involved good coordination between the ADA, the Police, the Ministry of Transport and others. Following up the MEDSTAR strategies, authorities in Riyadh City have commissioned the construction of a public transport system comprising a network of six metro lines linked with a bus network in an effort to reduce car dependency and integrate the majority of the city's districts. The full project is expected to be operational by 2018 (ADA 2015b).

3.5 Urban Administrations in Saudi Arabia

Several different government bodies are responsible for urban administration in Saudi Arabia. They include the Ministries (at national level) and their regional and local authorities.

3.5.1 Ministry of Municipalities and Rural Affairs

The MOMRA has an important role in Saudi Arabia as the body responsible for physical development in urban and rural areas including providing the necessary roads and infrastructure (MOMRA 2011). MOMRA has various departments and there are 243 municipalities in the country, each regulating its designated region while ensuring compliance with MOMRA's outline for the Kingdom's cities, rural areas, streets and construction designs. It also carries out studies relating to Saudi Arabia urban planning and Development (MOMRA 2011, p. 178).

3.5.2 Riyadh Development Authority

Ar Riyadh Development Authority (ADA), the high commission's executive, technical and administrative arm, was established in 1983. ADA duties include developing and improving Riyadh City main aspects such as urban plan, economic activities, environment management and social and cultural development and providing the city with the necessary public services and utilities. ADA also carry out the strategic urban studies, organise and follow up on urban development programmes carried out by government bodies (ADA 2015b).

3.5.3 Ministry of Transport

The Ministry of transport (MOT) was stablished in 1953 to be responsible for building, maintain and operate roads and bridges in and between major cities and villages. To introduce and publish statistical data relating to transport modes (Ministry of Transport 2011). MOT's has other responsibly such as conducting feasibility studies relating to road networks linking Saudi cities. These studies have been prepared by private consultants, but due to lack of population data, the absence of land use data, and traffic volume and travel pattern studies, these studies have been based on assumptions which has led to deficiencies in their outcomes (Ministry of Transport 2011).

3.5.4 The Public Transport Authority

The Public Transport Authority (PTA) is a new national authority established by a cabinet decree in October 2012. PTA is responsible for the design, construction and operation of all public transport systems in Saudi Arabia. It

also aims to organise public transport services (train, metro and bus) for passengers within cities and between cities, supervising and providing them at a good level and appropriate cost, and encouraging investment in accordance with the objectives of economic and social development in the Kingdom.

3.5.5 The General Administration for Traffic

The General Administration for Traffic (GAT) is the national department responsible for the operation, control and management of traffic in Saudi cities (GAT 2016). The GAT is located in Riyadh and has regional offices in each capital of the 13 administrative regions in the country (Ministry of Interior 2015).

GAT is in charge of preparing traffic plans and traffic management in case of accidents and operating traffic wardens (GAT 2016). GAT responsibilities include investigating and surveying traffic accidents. The traffic engineering unit in the traffic department is responsible for technical works relating to roads and vehicles. This unit's tasks include: coordination with other governmental bodies in relation to traffic engineering, i.e. municipalities, installation and maintaining traffic signs, and proposing and supervising the installation, operation, and maintenance of traffic lights (Ministry of Interior 2015).

3.6 Urban Transport in Riyadh City

3.6.1 Car ownership history and challenges

Despite the low rate of population growth in Riyadh City during the 1940s and 1950s, the first automobile road was built in Riyadh in the late 1940s, and in 1951 a railway station was constructed to the east of the city and an airport was built to the north in 1952 (Al-Hathloul 2002, p. 1). Since the late 1950s, Riyadh has been a car-dominated city (Aldalbahi and Walker 2016). Between 1996 and 2008, private vehicle ownership has increased by 185.9% which accommodates about 85% of 8 million daily trips, whereas just 2% of the trips are undertaken by buses (Al-Fouzan 2012; Alqahtani et al. 2012). In 2015, the car ownership rate in Riyadh was 1.7 cars per individual which is notably high compared to other countries (Alsalem 2016). Saeed (2000) maintains that there were limitations in the early stages of Riyadh master plans such as the

Doxiadis and SCET schemes, in which the public transport system was neglected, with serious consequences for city planning today. For example, the amount of traffic on the middle part of two of the most central routes, King Fahad Road from north to south and Khurais Road from east to west of the city, which were adopted within the Doxiadis master plan in the 1970s, has exceeded 320 thousand vehicles per day, exceeding its normal capacity of 160 thousand vehicles per day (Al-Manie 2001).

Additionally, in Saudi Arabia, fatal car accident rates are the highest in the world with more than 7,000 deaths each year (the figure represents deaths on site only and does not include those who die in the hospitals later on) resulting in losses exceeding $5.3 billion (General Department of Traffic 2015; Global Mass Transit 2015). It also estimated the average annual cost of traffic congestion to be $7 billion and the annual cost of environmental pollution $1.35 billion (Alsalem 2016).

The vast majority of Riyadh society have never used public transport and have built their way of life around their cars (Al-Dubikhi 2007; Alqahtani et al. 2012). Al-Fouzan (2012) reports that the lifestyle of Saudi families has been shaped by economic factors and urbanisation, including higher family income and the spreading of the cities. It is important to highlight that under the traffic and road regulations, women are banned from driving in cities (Al-Dubikhi 2007). Also, individuals under the age of 18 years are not allowed to drive; this segment of society represents 50% of Riyadh's population and in addition the majority of expatriates are not allowed to own cars. As a result, 70% of Riyadh's population are non-drivers (Al-Dubikhi 2007). All these three segments of the city's society heavily rely on privately owned hire cars with a chauffeur or taxis to meet their daily transport needs (Aldalbahi and Walker 2015).

3.6.2 Current public transport in Riyadh

The current poor public transport system in Riyadh City involves buses run by the Saudi Public Transport Company (SAPTCO) and privately owned 25-seat minibuses (Al-Fouzan 2012). SAPTCO started operations in 1979 with the aim to provide high-level bus services locally and across countries such as Jordan, Syria, Turkey and the Arab Gulf countries. Soon after its establishment

SAPTCO faced intense competition from privately owned minibus operators (AlGadhi 1994). Between 1982 and 1992, SAPTCOS's annual ridership and coverage decreased from 35 million passengers and 22 routes down to 6.1 million passengers and only 13 routes, respectively. Its market share in 1992 was 47% with the remaining proportion serviced by privately owned minibuses. Less than 9% of SAPTCO's users were women while it is worth noting that private minibuses do not allow women on board (AlGadhi 1994; Al-Fouzan 2012). As a result, the shortage in passenger numbers forced SAPTCO to decrease the number of intercity routes and limit the service to high-demand routes using private minibuses. As a consequence, many areas lost public transport service. Most importantly, subsidies of SAPTCO services were terminated in 1992, and the lack of coordination between SAPTCO and private minibus operators led to an overall decline of public transport in Riyadh, which has finally emerged as a travel option only for blue-collar non-Saudi workers (Al-Fouzan 2012). Currently, SAPTCO and some 30-year-old private minibuses provide irregular, limited coverage and poor-quality public transport services (Al-Fouzan 2012; Alqahtani et al. 2012).

In an effort to alleviate its difficulties SAPTCO embarked upon active Special Contracts services programmes by which buses with their drivers are contracted or rented out to customers. Their customers included government, schools, and private companies and organisations. Out of the 440 of SAPTCO’s buses that are allocated to the city of Riyadh, 315 of them were used for this programme – that is 71% of the total. The programme was on the increase, as it was found to be very profitable and the profits were being used to support the intra-city services. In an attempt to support the policy shift towards public transport, SAPTCO has redefined its goals and objectives, and due to its new strategy, SAPTCO designed and constructed integrated multi-modal public transport infrastructure and coordinated service timetables to provide interconnectivity across these transport modes (Global Mass Transit 2015).

3.7 Challenges Impeding the Development of Public Transport in Saudi Arabia

As mentioned early in Chapter two, (American Public Transportation Association 2010), poor planning such as poor locations of stations and lines, financial reasons such as high operating cost, and a general preference for private vehicles are the common challenges facing public transport systems.

In the case of Riyadh, in addition to the previous common worldwide challenges, according to some studies such as (Al-Dubikhi 2007), (Global Mass Transit 2015) and (Aldalbahi and Walker 2015) some unique challenges would face public transport success in Riyadh City. In the entire country of Saudi Arabia and particularly in Riyadh City, the conservative society desiring privacy is seen as a challenge facing public transport ridership.

Traditions and cultural norms are another special challenge for public transport. Although academic studies that show a connection between culture and use of public transport are scarce, there is evidence that points to at least an indirect connection. Many anthropologists confirm that personality is partly obtained through culture. Triandis and Suh (2002), for example, state that culture has an impact on personality development. Personality has been proven to be an important factor in terms of people's choices in using public transit (Bamberg et al. 2007). Consequently, culture is very likely to affect public transport use.

As shown in Table 3.2, Global Mass Transit (2015) reported a list of key challenges as regulatory, economic, and social aspects that would impede the feasibility of a successful public transport system in Saudi Arabia cities.

Table 3.2: Challenges impeding the development of public transport in KSA

Regulatory	Economic	Social and Cultural
Lack of appropriate policies and legislation to regulate services and facilitate shifting demand from private transport modes to public transport	The low financial attractiveness of the public transport sector deters private investors	Lack of awareness on the benefits of public transport
Differences in priorities of executive and legislative authorities responsible for setting up public transport infrastructure and administration	Easy accessibility to car ownership in relation to personal income, leading to a high ownership rate compared with other countries	High preference for privacy (especially for women) in sharing rides makes public transport socially unacceptable
Absence of special infrastructure provisions for public transport (such as dedicated bus/tram corridors or bus priority at traffic signals), especially in cities with a high density of private vehicles.	Low population densities in the Saudi cities due to horizontal expansion, results in a low load and lower revenue for public transport service.	The social status associated with car ownership.
	Low fuel prices (fuel is cheaper than bottled water) make operation of private automobiles very affordable.	

Source: Global Mass Transit (2015)

The World Bank (2011) reports that international literature on gender and transport explains inequalities between men and women with respect to accessing transport. The reports identify three key interconnected variables that adversely impact women. The first are gender-neutral norms of planning and policymaking for the transport sector, which fail to differentiate between women's and men's needs. The second is a patriarchal social system and its impact on power relations and division of labour between men and women, and materialisations on their different roles and needs. The third factor is poverty and its effects on women's access to and control of resources, which limits women's options, both with respect to having means of transport or paying for public means of transport. However, in the Saudi Arabian context, there are also demographic issues corresponding to high average household size (Abdul Salam 2013), and the ban prohibiting women from driving in cities (Al-Dubikhi 2007). All women and young children rely on males, private drivers or taxis to meet their daily transport needs including travel for education, jobs, shopping trips or other social life (Aldalbahi and Walker 2015). In Cairo, for religious reasons, metro and bus systems allocate private carriages for women or families in accordance with the Islamic Shari'ah (Islamic Law). Qureshi and Lu (2007) found that in Karachi, Pakistan, a country enforcing Islamic Shari'ah,

women have some freedom to travel; only 8% of 200 women using public transport reported resistance by male members of the family to travel as a reason for not travelling. However, allocating women-only carriages has been introduced by other countries, though not for religious reasons. For example, this practice has been introduced in Japan as a result of incidents where women were harassed by men and in response to the extensive groping (referred to in Japan as 'chikan') by men (Horii and Burgess 2012).

Indonesia is another example where women-only carriages have been introduced. This approach was used to protect women against harassment, given that segregation between men and women is rare, except in mosques and religious schools (Dunckel-Graglia and Brook 2013). Government officials, however, indicate that it is not mandatory for women to ride in other carriages, as they are free to ride with men in other carriages if they want to do so (Dunckel-Graglia and Brook 2013).

3.8 Riyadh's New Public Transport

As reported in ADA (2015b), in 24th April 2012, a Cabinet Resolution was issued by the General Secretariat, the Ministerial Council, to approve a project for public transport in Riyadh City (metro and buses) in accordance with studies prepared by ADA. A Committee was set up headed by HRH the Governor of Riyadh, the President of the High Commission for the Development of Riyadh, and the following members: Minister of Municipal and Rural Affairs, Minister of Transport and Minister of Finance. Specialised and qualified global companies with world-class technical experience were invited to participate in the project. Four consortia of international specialised companies were approved based on their demonstrated technical and financial competence in the process of implementation of the project (ADA 2014b). It was proposed that the supervisory committee responsible for implementation of the public transport project would grant the metro project to more than one consortium due to the scale and complexity of the project (ADA 2012, 2015b).

As shown in Figure 3.3, the new public transport in Riyadh (King Abdul-Aziz public transport project) that is currently under development will be the

backbone of the city's public transport and includes metro lines integrated with bus networks. Since the ground-breaking ceremony for the Riyadh metro on April 2014, 45% of the project has been completed and the entire project is expected to be in operation by 2018 (ADA 2015b). The total cost of Riyadh's metro scheme is $28 billion (Salter 2016), and it is fully financed by the Saudi Public Investment Fund (ADA 2015b). The project operation and service improvement will be handled in cooperation between ADA and PTA (ADA 2012, 2015b). The following sub-sections give more details of the Riyadh new public transport project.

3.8.1 Riyadh's new Metro system

The Riyadh metro system planned to provide an attractive level of service, encouraging inhabitants to use public transport services instead of their private cars (ADA 2015b); the overall design process aims to ensure that all trips should provide a fast and enjoyable experience from door-to-door.

Six main axes of metro lines have been selected with a total length of 176 km, comprising 85 stations, which cover most densely populated areas, and government agencies, as well as commercial, educational, health and activity areas (ADA 2014b). These axes and stations are linked to King Khalid International Airport, King Abdullah Financial District, major universities, the city centre and the centre of public transport. The six Riyadh metro tracks are distributed among the following:

- The first track (Blue Line): Bath-Ha'ir axis (38 km);
- The second track (Red Line): King Abdullah Road (25.3 km);
- The third track (Orange Line): Medina-Prince Saad bin Abdul-Rahman (40.7 km);
- The fourth track (Yellow Line): King Khalid International Airport Road (29.6 km).
- The fifth track (Green Line): King Abdul-Aziz Road (12.9 km);
- The sixth track (Purple Line): Abdul Rahman bin Auf Road-Sheikh Hassan bin Ali bin Hussein Road (30 km) (ADA 2014b).

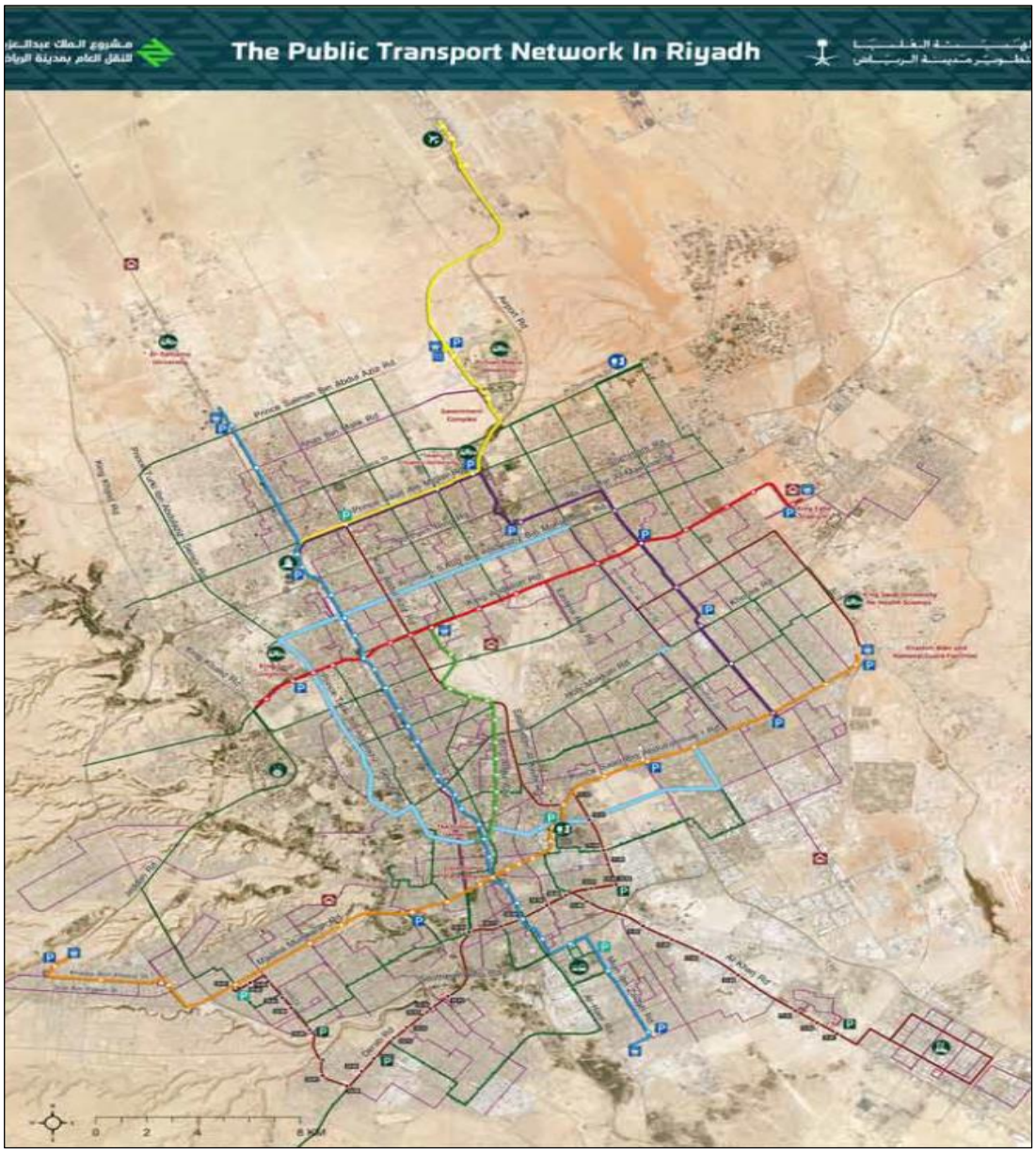


Figure 3.3: The public transport network in Riyadh City.
Source: ADA (2015b).

3.8.1.1 Metro design and specifications

The metro network is designed using state-of-the-art technology, operating an automatic metro system (driverless) from control operation rooms equipped to high specifications and with capabilities to follow up operations with high accuracy (ADA 2014b). The Riyadh's metro maximum design speed is 90 km/h and maximum operational speed will be 80 km/h (Salter 2016).

The carriage specifications also included state-of-the-art technology. The carriages can be separated from inside to accommodate various categories for services and provide carriages for families. The carriages also provide passengers with facilities for communication, and the transfer and exchange of information. A unified train design was also prepared (see an example in Figure 3.4), and all organisations implementing the systems were asked to comply with this to give a hallmark for Riyadh trains. The organisations involved confirmed their compliance to adopt this unified design (ADA 2015b).

Figure 3.4: An example of Riyadh's Metro design.

Source: Metro Report International by Salter (2016).

3.8.1.2 Metro stations

The Riyadh metro system consists of four main stations at the intersection of train tracks. These main terminals represent the most important factors for the success of the public transport system in Riyadh City as well as the key factor for attracting passengers, given that they are situated in high-density areas and at the intersection of train tracks and buses (ADA 2015b). This means that these main stations provide a variety of support services for the public transport system, such as provision of public parking areas and outlets for ticket sales, shops and customer service offices. These stations are also considered as an addition to Riyadh's public transport system and to have the

ability to improve the urban environment within the city. The project also includes five stations to transfer between the different train tracks and to integrate with the bus network to facilitate the movement of passengers within the various levels of public transport network in Riyadh City. The four main stations of Riyadh metro include the following:

1. The Qasr Al-Hukm district station, situated at the convergence of train track No. 1 (Al-Ulya-Batha) and train track No. 3 (through the Medina-Prince Saad Bin Abdul Rahman the First road, occupying an area of 19,600 m2).
2. Al-Olaya metro station serving as an interchange between line 1 (axis of Al-Olaya - Al-Batha Roads) and line two (axis of King Abdullah Road); the station features a public plaza, large entrance hall and open concourse, occupying an area of 11,000 m2.
3. King Abdullah Financial District (KAFD) metro station, situated on King Fahd Road on the eastern side of King Abdullah Financial Centre, occupying an area of 8,150 m2. It meets three train tracks: train track No. 1, train track No. 4 (King Khalid International Airport Axis) and train track No. 6 (Abdul Rahman bin Auf Street – Sheikh Hassan bin Hussein bin Ali Road Axis), and will be linked to the station by a monorail train of King Abdullah Financial Centre.
4. The western metro station, occupying an area of 12,500 m2 in the Central Vegetable Market at the Western Al-Suwaidi District, joining train track No. 3, with a dedicated bus line in Sheikh Mohammad bin Abdul-Latif Street. This station comprises one train stop and one bus stop, in addition to a car park accommodating 1,000 cars (ADA 2014b).

3.8.2 Riyadh new bus network

The plan includes the establishment of an integrated bus network that spans all parts of Riyadh City, complementary to the metro via common networks to create a comprehensive integrated public transport system, which will make a drastic change in the lifestyle of the capital city (ADA 2015b). The ADA report maintains that Riyadh Bus will be operating a total of 1,000 buses of different types and capacities. The bus network comprises 24 lines with a total length of 1,150 km and 6,730 bus stops/stations (ADA 2014b).

According to the design, as shown in Figure 3.5, Riyadh bus service has four levels of networks include axial network, supporting circle network, secondary arterial network and local network. Figure 3.6 shows also the planned main bus stops design.

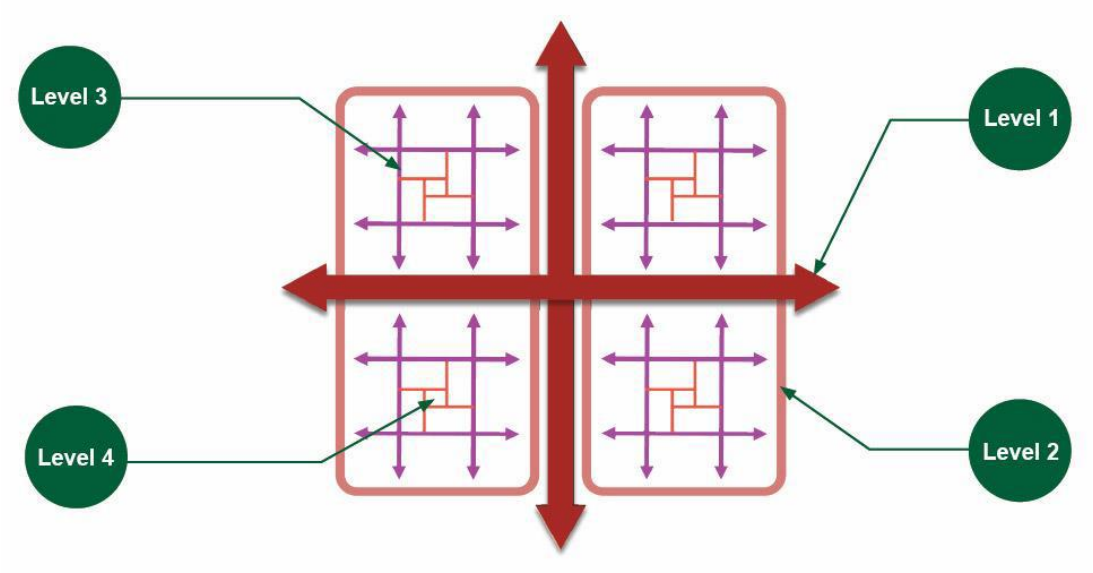


Figure 3.5: Riyadh's bus service levels,
Source: ADA (2013).

Figure 3.6: Design of bus stations in Riyadh City.
Source: ADA (2013).

3.9 Issues and Challenges

Riyadh needs to retain the momentum in implementing transport and traffic change. The key areas are in constructing and successfully operating new public transport systems, in creating a single transport authority and in reducing the dominance of cars in the city (ADA 2009, p. 1). The ADA report in 2012 indicated that the challenges for public transport development over the next five years and beyond include the following:

- Moving people out of cars and into public transport;
- Securing funding for capital works and operation of the integrated public transport system;
- Construction of the key metro and bus priority routes and associated infrastructure;
- Overcoming the cultural barriers to public transport usage through its promotion and efficient operation so that public transport is seen as a speedy, safe alternative to vehicle congestion;
- Ensuring the public transport network expands with demand up to 2030 to meet forecasted population growth, and that land is reserved for its implementation;
- Ensuring the integration of major centre development and higher density commercial and residential land use with public transport spines;
- Developing the central road spines such as King Fahad Road and Olaya Street as people movers rather than fast limited access arterials for car traffic by dedicating lanes to metro and bus priority and boulevard landscaping to change their visual character;
- Investigating the need and feasibility of introducing high capacity heavy rail routes for major commuting tasks;
- Preserving the option for high capacity heavy rail in the long term.

3.10 Summary

The chapter reviewed a history of Riyadh's metropolitan strategic plans that have contributed extensively to automobile dependence and dispersed urban form since the start of the 20th century. This chapter also presented a holistic

picture of the current situation of transport and factors affecting travel behaviour within the capital city of Riyadh.

Based on the information contained in this chapter, Riyadh has expanded and grown in an unsustainable manner and the complexity of the problems associated with a mobility-dependent society have grown due to lack of data in the early studies of city development stages of the city, such as population data, land use data, traffic volume and travel pattern. The studies prepared by private consultants were based on assumptions that have led to deficiencies in their outcomes (Ministry of Transport 2011). Moreover, this part of the research demonstrates that there is an urgent need for developing an effective public transport system and TDM strategies for the city of Riyadh to address the different issues that have resulted from the unsustainable development of the city planning and transport system during the last century. Against such a backdrop, the Metropolitan Development Strategy for the Riyadh Region adopted by policymakers is now considering introducing public transport infrastructure and enforcement policies.

CHAPTER FOUR: THE RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

This chapter provides an inclusive and comprehensive depiction of how the information and data required for the study were collected. It links the literature review of strategies for changing people's travel behaviour (Chapter Two) with the techniques yielding the findings (Chapters Five, Six and Seven) to achieve the thesis aims and objectives stated in Chapter One.

It is imperative to select a suitable research method to achieve the research aim and objectives, duly corroborated by findings, while proceeding throughout the research activity (Yin 2003; Bryman 2006). Crotty (2012, p. 3) describes methodology as "the plan of action, the approach, design or process behind the preference and application of certain techniques and in order to obtain the desired milestones, the research is likely to integrate the use of techniques with the preferences". The literature, for example, Fellows and Liu (2015) emphasise that the analysis, outcomes, conclusion, standards, and validity of the research are profoundly reliant on the applied data collection methods.

In this research study, a number of generally agreed methods are reviewed in order to identify the most appropriate method(s) to be followed. Thus, a mixed methods approach that involves quantitative and qualitative approaches was selected to be the suitable methodology in this research.

4.2 Research Question and Objectives

This section explores the research question and objectives to be addressed and answered by adopting suitable methodology. As mentioned before (Chapter Three, Section 3.4), in an effort to reduce the dilemma of traffic congestion and excess dependency on private vehicles in Riyadh City, authorities are considering introducing a public transport infrastructure. Proposals involve six metro lines integrated with bus networks which will be in operation by 2018 (ADA 2015b). Riyadh (referring to the city and its

population), has some unique characteristics which may negatively affect public transport ridership (Rahman and Al-Ahmadi 2010).

Against this background, the research question is, *what are the procedures and approaches that have to be undertaken to ensure public transport uptake in Riyadh City?"* This question was then associated with ten objectives namely:

1- Review potentially effective procedures and approaches of developed and developing countries in shifting people's travel modes towards sustainable transport modes.
2- Explore changes in people's behaviour with respect to using public transport and identify the causes of this behavioural change.
3- Investigate whether the existing TDM strategies are adequate to encourage public transport use in Riyadh City.
4- Identify the potential effectiveness, acceptability and applicability of a set of proposed interventions that could influence people's travel behaviour.
5- Consider the wider impacts of the new public transport system in Riyadh City on urban form, economics, environment, social norms and culture.
6- Analyse individual perspectives and attitudes towards the current travel conditions in Riyadh City
7- Investigate considerations and behavioural intentions to use Riyadh's new public transport system
8- Identify the potential barriers and facilitators for using the metro and bus in Riyadh
9- Explore public reactions towards various TDM strategies in order to encourage car users to use public transport
10- Explore the relationships between participants' behavioural intentions and the various factors that affect travel choices

To address these objectives, this thesis has been developed into three theoretical and practical stages, a literature review followed by semi-structured interviews and a general public survey.

4.3 Research Design and Methodology

The research design employed in this thesis, as illustrated in Figure 4.1, begins with an exploratory study through a literature review to discover the research gap and define the research questions. The research design can be seen as a logical approach and as a master plan of research work that sheds light on how the research will be conducted to answer the research question(s) (Thomas 2003). According to Bryman and Bell (2015), the selection of the research design depends on the decision regarding the priority that will be given to a number of aspects that are related to the research process. In other words, it provides the researchers with guidance for collecting and analysing the data in their research in order to ensure this data is relevant to their work and addresses the research needs (Churchill and Iacobucci 2009).

This study is based on collecting qualitative and quantitative evidence concerning future acceptance of the proposed public infrastructure and enforcement policies by the residents of Riyadh City. Thus, the study pillars are:

A) Qualitative, semi-structured interviews with stakeholders, including transport experts and representatives of Riyadh City authorities.
B) A quantitative, general public survey of a sample of Riyadh's residents using a social network-based survey tool as a methodology.

The Mixed Methods Research Approach containing both qualitative and quantitative methods has been chosen as the most suitable approach to be adopted in this research study. Creswell (2013) states that qualitative research is an approach which is used to explore and understand the significance persons or groups attribute to social or human problems. It is a suitable method for investigating objective theories by studying the relationship among variables. The study combines two research methods to enable gathering data from two groups of participants.

Recently, the evolution of research approaches has led researchers to develop an increasing interest in formal mixed methods research, and report the findings of quantitative and qualitative methods within a single study (Andrew and Halcomb 2009). Employing both, the qualitative and quantitative

techniques in one study, is also known as the 'Triangulation' method (Gill and Johnson 2010). The key postulation of the mixed methods approach is that combining quantitative and qualitative approaches provides a more wide-ranging perception of a research problem than either quantitative or qualitative approaches only (Creswell 2013). The key points to justify this choice include the following:

- Since Riyadh City's public transport demand is being discussed and captured in this research, both qualitative data (e.g. semi-structured interviews) and quantitative data (e.g. a questionnaire survey involving the general public) need to be employed to meet the different needs.
- The triangulation process is incorporated with the qualitative and quantitative approaches, so that both forms of data could be established. This is very useful as it obtains beneficial features and desirable consequences along with an effective decision-making (Fellows and Liu 2015).
- Access to significant information and these data collection methods has been facilitated in this technique; therefore, the reality of public transport demand in Riyadh is adequately reflected. According to Brannen (2005), quantitative research is concerned with attitudes and large-scale surveys rather than simply with behaviour and small-scale surveys.

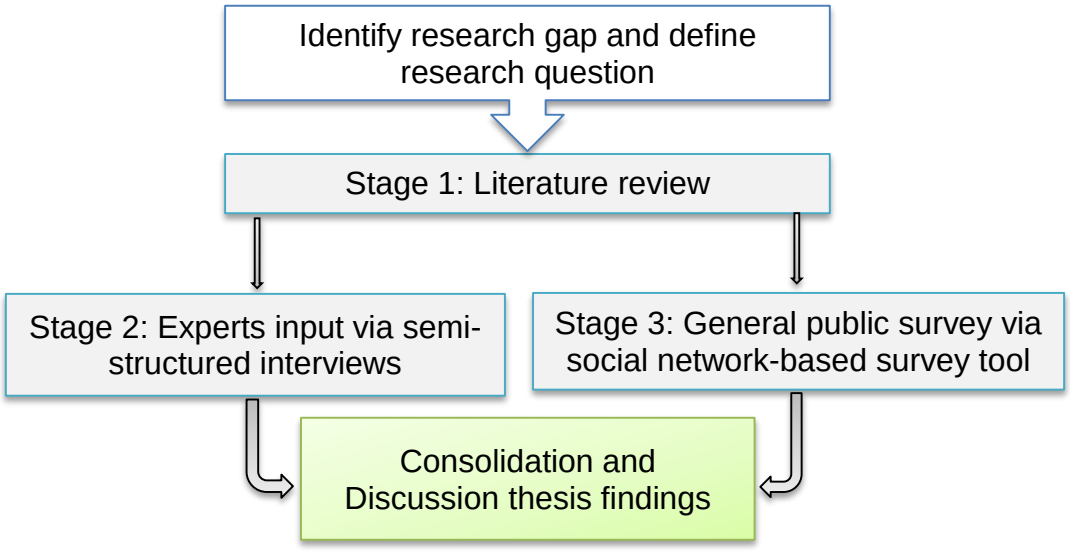


Figure 4.1: Research design and methodology

4.4 Semi-structured Interview

Semi-structured interviews with stakeholders, including transport experts and representatives of Riyadh City authorities, have been employed in research. As mentioned in Chapter One, this stage of the research aims to achieve three of the research objectives namely; (3) Investigate whether the existing TDM strategies are adequate to encourage public transport use in Riyadh City. (4) Identify the potential effectiveness, acceptability and applicability of a set of proposed interventions that could influence people's travel behaviour. (5) Consider the wider impacts of the new public transport system in Riyadh City on urban form, economics, environment, social norms and culture.

Addressing these objectives is a promising attempt to define the relevant set of TDM strategies for changing the travel behaviour of Riyadh residents. As explored in the study literature review, changing people's travel behaviour towards more sustainable transport modes is the main challenge in many urban areas (Banister 2008).

4.4.1 Justification of adopting semi-structured interview method

Generally, the interview method can be divided into three main categories: structured interviews, semi-structured interviews, and unstructured or in-depth interviews (Greener 2008). The semi-structured interview has features of both structured and unstructured interviews, in which the researcher usually has a list of questions and themes that need to be covered during the interview. Researchers who follow the semi-structured interviews method use both open and closed questions (Saunders 2011). Semi-structured interviews depend upon a specific array of questions and endeavour to steer the discussion to continue, more loosely, on such questions (Nagy Hesse-Biber et al. 2011). According to Saunders (2011), the employment of interview methods for the purpose of collecting primary data helps researchers to gather reliable and valid data that is related to their research questions and objectives. Furthermore, it enables the interviewer to steer the discussion in the most appropriate ways for collecting information from participants (Ghashat 2012). Interviews help the researchers to gather more data, especially more complex

data, and provide the interviewers with a comprehensive picture of the research area (Hall and Pain 2006; Saunders 2011).

Klenke (2008) states that semi-structured interviews are modelled more strongly on the unstructured than the structured interview which indicates that the subject theme directs the questions asked, though a more relaxed informal style is adopted between the interviewer and interviewee. Klenke (2016, p. 131) adds: “This leaves the interviewer free to rephrase the questions and add further inquiries such as “Who?” “Where?” “When?” “Why?” and “How?” based on the interviewee’s answers and conversation flow”. To this effect, Parker (2005, p. 53) states that an interview in qualitative research is always:

> “semi-structured because it invariably carries the traces of power that holds things in place and it reveals an interviewee’s, a co-researcher’s creative ability to refuse and resist what the research wants to happen. The task of radical research, then, is to make the interview an encounter that reveals patterns of power and creative refusal of a set research agenda.”

Table 4.1: Advantages and disadvantages of semi-structured interviews

Advantages	Disadvantages
Positive rapport between interviewer and interviewee	Dependent on skill of the interviewer (ability to formulate questions during the interview) and ability of respondent to articulated answers
Results in high reliability	Not very reliable
Addresses and clarifies complex issues	Time consuming and expensive
Reduces pre-judgement on part of the interviewer (i.e. researcher predetermining what will or will not be discussed due to few predetermined questions)	Depth of information difficult to analyse
	Generalisability limited
	Lack of validity

Source: Klenke (2016, p. 132)

4.4.2 Interviewee recruitment – panel selection

In this stage of the research seven main authorities that play a major role in sustainable development for Riyadh City, especially in mobility, have been targeted for sampling, namely:

1- The Ar Riyadh Development Authority.
2- The Public Transport Authority.
3- The General Administration for Traffic.
4- King Saud University (KSU).
5- Tatweer Educational Transport Services Company (TTC).

6- The Ministry of Municipal and Rural Affairs.
7- The Riyadh Municipality.

All interviewees were contacted in person. Copies of the interview documents were distributed to participants prior to the interviews via email or in hardcopy. Thus, twenty-five face-to-face semi-structured interviews were carried out in summer 2015.

The highest proportion of interviewees was from ADA because it is the responsible authority for design, implementing public transport infrastructure, and operation in the future, in collaboration with other authorities. After providing the interviewee with details for the study main objective, permission was sought to record the conversation.

4.4.3 Study themes and TDM strategies

Several examples of studies examining public attitudes towards TDM strategies are reported in the literature (Al-Mosaind 1998; Fujii and Taniguchi 2005; Garling and Fujii 2009). Some studies dealt with the respondents' behaviour in reaction to specific TDM strategies; car-use reduction measures on households in Sweden were examined by (Garling et al. 2009), and in another study, determinants of private car users' acceptance of road pricing in Sweden were explored (Jakobsson et al. 2000).

The literature review in Chapter Two such as (Garling and Schuitema 2007; Ison and Rye 2008b; Howarth and Ryley 2012) considered the experiences of many developed and developing countries with respect to the contributions of TDM strategies on changing people's travel behaviour to use more sustainable transport modes. As shown in Table 4.2, the majority of these strategies are included under the following themes:

1. **Planning and physical changes theme**: Studies demonstrate the effectiveness of planning and physical changes to encourage more sustainable transport modes. Examples include improvement of infrastructure for walking and cycling, land use planning to promote shorter travel times and park and ride schemes

2. **Legal policies theme**: Measures related to this theme may be applied to deter private car use, such as prohibition of car traffic in city centres, decreasing speed limits and introducing parking regulations.
3. **Economic policies theme**: Economic policies aim at making car use relatively more expensive. Examples of economic policies include congestion charges, road pricing taxation of fuels and cars.
4. **Social and cultural measures theme:** Social psychological factors such as problem awareness, perceived effectiveness and perceived fairness related to this theme are found to be effective strategies for shifting people from private cars to other transport modes (Garling et al. 2009). Cultural and religious measures are of particular relevance to Saudi society. In addition, as mentioned in Chapter Two, section 2.8.4, the unique aspects of Saudi society such being more conservative and bans the mixing of males and females in some public places and the gender inequalities found as crucial challenges that need to be highlighted in changing people travel behaviour.
5. **Information and technological theme:** Strategies include campaigns to raise people's awareness of negative environmental impacts on the atmosphere of the urban areas, particularly urban central areas. The role of new technology to facilitate public transport use and attract more users is also important, such as on board facilities like Wi-Fi, TV Screens, newspapers and mobile-tickets apps.

Table 4.2: The proposed transport policy measures

Themes	The Proposed Interventions
Planning and physical change measures	• Improvement of infrastructure for walking such as open space between buildings • Park and ride schemes • Transit stations/stops located centrally within acceptable walking distances • Limit supply of road space in key locations • More space to park in station car parks • Dedicated bus lanes • Luxury metro stations
Legal policies	• Banning car traffic from crowded areas • Operating and monitoring parking areas • Increase enforcement in urban areas • Updating the rules for issuing new driving licences • Limit supply of parking • Higher charges for parking and controls on workplace parking
Economic policies	• Taxing fuel • Taxing roads • Parking pricing • Congestion charge in crowded areas • Lowering public transport cost • Reduce cost of tickets for family, students, special needs, and seniors
Social and cultural measures	• Awareness of the environmental impacts of using private car • Separate families' carriages • The safety of public transport facilities such as on-board and stations • Comfort seats and luxury services • High-speed public transport • On-board facilities • Station facilities such as utilities offices • Encourage public school commuters • School programmes to encourage public transport use • Safe and pedestrian-friendly surroundings for all public transport stations
Information and technological measures	• Public information campaigns • Compulsory environmental awareness training during driving education • On-board facilities such as Wi-Fi, TV Screens, newspapers, etc. • Mobile-tickets app • Provide up-to-date information on public transport options, including timetables • Provide written directions for reaching sites by public transport to students, visitors, and staff • Provide personalised journey plans specially for employees

Source: Adapted from Garling and Schuitema (2007); Ison and Rye (2008b); and Howarth and Ryley (2012)

4.4.4 Interview design

The interview was organised into two sections based on the study objectives. The first section included five key questions branching into several sub-questions including short, closed questions and open-ended questions. It focused on evaluating and reshaping the existing travel strategies in Riyadh

City to accommodate public transport. In addition, this section aimed to elicit interviewees' opinions towards potential travel demand, the introduction of public transport services, and the willingness of society to use public transport and the expected barriers. The last question of the first section asked interviewees what priority should be given to the study themes in reshaping TDM strategies in Riyadh City.

The second section of the interview provided interviewees with the study's five themes and a set of most common travel strategies (see an example in Table 4.3). The second section aimed to evaluate critically to what extent respondents believe study themes and related interventions will be effective, acceptable, and applicable for implementation in Riyadh City. Moreover, this section investigated the expected effects of the new public transport system and related interventions on Riyadh City including aspects of urban form, economic elements, environment, social norms and the Saudi culture. The last two questions asked respondents to add more themes or interventions if they think any have been omitted or need modification to be more relevant to the Riyadh City context. According to Bryman and Bell (2015, p. 715) the Likert scale:

> "Is a widely used format developed by Rensis Likert for asking attitude questions. Respondents are typically asked their degree of agreement with a series of statements that together form a multiple-indicator or multiple-item measure. The scale is deemed then to measure the intensity with which respondents felt about an issue."

As shown on the example in Table 4.3, the scale system employed in this study was the five-point Likert scale based on the following meanings: A = Most effective, B = highly effective, C = Medium effective, D = Low effectiveness, E= No effect.

Table 4.3: An example of interview questions

Planning and physical change theme	A	B	C	D	E
1. Improvement of infrastructure for walking such as open space between buildings	□	□	□	□	□
2. Park and ride schemes	□	□	□	□	□
3. Transit stations/stops located centrally within acceptable walking distances	□	□	□	□	□
4. Limit supply of road space in key locations	□	□	□	□	□
5. More space to park in station car parks	□	□	□	□	□
6. Dedicated bus lanes	□	□	□	□	□
7. Luxury metro stations	□	□	□	□	□

4.5 General Public Survey

The general public survey is the second practical stage of the study. This stage adopted a questionnaire to address the following study objectives, namely;

6. Analyse individual perspectives and attitudes towards the current travel conditions in Riyadh City
7. Investigate considerations and behavioural intentions to use Riyadh's new public transport system
8. Identify the potential barriers and facilitators for using the metro and bus in Riyadh
9. Explore public reactions towards various TDM strategies in order to encourage car users to use public transport
10. Explore the relationships between participants' behavioural intentions and the various factors that affect travel choices

This stage attempts to obtain a deeper understanding of the anticipated users' travel behaviours, needs, and expectations. Thus, this stage investigated the attitudes, beliefs and preferences of the residents of Riyadh City. Also, it explored the factors influencing travellers' choice of transport mode and the preferences towards various transport policy measures intended to encourage a shift to public transport. In addition, this research sought to understand Riyadh citizens' attitudes, beliefs, travel decision-making and the likely impact of the proposed interventions for changing people travel behaviour to maximise public transport ridership. In this stage, to maximise the generalisability of the study results, the study has adopted a social network-based survey tool as a promising method to collect quantitative data in the research study area.

4.5.1 Justification of adopting the social-based recruitment chain

Saudi Arabia, as many developing countries, lacks a reliable sampling frame for recruiting survey participants. In the case of the present study, it is difficult to sample car users and public transport users in Riyadh City. It is impossible to obtain complete lists of private residents as their addresses and telephone or mobile phone numbers are unavailable, and the postal service for Riyadh City is still inadequate. In addition, the Saudi society is gender segregated,

largely conservative and religious, making participant recruitment – especially women – through random talk, extremely challenging.

To address these challenges, this study tested a social network-based survey tool as an innovative way to collect and enrich study data. The survey was conducted over the Internet and the recruitment process adopted principles of the Respondent-Driven Sampling (RDS) method in that participants used their social networks to invite their friends or relatives to participate in a survey. RDS is a chain-referral sampling technique that combines social network-based measures with statistical validity of standard probability sampling methods (Heckathorn 2011). Gile (2012, p. 1) defines RDS as follows: “a form of link-tracing network sampling, which is widely used to study hard-to-reach populations, often to estimate population proportions’’. The literature, for example, Schonlau and Liebau (2010) maintain that RDS is similar to snowball sampling designed for certain populations that are difficult to sample. The RDS method was introduced in the mid-1990s; Heckathorn (1997) and Salganik and Heckathorn (2004) present an alternative method which allows inference in populations for which conventional sampling methods are unattainable or not practical (see also Schonlau and Liebau 2010). RDS is argued to work as follows: seed respondents recruit a fixed number of further respondents from their network of friends, and at each wave, recruits keep recruiting from among their friends (Schonlau and Liebau 2010).

The strength of the social relationships among the study area residents is more likely to enhance response rate, reduce a volunteer bias, accelerate the data collection process and improve data quality. The web-based sampling allows the researcher to track and monitor the recruitment process and take necessary measures to ensure data collection is successful. The idea behind the method was that respondents were selected from the relationship network of existing members of the sample. As shown in Figure 4.2, the sampling process began with the researcher selecting a small number of participants as seeds who were the first individuals to participate in the study. These seeds then recruited others, etc. This process of existing sample members recruiting future sample members continued until the desired sample size was reached.

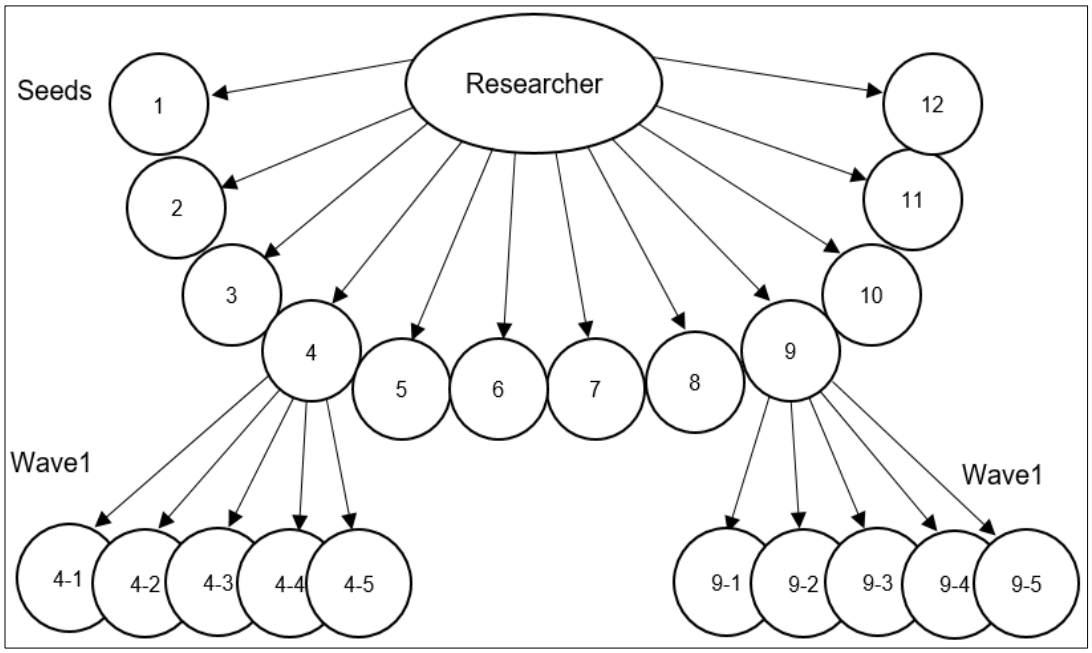


Figure 4.2: Social-based recruitment chain

4.5.2 Survey validity and implementation

The questionnaire content was discussed and reviewed internally with the researcher's supervisor and the progress-review committee members at Cardiff University. Externally the questionnaire was discussed and reviewed by two professors engaged in transport research at King Saud University in Riyadh City.

The survey questionnaire was programmed using PHP: Hypertext Processor (PHP, 2017), a general-purpose programming language. The online referral system shown in Appendix 2 (p. 236) was also programmed as part of the online questionnaire platform using the PHP language. Storage of the collected data was implemented using MySQL (2017), which stands for Structured Query Language, an open source relational database management system.

Programming of all survey tasks using PHP and storing the data on MySQL allowed for the survey to work in a dynamic mode (e.g. question routing) and thus responses to previous questions in the survey could feed into the attribute levels of the stated preference discrete choice experiment (e.g. travel time, travel cost, etc.).

Based on recommendations stated by Brace (2008) and Taylor et al. (2006), questions and the user interface of the online questionnaire were also tested by 21 postgraduate students studying at Cardiff University prior to the main stage of data collection. The times taken to complete the questionnaire were

measured, and the coding of the answers was practised to identify any difficulties that would be taken in consideration when producing the final version of the questionnaire. The final version of the survey was amended and reformulated in the light of the suggestions and comments made by the test sample.

Based on the population diversity in Riyadh City in which Saudis males and females have almost the same percentage with one third expatriates, the initial recruitments (seeds) were divided into three groups; four Saudi males, four Saudi females, and four expatriates. In the beginning of August 2016, the researcher emailed the questionnaire to twelve participants as seeds, who, in turn, recruited their friends and relatives to participate as well.

4.5.3 The survey design

The survey was designed in a series of reiterations to ensure that the questionnaire is in an appropriate format to achieve its aim.

The survey collection protocol began with an email invitation from the seeds inviting a friend or relative to participate in the survey, which included the researcher's name, the main purpose of the survey and the survey web link. The link takes the respondent to the survey web page interface with a brief introduction of the survey including the survey main objectives, the expected time it would take to finish the survey, and a polite note to recruit five friends by filling in the recruitment table on the last page of the survey.

When the respondent accepted to proceed with the survey, the second page presents the respondent with a descriptive video demonstrating the forthcoming new public transport system using a Riyadh City map that includes lines, stations, ways of use and the expected benefits. In addition to standard survey questions, the survey included an email reference system to enable respondents to recommend the survey to their friends and family by providing their email addresses at the end of the survey. As shown in Appendix 2, the survey consisted of five main parts. The following subsections give more details of questionnaire's parts.

4.5.3.1 Part one: Perceptions of traffic problems

The first part of the questionnaire reviewed respondents' perspectives of the current travel problems, and public transport experiences. This part included questions measuring the feasibility of public transport in Riyadh City from Riyadh residents' point of view. In addition, it explored to what extent the public think that introducing public transport services would improve mobility in Riyadh City, their willingness to use public transport, and acceptable walking distance to the nearest transit stop. This part consisted of closed, open-ended, and multiple-choice questions.

4.5.3.2 Part two: Daily travel

The second part consisted of seven questions that explore respondents' travel. The first question asked respondents to indicate their employment status, to allow the researcher to factor in respondents' experiences or biases when analysing survey results. The following four questions were designed as background questions to identify the value of attributes listed on part four of the questionnaire, such as the daily travel distance to work, school, and shopping. The questionnaire embedded an online mapping system, so that respondents can indicate where their home, place of work, study, and shopping locations are on a map of Riyadh (see Figure 4.3). These questions were presented sequentially. In addition, as it shown in Figure 4.3, in this part, respondents were given a choice between using the mapping system or if they did not wish to use it for any reason, they could indicate travel time in minutes and distances for commuting, study and shopping in kilometres, in provided spaces.

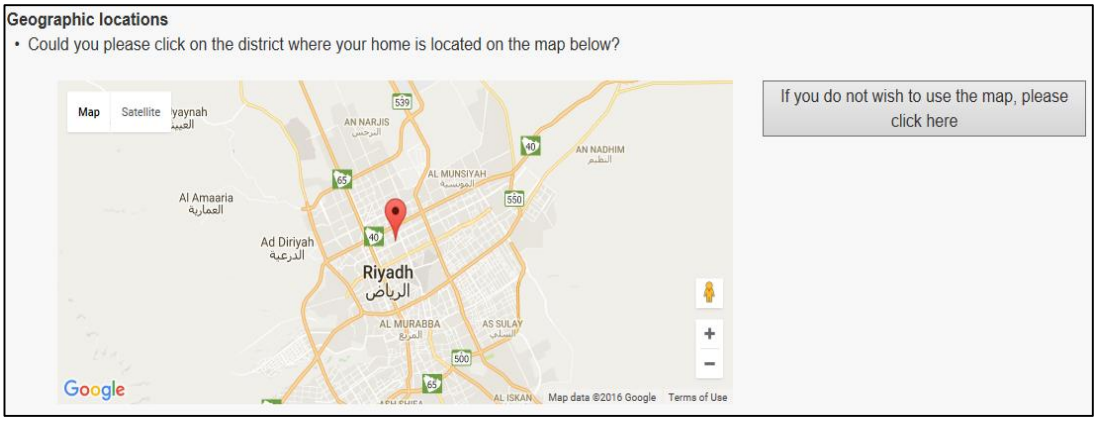


Figure 4.3: Home, work, study and shopping locations screenshot.
Source: Google maps (2016).

4.5.3.3 Part three: Attitudes, beliefs, and travel behaviour

This part was designed to explore participants' attitudes, beliefs, and transport behaviour. This part also measured public reaction towards various transport policy measures and incentives, such as strategies for urban areas, land use, increase of car maintenance and operation costs and potential parking fees, in order to encourage car users to use public transport. It investigated key barriers towards numerous travel strategies for more public transport ridership and the impact of respondents' experiences of public transport use. Following the study conducted by Tyrinopoulos and Antoniou (2008), this part has been amended according to the specific service and travel mode characteristics in Riyadh City. Thus, respondents were asked to choose one option that best aligns with their view throughout 25 statements using the Likert scale "strongly disagree, disagree, neutral, agree, and strongly agree".

4.5.3.4 Part four: Discrete choice experiment

This part of the survey designed as a discrete choice experiment adopting stated preference technique to explore people's sensitivity according to different variations associated with car and public transport such as travel cost and travel time. The focus of this experiment was to test a range of instruments for altering mode of travel, and explore the relationships between participants' behavioural intentions and the various factors that affect their travel choices.

Revealed Preference (RP) and Stated Preference (SP) techniques have been used to collect data in diverse fields to evaluating an individual's response (Adamowicz et al. 1994; Hensher 1994; Daniel et al. 2009). SP techniques have several advantages over the conventional RP techniques (Wardman 1988). RP techniques deal with actual behaviour and their applicability to non-existing situations is limited (Daniel et al. 2009), SP techniques would overcome these limitations by allowing for hypothetical scenarios. In addition, SP data are fully controlled by the researcher and may be collected in the form of rating, ranking, or choosing between alternative options (Adamowicz et al. 1994; Competition Commission 2010). SP techniques were originally developed to measuring preferences in marketing research in the early 1970s (Kroes and Sheldon 1988), and applied in transport demand analysis for

almost three decades (Bradley 2009). The following Table 4.4 shows RP and SP techniques characteristics.

Table 4.4: Revealed and stated preference methods

	Valuation Method	
	Revealed preference	Stated preference
Approach	• Individuals' preferences are revealed through their actions actual behaviour	• Individuals' are asked to state their preferences for hypothetical scenarios/alternatives
Direct methods	• Competitive market price	• Contingent valuation
Indirect methods	• Travel cost method • Hedonic pricing method • Discrete choice	• Discrete choice experiment
Disadvantages	• Limited to supply of information regarding values that have been experienced • Limited number of cases where non-market values/goods exhibit a quantifiable relationship with market goods • Choice sets, attributes of choice options and individual characteristics are not controlled and/designed a priori but rather occur/co-occur	• Observed preferences may not reflect actual behaviour • Absence of incentive for the respondent to provide accurate responses • Incentive for respondent to behave strategically • Overall costly evaluation (more complicated to design and analyse, and also more costly to undertake survey as show material often required for more complex choice task) • Vulnerable to violation of economic decision-making
Advantages	• External validity is maximised because the choices observed are real market choices in which consumers have committed money, time and/or other resources • Low-cost evaluation	• Provides preferences and information that are otherwise impossible to reveal when actual choice behaviour is restricted in some way

Sources: adapted from Competition Commission (2010, p. 4)

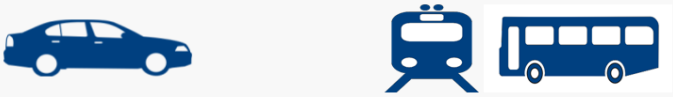
A review of the literature showed a clear evidence that SP techniques have previously been used to investigate the factors on influencing the individuals' decision of travel mode choice including metro, bus and private car, and indicate the importance of the different attributes of these modes to travellers (Baidoo and Nyarko 2015). In the case of this study as public transport service do not yet exist in Riyadh City, SP was found potentially suitable for investigating travel choice between car and public transport. The following points detail the stated preferences experiment design and the specific implementation processes:

4.5.3.4.1 Experimental design

As shown in the screen shot in Figure 4.4, prior to the choice scenarios, participants were asked to imagine they were about to go to work, study or shopping. There were two options of travel, the private car that they normally drive and public transport (metro and bus). In participating in the choice experiments, respondents were asked to select which of these alternatives they would choose to do the trip from their current residential location to their current workplace, study location, and shopping place. Based on the respondent's occupation, the experiment has two set of choices, one set was for commuting and study and another set was for shopping. Respondents were shown only ten cards selected randomly from both sets of experiment (five scenarios for commuting or study and five scenarios for shopping). Those who were not in work and not students were asked to do five shopping scenarios only.

The master design for the travel choice task was 45 scenarios for each set. Both choices sets were blocked to nine blocks. The block corresponds to five rows in the matrix; each row can be used to generate the values for one scenario. Therefore, every respondent was shown random samples of a number between one and five without replacement. Figure 4.4 shows examples of how experiment scenarios for work and study are presented in the survey.

12- Imagine that, you are about to go to your work and shopping. There are two options of travel, private **car** that you normally drive and public transport comprising **Metro And Bus.**



Please carefully review the available options and their characteristics and choose the one that you would like to travel the most to your work and shopping

Note: The prices of public transport tickets are for standard seats.

Scenario 1: Travel to Work

Please consider the following two options and tick your preferred preference

Attributes	Car	Public Transport
Cost of travel/fare [SR]	3	8
Parking Charge [SR/7 hrs]	Free Parking	-
Waiting Time (min)	-	1
Travel Time (min)	31	30
Walking time (min)	-	8
Number of changes	-	0
Transport Mode	-	Metro Only
Total Journey time (mins)	**31**	**39**
Total Cost (SR)	3	8
Please choose one option	○	○

Figure 4.4: An example of a stated choice screen.

4.5.3.4.2 Travel alternatives, attributes and levels

Binary travel choices (car and public transport) were considered with their attributes and attributes levels to generate hypothetical scenarios. The focus of the stated preference experiment was to assess the relationships between passenger behavioural intentions, namely cost of travel/fare, parking charge, waiting time, travel time, walking time, total journey time, number of changes, public transport mode (metro and bus). As detailed in the following points, the experiment considered ten attributes with different levels.

1) Car

Travel cost: This represented car-cost-attribute for each single trip from place of residence to work, study or shopping location. As shown in formula 4.1, this attribute was generated from gathering the average costs for fuel, tyres, service and labour, and replacement parts. According to the Automobile Association (2014), the average running cost of private cars in Riyadh City was 0.2 Saudi Riyal per kilometre. Therefore, the base and first level of the car cost attribute was the average cost of the private car per kilometre multiplied by travel distance from respondents' residential area to his/her workplace, study location, or shopping place. The car-travel-cost-attribute's increased by 25%, 50%, 75%, and 100% compared to current prices. The car cost attribute and levels were considered in this experiment to assess possible changes respondents would make as a response to the potential increase in car travel cost.

$$"Car\ travel\ cost = (fuel + tyres + service\ and\ labour + replacement\ parts) SR/Km * (Distance)\ Km \quad (4.1)"$$

Parking charge: Another method for reducing the attractiveness of private vehicle use was to introduce parking charges in Riyadh City. Here the experiment aimed to explore how sensitive respondents are to parking costs. Therefore, in this attribute parking charges were set at five levels. For example, the parking change was set to zero for the first level since there are currently no parking charges in Riyadh City, and the following four levels ranged from 2 to 5 Saudi Riyals per hour. As indicated in Table 4.5, it is

assumed that there will be parking charges for two hours for shopping trips and seven hours in work and study locations as the average daily work and study time in Riyadh City.

Travel time: For a car, the travel time refers to the current time the respondent travels from home to the workplace, study location or shopping area. As indicated in Table 4.5, this attribute has five levels, from the current travel time with an increase of 5, 15, 25, 40 minutes for four more levels respectively.

Table 4.5: Car attributes and level

Attributes	Attribute levels	
Cost of travel (SR)	1	Current travel cost
	2	+25%
	3	+50%
	4	+75%
	5	+100%
Parking Charge: • **2 hrs in shopping area** • **7 hrs in place of work or school**	1	Free
	2	2 SR/Hr.
	3	3 SR/Hr.
	4	4 SR/Hr.
	5	5 SR/Hr.
Travel Time (minutes)	1	Current travel time
	2	+5 minutes
	3	+ 15 minutes
	4	+ 25 minutes
	5	+ 40 minutes

2) Public Transport (metro and bus)

Cost of travel/fare: This attribute considered just public transport that focuses on the price of a one-way ticket for one-person use in commuting and study trips and for the family in case of shopping trips. As shown in Table 4.6, the travel cost attribute had five levels of prices 2, 4, 6, 8, and 10 Saudi Riyal per single journey.

Walking time: This attribute represented the time a respondent would need to walk to the nearest transit station or bus stop. As shown in Table 4.6, walking time increased by 1, 2, 4, 6 and 8 minutes, which added to the total public transport travel time.

Waiting time: This attribute gave the time in minutes for public transport frequencies and ranged from high frequency of 1 minute to a low of 8 minutes waiting time.

Travel time: For public transport, this attribute refers to the time spent travelling in public transport (in-vehicle time) for the whole journey using metro only, bus only, or integrated service between metro and bus.

Total journey time: The total journey time using public transport is an accumulation of walking time, waiting time for the service, and the total time spent in the public transport (In-vehicle time for one way).

Public transport mode (metro and bus): It represented the public transport modes for the single journey from home to the destination, using metro only, bus only, or metro and bus as the attribute levels. This attribute measures how sensitive respondents are to the public transport mode.

Number of changes: This attribute represented the number of changes the commuter has to do to reach the destination using public transport service whether between metro lines, bus or both of them. The attribute has four levels: no change, once, twice, and three changes in the commuter's single trip. The following Table 4.6 shows public transport attributes and levels.

Table 4.6: Public transport attributes and attribute levels

Attributes	Number of levels	Attribute levels
Travel cost (SR/single trip)	1	2 SR
	2	4 SR
	3	6 SR
	4	8 SR
	5	10 SR
Walk time (minutes)	1	1 minute
	2	2 minutes
	3	4 minutes
	4	6 minutes
	5	8 minutes
Waiting time (Frequency)	1	1 minute
	2	2 minutes
	3	4 minutes
	4	6 minutes
	5	8 minutes
In-vehicle travel time (minutes)	1	The current travel time
	2	+ 25%
	3	+50%
	4	+75%
	5	+100%
Public transport modes	1	Metro only
	2	Bus only
	3	Metro and bus
Number of changes	1	No change
	2	One
	3	Two
	4	Three

4.5.3.5 Part five: Socio-demographic characteristics

Part five aimed to create a larger picture about each individual's travel behaviour. It explores the influence of respondents' socio-demographic characteristics on travel behaviour and opinions, such as gender, age, marriage status, income, nationality, number of children and adults, number of cars owned by the household. In this section, the participants were asked closed, open-ended, and multiple-choice questions.

4.6 Summary

The main purpose of the chapter is to provide an overview of the research design and methodology. It includes an explanation of the different research philosophies and approaches in general and particularly focuses on the selected research approach for this research. The Mixed Methods Research containing both the qualitative and quantitative methods have been chosen as the most suitable approach to be adopted in this research study. The research methodology used for the purposes of this study was introduced in detail throughout this chapter, including the discussion of different research methods such as quantitative and qualitative methods. In the first practical stage semi-structured interviews were chosen as an appropriate way to collect a qualitative data. In the second practical stage general public survey questionnaire was chosen as tactic way to collect a quantitative data.

CHAPTER FIVE: SEMI- STRUCTURED INTERVIEW RESULTS

5.1 Introduction

This chapter is an explanation of the first stage of the study practical section. In this stage of the research, a semi-structured interview was conducted with stakeholders including transport experts and representatives of Riyadh City authorities to achieve two of the research objectives. The first objective is to investigate whether the current status of Riyadh City transport policy measures are adequate to encourage public transport use. The second objective is to identify the potential effectiveness, acceptability and applicability of a set of proposed transport policy measures that could influence people to use public transport. Therefore, the primary aim of this stage is to address the following three objectives:

3. Investigate whether the existing TDM policies are adequate to encourage public transport use in Riyadh City
4. Identify the potential effectiveness, acceptability and applicability of a set of proposed interventions that could influence people's travel behaviour.
5. Consider the wider impacts that are assumed to occur such as the effect on urban form, economics, environment, social norms and culture when the new system of public transport being in operation in Riyadh City

In this sense, the stakeholders' views including transport experts and representatives of Riyadh City authorities could be considered as a design guidance and evaluation tool for the interventions of TDM strategies. Interview feedback would help to identify and assess the feasibility of these travel strategies. In addition, it provides a measure for its expected effectiveness with regard to public acceptance and applicability for implementation in Riyadh City. The following sections and subsections detail the study methods, results, discussion the obtained results, and conclusion.

5.2 Methods

5.2.1 Sampling

The core of this stage of the study lies in designing attitudinal interviews to elicit the judgement of transport, traffic, and planning representatives in Riyadh City, regarding potentiality of TDM strategies for more success public transport. The study has targeted the most suitable stockholders-representatives' authorities' in Riyadh City. The targeted authorities are in charge of sustainable development, urban planning, built environment, transport and infrastructure, and academic researchers that specialise in transport studies in Riyadh City. Participants in this study were individuals engaged in public transport projects and sustainable development for Riyadh City across seven authorities:

1. The Ar Riyadh Development Authority, 11 interviewees, including the director of transport and planning, director of designing and urban planning, consultant of the Ar Riyadh metro project, director of transport economics, and other engineers in transport and planning departments.
2. Public Transport Authority, the director of the public transport authority.
3. The General Administration for Traffic, two interviewees, including the general director of the general administration for traffic in Saudi Arabia, and director of the traffic safety department.
4. King Saud University (KSU), three university academics engaged in transport research.
5. Tatweer Educational Transport Services Company (TTC), the chief executive officer.
6. Ministry of Municipal and Rural Affairs (MOMRA), including the General director of urban planning and consultant of the Ar Riyadh metro project.
7. Riyadh Municipality, including the director of studies and planning, and four engineers engaged on Riyadh's new public transport project studies and design.

These are the main authorities jointly sharing a number of tasks and duties related to the development of Riyadh City through joint meetings and the formation of committees.

5.2.2 Recruitment of participants

The researcher arranged a meeting with the director of transport planning at ADA to participate in the interview, and recruit other participants engaged in public transport projects across other ADA departments. Copies of the interview documents were distributed to participants prior to the interviews via email or in hardcopies. Twenty-five face-to-face semi-structured interviews were conducted in Riyadh City, during June and July 2015. The majority of interviewees were from ADA because it is the lead authority for regulating, planning, designing, and implementing public transport policies and infrastructure in Riyadh in collaboration with other authorities. On average, each interview lasted 45 minutes, and all interview conversations were recorded with the permission of the interviewees.

5.2.3 Interview Protocol

The interviews were organised into two sections. As shown in Table 5.1, the first section aimed to address the first research objective by eliciting expert views on the existing TDM strategies and the possibility of reshaping these to accommodate public transport. The participants were also asked to what extent they would support or oppose the introduction of public transport services and new transport policy measures in Riyadh City. They were asked to express their views about possible acceptance of public transport use among Riyadh's society and any expected barriers. Finally, they were asked to indicate what priority should be given across five themes namely, planning and physical changes, legal, economic, social and cultural, and information and technology in reshaping the current TDM strategies to encourage public transport use in Riyadh City (see Figure 5.1 and question 5 in Table 5.1).

The second section was designed to address the second research objective, namely, to identify the potential effectiveness, acceptability and applicability of a set of proposed transport policy measures that could influence people to use public transport. Interviewees were asked to comment on the appropriateness of proposed transport policy measures of such TDM strategies in Riyadh City (Table 5.2). These TDM strategies were organised under the same five key themes as indicated in Figure 5.1. In this section, interviewees were asked

about the potential effectiveness of these initiatives in changing travel behaviour, the expected level of acceptability by the general public and the level of applicability in local contexts. Tables 5.1 and 5.2 present a summary of the interview questions and their purposes.

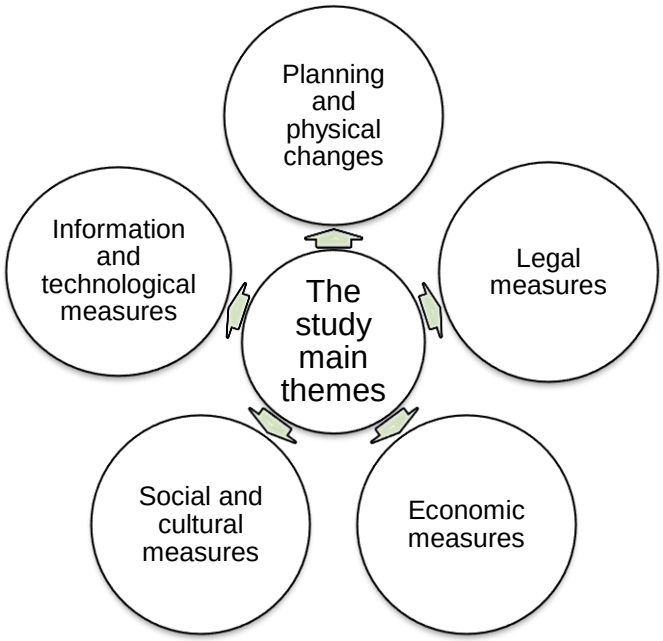


Figure 5.1: The study main themes

Table 5.1: Semi-structured Interview protocol, section 1

Question	Purpose	Contents
Opening	Provide interviewee details for the study question, aims, objectives, and ask for permission to record the conversation	Cover letter/Introduction to the Interview
1	To investigate the current status of Riyadh transport policy measures and whether they are adequate to encourage public transport use	Do you think, on the whole, the current status of Riyadh TDM strategies are adequate for encouraging public transport ridership? And why?
2	Measure experts' opinions for the necessity of introducing public transport services in Riyadh City	In your view, to what extent do you agree or disagree with introducing public transport services in Riyadh City now? And why?
3	Measure the extent to which Riyadh society are ready to use public transport. Question whether there are barriers for such use	Is our society ready for a wide use of public transport? If no what are the barriers?
4	Measure experts' opinions for the necessity of implementing TDM strategies to change Riyadh residents' travel behaviour	How much do you favour implementing TDM strategies to change Riyadh residents' travel behaviour?
5	Measure the level of priority of the main themes for reshaping TDM strategies	What priority should be given to the planning and physical changes, legal, economic, social and cultural, and information and technology themes in reshaping TDM policies in Riyadh City?

Table 5.2: Semi-structured Interview protocol, section 2

Question	Themes	Related TDM strategies
6	**Planning and physical changes**	• Improvement of infrastructure for walking such as open space between buildings • Park and ride schemes • Transit stations/stops located centrally within acceptable walking distances • Limit supply of road space in key locations • More space to park in station car parks • Dedicated bus lanes • The luxury metro stations
7	**Legal**	• Banning car traffic in crowded areas • Operating and monitoring parking areas • Increase enforcement in urban areas • Updating the rules for issuing new driving licences • Limit supply of parking
8	**Economic**	• Taxing fuel • Taxing road • Parking pricing • Congestion charge in crowded areas • Lowering public transport cost • Reduce cost of tickets for family, students, special needs, and seniors
9	**Social and cultural**	• Awareness of the environmental impacts of using private car • Separate family carriages • Promote the safety of public transport facilities such as on board and stations • Comfort seats and cleanliness • Frequency of public transport service • On-board facilities and luxury services • Station facilities such as utilities offices • Encourage public school commuters • School programmes to encourage public transport use • Safe and pedestrian-friendly surroundings for all public transport stations
10	**Information and Technology**	• Public information campaigns • Compulsory environmental awareness training during driving education • On-board facilities such as Wi-Fi, TV Screens and newspapers • Mobile tickets app • Provide up-to-date information on public transport options, including timetables • Provide written directions for reaching sites by public transport to students, visitors, and staff • Provide personalised journey plans especially for employees

5.3 Data analysis

All the interviews were recorded and the obtained data were transcribed verbatim. During the transcription, the data were documented according to the study questions and themes. Thus, the study themes were considered as the main categories for analysis. All were located within the range between high priority and not at all a priority. In section two, the proposed examples of TDM measures related to each category were evaluated based on their importance for changing people's travel behaviour in Riyadh City. They were given a range between highly effective and not at all effective.

NVivo 9 qualitative software was used to analyse the data. The aim of the analysis presented in the following section is to elicit whether there is any significant statistical difference in the responses of transport experts and representatives of Riyadh City authorities.

In order to more fully describe the study results, some studies such as Sandelowski (2001) and Cauwenberg et al. (2012), suggested quantitizing qualitative data to be presented numerically in score or scale when respondents are discussing a certain factor. We adopted mapping of responses based on Simons et al. (2013), thus based on the study questions design and themes, in interpreting the study results, 'all interviewees, respondents or the study sample' means there was full agreement or similar belief among the entire sample. More than 75% agreement is called 'the majority', between 75% and 50% is called 'a lot of or many', 'some' is between 50% and 25%, and less than 25% is called 'few'. The meaning qualitative researchers seek depends, in part, on number, just as number depends on meaning.

5.4 Results

5.4.1 Section One: Current status of travel in Riyadh City

The first section of the qualitative data was analysed based on the order of the questions presented in Table 5.1.

5.4.1.1 The existing travel strategies

All respondents thought that currently there are no direct transport policy measures to promote use of public transport because currently there is no effective public transport system. An ADA interviewee stated that: 'Current travel management policies involve just conventional transport strategies, e.g. increasing road infrastructure to match the growth of private vehicle ownership'. Another respondent from ADA felt that: 'The only current traffic system is for the regulation of traffic and parking on streets'. In general, interviewees felt that due to poor services provided by the existing buses of SAPTCO and private minibuses, the existing TDM strategies have ignored public transport.

5.4.1.2 The demand for public transport system

Respondents were asked to present their views about public transport in Riyadh City with three options, namely: not necessary, a welcome change and high priority. There was a strong agreement across all interviewees indicating a high priority for introducing public transport. A lot of respondents said that the high reliance on the private car and absence of effective public transport in Riyadh City reduced mobility and increased the detrimental environmental impacts. They added that public transport is the best solution to alleviate the current trend of travel delays, pollution, fatal car accidents and improving the daily mobility of all segments of society. One interviewee from KSU argued: 'No city of the size of Riyadh with a population of nearly 6 million would be sustained with a road transport network alone. It has to be supplemented by public transport'.

5.4.1.3 The willingness to use public transport

The majority of respondents felt that Riyadh's society is partly ready for public transport use. And they gave the example that people who have no access to private cars would be more likely to use public transport, including expatriates, women, students, and the elderly. They asserted that the majority of expatriates have been accustomed to using public transport prior to coming to Riyadh. Therefore, interviewees thought expatriates would be more prepared to use public transport than others, especially at the commencement of public transport service. In Saudi Arabia, due to that women are not allowed to drive,

and the rules are against women being alone with unrelated men even a taxi driver, interviewees felt that women could be possible users of public transport. Other possible users are students of both genders, because some cannot drive, afford to buy a car or hire a driver. It perceived that accessible, low fares and a reliable public transport system would be the best choice of transport mode for students. Nevertheless, some respondents stated that there could be potential demand for many public transport trips in Riyadh city from those people who have no access to a car for economic or social reasons. Lastly, there was a thought that public transport would provide new choice of mobility mode for elderly who are in need of move around and for socialising and to be active in life.

Some of respondents commented that, in addition to the lack of experience in public transport use in Riyadh society, there are four unique challenges that would be barriers affecting Riyadh society willingness to use public transport. For example, the first challenge would be the current lacking in city planning. They added that Riyadh City planners have not taken into consideration any other travel means than private cars. One participant from ADA commented that, “The massive sprawl in Riyadh City created an unfriendly pedestrian environment and more reliance on the private car. He added that, there are plans now to reshape the city planning, for increased population density along with public transport corridors and TOD systems”.

Low car operational cost in Saudi Arabia such as low petrol prices, absence of road taxing, no parking charges etc. were expected by some of the study participants to be the second barrier for success public transport use. They stated that, the challenge is whether to make public transport more appealing and cars less appealing by increasing car operational cost and lowering public transport fares.

The City culture suggested by some of the study sample was the third challenge. They perceived that, the current bad image of the current bad condition of local buses and the sensitivity of sharing space in Saudi society would be barriers facing public transport use in Riyadh City. They added that the general perception for public transport (especially bus) is a ‘low class’ form of travel. One of ADA interviewee stated that, “some Mall management object

and complain against locating bus stops in front of malls, believing that public transport passengers are lower in rank than their customers". Interviewees added that, Saudi society is not ready to condone sharing spaces yet; sharing space is limited in public places such as hospitals and malls. The public transport designers have taken this viewpoint of space sharing into consideration by offering more spaces between seats in metro compartments and buses, and separate private compartments for family use only. They added that, these efforts would help to break these barriers with time, when people are becoming more familiar with the service.

The fourth challenge is the country's climate. Interview respondents stressed that the climate in Riyadh City has to be taken into consideration as a challenge facing public transport use. They stated that, the climate is hot and summer temperatures can rise to almost 50°C, and generally dry and dusty. They also added that, shaded pathways, air conditioning in all stations and bus stops could help to reduce this suffering.

5.4.1.4 Reshaping TDM strategies in Riyadh City

Respondents were then presented with a total of five options (very favourable, favourable, neutral, unfavourable, and very unfavourable) to rate how much they think reshaping the current transport policy measures will influence people's travel behaviour in Riyadh City. All interviewees felt reshaping the current TDM strategies would play a very important role in providing a successful public transport service in Riyadh City. For instance, one of participants illustrated that: 'We need to do as it is applied in developed countries, they focus on choosing the best systems and encouraging measures to promote the use of these facilitates, such as higher fuel prices, and levying parking charges'. Another interviewee stated that, 'People may use public transport during a period of curiosity in the beginning of its introduction, but after that will be a decline in public transport ridership. So, in my opinion reshaping the current transport policy measures are indeed necessary.' The interviewee from ADA argued that, 'We try to make the public transport more attractive, but that is not enough.' He claimed, 'A stick and carrot approach is needed, where a carrot is a nice and easily accessible public transport service, while the stick is a sound strategy that has the effect

of making private vehicles use not as easy and cheap as it is currently is'. Generally, they thought that the city is completely reliant on private cars for long time and a fundamental rethinking involving reshaping the current travel policies and implementing new transport policy measures is indeed required along with introducing a public transport system.

5.4.1.5 Level of priority of the study themes for reshaping TDM strategies

As presented in Figure 5.2, the most popular responses are highest and high priority across all themes.

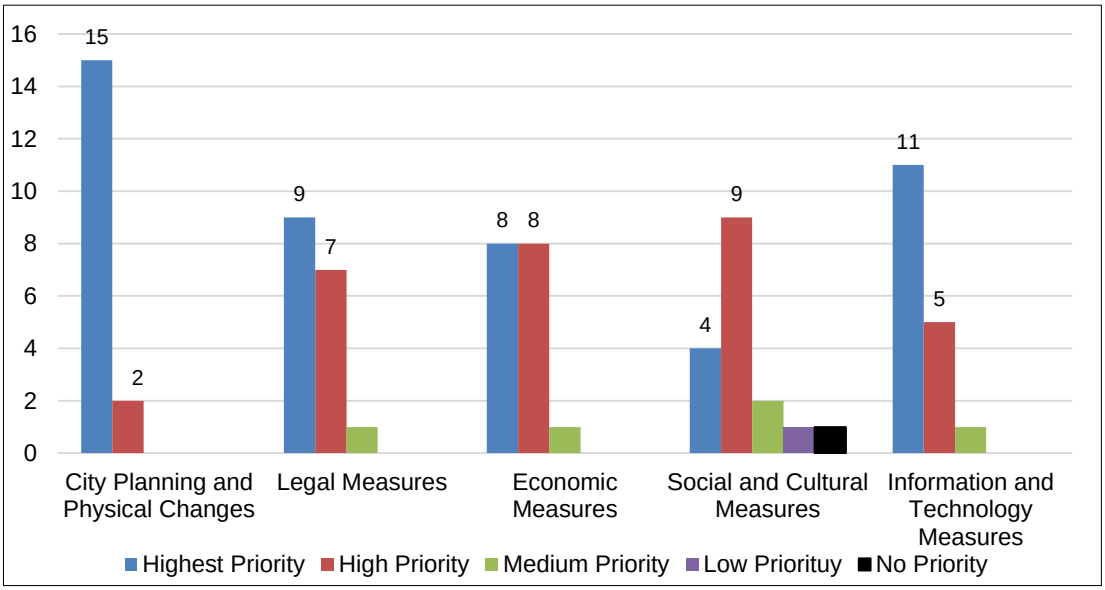


Figure 5.2: The priority of five themes in reshaping TDM strategies.

5.4.1.5.1 City planning and physical change measures theme

A lot of respondents rated city planning and physical changes as having the highest priority of all the five themes assessed. They thought that strategies related to the planning and physical change are visible and tangible, which would make people consider other travel alternatives. Some of them argued that in Riyadh City planning is seen as one of the hardest challenges for the successful operation of public transport. They stated that due to the bad conditions of the current buses, previous strategies have not taken public transport into consideration, which has caused the serious conditions of the city's planning today. They added that introducing public transport services requires reshaping the city's planning and population density to settle more along the public transport corridors. The Riyadh climate is generally dry, dusty and hot, so interviewees thought that introducing safe, shaded and attractive

pedestrian paths, easy public transport access, disabled access, air conditioning at all stations and bus stops, and easy integrations between public transport services pathways are very important strategies to encourage use of public transport.

5.4.1.5.2 Legal policies and measures theme

Interviewees felt that strategies related to the legal theme play a vital role as well. They sensed that along with introducing public transport, private car movement and ownership has to be restricted. They added transport policy measures to make cars less attractive such as speed management, illegal parking control, enforcements for driving without a driving licence, and obeying traffic regulations are needed in Riyadh City. Many respondents thought that effective legal transport policy measures would increase road safety and restrict the massive use of private cars in Riyadh.

5.4.1.5.3 Economic policies theme

The participants also felt that the economic aspect has to be considered. Many of the interviewees asserted that reform of transport charges in Riyadh City is needed. For example, increasing the cost of car operation and decreasing the cost of other transport alternatives such as metro and bus will make people re-think about the expensive use of the private car. Nevertheless, other regulations to affect the transport industry such as the decrease of subsidies for vehicle production and operations were recommended by many of the respondents.

5.4.1.5.4 Social and cultural measures theme

The unique aspects of Saudi society and culture would be a barrier for public transport use such as the high income of household and privacy. Respondent from GAT indicated: ‘The Riyadh society have got a bad image from the current bus service conditions’. He added: ‘This image has to be changed using more public campaigns and advertisement for the new public transport system’. Some of the interviewees also admitted that society has to know more about the new service implemented in Riyadh, and that people could be informed via public campaigns and new school sessions to teach pupils the main benefits of public transport, signs and usage. According to the majority

of respondents, large families, the need for privacy and gender segregation are other factors which would influence choice of transport mode. Some interviewees also suggested that, separate compartments for women with their children or men and their wives, or individuals alone, a higher than usual screen for windows for family compartments in public transport are important strategies.

5.4.1.5.5 Information and technological measures theme

Almost all the study sample expected reshaping strategies related to information and technology would play a great role in changing people's travel behaviour in Riyadh. One respondent from ADA stated that 'The Saudi society is a young society; the majority of its population is less than 20 years old and has the ability to adapt to modern issues; hence, these systems are likely to be accepted when implemented'. Some interviewees stated that it is very important to provide all members of society with information about public transport services, a high standard of communicating with the society such as daily timetables and journey planners. They added that an Internet website concerning plans and daily changes of public transport including ticket prices, or any changes in programmed journeys should be available.

5.4.2 Section Two: The potential effectiveness, acceptability and applicability of a set of proposed TDM strategies

This section provides interviewees with potential TDM strategies on the same themes as in Figure 5.1. Respondents were asked a series of questions (see Table 5.2) to elicit interviewees' opinions to what extent they believe the proposed interventions will be effective in shifting Riyadh's residents towards public transport use, acceptable by general public, and applicable in the local context. The following subsections detail interviewees' opinions:

5.4.2.1 Planning and Physical Changes theme

All study participants perceived that park and ride schemes outside the city centre, transit stops located centrally within acceptable walking distances, and dedicated bus lanes were scaled as most effective and highly effective strategies. Some interviewees suggested that, allowing for high-rise building along with public transport corridors and selecting appropriate TOD sites is

very important to increase the density and promote public transport use. In addition, the majority of interviewees thought that the availability of luxury metro stations would not be a strategy that is more effective, especially for those regular commuters. They indicated that luxury metro stations would be welcomed but did not think it would encourage public transport use as frequency and low cost would do. Limiting the supply of road space in key locations in the city was seen as complicating mobility and having low acceptability that would lead to low effectiveness as well.

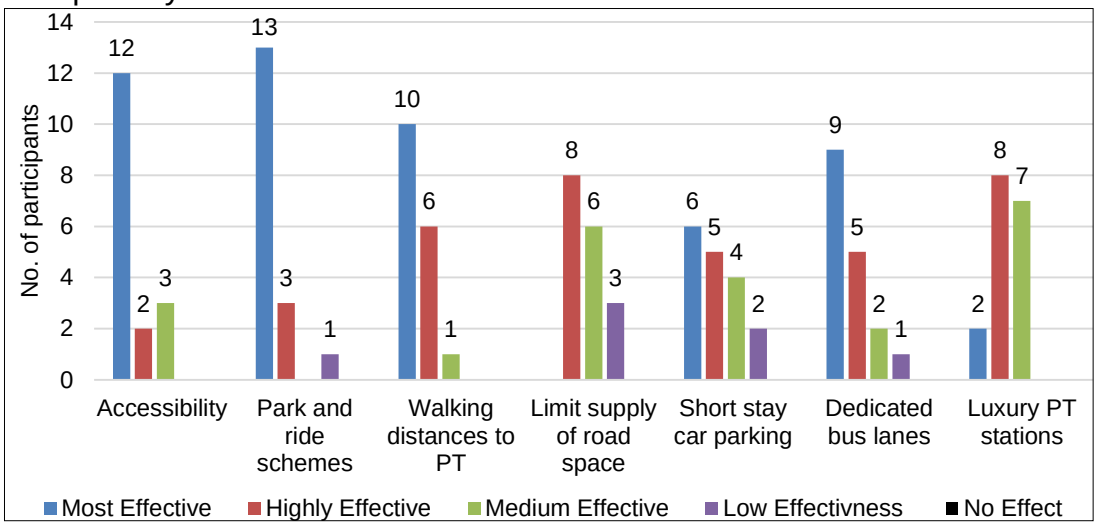


Figure 5.3: Planning and physical changes measures

5.4.2.2 Legal policies

Interviewees felt that banning car traffic in congested areas is an effective transport policy measure in many cities, but would not be acceptable or applicable in Riyadh City. The majority of participants maintained that banning car traffic would need more complicated physical changes in the planning of Riyadh City centres, attributed to the multiplicity of congestion places and lack of coverage of public transport services. The majority of respondents thought that operating and monitoring parking areas and parking control would be highly effective, acceptable and applicable strategies. According to some interviewees transport policy measures including updating the rules of issuing new driving licences, and reducing speed limits and increasing enforcement in urban areas were perceived as having a medium effectiveness and acceptability.

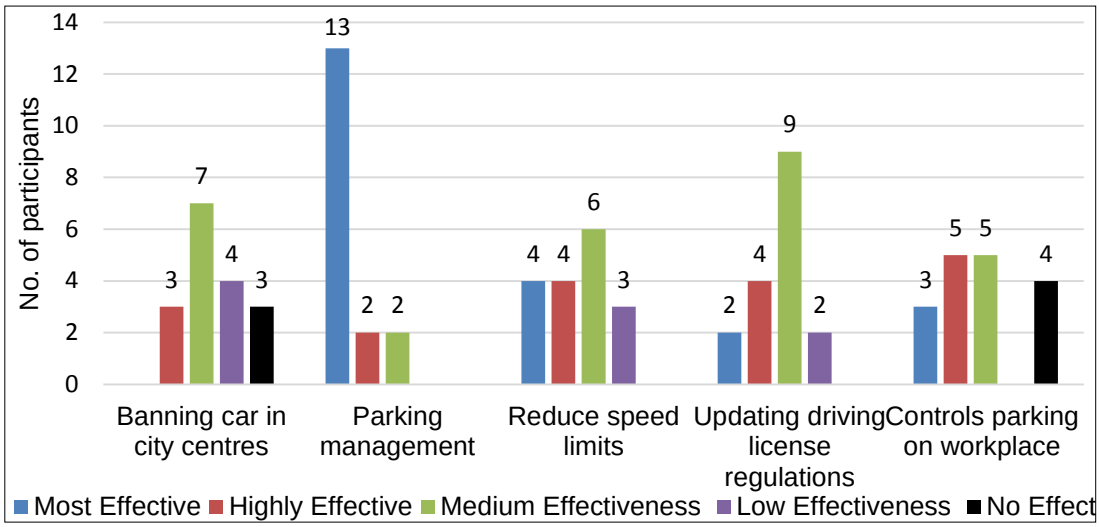


Figure 5.4: Legal policies

5.4.2.3 Economic Strategies

All respondents felt that lowering public transport cost, and subsiding the cost of tickets for students, families and the elderly would be highly effective strategies. As shown in Figure 5.5, the majority of interviewees perceived parking charges as the most effective strategy in this theme. Congestion charges, taxing fuel, and taxing roads were found to be effective economic strategies as well, but would be less acceptable by the general public. Some of the interviewees felt that people would consider fuel taxing unfair as the country is one of the biggest oil producers, or think public transport had brought negative changes to them and oppose the strategies. One of the respondents suggested that, 'Allocating certain amounts of fuel to each vehicle monthly at a lower price, and in the event of reaching this quantity before the end of the month fuel price will be doubled would be effective strategy'.

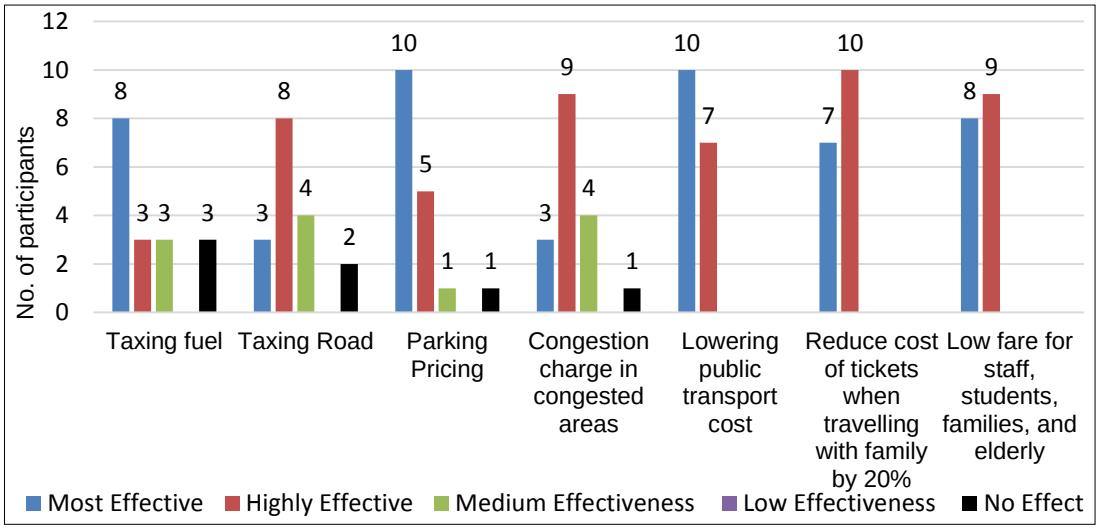


Figure 5.5: Economic strategies

5.4.2.4 Social and cultural strategies

The majority of interviewees believed that frequent services with a good safety of public transport would be the most effective strategies to encourage public transport ridership. A lot of interviewees felt that the provision of separate family carriages, school programmes, and encouraging school commuters would be highly effective strategies. High frequency of public transport, comfortable seats, cleanliness and the provision of safe and pedestrian-friendly surroundings for all public transport and station facilities such as utilities offices were thought to be highly effective strategies by the majority of the study participants. On the other hand, many of the interviewees perceived that on-board facilities, luxury services, and awareness of the environmental impacts of having private cars as strategies would not play a great role in terms of encouraging public transport use. They attributed these thoughts to the expected main motivation of public transport use, which are improving people's mobility and saving time.

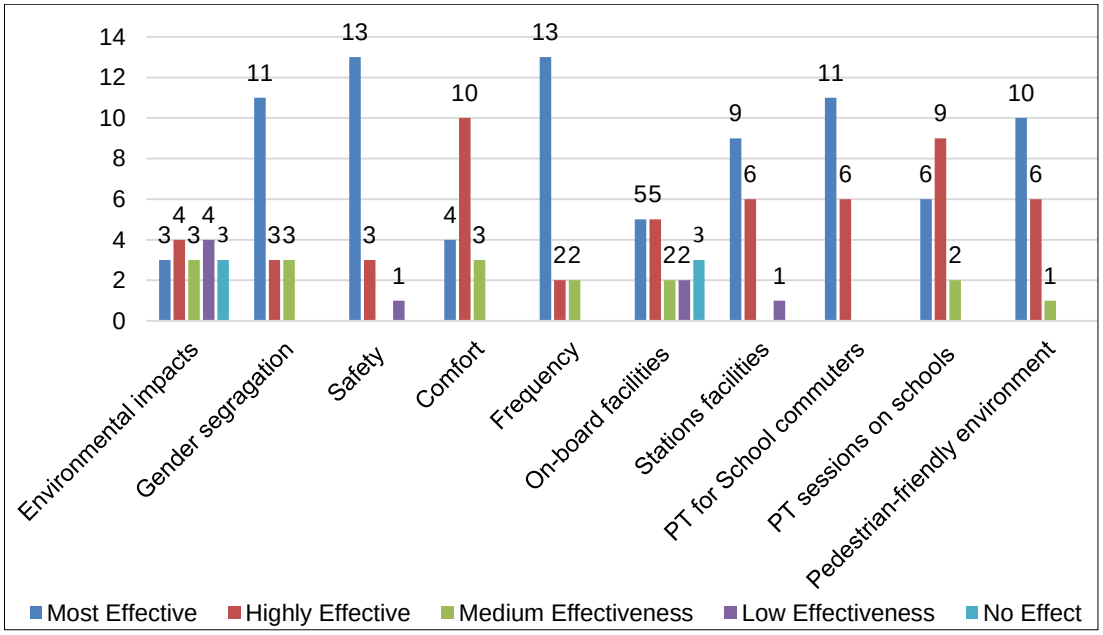


Figure 5.6: Social and culture strategies

5.4.2.5 Information and Technology Strategies

As shown in Figure 5.7, in general, strategies related information and technology to promote public transport use are very effective, acceptable and applicable compared to strategies for other themes. For example, all respondents expected high effectiveness of transport policy measures include

mobile tickets apps, providing up-to-date information on public transport options, and public information campaigns. According to some participants, on-board media, such as Wi-Fi, and TV screens were felt to be effective as well. Providing personalised journey plans especially for employees, written directions for reaching sites by public transport to students, visitors and staff were ranked as the lowest effective strategies in this theme.

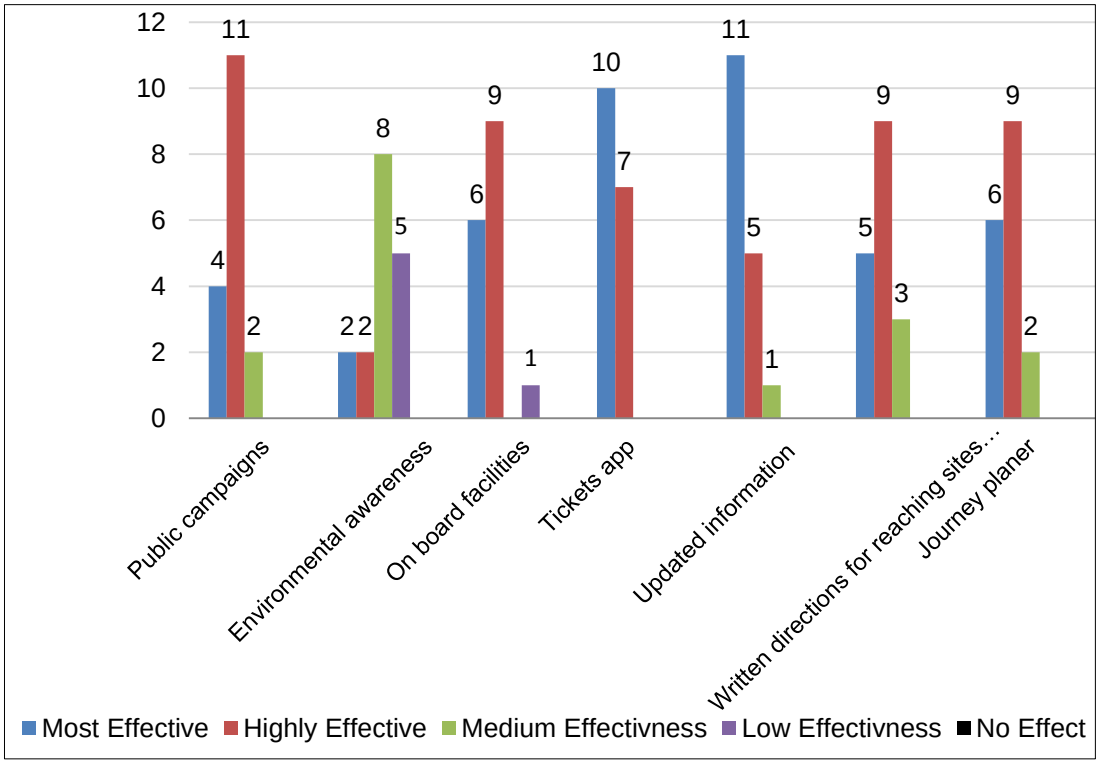


Figure 5.7: Information and technology strategies

5.4.3 Section three: The Impacts of Investment on public transport system for the City Main Aspects

The last question in the interview investigates to what extend interviewees believe Riyadh City's aspects will be impacted as a result of introducing public transport services along with implementing new TDM strategies. As shown in Figure 5.8, interviewees were given four main vital elements, namely: urban form, city economy, city environment and social norms and culture.

Figure 5.8: Structural elements

As presented in Figure 5.9, generally, interviewees felt that the majority of city aspects are already formed and that the possible impacts of introducing public transport and related interventions in Riyadh would take at least 10 years to be obvious. The city form gained the highest proportion of the interviewees thought of impact as a result of introducing public transport and new travel interventions in Riyadh City, followed by city economic, environment and lastly social norms and culture.

5.4.3.1 City form

As shown in Figure 5.9, city form was expected to be subject to the highest impact in contrast to the remaining city aspects. One interviewee mentioned that “Reshaping the city form is part of the reason for introducing public transport in Riyadh City, we cannot continue expanding the city and relying on private cars for use. It has impacts on expansion of infrastructures, cost, city life of citizens, time lost in car traffic, the decreasing quality of air, as well as difficulty for pedestrians”. Interviewees felt that the mode of travel plays a vital role on the city planning in which the current planning is compatible with private cars. It was thought that there would be changes in travel demand and population density and more activities around public transport corridors and stations.

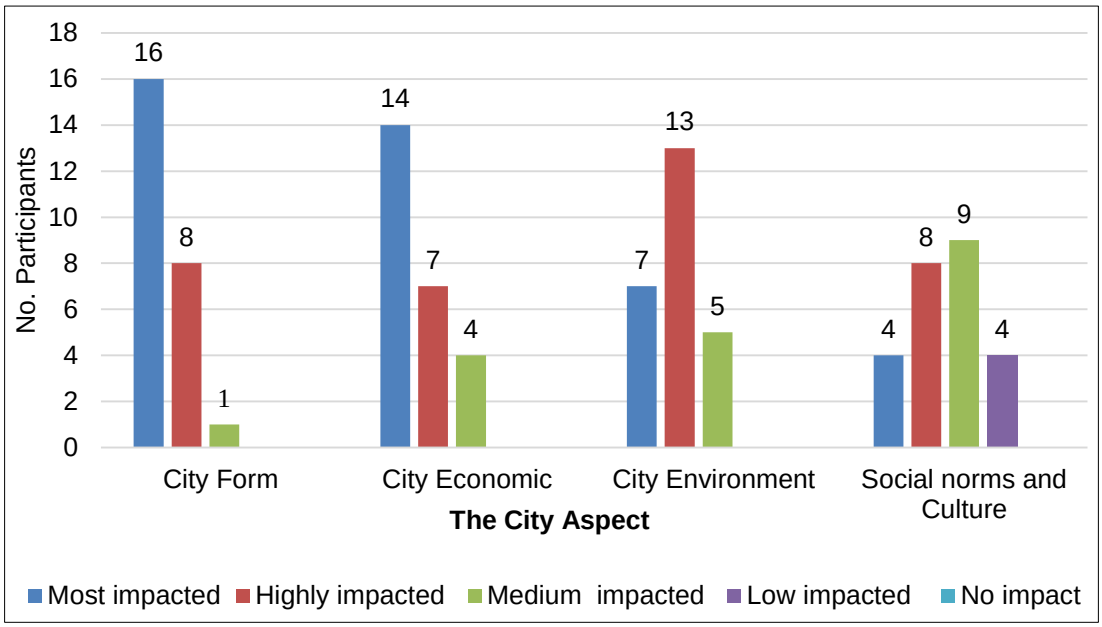


Figure 5.9: The expected impact of implementing public transport and related interventions

The majority of interviewees agreed for that along with the introduction of public transport services, appropriate strategies related to city planning have to be implemented as well. They added that allowing for high-rise buildings, TOD sites connected with a high-frequency public transport service, parking monitoring, and improvement of infrastructure for walking, would play a major role in changing the current city form positively. One interviewee from ADA felt a reshaping of the current city form would be necessary “since it is the first project in Riyadh City; it will change urban development around the main public transport stations and around transit-oriented areas, which amount to 13 areas inside Riyadh City”. Another participant hoped that “the successful operation of public transport in Riyadh City would slow down the current city sprawl”. One of the interviewees argued, “due to economic growth, the low cost of travelling long distances by car, and no natural borders for Riyadh City, [has caused the city to] expand many times”. Generally, there was a belief among the majority of interviewees that the proposed Riyadh’s new public transport project size in providing six lines of metro and bus networks and other transport services in Riyadh City would definitely change urban development, especially around public transport stations, corridors, and TOD areas.

5.4.3.2 City economy

Many participants argued that the capital investment of $ 22 billion in the city for building a new public transport system is considered a significant economic value added to the city's economy. One interviewee from ADA indicated that the project was expected to reduce unemployment by offering 15,000 jobs for Saudi society in public transport or in the surrounding areas, such as hotels, offices and shops.

They added that investing in public transport and related interventions undoubtedly will expand services and improve city mobility. The majority of interview participants stated that currently Riyadh roads are over congested and this adversely affects businesses and households' mobility, so they hoped that public transport would provide direct travel cost savings for those people who switch to use public transport services, leading to a shift in consumer spending. Some of the participants mentioned that they hoped that public transport would improve accessibility of the whole city which will aid travellers and improve productivity of city business.

Another interviewee stated that public transport would save the household budget, for example, nowadays each family would do more than four morning trips to different destinations. He added that in this case the family opt to pay more for costs associated with cars and hire drivers or arrange taxis. So, there is a general hope among the study participants that public transport would help reduce vehicle ownership costs when family members walk or need just one car to drive all family members to the nearest station and they can reach their destinations by public transport.

5.4.3.3 City environment

The majority of interviewees felt that the Riyadh City environment would be positively impacted and that was one of the main objects of the project. For example, one of the participants stated that currently 17 million litres of fuel burn daily in Riyadh City as a result of reliance on private cars, so public transport will definitely help to reduce this amount and that would positively reflect on the city environment. Some of the interviewees felt that successful

operation of public transport in Riyadh City would be a great solution for the current city environmental problems.

5.4.3.4 Social norm and culture

Generally, it was felt that both social norms and the Saudi culture will be impacted by introducing public transport services related interventions, but it will take time for behaviour to become modified in comparison to other themes. Interviewees felt that there would be more social interaction along with the introduction of public transport services since daily journeys are a part of social life and culture. They added that the shift from private cars to public transport would result in a qualitative move and closeness in society. One of Riyadh Municipality interviewees thought that, “Introducing a public transport system in Riyadh City would be one of the programmes to change social norms in positive way”. The majority of interviewees thought that offering a reliable public transport service would make people more aware of time and respect public places. Another interviewee from Riyadh Municipality stated, “More strict strategies are planned to be implemented along with introducing a public transport system in Riyadh City. For example, there will be safety measures and tools to restrict anti-social acts and protect staff, passengers and property of public transport. The interviewee felt that these roles aim to encourage public transport use and at the same time would play a vital role in the social life of communities. He added that there would be a penalty for using the public transport service without paying for a ticket and for any vandalism on all public transport facilities”.

5.5 Discussion

5.5.1 TDM strategies to change Riyadh’s residents travel behaviour

The present study reports a series of semi-structured interviews to evaluate existing and future TDM strategies in Riyadh City, Saudi Arabia to encourage a shift from private car to public transport. The study findings strongly emphasise the city’s needs for a competitive public transport system. This finding is in line with the Global Mass Transit Report (2011) and Alqahtany (2014) who state that neglecting public transport in Riyadh City for no obvious reasons affects the city aspects negatively, especially planning. Thus, from

interviewees' perspectives, sustainable public transport system operation would be a key element for solving the existing major travel issues for this large metropolitan city when providing another alternative to the private car. Improving the city mobility, economic and environmental benefits, together with an improved quality of urban life are more benefits hoped to be achieved by sustainable operation of public transport in Riyadh City. These results agree with the ADA report (2015b) and the results of other studies, for example a previous study by Tran and Kleiner (2005) and recent studies by Weisbrod et al. (2014b) and Litman (2015a) who highlight direct and indirect urban area benefits of investment in public transport such as improved mobility, recentralised city activity, increased productivity and reduced emissions.

The study findings highlight the absence of existing direct transport policy measures that may encourage or motivate Riyadh's residents to use public transport due to the ineffective current public transport system. Throughout the interviews, it was felt that the potential for public transport success in Riyadh might be at risk given the low operational costs of private car use, including abundant free parking areas and low fuel prices. The latter may indicate that Riyadh residents perceive public transport as a mode to serve lower class Saudi citizens and the foreign labouring classes. The Global Mass Transit Report (2011) states that high income, lack of city planning, low car operational cost, culture and climate are certain barriers that would prevent the increase of public ridership among Riyadh society. Thus, to reduce the effects of these barriers and attract more car users, there was more emphasis among study participants for reshaping the existing TDM strategies and implementing new appropriate transport policy measures along with introducing a public transport system in Riyadh City by 2018. These results confirmed Rahman and Al-Ahmadi (2010) study that concluded a potential need for understanding the Saudi unique historical, cultural, socioeconomic and religious character forms when authorities consider new transit systems and transport policy measures in the future

The study findings also declared that some segments of the Saudi society would be more likely to use public transport including the elderly, students, expatriates and women. Interviewees claimed that these groups may have not

been able to drive because of economic reasons or obeying Saudi law, given that under traffic and road regulations women, people under the age of 18 years and many foreign labourers are prohibited from driving (Al-Dubikhi 2007; Al-Atawi 2015).

In regards to addressing the TDM strategies related to the study themes, the study results showed a high priority for reshaping strategies related to city planning and physical change to improve the access to public transport services. This finding is consistent with Banister (2008), Loader and Stanley (2009) and Redman et al. (2013) who found that improving city accessibility is an important factor in attracting more public transport users. Alqahtany (2014) found that transport policies and traffic infrastructure were not carried out in Riyadh city in a sustainable manner as a result of ignoring public transport, and the high reliance on private cars. Moreover in line with Garling and Schuitema (2007), throughout the interview results it became clear that the proposed transport policy measures including park and ride schemes outside the city centre, improving infrastructure for walking, transit stops located centrally within acceptable walking distances, and dedicated bus lanes were scaled as acceptable and highly effective strategies. On the other hand, Balcombe et al. (2004) argue that there is no more evidence for reduction in car use in cities centres as a result of introducing park and ride schemes. Basso et al. (2011) found a dedicated bus lanes policy is the best for improving mobility and achieving social welfare compared to transit subsidization or congestion pricing. In contrast with the suggestion of Kenworthy (2006) to limit the supply of road space to curb automobile dependence, the present study found minimal road capacity as complicating mobility and having low acceptability that would lead to low effectiveness as well.

As suggested by respondents themselves, allowing for high-rise building along public transport corridors and selecting appropriate TOD sites at Riyadh City and connecting them with the main public transport lines would be required to increase the density and promote active public transport. This is in line with the study of Cervero and Murakami (2008) and Newman (2012) who refer to TOD as one of most sustainable forms for decreasing private car travel, promoting transit riding and can offer cities economic advantages.

Legal transport policy measures are imperative in reducing private car use and ownership such as illegal parking control, monitoring parking, and limiting the supply of parking. These findings are consistent with the study by Javid et al. (2013) in Auckland City, in which the authors report that parking management reduced the rate of private car trips by 8–18%. In addition, according to iCommute (2012), private parking often comprises 50% or more of a city centre's parking stock, and even complete control of all parking fails to control through traffic, often comprising one-third or more of all traffic entering a city centre. Furthermore, in this study, other legal policies including speed management, enforcements for driving without a driving licence, and obeying traffic regulations were found as the most effective, acceptable and applicable legal strategies to be implemented in Riyadh City. A recent study from Bliss and Breen (2012), confirms these findings, as they report that such legal strategies hoped to change social norms toward sustainability and increase road safety. On the other hand, in line with the study of Schlag and Teubel (1997), prohibiting car traffic in city centres and congested locations was found to be fairly affective but less acceptable compared with other legal policies.

In agreement with previous studies by Ison (2000), Hensher et al. (2003) and Garling and Schuitema (2007), the economic theme is seen by authorities' representatives as a very important factor which would influence transport mode choice in Riyadh City. Thus, levying car-parking fees, low public transport fares, special offers such as issuing daily, monthly and annual tickets were seen as highly effective strategies by the majority of the study sample. They perceived that accessible, and reliable public transport with low fares would be the chosen mode of mobility among students. Lastly, they added that the elderlies are in need of public transport to move around and for socialising and to be active in life.

Al-Fouzan (2012) concludes that authorities in the UK and USA are more aware of the influence of car parking requirements in addition to other transport policy measures to encourage sustainable transport alternatives. Another study by Ison and Wall (2002) found workplace parking charges as effective transport policy measures, but at the same time it has the lowest acceptability compared with other pricing measures such as taxing roads and fuel.

Balcombe et al. (2004) maintain that parking polices are not always effective but there are many examples of the effects of restricting parking places or applying charges for changing people's travel behaviour towards public transport.

Despite Ison and Rye (2005) and Litman (2011) argue that the London congestion charge has reduced traffic and congestion significantly, and Small (2004) states that congestion charging creates a virtuous cycle in shifting private car users to public transport. Interviewees perceived that congestion charges might increase the burden of driving their cars, and give them a sense that public transport has brought about negative changes for the City. Moreover, in the current study road pricing and taxation, or increasing fuel prices were seen as effective strategies, but might be not accepted by the public in Riyadh City. This result agreed with the work of Ison (2000) who found that 80% of the key stakeholder groups in the UK feel urban road pricing publicly unacceptable. With regard to increasing fuel prices, studies in Italy by Gallo (2011) and Tehran by Khalilikhah et al. (2016) yielded the same results when remarkable increases in fuel prices led to little decrease in car use and serious dissatisfaction for the people.

With respect to the social and culture theme measures, similar to findings by Alqahtani et al. (2012), our participants claimed that Saudi society has no experience of using modern public transport, a bad image of the current bus service conditions, high income of households, and possesses unique characteristics from religion and tribes. It was thought that these would be a major effect on travel behaviour and transport mode choice in Riyadh City. Interviewees felt that there is a need to change people's awareness, approaches, beliefs, values and personal norms in relation to car use in Riyadh City. For instance, in line with Stead and Banister (2001), Garling and Schuitema (2007) and Meloni et al. (2012) the study findings indicated that providing information about negative aspects of car use through education and public campaigns, holding new sessions to teach pupils the main benefits of public transport, signs, and usage were found to be effective strategies in this study. Moreover, participants thought that integrating public transport services

with school transport services to transport high school pupils would entice them to use public transport in the future.

This study found that high frequency of public transport, comfortable seats, and cleanliness would be highly effective strategies to attract more public transport users. The results agreed with Ison (2000), Balcombe et al. (2004) and Dell'Olio et al. (2011) who also found these strategies as the most affective and acceptable to attract the current and the future public transport users. Security measures, personal safety, and pedestrian-friendly surroundings for all public transport premises were also thought to be highly effective strategies by the majority of the study participants. This is in line with surveys in cities throughout Europe that state that developing safety and security measures across public transport facilities have raised passenger confidence to increase public transport use (Gaggi et al. 2013). Ison and Wall (2002) found that improved public transport and carrots such as safe walking and cycling routes are the most acceptable. A study by Delbosc and Currie (2012) argued that even though the perception of the influence of safety measures on public transport ridership seems small, it affects more than household car ownership.

The strict gender segregation is an important aspect in Saudi society which is fully enforced by the country's rules and religious life (Ezzi et al. 2014; Alhazmi and Nyland 2015). Therefore, from this study finding, it became clear that allocating buses for female students, and gender separation at bus stops, waiting areas in transit stations, and separate carriages for families were perceived as effective strategies to promote public transport ridership in Riyadh City. Dunckel-Graglia and Brook (2013) describe separating women's carriages in public transport as a good idea to ensure their safety and modify their travel behaviour towards increased use of public transport.

In terms of information and technology strategies, participants perceived that information and technology services are effective, acceptable and applicable and should be available to promote public transport. Implementing a clear and accurate passenger information strategy using the appropriate media for each person is very important to ease the access to public transport services (Institute for Transport Studies 2010). The study participants felt that the

employment of new technical features such as a Smart ticketing system would reduce barriers to the use of public transport. Other effective information and technical strategies include mobile tickets app, providing up-to-date information on public transport options, including timetables, on-board facilities, such as Wi-Fi, TV screens, and newspapers.

5.5.2 The wider impacts of the new public transport system in Riyadh City

The current study investigated impacts of introducing a public transport system and related interventions in Riyadh City for the city form, economics, environment, social norms and culture. The findings show that public transport would make a positive contribution on all city aspects within different scales of time. City form would be more highly impacted than the economy but in terms of time scale the economic influence of investment in public transport has already appeared since the Riyadh's new public transport project work started. A medium impact is expected on the city environment while impacts on social norms and culture would take a long time to become obvious.

The study findings show that the current Riyadh City form is highly dominated by private transport infrastructure, and there is a disconnect between land use and other travel alternatives such as walking. As the Riyadh's new public transport project is the biggest project in the country and the first travel alternative, study participants believe it will reshape city form. In line with this view, Amin et al. (2013) state that sustainable mobility shapes the urban form. TOD sites, park and ride schemes, metro stations and bus stops, and physical change measures to re-establish connection to public transport services would bring about dramatic changes in the current city form. Sustainable operation of Riyadh public transport and activating related interventions would decrease the rate of current city expansion and increase density. Cervero and Murakami (2008) maintain that physically TOD's features refer to three dimensions; density in accommodating enough population living within acceptable walking distances from public transport services; diversity in land uses and housing types; and design that embodies physical features encouraging walking, biking, and public transport ridership as well as social engagement.

Interview results show a widespread support for allowing high-rise buildings along public transport lines and surrounding areas. These are seen as necessary strategies to improve city sprawl, increase density, recentralise city activity, improve access to public transport services, and increase ridership. A recent study from Pojani and Stead (2015) confirm these findings as they found that success of non-motorised travel modes and public transport practically and financially required high density and mixed land use.

In economic terms, introducing public transport would lead to direct and indirect economic benefits broadening economic growth in Riyadh City. In the study results, the impact of spending on the project capital investment and operations cost will support the city economy through creating jobs and stimulating the economy. Moreover, public transport would lead to mixing land use and improving properties value. These results are in line with the study by Aschauer and Campbell (1991) in the last decade and a recent study by Weisbrod et al. (2014b) which state that investing in public transport supports the city economic in several ways, such as improving employment status and centralising the economic activities. As it is stated by Al-Mosaind (2001) and confirmed by the majority of participants, households' spending for daily mobility in Riyadh increased dramatically as a result of the spreading of the city, increases in average household size, and the unique social characteristics and culture. Thus, the study results revealed a general hope among the majority of interviewees that the introduction of public transport would reduce households spend when they modify their travel behaviour by switching to use the nearest public transport station instead of private cars. Moreover, public transport would improve city accessibility, save costs and time for passengers and at the same time it would reduce congestion costs and improve automobile mobility, saving time and costs of peak period automobile travellers.

Nevertheless, the study results maintain that the sustainable operation of Riyadh public transport would improve city mobility on the whole and provide access for jobs and education; reduction of accidents will save lives and damage to roads and associated expenditure; and reduce emissions. All these results are in line with recent studies by Weisbrod et al. (2014b) and Litman

(2015a) which classify the benefits of investing in public transport in urban areas to direct and indirect benefits.

From a viewpoint of environmental impact, the study results show that the traffic demand has exceeded 8 million vehicle trips in Riyadh City, generating thousands of tonnes of solid waste. The city weather is dusty, dry and very hot in the summer. The city air quality shows elevated levels of pollution including Co_2 emissions and Particulate Matter (Alharbi et al. 2015). The study results show that Riyadh public transport is expected to reduce motorised travel by 10% to 15% and this number would increase with time when people become familiar with the service. Thus, sustainable operation of public transport in Riyadh City is hoped to minimise environmental pollution by reducing motorised travel. Riyadh public transport has been designed using solar energy and other environmental friendly power such as electric metro and ultra-low emission technologies for buses. The majority of the study sample argued that a sustainable national plan is needed to improve the city air quality and noise. It is important to raise awareness of environmental considerations in education and the workplace. Developing environment–friendly practices such as integrated and safe pedestrian networks in most important parts of the city will discourage the use of private cars and encourage people to walk.

There is less expectation that social norms and culture, which are regularly stated to be barriers of public transport ridership in Saudi Arabia, will be affected in the short-term as a result of introducing a public transport service in Riyadh City. The social norms and culture in Riyadh City are derived mainly from Islamic religion. This aspect must be taken into account and respected in all services and interventions such as privacy and preventing the mixing of men and women. Moreover, Riyadh society is highly reliant on private cars and has not been accustomed to any other kind of transport modes. The study findings show that changing social norms and culture towards public transport ridership in Riyadh City will need persuasive, soft measures directed at households and individuals. The shift from private car to public transport will result in a qualitative move and closeness in society. Providing a service which is comparable in time and comfort to using private cars is perhaps the major

challenge to persuade the general population to shift to public transport in Riyadh City (Aldalbahi and Walker 2015).

Arguably, hard measures such as building infrastructure and pricing policies are not sufficient to change people's perception towards private car and public transport (Zhang et al. 2015). With reference to soft measures, the study means the quality of public transport service such as security, safety, comfort, convenience and reliability would play major roles in influencing travel mode choice in Riyadh City. Litman (2015a) argues that the quality of public transport such as providing a comfortable and convenient service would attract more public transport users; even if the trip takes somewhat more time compared to driving. Moreover, the study findings show that a sustainable public transport operation with a high quality of service such as reliability, security and safety would reinforce the spirit of commitment of time and deadlines, and provide more respect for public places in Riyadh society, as well as increase women's participation in employment and other activities. Moreover, general public campaigns and school lessons teaching general people and students the benefits of public transport services, how they can pay for tickets and information about prices, and how they would behave on board, would be essential strategies for social norms and culture to able to use the public transport service. According to Aldalbahi and Walker (2015) changing Saudi attitude and then travel behaviour is a gradual process and will take a long time to be achieved. People will only change their behaviour if they have the opportunity, ability and motivation to do so (Boschetti et al. 2014b).

Additionally, the strength of the present study arises from being the first ever study to look into the potential demand for public transport in the Riyadh City, Saudi area. This study takes a holistic view in the sense that it employs a qualitative approach to engage key stakeholders targeted from authorities in Riyadh City engaged in transport such as ADA and PTA.

Regarding the limitations, due to the cultural context of the society all interviewees in this study were males. There is a lack of secondary data about the reality of the current transport policy measures of the city of Riyadh with respect to sustainability. Moreover, there is no prior information about the

public transport operational criteria such as the ticket prices and the service frequencies.

Finally, a subsequent part of this study will involve a quantitative survey of the general public from a sample of Riyadh's residents. The survey aims to investigate the general public's perspectives regarding the potential uptake of public transport services in Riyadh City. The survey will also explore the general public's attitudes towards public transport and the proposed set of TDM strategies to encourage public transport ridership, and investigate residents' transport behaviour adopting a stated preference experiment.

5.6 Summary

In summary, the study indicated an absence of direct transport policy measures and regulations that may encourage or motivate Riyadh's residents to use public transport in Riyadh City or travel policies to encourage public transport ridership and an urgent need for TDM strategies in Riyadh City. Moreover, it was found that many sectors of society are in real need for effective public transport facilities, such as high school students, university students, elderly, and women. Modern attractive public transport facilities in terms of a high quality service, ease of reach, reduced fares for families, students and elderly people are the key elements for the success of these facilities within the society. Moreover, availability of information regarding these facilities' timing, service plans, changes, and route planning through modern mobile communication devices are very important for its success.

It is also perceived that selecting appropriate TOD sites, improving infrastructure to enhance the accessibility to and from transit stations, and park and ride schemes were the most effective strategies. Economically, increasing fuel prices was also considered to be effective, but might lead people to sense that public transport has brought about negative changes for their City. Social and cultural strategies are deemed to be very important for changing people's travel behaviour, and separate carriages for families and the safety of public transport facilities on-board and on-stations were seen as the most effective strategies to encourage public transport ridership in Riyadh City. There is a general feeling that strategies related to information and technologies to

promote public transport use are very effective, acceptable and applicable to be implemented in Riyadh City.

CHAPTER SIX: GENERAL-PUBLIC SURVEY RESULTS

6.1 Introduction

In this stage of the research, a general-public survey was conducted in Riyadh City during August and September 2016. As indicated earlier in the study design and methodology chapter, this stage of the research aims to examine public reactions regarding the introduction of a new public transport system (metro and buses) in Riyadh, which is expected to be in operation by 2018 (ADA 2015a). In particular, this stage aims to analyse individual perspectives and attitudes about the current travel conditions in Riyadh, considerations and behavioural intentions towards Riyadh's new public transport system. Finally, it explores public reactions towards various TDM strategies include hard and soft policy measures in order to encourage public transport ridership.

In this sense, investigating general-public views using a questionnaire would be considered the most suitable and widely used research instrument to address the research question and accompanying areas of interest. As it is also indicated in the research methodology chapter, Saudi Arabia, as many developing countries, lacks a reliable sampling frame for recruiting survey participants. It was impossible to contact private car or public transport users because their addresses and phone numbers are not systematically listed, whereas postcode and postal services provide little opportunity for a mail survey. Also, the Saudi society is gender-segregated, largely conservative and religious, making participant recruitment – especially women – through random talk, extremely challenging.

To address these challenges, this study tested a social-network based survey tool. The survey was conducted over the Internet and the recruitment process adopted principles of the RDS method in that participants used their social networks to invite their friends or relatives to participate in a study. RDS is a chain-referral sampling technique that combines social network-based measures with statistical validity of standard probability sampling methods (Heckathorn 2011). The strength of the social relationships among the study area residents is more likely to enhance response rate, reduce volunteer bias, accelerate the data collection process and improve data quality. This web-

based sampling allows the researcher to track and monitor the recruitment process and take necessary measures to ensure data collection is successful. The following sections provide details on the data and the results obtained through the quantitative survey of the general public in Riyadh.

6.2 Results

6.2.1 Data Collection Procedure

Based on Riyadh City population diversity in which Saudi males and females have almost the same percentage and a third of city population is expatriates, the first round of recruitment (seeds) included three groups: four (4) Saudi males, four (4) Saudi females, and four (4) expatriates. As detailed in the research design and methodology (Chapter Four), seeds were invited via email by the investigators of this study and upon completion of the survey, they were then asked to invite friends and relatives via the survey's email system at the end of the questionnaire. Thus, the initial survey was mailed out to 12 seeds in the first week of August 2016.

6.2.2 Descriptive Analysis

The survey was conducted between August and September 2016, and 741 residents of Riyadh City, including Saudis and non-Saudis, were invited to participate in the survey. In total, 250 participants (33.7% of the invited target group) completed the survey questionnaire. The beginning and the last week of the recruitment processes were slower than expected. The sample analysis was conducted using Stata 13.

6.2.3 Individual Characteristics

As shown in Table 6.1, more than two-thirds of the participants were males. Almost half of participants were between 25 and 34 years old (46%) with the great majority being Saudi nationals (86%). The proportion of married people among the study participants was 75%. In terms of education, over half of the survey participants (52%) held a bachelor's degree followed by those who held a post-graduate degree (27.6%). Finally, almost three-quarters of participants worked full-time (72%), only 4% worked part-time, and 3.2% were self-employed and unemployed, respectively.

As shown in Table 6.1, a Chi-square test revealed that the sample proportions do not directly align with the available Census data. The sample over-represents males and those aged between 25 and 44 years, as well as those with high qualifications. The sample also under-represents individuals aged between 16 and 24 and over 55 years. On the other hand, the sample is representative of married individuals in Riyadh. Although the sample is not in many aspects representative of the general population, it provides a good representation of labour-active individuals, the target population of Riyadh's metro system.

Table 6.1: Individual socio-economic characteristics of participants and Census in 2015

Socio-economic characteristics		**Sample**		**Population**		**p-value**
		Frequency	Percent	Number	Percent	
Gender	Female	55	22.0%	1743589	42.3%	0.000
	Male	195	78.0%	2378370	57.7%	
Age range	16-24	25	10.0%	902709	21.9%	0.000
	25-34	115	46.0%	1401466	34.0%	
	35-44	85	34.0%	919197	22.3%	
	45-54	21	8.0%	671879	16.3%	
	55 and over	4	1.6%	226707	5.5%	
Marital status	Married	187	74.8%	3009029	73.0%	0.520
	Single	63	25.2%	1112930	27.0%	
Nationality	Saudi	216	86.4%	2584468	62.7%	0.000
	Non-Saudi	34	13.6%	1537491	37.3%	
Education level	Primary	3	12.0%	1187370	19.3%	0.000
	Intermediate	3	12.0%	1544197	25.1%	
	Secondary	46	18.4%	1132001	18.4%	
	Bachelor	129	51.6%	953587	15.5%	
	Post-graduate	69	27.6%	141500	2.3%	
Employment status	Full-time employed	179	71.6%			
	Part-time employed	10	4.0%			
	Self-employed	8	3.2%			
	Unemployed	8	3.2%	N/A	N/A	
	Student	27	10.8%			
	Retired	15	6.0%			
	Looking after the home	2	0.8%			
	Other	1	0.4%			

Notes: N/A = not applicable

6.2.4 Household Characteristics

The highest proportion of participants (35.2%) earned between 10,001 and 15,000 Saudi Riyal per month, which was equivalent to £2,000 to £3,000 (2016 prices). In addition, as indicated in Figure 6.1, 9.2% of the participants earned less than 5,000 Saudi Riyal and 14% stated that they earned 20,000 Saudi

Riyal per month, the lowest and highest income categories in the questionnaire, respectively. There was an equal proportion of participants (18.4%) with no children or one child per household, whereas the highest proportion was those having two children (22%). Moreover, a quarter of the participants lived with three adults, and 15.2% with two adults. Finally, as shown in Figure 6.2, more than 75% of the participants indicated that their household owned two to three automobiles.

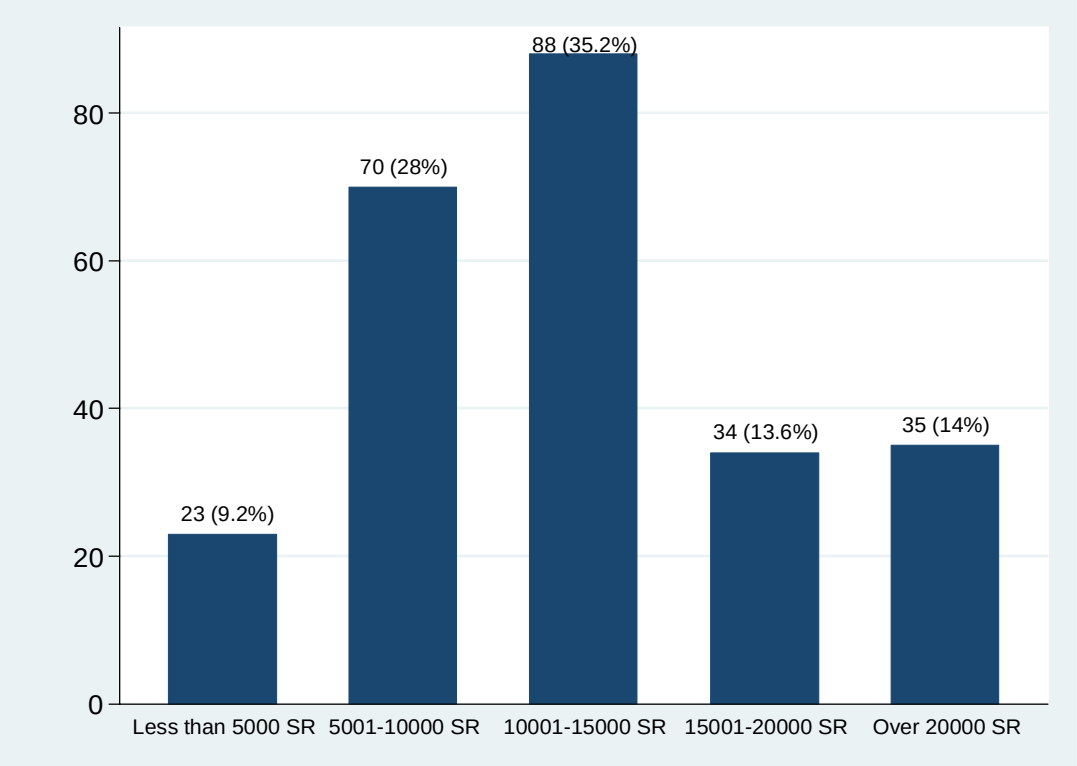


Figure 6.1: Monthly household income

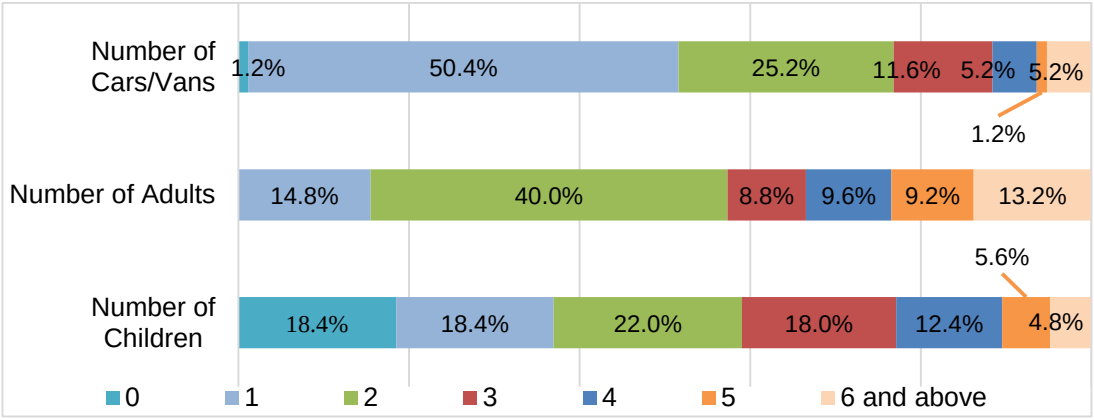


Figure 6.2: Number of households' members and automobiles

6.2.5 Travel Behaviour

In this section, the survey asked a series of questions to gain a better understanding of respondents travel behaviour and characteristics. As shown in Figure 6.3, the questionnaire embeds an online mapping system that respondents can indicate where their home, work, study, and (regular) shopping locations are on a map of Riyadh. These questions presented sequentially. The distance from households to destinations calculated through google maps.

Figure 6.3: Home, work, study and shopping locations screenshot, Source: Google maps (2016)

6.2.5.1 Commuting distance

Among the 201 participants who worked, almost half (44.9%) lived between 5 and 15 km from their workplace and only 4.5% of them lived within 1 km from their workplace. As indicated in Table 6.2, the mean distance for commuting was 12.5 km.

6.2.5.2 Distance to school

Among 51 respondents travelling to school, the highest proportion (29.4%) made a school journey between 5 to 10 km, followed by 17.4% of respondents who travelled more than 10 km and the same proportion travelled less than 5 km. Those who travelled less than 1 km to attend schools made up 13.7% of the sample. The mean distance to school was 14.3 km.

6.2.5.3 Distance to shopping

Almost a third of respondents (28%) travelled less than 5 km for shopping, while almost a quarter of the sample (23%) travelled between 5 and 10 km. As indicated in Table 6.2, the mean distance to shopping was 10.4 km.

Table 6.2: Travel distances (Km)

Journeys	Mean	Std. Deviation	Min	Max	Observations
Commuting	12.5	8.8	1.2	52	201
School	14.3	9.6	1.1	32.1	51
Shopping	10.4	8.4	0.3	45	250

6.2.5.4 Mode of travel

Participants were asked about the mode of transport they most frequently used for their travel. The results showed that a considerable proportion of the participants (67.0%), primarily drive alone, 18.8% of the respondents answered that they travel as a passenger in a family vehicle, 10% that they drive with someone else, while just 3.6% as a passenger in someone else's vehicle.

6.2.5.5 Acceptable walking distance

Participants were asked about their acceptable walking distance to the nearest bus stop and transit station. As shown in Figure 6.4, although a considerable proportion of participants (31.1%) indicated a short walking distance (less than 200 metres, 5 minutes' walk), the majority of the respondents (37.6%) were willing to walk up to 300 metres (7 minutes).

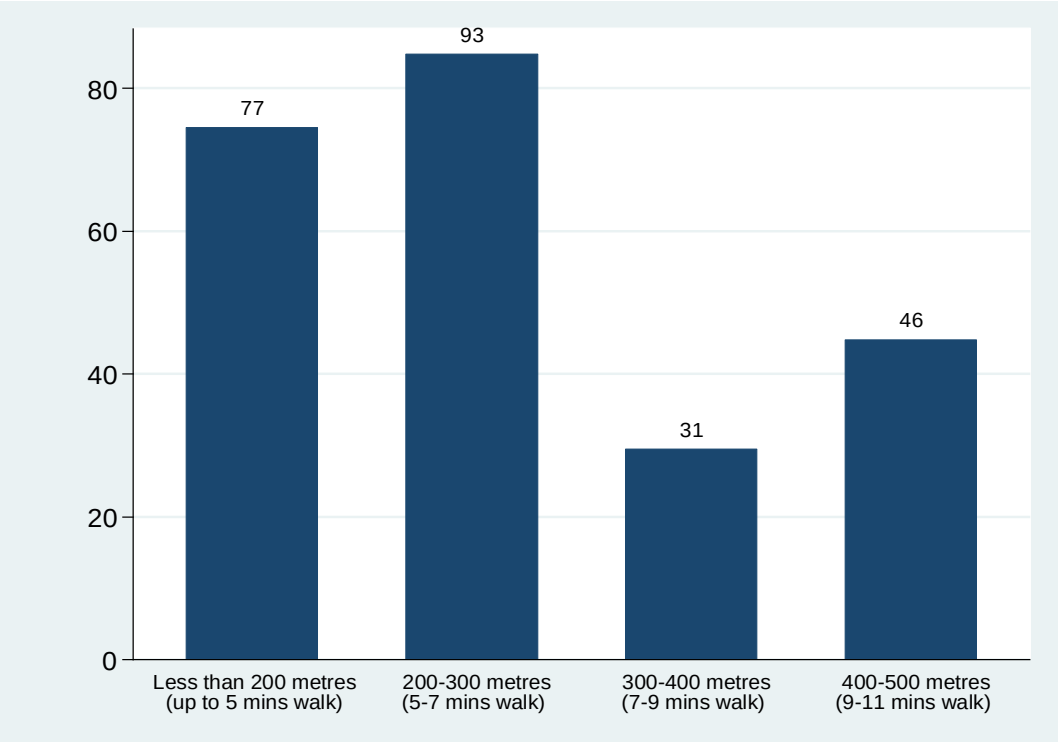


Figure 6.4: The acceptable walking distance

6.2.5.6 Experience with public transport use

Participants were asked if they had any experience of public transport use. They were given three choices: yes, no and not sure. Almost two-thirds of the participants (60.0%) indicated that they had experienced public transport use.

6.2.6 Evaluation of the current traffic conditions

The findings showed that more than two-thirds of the participants (66.4%) were dissatisfied with the current road traffic conditions in Riyadh City. Almost all participants (91.69%) were in favour of introducing a public transport system, and finally the majority of participants (86.8%) were willing to use public transport.

6.2.7 Exploring Individual Perceptions and Economic-demographic Relationships

Chi-square tests were carried out to examine possible associations between respondents' perceptions and gender, age, income and nationality. For brevity, only those questions that had significant associations with respondents' demographic and economic characteristics are presented in Table 6.3. In addition, the proportions listed in Table 6.3 correspond only to

those respondents who either strongly agreed or agreed to the corresponding perceptions presented on the left-hand side of the table.

A significantly higher level of satisfaction regarding current road traffic in Riyadh, though overall small, was expressed by respondents aged between 16 and 34 years of age relative to those aged 35 years and over. There was also a marginal difference between Saudi and non-Saudi respondents when they were asked about being in favour of introducing public transport in Riyadh City; the proportion of Saudi citizens who agreed or strongly agreed in favour of a new public transport system was higher than non-Saudis.

Table 6.3: Participants' opinions about the current status of transport

	Gender (%)			**Age, yrs. (%)**			**Income, 000 SR**			**Nationality (%)**		
	M	F	Sig.	16-34	>35	Sig.	≤15	>15	Sig.	S	N	Sig.
Satisfied	8	3		8	6	**	9	6		6	12	
In favour	92	92		93	88		95	90		93	84	*

*Key: Satisfied= Satisfied with the current road conditions; In favour= In favour of introducing new PT in Riyadh; M=male; F=female; PT= public transport; S= Saudi; N=Non-Saudi; * p<0.05; ** p<0.01; *** p<0.001.*

6.2.7.1 Attitudes, Beliefs, and Transport Behaviour

The survey investigated respondents' attitudes on current traffic conditions, public transport, and economic, social and cultural aspects. The available responses were 'strongly agree', 'agree', 'neutral, 'disagree' and 'strongly disagree'. Unless otherwise stated, the percentages below are the combined percentages of participants who responded either 'strongly agree' or 'agree'; for brevity, these participants were categorised into a single 'agree' category. Similarly, those who responded 'strongly disagree' or 'disagree' were categorised below as 'disagree'.

6.2.7.2 Current traffic conditions

As shown in Figure 6.5, most participants (82%) indicated that road congestion would make them more open to using public transport. In the case of safety, 80% were worried about car accidents and confirmed they would be willing to switch to public transport. Only 20% of respondents strongly agreed that no access to a car would make them use public transport in the future. In addition, limited parking at destinations and on-street parking control was affirmed by 70.2% of the participants as important strategies that would encourage them to use public transport. Finally, nearly three-quarters of the participants felt

that they would switch to public transport to stop worrying about traffic violations such as speeding on speed cameras.

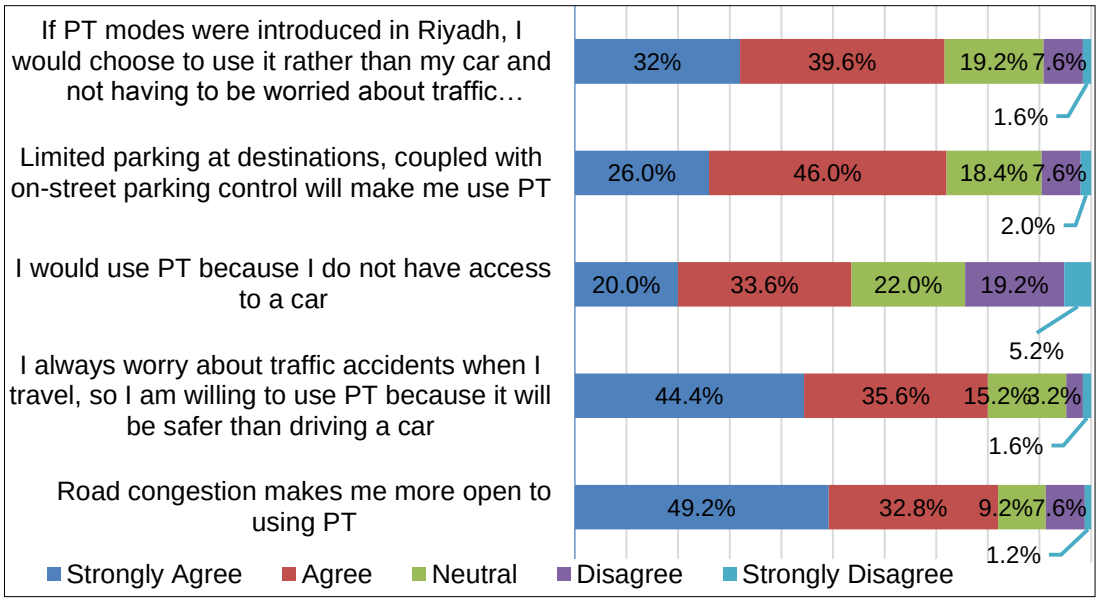


Figure 6.5: Current traffic characteristics

6.2.7.3 Public transport factors

As shown in Figure 6.6, nearly three-quarters of the participants (71.6%) agreed that high-quality public transport elements such as comfortable seats, air conditioning and cleanliness would encourage use of public transport, even if journeys took longer than driving. Most participants (93.2%) indicated that obtaining a journey planner application on their computer and phone would encourage them to use public transport. Also, frequency of the public transport service and clear passenger information was highly supported by almost all participants (95.6%). Finally, 92.4% felt that ease of reaching metro stations and stops, particularly on foot, would make them more open to using public transport.

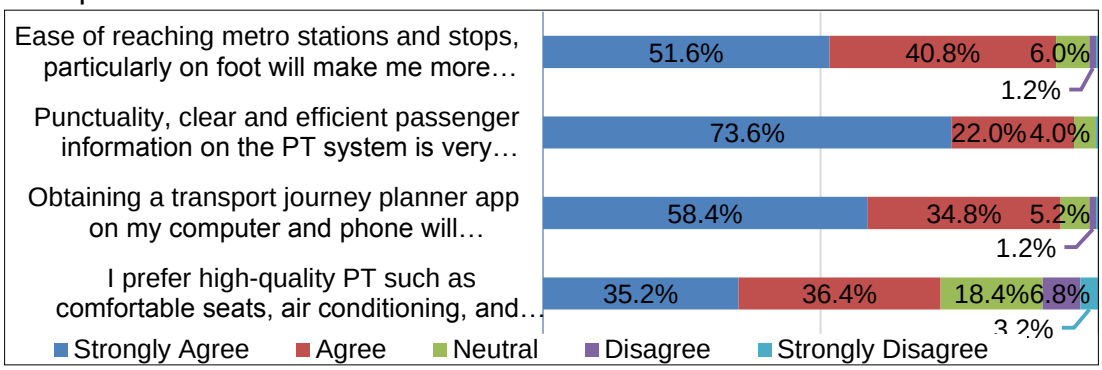


Figure 6.6: PT factors influencing ridership

6.2.7.4 Economic factors

As Figure 6.7 shows, more than half of the participants agreed that increasing fuel price would encourage them to use public transport. The majority (79.6%) preferred buying tickets for public transport that offer discounts or special offers in malls and local shops. The results also indicated that more than half of respondents (56.8 %) felt that paying road tax and/or parking charges would strongly support their shift to public transport, while 27.6% were neutral. More than half of the study sample felt that the chance of winning prizes such as smartphones and tablets every month through a raffle draw would encourage them to use public transport.

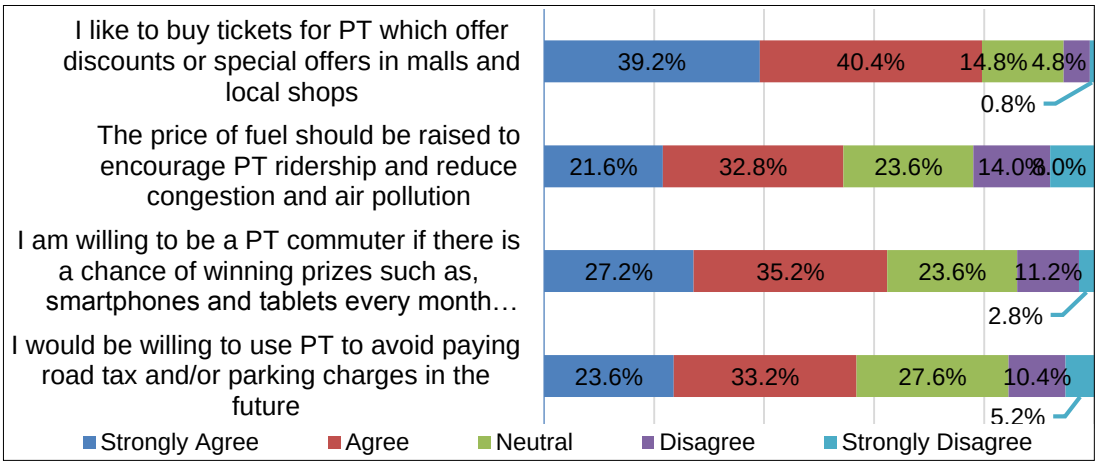


Figure 6.7: Economic strategies to increase PT ridership

6.2.7.5 Social and cultural factors

In terms of the social status associated with using public transport, participants were asked if they disliked mixing with others when travelling or felt embarrassed while using public transport. As shown in Figure 6.8, 37.2% of respondents were neutral, 34.8% disagreed and 28% felt that public transport was only for less fortunate people. In another statement, more than half of the participants (53.6%) agreed that they would use metro but would not use buses. In the case of safety and security, most participants (91.6%) held the view that feeling safe and secure while travelling were very important elements in their decision to switch to public transport.

The majority of participants (88%) agreed that they would allow and encourage their children and family to use public transport if there were separate carriages for families. Three-quarters of the participants (74.8%) were in

favour of public transport use if the main stations had shops and utility offices such as telecom and passport offices. Statements investigating participants' perceptions of public transport reveal that more than 80% of respondents felt that public transport would be a major solution to provide women with access to transport.

The respondents had a reasonably bad perception of bus use, as less than half (43.6%) stated negative impressions about bus use. A significant majority of the study sample (73.6%) agreed that Metro carriages provided with standard seats, family carriages and first-class seats are very important in influencing their decisions to shift to public transport. Most of the participants (82%), agreed that taking more pupils to school by public transport rather than school buses in Riyadh would entice them to use public transport in the future. Providing metro compartments with entertainment such as videos or Internet would attract 75.6% of the participants to use it. Finally, less than half (43.6%), affirmed that if they had to use public transport instead of cars, they would have to cancel some daily activities.

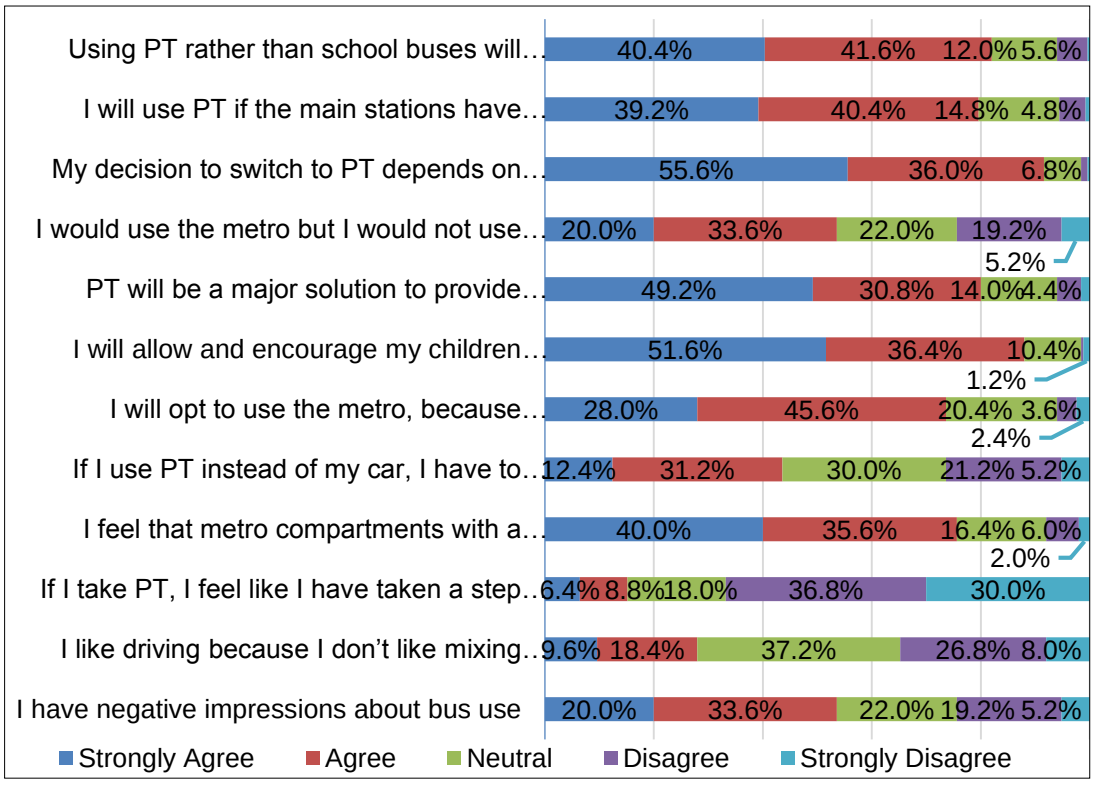


Figure 6.8: Social and cultural factors influencing PT ridership

6.2.8 Exploring Differences between Participants' Responses

Chi-square tests were carried out to examine possible associations between respondents' responses to attitudinal statements and gender, age, income and nationality. For brevity, only those five statements that had significant associations with respondents' demographic and economic characteristics are presented in Table 6.4. In addition, the proportions in the table only correspond to those respondents who either 'strongly agreed' or 'agreed' to the corresponding statements presented on the left-hand side of the table.

With regard to a prize-winning raffle draw for public transport users, a marginally higher level of agreement was expressed by respondents aged between 16 and 34 years of age relative to those aged 35 years and over, and Saudi relative to non-Saudi citizens. Likewise, a higher level of agreement was reported by respondents earning 15,000 Saudi Riyal or less relative to those earning more than 15,000 Saudi Riyal a month. Moreover, Saudi citizens expressed a marginally higher level of agreement regarding statements offering discounts in malls for public transport riders and parking control relative to non-Saudi. As shown in Table 6.4, access to a car presented differences between respondents. A higher level of agreement was expressed by females (vs. males), those aged between 16 and 34 years of age (vs. 35 and over), and those earning less than 15,000 Saudi Riyal per month, that no access to a car would encourage them to use public transport. Similarly, females were more likely to agree that a variety of entertainment would be an attractive feature to encourage use of public transport. Finally, those travelling more than 5 km felt that using public transport would make them cancel some daily activities.

Table 6.4: Summary results for attitudinal and belief statements

Statements	Gender (%)			Age, years (%)			Income, 000(%)			Nationality (%)		
	M	F	Sig.	16-34	>35	Sig.	≤15	>15	Sig.	S	N	Sig.
Prizes	60	69		70	52	*	77	53	***	64	47	*
Discounts	76	89	N/A	83	74		83	77		81	64	*
Parking	73	65		70	73		69	73		75	52	*
Access	30	60	***	42	29	**	45	31	**	38	23	
Entertainment	77	69	*	77	73		76	75		77	64	

*Key: prizes= winning prizes when use PT; Discounts= Discounts in malls for PT commuters; Parking= Limited car park in destinations; M=male, F=female, PT= public transport, S= Saudi, N=Non-Saudi, * p<0.05, ** p<0.01, *** p<0.001 by analysis of STATA 13.*

6.2.9 Factor Analysis

A factor analysis was conducted to further investigate participants' perspectives, attitudes and willingness to change travel mode from car to public transport. The analysis was based on 28 questions and attitudinal statements (listed in previous Figures 6.5, 6.6, 6.7 and 6.8) and measured on a 5-point Likert scale, in which score 1 represents 'strongly agree' and score 5 represents 'strongly disagree'.

6.2.9.1 Adequacy of study sample

Prior to conducting the factor analysis, the Kaiser-Meyer-Olkin (KMO) equal to 0.79 indicated that the sample size is factorable and falls into the range of 'middling' (Hutcheson and Sofroniou 1999). The minimum KMO values for individual items in the sample were greater than 0.55, which is above the acceptable limit of 0.5 (Field 2013). The intercorrelation between all 28 questions was analysed showing that 27 out of the 28 items were correlated with the minimum threshold value of Pearson's correlation coefficient set at 0.3 suggesting suitability of the sample for factor analysis (Field 2013). The Bartlett's Test of Sphericity was significant ($\rho<0.05$) indicating that the correlation matrix was significantly different from an identity matrix, in which correlations between variables are all zero.

6.2.9.2 Validity and reliability testing

An initial step in the analysis obtained eigenvalues for each factor in the data. According to Stevens (2002), the critical values of factor loadings should lie between 0.298 and 0.364 for a sample size between 300 and 200, respectively. The varimax rotation was run to simplify the sample structure and minimise the number of variables that have high loadings on more than one factor. Given the sample size in this study is 250, two items with factor loadings less than 0.3 were excluded. The factor correlation matrix was also estimated to decide between orthogonal and oblique rotation. Variables with loadings higher than 0.5 are presented in bold.

As shown in Table 6.5, the results of an orthogonal rotation of the solution for the 24 remaining items explained 72.4% of the variance. Three factors were retained because of the convergence of scree plot with eigenvalue larger than

one (shown in Figure 6.9), and Kaiser's criteria in this value. None of the factor correlation matrix exceeded 0.32 and thus the solution remained nearly orthogonal (Tabachnick and Fidell 2007). Moreover, the reliability of all the survey items was examined to measure the internal consistency of the items in the scale. An initial examination produced a reliability coefficient of 0.79, which falls in the acceptable range (George and Mallery 2003).

6.2.9.3 Factors related to public transport use

As shown in Table 6.5, three factors/domains appear to capture respondents' practicalities with regard to public transport use: conditions of travel, financial considerations and cultural aspects about public transport.

The first factor is the most important and is captured by 14 items, which account for 47% of the variance. The highest loadings in this factor are for the items related to various possible characteristics of public transport. For example, the highest loadings are for those statements "I am worried about traffic accidents, and willing to use public transport because it is safe", "punctuality, clear and efficient passenger information in public transport", "public transport is a solution to provide women access to transport" and "I will allow and encourage my children and family to use public transport because there are separate families' carriages". These factors can be summarised under the name 'Conditions of travel'. The Cronbach's alpha value for this factor is 0.83, which falls in the good range (George and Mallery 2003).

The second factor comprises eight items accounting for 26% of the variance. It is clear from Table 6.5 that these eight items are all related to financial considerations. The highest loadings in this factor are for those statements "the price of fuel should be raised to encourage public transport ridership and reduce congestion and air pollution" and "I would use public transport to avoid paying road tax and/or parking charges". This is therefore called 'Financial considerations'. The Cronbach's alpha reliabilities for the responses to items in the second factor is 0.75, which is within the acceptable range (George and Mallery 2003). Finally, the third factor corresponds to five items and accounts for 25% of the variance. This factor includes items describing cultural aspects and public transport such as, "if I take public transport, I feel like I have taken

a step down in the world", "I have negative impressions about bus use", and "I do not like mixing with others in public transport". The third factor is therefore named 'Cultural perceptions about public transport'. As shown in Table 6.5, the Cronbach's alpha value for the third factor is 0.74, which is within the acceptable range.

Table 6.5: Results of the factor analysis

Statements	**Conditions of travel**	**Financial considerations**	**Cultural aspects about PT**
High-quality PT such as comfortable seats, air conditioning, and cleanliness	0.3815		
The main PT stations have utilities offices	0.3165		
A variety of entertainment such as videos, Wi-Fi	0.3660		
A transport journey plan application	**0.5826**		
Separate families' carriages	**0.5808**		
Worry about traffic accidents; PT is safe	**0.5919**		
PT provides women access to transport	**0.5703**		
Taking more pupils to school by PT would help encourage use in the future	0.3672		
Punctuality, clear and efficient passenger information on PT would make me ride it	**0.5225**		
PT safety and security	**0.5523**		
Ease of reaching metro stations	**0.5011**		
I would use PT to avoid traffic violations	0.4503	0.3024	
A chance of winning prizes through a raffle draw	0.3907	0.4238	
PT tickets should offer discounts in malls	**0.5735**	0.3706	
New public transport service in Riyadh City		0.3009	
The price of fuel should be raised		**0.6042**	
Use PT to avoid road tax and parking charges		**0.6166**	
Limited parking and control of on-street parking		0.4922	
Willing to use public transport		0.3843	
Use PT I have taken a step down in the world			**0.6191**
Don't like mixing with others in PT			**0.5564**
PT would make me cancel some activities			**0.5199**
I would use the metro but I would not use buses			**0.6764**
I have negative impressions about bus use			**0.6593**
Cronbach's Alpha	**0.83**	**0.75**	**0.74**
% variance explained	**0.724**	**0.260**	**0.250**
Kaiser-Meyer-Olkin	**0.7939**		
Bartlett's Test of Sphericity	**Approx. Chi-Square:**		**1728.002**
	Df		**325**
	Sig.		**.000**

Note. Loadings < 0.30 are omitted.

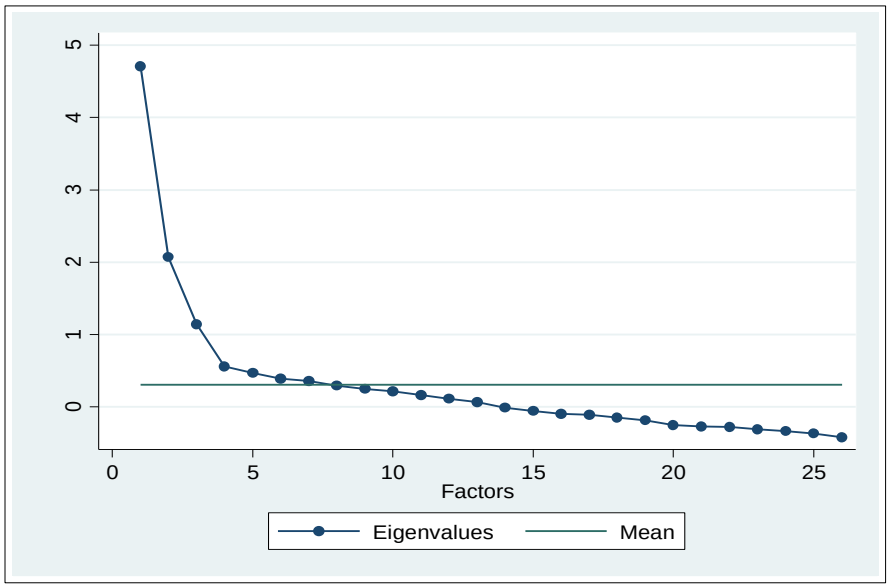


Figure 6.9: The scree plot of eigenvalues after factor

6.2.10 Structural Equations Model

The structural equation model (SEM) has been widely adopted in several fields of research (Eboli and Mazzulla 2012). Recently SEM has been a frequently used methodology in transport research to evaluate and investigate the relationship between observed and unobserved (latent) variables (De Oña et al. 2013). For example, in Granada (Spain), De Oña et al. (2013) adopted SEM to determine the impact of a series of characteristics describing the quality of the bus transit service on the overall service quality. In Spain also, De Oña et al. (2015) developed SEM to investigate the relation between public transport users' satisfaction, quality of service and behavioural intentions of the Metro of Seville. Moreover, Ye and Titheridge (2016) used SEM to measure the impact of the built environment, travel attitudes and travel characteristics on the satisfaction of commuters. In Canada, Van Lierop and El-Geneidy (2016) used SEM models to investigate the loyalty of transit users, measuring the impact of quality of service, satisfaction and behavioural intentions on ridership.

Based on the findings of the factor analysis, a SEM was conducted to capture the associations across attitudinal and belief statements, socio-demographic characteristics and three latent variables (factors). The model was developed in Stata 13 and the full path diagram is shown in Figure 6.10. Table 6.6 shows

the calculated goodness-of-fit measures. Also, as shown in Table 6.6, the majority of measures meet the commonly used criteria of goodness-of-fit.

Table 6.6: Goodness-of-fit measures for the structural equation model.

Goodness-of-Fit Measure	Index	Criteria
χ2/df	0.000	< 5.0
RMSEA	0.060	< 0.08
SRMR	0.05	< 0.05
CFI	0.824	> 0.9
TLI	0.825	> 0.9

Notes: χ2 = Chi-square; df = degree of freedom; RMSEA = root mean square error of approximation; SRMR =standardized root mean square residual; CFI = comparative fit index; TLI = Tucker Lewis index.

As it was only possible to find consistent effects for age, gender, income, number of children, nationality and education level, the study reported results of the SEM for these socio-demographics. Emerging from the factor analysis were three elements: conditions of travel, financial considerations, and cultural aspects (Table 6.5). The follow up SEM pointed towards a positive association between income, conditions of travel and financial considerations. As shown in Table 6.7, lower-income individuals (<15,000 SAR) were more likely to consider travel characteristics and pricing and subsequently place higher ratings on attitudinal statements related to conditions of travel, such as ticket subsidies (e.g. prizes), efficiency, provision for family carriages and safety and security, as well as attitudinal statements on public transport ticket prices, fuel price and have an overall willingness to use public transport.

Also, educational qualifications were positively associated with respondents' higher financial considerations at 94% level, and cultural perceptions at 92% level about public transport. In other words, individuals holding a bachelor's degree or higher were more likely to take into account elements around pricing, public transport tickets and fuel prices. Most importantly, those holding a higher education degree were more likely to score higher on the 'cultural aspects about public transport' factor and thus feel more strongly that taking public transport would be 'taking a step down in the world', 'dislike mixing with others', 'having negative impressions about bus use' and would rather use metro instead of bus.

Table 6.7: Structural equation model of six outcomes: gender, age, income, children, nationality and education level

Factors	Male	Age	Income< 15000	Children	Nationality	Education
Conditions of travel	0.1092 (0.154)	0.0571 (0.362)	0.1137 (0.070)	-0.0162 (0.212)	0.0743 (0.400)	0.0925 (0.188)
Financial considerations	-0.0787 (0.416)	0.1049 (0.191)	.1936 (0.018)	-0.0251 (0.129)	0.1047 (0.364)	0.1697 (0.060)
Cultural perceptions about PT	-0.0121 (0.922)	0.0781 (0.464)	0.0823 (0.416)	-0.0141 (0.526)	0.1114 (0.450)	0.3744 (0.002)

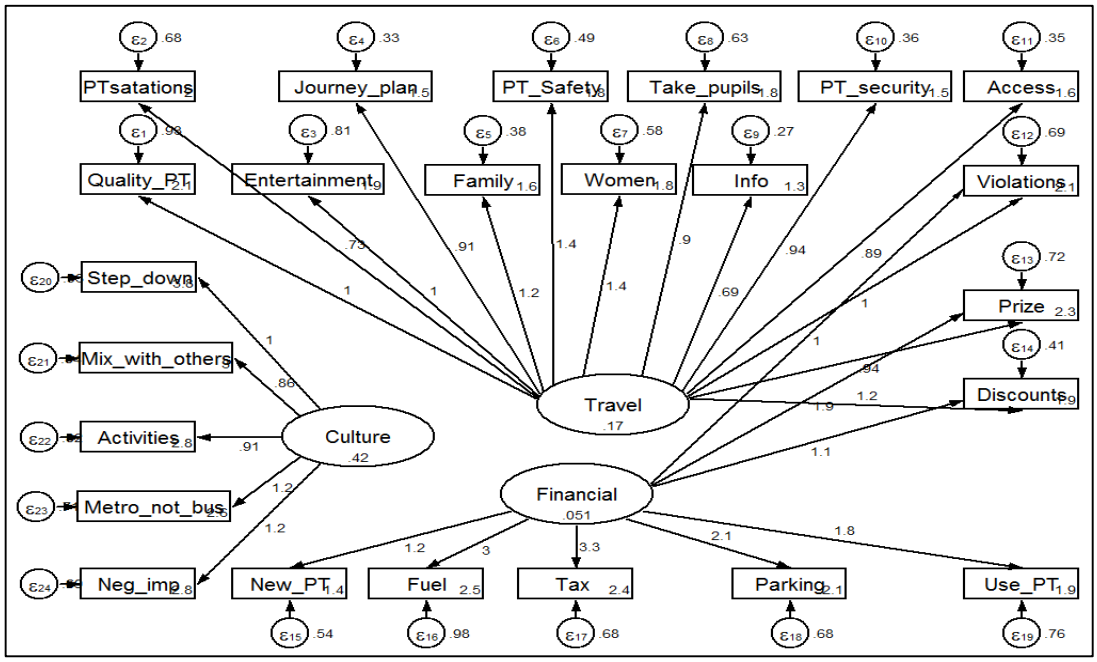


Figure 6.10: Full path diagram of hybrid choice and latent variable model of demand.

Note: **Neg_imp**= I have negative impressions about bus use; **Metro_not _bus**= I would use the metro but I would not use buses; **Activities**= If I use PT instead of my car, I have to cancel some activities; **Step_down**= If I take PT, I feel like I have taken a step down in the world; **Family**= I will allow and encourage my children and family to use PT because there are separate families' carriages in Riyadh metro and buses; **Women**= PT will be a major solution to provide women access to transport, since they don't drive in our society; **Info**= Punctuality, clear and efficient passenger information on PT system is very important; **Violations**= I would choose to use PT rather than my car and not having to be worried about traffic violations; **Prize**= I am willing to be a PT commuter if there is a chance of winning prizes through a raffle draw; **Discounts**= I like to buy tickets for PT which offer discounts; **PT stations**= I will use public transport if the main stations have shops and utilities offices; PT; **Take_pupils**= Taking more pupils to school by PT rather than school buses in Riyadh, will help familiarise with PT and use it in in the future; **Access**= Ease of reaching metro stations and stops, particularly on foot will make me more open to use PT; **New_PT**= I agree with new PT service in Riyadh City; **Use_PT**= I am more likely to use Riyadh PT when it is in operation.

6.3 Discussion

This study implemented a public survey in Riyadh City to analyse individual perspectives and attitudes about the current travel conditions in Riyadh, considerations and behavioural intentions towards Riyadh's new public

transport system, and explore public reactions towards various TDM strategies in order to encourage public transport ridership

The findings showed that more than two-thirds of the participants were dissatisfied with the current road traffic conditions in Riyadh City, including congestion, road safety and driving behaviour, and were highly in favour of more travel options. The findings also revealed that people in Riyadh were dependent on their private cars. Although a large proportion of the participants confirmed that they will use public transport when it is in operation, a notable percentage would prefer the car as their mode of transport.

In line with Aljoufie (2016), results indicated that the majority of the respondents were willing to walk up to 300 metres (equal to 7 minutes' walk) to the nearest bus stop and transit station. Rahul and Verma (2014) state that generally people would walk from 5 to 15 minutes to get to or from a transit station or stop. They add that people would be vary in their acceptability of walking distance depends on their socio-demographic characteristics and trip characteristics such as trip purpose and time.

In addition, the analysis revealed that a significantly higher level of satisfaction regarding current road traffic in Riyadh was expressed by respondents aged between 16 and 34 years of age relative to those aged 35 years and over. Also, the proportion of Saudi citizens in favour of a new public transport system was higher than non-Saudis.

Factor analysis revealed that perceptions around travel were important and were summarised into three groups: conditions of travel, financial considerations and cultural perceptions towards public transport. Further analysis showed that in line with Beirão and Cabral (2007), travel time and safety played a key role in order to encourage public transport use, in which the majority of participants expressed their willingness to shift to public transport to avoid traffic congestion and accidents. Litman (2014) argues that increased congestion would make some travellers change route, destination, travel time and mode to avoid delay.

With regard to financial considerations, and in line with the Department for Transport (2015) report, the factor analysis in this study revealed that costs

related to car use and public transport such as fuel prices and road taxes were also an important element influencing public transport ridership.

Moreover, the study also investigated public attitudes regarding transport policies and incentives to encourage public transport use. The findings obtained in this study are generally in line with previous studies, for example, motivating factors promoting the use of public transport included increased fuel prices (Gallo 2011; Khalilikhah et al. 2016), introducing road tax (Buehler and Pucher 2012; Dieplinger and Fürst 2014), introducing parking charges (Ison and Wall 2002), penalising traffic violations, and discounts in malls.

With regard to the demographic characteristics of the respondents, further analysis found that respondents aged between 16 and 34 years, respondents with a low income (Balcombe et al. 2004; Chen et al. 2008), and Saudi citizens were more likely to shift to public transport use in response to economic incentives such as winning prizes as public transport commuters. This study found that limited parking at destinations, coupled with on-street parking control were important strategies that would make people more open to use public transport. These findings support study results by Topp (1993) in German cities. Another recent study by Agarwal and Collins (2016) conducted at Kingston City, Canada, found that free parking on the street and the availability of a low cost monthly parking permits are a strong motivation to drive to work regularly among Queen's University employees. The quality of service in the public transport system was another set of factors influential in increasing transit ridership. In agreement with a number of studies of travel behaviour, such as a qualitative systematic review by Redman et al. (2013), and a quantitative study in Winchester City by Wall and McDonald (2007), this study found that frequency of the service, comfort of travel and punctuality were more positive influences for public transport ridership. In line with a previous study by Gripsrud and Hjorthol (2012), this study revealed that provision of wireless Internet and updated information for public transport services would make passengers' journeys more enjoyable.

In addition to the more tangible aspects of travel, other perceptual features can substantially affect travel decisions, for example, in line with Agarwal and Collins (2016) who found that time spent getting from the point of origin to the

first transit stop, and getting to the destination from the last stop is one of the key barriers to public transit ridership, this study found that transit stops located centrally within acceptable walking distances and improving city accessibility to make it easy to reach public transport services, are important measures in attracting more public transport users in Riyadh City. Banister (2011) found that improved accessibility would decrease number of household own cars to 10–30% and drive 10–30% less miles.

Most importantly, there are social and cultural perceptions that need to be taken into consideration. Statements relating to people's perceptions about public transport, such as negative impressions about public transport and mixing with other people were important and the results of the factor analysis agreed with Dunckel-Graglia and Brook (2013). In order to increase public transport ridership and compete with dominant car reliance, the future planning of the public transport system in Riyadh City has to pay considerable attention to city lifestyle and social and cultural perspectives. The provision of separate compartments for family use only and ensuring security and privacy would be important factors here. The findings showed that in Riyadh's metro the following would be major factors attracting use of public transport: safety (Delbosc and Currie 2012), family carriages (Horii and Burgess 2012), carriages provided with standard seats, first-class seats, entertainment, and main stations with shops and utility offices such as telecom and passport offices. The study participants felt that public transport incorporating these aspects would be a major solution in providing women access to transport, since women do not drive in cities in Saudi Arabia (Al-Dubikhi 2007). Moreover, the idea of taking more pupils to school by public transport rather than school buses in Riyadh, to entice students to use public transport in the future, was strongly recommended by almost the entire group of survey participants. This finding was also supported by a qualitative part of a previous study on stakeholders and policymakers in Riyadh City by Alotaibi and Potoglou (2017). In another case, in line with Al-Fouzan (2012), participants held bad impressions about the current bus services and expressed more willingness to use metro rather than bus.

The SEM analysis depicted that there are positive associations between respondents' income, conditions of travel and financial influence factors. In sum, there are no direct associations between gender, age, number of children, nationality and the study factors. In contrast, two studies in the USA by Chen et al. (2008) at the New York Metropolitan Region and Kim and Ulfarsson (2008) at the Puget Sound Regional found a negative association between number of children and public transport ridership.

In line with a study by Bopp et al. (2015) in the mid-Atlantic region of the USA, there are previously uncovered significant associations between cultural perception of public transport and education qualifications. This is a significant finding indicating that individuals with higher educational qualifications would still look at public transport use as an inferior means of transport relative to the private car. Also, evidence indicates that for that group of individual/potential users the metro would be a more preferable means of travel rather than bus.

6.4 Summary

This study used a public survey in Riyadh City to obtain an understanding of Riyadh citizens' attitudes, beliefs and travel preferences in light of new Riyadh's public transport system. As pointed out above, this study suggests cultural aspects play an important role influencing perceptions of public transport given the geographical context of this study. The unique cultural characteristics might cause failure of many traditional TDM strategies. Public transport services that provide safety, quality and separate families' carriages in Riyadh metro and buses have the potential to attract private car users among Riyadh City residents. It is also perceived that selecting appropriate TDM strategies such as improving infrastructure to enhance the accessibility to public transport services, increasing car operation costs and parking charges were the most effective strategies to ensure sustainability of public transport. The results demonstrate that strategies related to conditions of travel such as public transport safety and security, punctuality and separate families' carriages are more important than these related to financial influence and cultural perceptions about public transport.

CHAPTER SEVEN: DISCRETE CHOICE EXPERIMENT ANALYSIS

7.1 Introduction

Chapter Six analysed data from the first part of the general public survey. The second part of the general public survey was divided to a discrete choice experiment, the results of which will be analysed in this Chapter. In general, discrete choice experiments postulate that, “the probability of an individual choosing a given option is a function of their socio-economic characteristics and the relative attractiveness of the options” (de Dios Ortuzar and Willumsen 2001, p. 220). In this study, the discrete choice experiment was found to be a promising method of measuring respondents’ valuations of the influence of different attributes such as travel cost and journey time for cars and public transport. A discrete choice experiment has had wide applicability in numerous subject areas, including transport, over the last 30 years (e.g. Iragüen and Ortúzar 2004). A discrete choice experiment has the capacity to solve common issues in modelling market behaviour such as multi-attributes, and explore non-existing alternatives (Hensher et al. 2005a).

In the study survey, a discrete choice experiment was conducted using the stated preference method in which each respondent was offered scenarios that showed various public transport attributes at different levels, such as different prices for tickets, different service frequencies and different walking times. Attributes related to cars had five levels each. For example, the total travel cost for the car included parking charges and car travel cost. The car travel cost begins with the current car travel cost for the respondent’s trip for commuting or shopping as a base and the cost increased by 25%, 50%, 75% and 100%. Car travel time includes respondents’ travel time using the distance from respondents’ home to commuting, study and shopping, and the average car speed in Riyadh City. Travel time is increased by 5 minutes, 15 minutes, 25 minutes and 40 minutes to reflect different levels of congestion. Students and employed people including full-time, part-time, and self-employed were offered ten (10) scenarios, five (5) scenarios for commuting /study trips and five (5) scenarios for shopping selected randomly from an optimal plan of 64

scenarios with zero priors. The rest of the respondents, including people who were retired, unemployed and those looking after their home, were presented with only five scenarios for shopping. The aim was to explore the probability of choosing between the car and public transport and to measure how this probability was affected by changes in the attributes of the alternatives (see Chapter Four, the study design and methodology for more details). In the following sections, this chapter evaluates the quality of the responses in the experiment tasks through descriptive analysis and the value respondents would place on their car in comparison to public transport, investigating responses to the experiment's tasks through the estimation of multinomial logit models.

7.2 Data Quality

The data used in this section was collected in Riyadh City over August and September 2016 as part of the general public questionnaire survey (see Chapters Four and Six for more details about the data collection process). The 250 respondents who completed the survey and generated 2,365 observations did not report any major issues with the survey instructions. As shown in Figure 7.1, respondents were asked to what extent they understood the SP tasks. The vast majority (91.6%) of the respondents found all the survey sections easy to understand and complete.

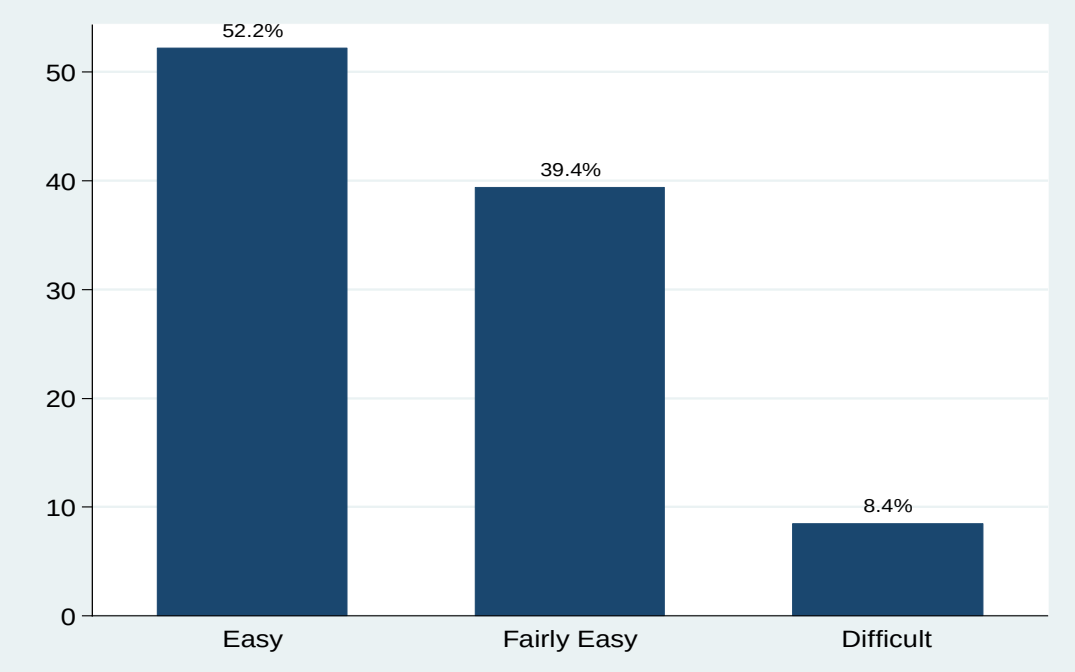


Figure 7.1: Understanding the experiment tasks

7.2.1 Missing data

The first stage of processing the SP data was to review all observations and identify the number of issues relating to the pre-analysis and cleaning of the SP tasks' data. A total of 250 respondents completed the survey and generated 2365 observations. Of these, 431 scenarios did not show the travel distance to commuting/study or shopping and travel mode was not selected in another four (4) scenarios. The major source of missing data would be due to misunderstanding of the provided Google map in the survey in which some respondents selected the same coordinates for home, work, study and shopping. In those cases, the generated travel distance was zero. Therefore, the software calculations for car travel cost, travel time, and public transport journey time variables were zero as well. In view of this issue, 44 respondents representing 475 scenarios were screened from the analysis of the SP data. As shown in Figure 7.2, in total, 207 respondents representing 1890 scenarios were finally used in the analysis.

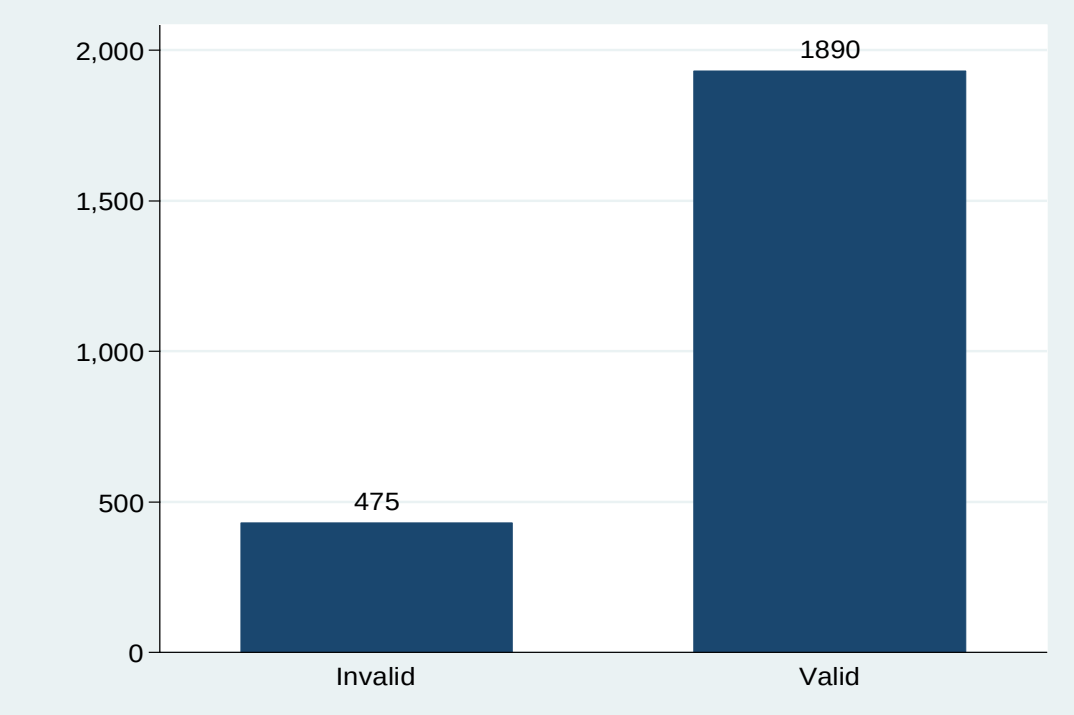


Figure 7.2: The final scenarios used in the analysis

7.2.2 Non-trading choice behaviour

Non-trading in a SP experiment is a contentious issue requiring examination of the number of respondents who only selected the same alternative across all scenarios (Hess et al. 2010). Non-trading may indicate that a respondent is not utility-maximising between different alternatives and this can impact data quality. Crabbe and Vandebroek (2012, p. 23) maintain, “The existence of dominant alternatives in choice sets can be problematic and detrimental to the quality of the choice data, as the choice then provides little information about how the respondent has made the decision”. It was therefore useful to investigate whether any alternatives dominated in the choice experiment by considering the frequency with which each alternative was selected from the total choice tasks. In this study non-trading in choice behaviour was considered. As shown in Figure 7.3, out of 250 total respondents, only 44 respondents always chose the same alternative across all scenarios, with five respondents having selected a car throughout, and 39 having selected public transport. The remaining 206 respondents all traded-off between two alternatives across the scenarios presented.

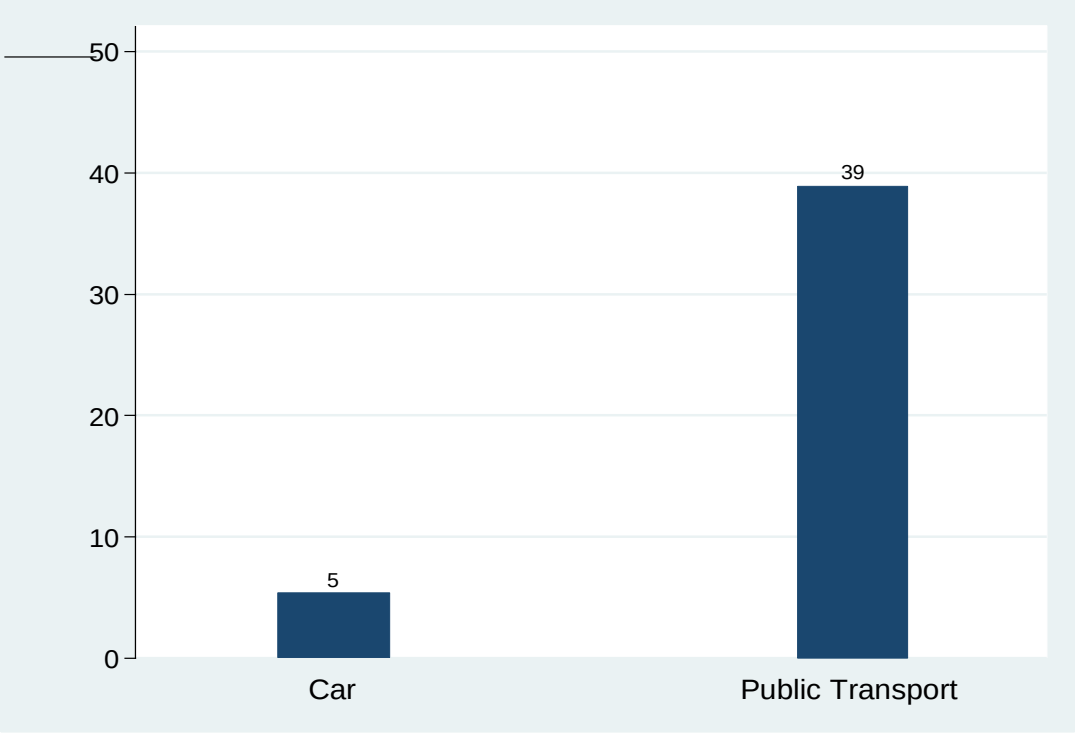


Figure 7.3: Frequency of non-trading

There are a number of reasons for non-trading which may include poor understanding of the choice exercise, boredom, fatigue, or an extreme preference for the selected alternative (Hess et al. 2010). However, the overall impact of this behaviour on data quality was judged to be low due to the relatively low number of incidents of non-trading, and absence of the reason for non-trading. It was then elected not to remove these responses from the data before further analysis. Sensitivity analysis did not result in any significant difference, with or without these observations.

7.3 Exploratory and Analysis

7.3.1 Respondent survey completion status

In total, 1890 scenarios were found valid for analysis. As shown in Figure 7.4, out of 1890 analysed scenarios, public transport was selected 1,297 times (68.6%) as a preferred travel mode, whilst the car was selected 593 times (31.4%). This indicates that the public transport alternative was the most preferred travel choice.

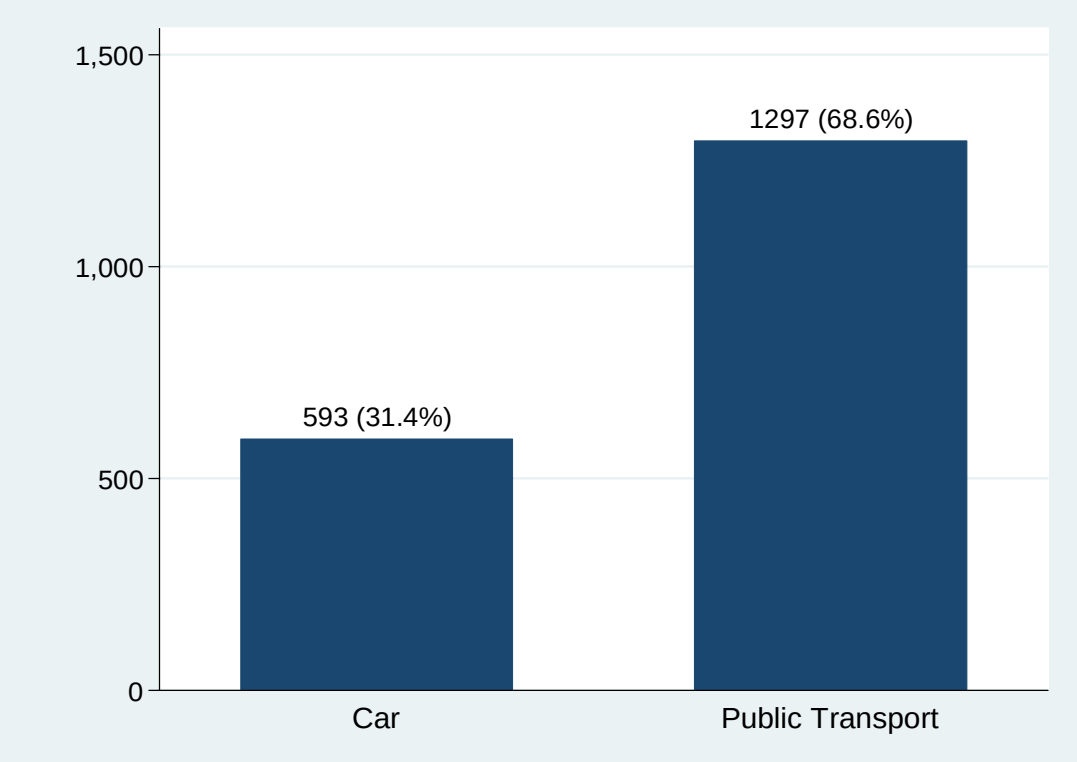


Figure 7.4: Frequency of choices

Figure 7.5 provides a further overview of the extent of choices by respondents, showing the number of respondents who selected metro, bus, or metro & bus. Among the 68.6% of respondents who selected public transport, the most popular selection was metro and the lowest was bus. The car is the second mode choice preferred among the other options.

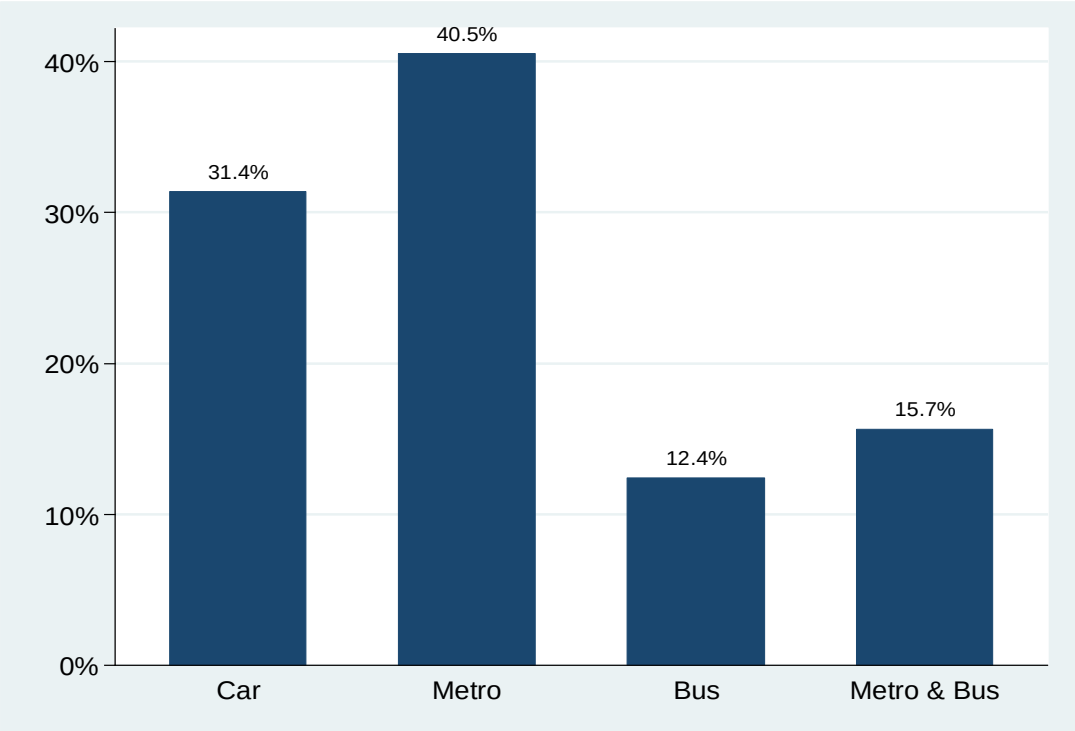


Figure 7.5: Percentage of choices includes all modes

7.3.2 Individual characteristics and travel mode selection

As shown in Table 7.1, individual socio-economic characteristics were grouped in binary categories. The analysis of respondents' preferences revealed that the metro was the most preferred travel mode. The car was more popular among females and non-Saudis. The bus was the least preferred mode. The last column in Table 7.1 presents the relationship between individual characteristics and the preferred travel mode. It shows a marginal association between gender and travel mode choice at a 95% level, with 99% between respondents' nationality and travel mode choice, and 90% with respondents' level of qualification. Finally, there were no significant associations between travel mode selection and respondents'' age and marital status.

Table 7.1: Individual socio-economic characteristics and travel mode selection

Socio-economic characteristics		Travel mode selection				p-value
		Car	Metro	Bus	Metro & Bus	
Gender	Males	484	663	193	238	0.028
	Females	109	103	42	58	
Age	16-34 years	307	403	117	146	0.745
	>35 years	286	363	118	150	
Income	<15,000	226	254	80	109	0.257
	>15,000	367	512	155	187	
Marital status	Married	443	593	182	241	0.163
	Single	150	173	53	55	
Occupation	Employed	480	638	182	240	0.227
	Unemployed	113	128	53	56	
Education	< Bachelor	95	141	46	56	0.081
	=>Bachelor's	498	625	189	240	
Nationality	Saudi	490	673	209	246	0.012
	Non-Saudi	103	93	26	50	

7.4 Analytical Framework

The logit family of models for studying discrete choices has been recognised since the late 21st century (Hensher and Greene 2001). The discrete choice models are based on utility maximisation and random utility theory (McFadden 1974; Fang et al. 2014, p. 2) to estimate the value of attributes related to travel alternatives. Utility is the function of the selected object's properties and the decision makers' characteristics (McFadden 1974). As the stated choice experiment focused on nominal outcomes, and there are more than two alternatives of interest, multinomial logit models (MNL) were the appropriate analytical tool to investigate choice of travel mode (Train 2000). Following the utility maximisation rule of random utility theory, rational decision makers are assumed to choose the alternative which provides the highest utility (Koppelman and Bhat 2006, p. 12). According to random utility theory, developing an MNL requires the specification of the utility function that comprises an observable and an unobservable part (Hensher et al. 2005b, p. 45). The utility expression is represented by the equation below:

$$U_{ji} = V_{ji} + \varepsilon_{ji} \quad (7.1)$$

Where:

U_{ji} is the utility function of the alternative travel mode j *(j= 1, 2, … j)* of trip makers i *(i = 1, 2, ... i);*

V_{ji} is the observable part of the utility function; and

ε_{ji} is the unobservable part of the utility, or error (Koppelman and Bhat 2006, p. 18).

The observed part of the utility is derived from other components that would influence people's choice of preferences including the attributes of alternatives, the socio-economic characteristics, and the interactions between attributes and characteristics (Ben-Akiva and Lerman 1985). This part of the utility function is expressed as follows:

$$V_{ji} = V(S_i) + V(X_j) + V(S_i, X_j) \quad (7.2)$$

Where:

V_{ji} is the observable portion of utility of alternative j for individual i,

$V(S_i)$ is the portion of utility associated with the individual S_i characteristics,

$V(X_j)$ is the part of utility of alternative j associated with the attributes of the alternative, and

$V(S_i, X_j)$ is the portion of the utility resulting from interactions between the attributes of alternative j and the characteristics of individual i (Koppelman and Bhat 2006, p. 19).

7.4.1 Model attributes

There is an exclusive association between the utility component and alternatives and these variables are related to the alternative's attributes. These attributes are measurable, differ across alternatives for the same individual, and are expected to affect people's preferences/choices among alternatives such as travel time, cost and others (Koppelman and Bhat 2006, p. 20). For example, this part of the utility formula would be in the following expression:

$$V(X_i) = \beta_1 * X_{i1} + \beta_2 * X_{i2} + \cdots + \beta_k * X_{ik} \quad (7.3)$$

Where:

β_k is the parameter, k is the attribute, X is the value of attribute, and i is the alternative.

7.4.2 The probability

The MNL is a model that is used to explain and predict the probability that a decision maker will choose an alternative, and the influence of different attributes on this probability. In this study, the probability of any alternative being chosen in a choice between four travel mode options ‘car’, ‘metro’, ‘bus’ and ‘metro & bus’ is as follows:

$$PR(j) = \frac{\exp(Vj)}{\exp(V_{Car}) + exp(V_{Metro}) + exp(V_{Bus}) + exp(V_{Metro\&Bus})} \quad (7.4)$$

Where j indicates the alternative (i.e. car, metro, bus, or metro & bus) for which the probability is being computed. So, under this formula, the probability that an alternative will be chosen increases with an increase of its utility and decreases with increases of the utility of each of the other alternatives (Koppelman and Bhat 2006, p. 30).

7.4.3 Value of travel time

The value of travel time (VOTT) can be defined as “the price people are willing to pay to acquire an additional unit of time” (Athira et al. 2016, p. 116). Measuring the VOTT depends on several parameters. VOTT is very volatile; it is different and changeable from place to place and even from one person to another. The VOTT for freight and passenger travel is estimated in many studies using discrete choice models (Antoniou et al. 2007). In terms of data, the authors maintain that, due to the difficulty of obtaining revealed preference data, most studies use SP data. The idea of considering the value of time for any activity goes back to the theory of the allocation of time by Becker (1965). Most of the studies aiming at the estimation of VOTT for freight and passenger travel use discrete choice models. Due to practical reasons, most studies use logit models, while recent studies, such as of that by Bierlaire and Thémans (2005) use more advanced models such as mixed logit. In terms of data, most studies use stated preference data, no doubt due to the difficulty of obtaining revealed preference data. The inclusion of socio-economic characteristics into the model formulation is recommended. Richardson (2002) demonstrated the use of adaptive stated preference surveys using simulated data.

$$V = \beta_0 + \beta_{cost} * t\ cost + \beta_{time} * t\ time + \cdots \quad (7.5)$$

Where: β are the coefficients to be estimated

$t\ cost$ and $t\ time$ are the variables associated with travel cost and travel time, respectively

… Corresponds to additional explanatory parameters in the model.

$$Value\ of\ time = \frac{\beta_{time}}{\beta_{cost}} * 60 \quad (7.6)$$

7.5 Model Estimation Results

This section highlights the results of the discrete choice analysis in practical model estimations. All estimations were performed using Biogeme (Bierlaire et al. 2004), to estimate the parameters of attributes using responses from 207 participants which result in 1890 observations.

Model 1 includes responses on choosing between four travel modes, namely car, metro, bus and metro & bus, and examines the effect of travel time, travel cost and number of changes of public transport modes as the explanatory variables. The following equations (7.7, 7.8, 7.9 and 7.10), define the utility function for each alternative by adding the attributes that are included in the Model.

$$U_{Car} = Constant_{Car} + \beta_1 * TTime_{Car} + \beta_2 * T.Cost_{Car} \quad (7.7)$$

$$U_{Metro} = Constant_{Metro} + \beta_1 * TTime_{Metro} + \beta_2 * T.Cost_{Metro} + \beta_3 * Number\ of\ changes\ _{Metro} \quad (7.8)$$

$$U_{bus} = Constant_{bus} + \beta_1 * TTime_{bus} + \beta_2 * T.Cost_{bus} + \beta_3 * Number\ of\ changes\ _{bus} \quad (7.9)$$

$$U_{Metro\&bus} = Constant_{Metro\&bus} + \beta_1 * TTime_{Metro\&bus} + \beta_2\ T.Cost_{Metro\&bus} + \beta_3 * Number\ of\ changes\ _{Metro\&bus} \quad (7.10)$$

Model 2, is as Model 1, but introduced cost coefficients for different income bands. So Model 2 was developed to investigate the effect of the interactions between total travel cost and personal income to capture the prior that

respondents with different levels of income would have different sensitivity to travel cost. In this model, respondents' income was coded into two categories of high income (more than 15,000 SR per month) and low income (less than 15,000 SR per month) as was the case in the analysis of data in Chapter Six.

Model 3 was developed as Model 2, but introduced constants for some socio-economic characteristics, namely age, gender, education and number of children and choice of car mode as the preferred travel means. Also, in this model the considered socio-economic characteristics were divided into two categories as the case in the analysis of data in Chapter Six.

Model 4 was as Model 3 with separate time parameters for shopping and commuting trips. So, this model was developed to consider the effect of interaction between travel purposes and choice of car mode as the preferred travel means. In this model, travel purposes were divided into travel to commuting and travel for shopping, as was the case in the questionnaire and the previous data analysis section in Chapter Six. Model 4 also has two versions, one that includes error components to control for panel effects and one with time parameters for shopping and commuting being log-normally distributed.

Model 5a is as Model 3, but cost coefficients are different for shopping, commuting, car and public transport trips. Model 5b also has a version in which error components are introduced.

7.5.1 Model 1: Benchmark travel time and travel cost

Table 7.2 shows the estimated parameters for Model 1, as a model in which all alternatives have a fixed value for all decision makers and no variables are included explicitly. The estimated alternative specific constant for each of the travel modes included the car, metro, bus, metro & bus. The alternative "bus" is the reference alternative in the model. The remaining constants were positive relative to the reference alternative. The metro had the highest marginal utility for respondents with a value of 0.509, followed by the car (0.384) and metro & bus (0.066). Hence, the model implies that all else being equal, the metro has the highest probability of being chosen, followed by the car, and then metro & bus.

Model 1 includes also the three attributes of total travel cost, total travel time and number of changes between public transport modes. As shown in Table 7.2, in line with prior expectations and as with the work of Koppelman and Bhat (2006, p. 77) the sign of the parameters were negative. Subsequently, the negative sign of the coefficient of these attributes implied that the utility of a mode and the probability to be chosen decreases as a result of increases of the total travel time, total travel cost or number of transfers in-between public transport modes.

As shown in Table 7.2, the p-value of the travel time and travel cost was less than 0.05 (the critical values) and the null hypothesis was rejected. That means that travel time and travel cost coefficients significantly differ from zero at 95%, and had a significant effect on the utility of each on the model (Wonnacott and Wonnacott (1972).

Table 7.2: MNL Base Model 1

Variable	**Coefficient**	**Rob. St. Error**	**t-test**	**p-value**
Non-random parameters				
Constant: Car	0.384	0.143	2.7	0.010
Constant: Metro	0.509	0.132	3.9	0.000
Constant: Bus		Reference		
Constant: Metro & Bus	0.066	0.162	0.4	0.680
Total travel cost (SR)	-0.074	0.004	-8.6	0.000
Number of changes	-0.054	0.069	-0.8	0.430
Total travel time (mins)	-0.044	0.004	-10.5	0.000
Number of observations				1890
Number of respondents				207
Log-likelihood at convergence				-1010.806
VOTT (SR)				35.65

In terms of value of time estimations all values were converted in US dollars ($) because there is a fixed ratio between Saudi Riyals (SR) and US dollars ($). The computed value of time in the model is 35.7 SR per hour which is equivalent to $9.5, calculated as a ratio of the time parameter (-0.044) divided by the cost parameter (-0.074), (see equation 7.6) (Hensher et al. 2005b, p. 464; Koppelman and Bhat 2006, p. 98). It is worth highlighting that there is no official record for travel saving recorded in Saudi Arabia; this study will use the study of the closest country which is the United Arab Emirates. So, the model result for the value of time is slightly more than the value of time reported in Dubai City in 2007, which is 28.5 Arab Emirates Dirham, equivalent to 29.1 SR and $7.6 (Clarke et al. 2007). Hence, the indicated value of time in the model

is not unreasonably high, and in this case the model is still suitable for considering the influence of travel time and cost on utility.

7.5.2 Model 2: The interaction between income categories and travel cost

Model 2 considers the utility specification by including an interaction between respondents' income and total travel cost, reflecting the reasoning that cost is less important to choice of car mode as income increases (Koppelman and Bhat 2006, p. 45). As shown in Table 7.3, the income parameter is categorised to high income (more than 15,000 SR ≈ $4,000 per month) and low income (less than 15,000 SR ≈ $4,000 per month). From the output in the same table below, the estimated results show that the increase in income decreases the sensitivity to travel cost increases in the high income group, while the low income group were more sensitive to increases in the cost of travel. As it is shown in Table 7.3, the p-value of the travel cost and income parameters in both categories were less than 0.001 (the critical values) and the null hypothesis was rejected. That means that the travel cost and income parameters' coefficients were significant at the 1% level, and had a significant effect on the utility of each on the model (Wonnacott and Wonnacott (1972).

Table 7.3: Model 2, the income and total travel cost attributes

Variable	Coefficient	Rob. St. Error	t-test	p-value
Non-random parameters				
Constant: Car	0.391	0.143	2.7	0.010
Constant: Metro	0.528	0.133	4.0	0.000
Constant: Bus		Reference		
Constant: Metro & Bus	0.098	0.161	0.6	0.540
TTC(SR) * Income < 15,000 SR	-0.089	0.009	-9.5	0.000
TTC(SR) * Income > 15,000 SR	-0.054	0.012	-4.6	0.000
Number of changes	-0.056	0.069	-0.8	0.420
Total travel time (mins)	-0.044	0.0042	-10.5	0.000
Number of observations				1890
Number of respondents				207
Log-likelihood at convergence				-1010.806
VOTT(SR) for income < 15,000 SR				29.7
VOTT(SR) for income > 15,000 SR				48.9

Notes: VOTT= Value of travel time, TTC= Total travel cost

Similar to the Model 1 value of time calculation, the computed value of time in Model 2 is a ratio of the time parameter divided by total travel cost parameters for both low and high income groups. As cited in the Table above, the implicated value of time for the low income group is 29.7 SR ≈ $7.9 and for the

high income group is 48.9 SR ≈ $13. Hence, the indicated value of time for both groups in the model is still not unreasonably high, and in this case the model is still suitable for considering the influence of travel time and cost on utility.

7.5.3 Model 3: Influence of socio-economic characteristics

Model 3 is a further refinement for the utility specification that considers the effect of interaction between some socio-economic characteristics and choice of car mode as the preferred travel mean. In this mode the respondent's age, gender, level of education and number of children variables were considered in the model. As it indicated in Table 7.4, each variable was categorised into two groups as was the case in the analysis of data in Chapter Six.

From the output in Table 7.4 below, it appeared that the estimated age's parameter coefficient was positive. However, the variable probability is very high and not significant at a 99% level. So the null hypothesis of no effect for the age variable is accepted.

As can be seen in Table 7.4, the estimated gender coefficient was negative and the probability test was very high as well. So the null hypothesis of no effect for gender is accepted (Wonnacott and Wonnacott 1972).

in terms of level of education which is the highest estimated positive coefficient across all considered characteristics, the estimation results show that those with higher qualifications are more likely to choose the car no matter its travel characteristics. The p-value of both education categories was marginally statistically significant at a confidence estimates at 96% level, so the null hypothesis that says the interaction between level of education and car preference has no effect on the model utility is rejected here. The last socio-economic characteristic estimated in this model was number of children in households, results show that those respondents from households that have less than three children were more likely to be driving a car than others that have three children or more. The p-value of both categories of number of children groups were equal to 0.05 (the critical values) and the null hypothesis was rejected. That means that the number of children parameter's coefficient

significantly differs from zero at 95%, and had a marginal significant effect on the model utility (Wonnacott and Wonnacott (1972).

Table 7.4: Model 3, age, education, gender and number of children attributes

Variable	Coefficient	Rob. St. Error	t-test	p-value
Non-random parameters				
Constant: Car	0.0808	0.23	0.4	0.730
Constant: Metro	0.486	0.134	3.6	0.000
Constant: Bus		Reference		
Constant: Metro & Bus	0.0476	0.162	0.3	0.770
TTC (SR) * Income < 15,000 SR	-0.0912	0.00942	-9.7	0.000
TTC (SR) * Income > 15,000 SR	-0.0543	0.0117	-4.7	0.000
Number of changes	-0.0602	0.0699	-0.9	0.390
Age < 35 years of age (car alternative)	0.126	0.112	1.1	0.260
Education ≥ Bachelor (car alternative)	0.305	0.149	2.1	0.040
Gender: Male (car alternative)	-0.19	0.15	-1.3	0.200
No of children < 3 (car alternative)	0.223	0.115	1.9	0.050
Total travel time (mins)	-0.0437	0.00422	-10.3	0.000
Number of observations				1890
Number of respondents				207
Log-likelihood at convergence				-1010.806
VOTT(SR) for income < 15,000 SR				28.8
VOTT(SR) for income > 15,000 SR				48.3

Notes: VOTT= Value of travel time, TTC= Total travel cost

The implicated value of time from the units of interactions for socio-economic characteristics variables is 28.8 SR ≈ $10.95 for the low income group, and 48.3 SR ≈ $12.88 for the high income group. So, as indicated in Model 2, the value of time for both groups in Model 3 is still not unreasonably high compared to the car driving value of time in Dubai City which is approximately 29.1 SR ≈ $7.6 (Clarke et al. 2007), and in this case the model is still suitable for considering the influence of travel time and cost on utility.

7.5.4 Model 4a: Influence of travel purpose

In Model 4a, the effect of total travel time was estimated for two travel purposes, commuting and shopping. As shown in Table 7.5, the utility specification considered the interaction between total travel time and purpose. The estimated coefficients for both travel purposes had negative signs and were statistically significant at 99%.

In contrast with a study by Mackie et al. (2001), it is worth noting that the absolute value of the utility coefficient for shopping was higher than for commuting, and subsequently the value of time for shopping was higher than

the value of time for commuting. This would be because the typical working schedule in Riyadh City is between 8 am to 2 pm.

As shown in the Table 7.5, the value of time for shopping for those earning less than 15,000 SR ≈ $4,000 a month was 31.8 SR ≈ $8.5, and for commuting was 23.2 SR ≈ $6.2. Similarly, the value of time for shopping for those earning more than 15,000 SR ≈ $4,000 was 52.1 SR ≈ $13.9, and for commuting was 38.0 SR ≈ $10.1.

Table 7.5: Model 4a, commuting and shopping

Variable	Coefficient	Rob. St. Error	t-test	p-value
Non-random parameters				
Constant: Car	0.089	0.231	0.4	0.700
Constant: Metro	0.462	0.135	3.4	0.000
Constant: Bus		Reference		
Constant: Metro & Bus	0.030	0.162	0.2	0.860
TTC (SR) *Income < 15,000 SR	-0.095	0.010	-9.8	0.000
TTC (SR) *Income > 15,000 SR	-0.058	0.012	-4.9	0.000
Number of changes	-0.057	0.070	-0.8	0.410
Age < 35 years of age (car alternative)	0.129	0.112	1.2	0.250
Education ≥ Bachelor (car alternative)	0.305	0.150	2.0	0.040
Gender: Male (car alternative)	-0.207	0.152	-1.4	0.170
Number of children < 3 (car alternative)	0.227	0.116	2.0	0.050
Total travel time: Commuting (mins)	-0.037	0.006	-6.3	0.000
Total travel time: Shopping (mins)	-0.050	0.005	-9.8	0.000
Number of observations				1890
Number of respondents				207
Log-likelihood at convergence				-1010.806
VOTT(SR) for income < 15,000 SR: Commuting				23.2
VOTT(SR) for income > 15,000 SR: Commuting				38.0
VOTT(SR) for income < 15,000 SR: Shopping				31.8
VOTT(SR) for income >15,000 SR: Shopping				52.1

Notes: VOTT= Value of travel time, TTC= Total travel cost

7.5.5 Model 4b: Error-component MNL

Despite the fact that the multinomial logit model is a powerful tool, it has some limitations such as measuring correlation across alternatives (Transport and infrastructure council 2015, p. 62). Over the last three decades, researchers have proposed dramatic changes to transport models based on discrete choice methods (Bastin et al. 2006). In the recent past, practitioners started to use mixed logit models or an error component for better understanding of some complex decisional processes and overcame most of the limitations of multinomial. For many reasons and regardless of the number of choices in the sample, there are possible unobserved effects that are correlated among alternatives (Hensher and Greene 2001). There are different models to

describe various error specifications in discrete choice models, including random parameters, taste variation and error components (Walker 2001). Sorensen (2002) studies the error component models often used with other logit models to describe various error specifications in discrete choice models' repeated observations from the same respondent. Several studies, including Train (2000) provide evidence that ignoring repeating measures in discrete choice experiment data would cause correlation and potential bias in parameter estimates. A method to handle the issue of serial correlation in a discrete choice modelling context has been proposed by Morikawa et al. (1992) and Hensher (1993). In this stage of the study, Model 4b was developed to specify an error component MNL to control serial correlations in the data. In addition, to secure a stable set of parameter estimates and gain the approximate choice probability for estimated parameter coefficients (Hensher and Greene 2001) the research ran a model between 25 to 2000 draws, as recommended in the study by Hensher and Greene (2001).

As shown in Table 7.6, the parameters including total travel cost, total travel time and number of public transport changes for both the car and public transport modes were specified for drawing using 1000 draws (Train 2000; Hensher and Greene 2001). The models were estimated as expressed in the following equations using Biogene software (Bierlaire et al. 2004). The equations define the utility expression by adding the appropriate utility specification for each travel alternative in the traditional utility formula.

$$
\begin{aligned}
&U_{Car} \\
&= Constant_{Car} + \beta_{1-1\,Shopping} * TTime_{Car} + \beta_{1-2\,Work} * TTime_{Car} \\
&+ \beta_{2-1} * T.Cost_{Car(if\ income<15K)} + \beta_{2-2} * T.Cost_{Car}\,(if\ income > 15K) \\
&+ \beta_3[\![*\,(Age < 35yrs]\!]) + \beta_4 * (Education \geq Bachelor) + \beta_5 * Male + \beta_6 \\
&* (no\ of\ children < 3\,) + \sigma_{Car} * \delta_{Car\,i} \\
&+ \varepsilon_{i\,Car}
\end{aligned}
\tag{7.11}
$$

$$U_{Metro} = Constant_{Metro} + \beta_{1-1\,Shopping} * TTime_{Metro} + \beta_{1-2\,Work} * TTime + \beta_{2-1} * T.Cost_{Metro(if\ income<15K)} + \beta_{2-2} * T.Cost\ (if\ income > 15K) + \beta_3 * (Age < 35yrs) + \beta_4 * (Education \geq Bachelor) + \beta_5 * Male_{Metro} + \beta_6 * (no\ of\ children < 3) + \beta_7 * Number\ of\ changes + \sigma_{Metro} * \delta_{Metro\,i} + \varepsilon_{Metro} \quad (7.12)$$

$$U_{bus} = \mathrm{Constant_{bus}} + \beta_{1-1\,Shopping} * \mathrm{TTime_{bus}} + \beta_{1-2\,Work} * \mathrm{TTime}_{bus} + \beta_{2-1} * \mathrm{T.Cost}_{bus(if\ income<15K)} + \beta_{2-2} * \mathrm{T.Cost}_{bus}(if\ income > 15K) + \beta_3 * \mathrm{Age} < 35\mathrm{yrs} + \beta_4 * (Education \geq Bachelor) + \beta_5 * \mathrm{Male} + \beta_6 * (\mathrm{no\ of\ children} < 3) + \beta_7 * \mathrm{Number\ of\ changes} + \sigma_{bus} * \delta_{bus\,i} + \varepsilon_{bus} \quad (7.13)$$

$$U_{Metro\&bus} = \mathrm{Constant}_{Metro\&bus} + \beta_{1-1\,Shopping} * \mathrm{TTime}_{Metro\&bus} + \beta_{1-2\,Work} * \mathrm{TTime}_{Metro\&bus} + \beta_{2-1} * \mathrm{T.Cost(if\ income} < 15\mathrm{K}) + \beta_{2-2} * \mathrm{T.Cost(if\ income} > 15\mathrm{K}) + \beta_3 * \mathrm{Age} < 35\mathrm{yrs} + \beta_4 * (Education \geq Bachelor) + \beta_5 * \mathrm{Male} + \beta_6 * \mathrm{no\ of\ children} < 3 + \beta_7 * \mathrm{Number\ of\ changes} + \sigma_{Metro\&bus} * \delta_{Metro\&bus\,i} + \varepsilon_{Metro\&bus} \quad (7.14)$$

The error components for Model 4b estimation results are shown in Table 7.6. It can be noted that the metro is still the most popular mode of travel followed by car and metro & bus. The model also shows no correlation between observed and unobserved parameters in the case of travel mode choices except for the bus (Cantillo et al. 2007).

Table 7.6: Model 4b, Error Component MNL

Variable	Coefficient	Rob. St. Error	t-test	p-value
Non-random parameters				
Constant: Car	0.167	0.588	0.3	0.780
Constant: Metro	0.740	0.211	3.5	0.000
Constant: Bus		Reference		
Constant: Metro & Bus	0.081	0.221	0.4	0.710
Total travel cost * Income < 15,000 SR	-0.142	0.016	-8.9	0.000
Total travel cost * Income > 15,000 SR	-0.088	0.019	-4.6	0.000
Number of changes	-0.060	0.099	-0.6	0.540
Age < 35 years of age (car alternative)	0.262	0.347	0.8	0.450
Education ≥ Bachelor (car alternative)	0.422	0.438	1.0	0.340
Gender: Male (car alternative)	-0.315	0.456	-0.7	0.490
No of children < 3 (car alternative)	0.290	0.349	0.8	0.410
Total travel time: Commuting (mins)	-0.062	0.013	-4.8	0.000
Total travel time: Shopping (mins)	-0.075	0.010	-7.4	0.000
Number of observations				1890
Number of respondents				207
Log-likelihood at convergence				-1010.806
Number of draws				1000
VOTT(SR) for income < 15,000 SR: Commuting				26.0
VOTT(SR) for income > 15,000 SR: Commuting				42.0
VOTT(SR) for income < 15,000 SR: Shopping				31.5
VOTT(SR) for income >15,000 SR: Shopping				50.9
Sigma_Car	0.200	0.270	0.7	0.460
Sigma_Bus	2.080	0.217	9.6	0.000
Sigma_Metro	-0.487	0.388	-1.3	0.210
Sigme_Metro & Bus	-0.588	0.734	-0.8	0.420

Notes: VOTT= Value of travel time, TTC= Total travel cost

Changes in statistical inference between the classical Model 4a and error components model were also observed. For the classical model case, education and number of children variables were significant at 96% and 95% levels respectively, but not in the error component model.

In terms of value of time, there was a slight increase observed in the value of travel time among all categories considered in modelling estimations between the error components model and the classical Model 4a. As shown in Table 7.6, the value of time for a commuting journey for those earning less than 15,000 SR ≈ $4,000 a month was 26 SR ≈ $6.9, and for shopping was 31.5 SR ≈ $8.4. Similarly, the value of time for commuting for those earning more than 15,000 SR ≈ $4,000 was 42 SR ≈ $11.2, and for shopping was 50.9 SR ≈ $13.6.

7.5.6 Model 4c: Time log-normal distributed

In Model 4c, lognormal distribution was adopted to specify and estimate a distribution for the coefficients and parameters in models. Hensher et al.

(2005b) stress the necessity for examining the distributions of random parameter or error component estimated results. The four most popular distributions are normal, lognormal, triangular and uniform distribution (Hensher et al. 2005b). Mariel et al. (2013) argue that choosing the accurate distribution in the context of a discrete choice experiment modelling is still one of the major research interests.

Variable	Coefficient	Rob. St. Error	t-test	p-value
Non-random parameters				
Constant: Car	0.112	0.263	0.43	0.67
Constant: Metro	0.614	0.157	3.91	0.000
Constant: Bus		Reference		
Constant: Metro & Bus	0.123	0.187	0.66	0.51
TTC (SR) * Income < 15,000 SR	-0.113	0.0129	-8.8	0.000
TTC (SR) * Income > 15,000 SR	-0.0695	0.0152	-4.6	0.000
Number of changes	-0.0957	0.0801	-1.2	0.23
Age < 35 years (car alternative)	0.123	0.128	0.96	0.34
Education ≥ Bachelor (car alternative)	0.342	0.172	1.99	0.05
Gender: Male (car alternative)	-0.191	0.175	-1.1	0.27
No of children < 3 (car alternative)	0.242	0.131	1.84	0.07
Total travel time: Commuting (mins)	-3.68	0.398	-9.3	0.000
Standard deviation: Commuting	-2.08	0.738	-2.8	0.000
Total travel time: Shopping (mins)	-3.05	0.163	-19	0.000
Standard deviation: Shopping	-1.12	0.457	-2.5	0.01
Number of observations				1890
Number of respondents				207
Log-likelihood at convergence				-1010.806
Number of draws				1000

Table 7.7: Model 4c, time log-normal distributed

Notes: VOTT= Value of travel time, TTC= Total travel cost

The lognormal distribution has the useful property that the marginal utilities are constrained to have the same sign for all respondents (Berg et al. 2008, p. 10). Model 4c in this stage included parameters of shopping and commuting being log-normally distributed and the given finding, the travel time, is expected to be negative (Ben-Akiva et al. 1993). It can be noted also that the estimated standard deviation coefficients for this distribution were small enough that they ranged between 2.08 and 1.12 for commuting and shopping journeys respectively. Both parameters were statistically significant with travel time at a 1% level, indicating a correlation and varying of parameters among respondents, in which the null hypothesis for no relationship between travel purpose and value of time is rejected here.

7.5.7 Model 5a: Travel mode and purpose

In Model 5a, as shown in Table 7.8, the effect of total travel time was estimated as in Model 4a but additionally the utility specification considered the interaction between total travel time, journey's purpose and travel mode. The estimated coefficients for both travel purposes and modes had negative signs and were statistically significant at 99%.

As in Model 4, in Model 5 the absolute value of the utility coefficient for shopping was higher than for commuting. This indicates that travel for shopping appears more valuable than for commuting. Thus they had a significant effect on the respondents' utility and for those the null hypothesis was rejected (Wonnacott and Wonnacott (1972).

Table 7.8: Model 5a (MNL)

Variable	Coefficient	Rob. St. Error	t-test	p-value
Non-random parameters				
Constant: Car	0.083	0.248	0.3	0.740
Constant: Metro	0.459	0.135	3.4	0.000
Constant: Bus	Reference			
Constant: Metro & Bus	0.009	0.163	0.1	0.960
TTC (SR) * Income < 15,000 SR	-0.101	0.010	-9.9	0.000
TTC (SR) * Income > 15,000 SR	-0.068	0.013	-5.3	0.000
Number of changes	-0.063	0.070	-0.9	0.370
Age < 35 years (car alternative)	0.120	0.114	1.1	0.290
Education ≥ Bachelor (car alternative)	0.286	0.151	1.9	0.060
Gender: Male (car alternative)	-0.217	0.153	-1.4	0.150
No of children < 3 (car alternative)	0.233	0.116	2.0	0.040
Total travel time: Commuting (mins): Car	-0.038	0.006	-6.3	0.000
Total travel time: Shopping (mins): Car	-0.050	0.005	-9.6	0.000
Total travel time: Commuting (mins): PT	-0.042	0.006	-6.5	0.000
Total travel time: Shopping (mins): PT	-0.050	0.005	-9.1	0.000
Number of observations				1890
Number of respondents				207
Log-likelihood at convergence				-1010.806
Number of draws				1000
VOTT (SR) for income < 15,000 SR: Commuting , Car				22.6
VOTT (SR) for income < 15,000 SR: Commuting , PT				24.8
VOTT (SR) for income > 15,000 SR: Commuting , Car				33.9
VOTT (SR) for income > 15,000 SR: Commuting , PT				37.2
VOTT (SR) for income < 15,000 SR: Shopping, Car				29.7
VOTT (SR) for income < 15,000 SR: Shopping, PT				29.6
VOTT (SR) for income >15,000 SR: Shopping, Car				44.4
VOTT (SR) for income >15,000 SR: Shopping, PT				44.3

Notes: VOTT= Value of travel time, TTC= Total travel cost

As indicated in the model results in Table 7.8, the value of time for those earning less than 15,000 SR ≈ $4,000 when they are commuting using a private car was 22.6 SR ≈ $6.02, and when they use public transport was 24.8

SR ≈ $6.61. For the other category, for those earning more than 15,000 SR, the value of time when they travel for commuting using a private car was 33.9 SR ≈ $9.04. Finally, as indicated in Table 7.8, when the trip was for shopping, there were no significant differences in the value of time between the car and public transport for the shopping journey.

7.5.8 Model 5b: error component MXNL

As the utility specification considered the influence of the interaction between total travel time, the journey's purpose and travel mode in Model 5a MNL, in Model 5b a mixed logit model was applied to obtain the unobserved part of the utility and normalise parameters on the basis of the unobserved part (Greene et al. 2006). Mixed logit allows for discrete choice experiments' parameters to vary across respondents and heterogeneous preferences (Mariel et al. 2013). The earliest applications of mixed logit appeared in the 1980s in the papers by Boyd and Mellman (1980) and Cardell and Dunbar (1980), as a fundamentally useful tool in the analysis of the automobile demand models (Brownstone and Train 1999). "Mixed logit generalizes standard logit and allows efficient estimation when there are repeated choices by the same individual and to control for unobserved heterogeneity in the marginal utilities" (Tseng 2008, p. 73).

As indicated in the model results in Table 7.9, there was a slight increase in the mode value of time compared to Model 5a. On the other hand, generally, the model results show that there were no significant differences in the value of time as a result of considering travel mode in the utility specification. So as apparent in the table below, changes in statistical inference between the standard Model 5a and mixed logit Model 5b were also observed. Parameters for education and number of children were statically significant at 94% and 96% respectively in the standard Model 5a, but not significant in the mixed logit Model 5b. The model also observed a correlation between observed and unobserved parameters in the case of the car while there was no correlation with other travel mode choices (Cantillo et al. 2007).

Finally, throughout the study modelling results it was noted that increasing the complexity of models by adding interactions and normalised parameters in the generalised linear MXNL model provided additional benefits to travel time and cost significance and fit. It was also found that values of time did vary in all models.

Table 7.9: Model 5b, Error Component MXNL

Variable	Coefficient	Rob. St. Error	t-test	p-value
Non-random parameters				
Constant: Car	0.156	0.620	0.3	0.800
Constant: Metro	0.743	0.209	3.6	0.000
Constant: Bus		Reference		
Constant: Metro & Bus	0.060	0.221	0.3	0.790
TTC (SR) * Income < 15,000 SR	-0.146	0.017	-8.7	0.000
TTC (SR) * Income > 15,000 SR	-0.094	0.022	-4.3	0.000
Number of changes	-0.064	0.099	-0.6	0.520
Age < 35 years (car alternative)	0.273	0.365	0.8	0.450
Education ≥ Bachelor (car alternative)	0.423	0.435	1.0	0.330
Gender: Male (car alternative)	-0.351	0.484	-0.7	0.470
No of children < 3 (car alternative)	0.301	0.357	0.8	0.400
Total travel time: Commuting (mins): Car	-0.062	0.012	-5.3	0.000
Total travel time: Shopping (mins): Car	-0.074	0.010	-7.5	0.000
Total travel time: Commuting (mins): PT	-0.065	0.013	-5.2	0.000
Total travel time: Shopping (mins): PT	-0.074	0.011	-6.8	0.000
Number of observations				1890
Number of respondents				207
Log-likelihood at convergence				-1010.806
Number of draws				1000
VOTT(SR) for income < 15,000 SR: Commuting, Car				25.6
VOTT(SR) for income < 15,000 SR: Commuting, PT				26.7
VOTT(SR) for income > 15,000 SR: Commuting, Car				39.8
VOTT(SR) for income > 15,000 SR: Commuting, PT				41.5
VOTT(SR) for income < 15,000 SR: Shopping, Car				30.5
VOTT(SR) for income < 15,000 SR: Shopping, PT				30.4
VOTT(SR) for income >15,000 SR: Shopping, Car				47.4
VOTT(SR) for income >15,000 SR: Shopping, PT				47.2
Sigma_Car	2.080	0.218	9.5	0.000
Sigma_Metro	-0.519	0.419	-1.2	0.220
Sigma_Bus	0.108	0.290	0.4	0.710
Sigme_Metro & Bus	0.405	1.470	0.3	0.780

Notes: VOTT= Value of time, TTC= Total travel cost

7.6 Discussion and Conclusion

This Chapter presented the results of a discrete choice experiment as part of a quantitative survey conducted in Riyadh City. The aim of this Chapter was to understand the value individuals would place on the car in comparison to public transport in terms of attributes related to each travel mode. To address this objective, respondents were presented with scenarios and asked to express their preferences of travel mode for their future trip. The attributes that were chosen to describe each alternative were travel time, travel mode and number of changes of public transport modes (Hensher 1994). Scenarios were presented with these attributes in different levels to measure how the value of the attributes differ between individuals with varying socio-economic characteristics. Following data quality checks, a final sample of 207 individuals corresponding to 1,890 observations were analysed. The first section of this Chapter included exploratory analysis focussing on the relationship between individual socio-economic characteristics and choice of travel mode.

Choice frequencies show that public transport was the most popular travel choice compared to the private car. A further overview of the extent of choices including all modes showed the metro was the first choice preferred among the other options, followed by the car, metro & bus and bus. The relationship between individual socio-economic characteristics and travel mode choice revealed that the car was more popular among females and non-Saudis. The results also found a marginal association between gender and travel mode choice, in which males were more likely to use public transport than females. It was also showed that Saudis and less educated groups of people were more likely to use public transport than non-Saudis and those with educational qualifications (bachelor's or above). Finally, there were no significant associations between travel mode choice and respondents' age and marital status. Transport for London (2012) reported the nature of women's commuting which was often at home, influenced travel behaviour and attitudes. The report also found women would take a slightly greater number of trips than men but that the trips were of shorter duration; women were more likely to use buses than trains, to be passengers, not to drive and they do less commuting trips compared to men.

The second section of the study analysis concerned modelling estimations using Biogene software (Bierlaire et al. 2004). The utility of the travel modes was compared to define the important reasons behind the choice of a particular mode and the circumstances that may cause participants to change their choice of the car. As recommended by previous studies (seeMcFadden 1974; Antoniou et al. 2007; Cantillo et al. 2007), this study examined classical MNL models without considering serial correlation and models that incorporate serial correlation. The explanatory variables included in the models were socio-economic characteristics, trip purpose, and mode attributes (Nurdden et al. 2007).

In the benchmark model, the utility of the travel modes was compared by developing mode constant parameters (de Dios Ortuzar and Willumsen 2001). The model implied that when all alternatives have a fixed value for all participants and no variables were included, the metro provides the highest utility to respondents, followed by the car, metro & bus and bus. This implies that all things being equal, the metro has the highest probability of being chosen out of the provided other modes by respondents travelling in Riyadh City. Model 1 also examined the effect of total travel time, total travel cost and number of changes of public transport modes as the explanatory variables. The model estimation implied negative signs for all these parameters indicating a decrease in the probability of choice of travel mode as a result of increase of the total travel time, total travel cost or number of transfers in-between public transport modes (Antoniou et al. 2007). Thus, the likelihood of shifting people from private cars to public transport in Riyadh City would increase by a reduction in public transport cost, number of changes and increase in the service frequency (Nurdden et al. 2007). From the modelling estimation results the value of time coefficients were 35.65 SR in the base model which was not unreasonably high compared to the value of time in the United Arab Emirates (Clarke et al. 2007).

In Model 2, the study considered the utility specification by including an interaction between respondents' income and total travel cost, reflecting the reasoning that cost is less important to the choice of car mode as income increases. The results of the situation reflect a direct relationship between per

capita income and the sensitivity to the cost of travel. The study found that people earning more than 15,000 SR a month were less sensitive to increases in the cost of travel and vice versa. In line with Paleti et al. (2015), this study found that the value of time has a positive relationship with household income (28.8 SR ≈ $10.95 for the low income group, and 48.3 SR ≈ $12.88 for the high income group).

In Model 3 there is a further refinement for the utility specification by considering the effect of interaction between age, gender, level of education and number of children and choice of car mode as the preferred travel means. In consistence with the results of a previous study in Xi'an, China by Chen et al. (2015), the model estimation found significant impacts of respondents' level of education and number of children on influencing people's travel mode choice. In age and gender cases, variable probability was very high and not significant at a 99% level. So the null hypotheses of no effect for age and gender variables were accepted. It is worth noting, however, that respondents with lower qualifications, less than three children and males, are willing to choose public transport no matter its travel characteristics. A study by Nielsen (2000) confirmed that in addition to the level of service provided by the transport, travel mode choice relates to individual attributes and travel characteristics.

Nevertheless, in Model 4a the estimated coefficients for the interaction between total travel time and travel purposes (commuting and shopping) had negative signs and were statistically significant at 99%. Against several studies, for example (Mackie et al. 2001; Antoniou et al. 2007; Paleti et al. 2015), it is worth noting that the absolute value of the utility coefficient for shopping was higher than for commuting, and subsequently the value of travel time for shopping was higher than for commuting. This would be because the typical working schedule in Riyadh City is between 8 am to 2 pm. Small (2012) maintains that ignoring some explanatory variable effects in the model would cause unexplained variance for value of time.

As stated early in this chapter, due to the limits of MNL to reveal sources of heterogeneity, in Model 4 an error components model was applied as an attempt to capture unobserved heterogeneity in the previous models'

estimations and control serial correlations in the data. The model results found that the metro was still the most popular mode of travel followed by the car and metro & bus. The model statistical results show no correlation between observed and unobserved parameters in the case of travel mode choices except for the bus (Cantillo et al. 2007). Changes in statistical inference between the classical Model 4a and the error components model were also observed. For the classical model case, variables for education and the number of children were significant at 96% and 95% levels respectively, but not in the error component model. In Model 4c lognormal distribution was applied to estimate the choice probability among the survey sample. The results found that the estimated standard deviation coefficients for this distribution were small enough that they ranged between 2.08 and 1.12 for commuting and shopping journeys respectively. Both parameters were statistically significant with travel time at a 1% level, indicating a correlation and varying of parameters among respondents, in which the null hypothesis for no relationship between travel purpose and value of time is rejected here.

Nevertheless, another area of interest in this study was to determine the influence of travel purpose on the total travel time effect. Thus, in Model 5a, the utility specification considered the interaction between total travel time, the purpose of the journey and travel mode. The results found that the estimated coefficients for both travel purposes and modes had negative signs and were statistically significant at 99%.

In Model 5b, mixed logit model results found no significant differences in the value of time as a result of considering travel mode in the utility specification.

Finally, the modelling results noted a gradual increase in the ratio between total travel time and total travel cost differences from MNL to the generalised linear MXNL model as a result of adding interaction between parameters and normalised parameters to increase the complexity of modes.

CHAPTER EIGHT: CONSOLIDATION AND DISCUSSION OF THE RESEARCH FINDINGS

8.1 Introduction

The purpose of this Chapter is to consolidate the research findings and discuss the associated evidence. In light of Riyadh's new public transport system, the study's primary research question was: "*what are the procedures and approaches that have to be undertaken to ensure public transport uptake in Riyadh City*?" This question was then associated with ten objectives.

To address these objectives, this thesis has been developed into three theoretical and practical stages. The first stage was a theoretical one, while the other two stages were practical. The theoretical stage focused on the literature review to establish a comprehensive picture of public transport demand and travel behaviour change towards more sustainable travel modes (see, Chapters One and Two). Throughout the literature review, a set of TDM strategies were gathered and classified into five main themes (see Chapter Two), including planning and physical changes, legal policies, economic policies, social and culture measures and Information and technological measures.

In the practical stage, this thesis followed a mixed-method approach using both qualitative and quantitative methods (see Chapter Four) to address eight objectives listed in Table 8.1. Firstly, a series of semi-structured interviews with key stakeholders from authorities based in Riyadh City and engaged in transport such as Ar Riyadh Development Authority, the Public Transport Authority and other were conducted to take a holistic view. Also, a general public survey questionnaire was designed and administrated to gauge the reactions and potential perspectives on uptake of public transport in Riyadh City.

Table 8.1: Conducted methods and study objectives

Practical stages	Objectives need to address
Qualitative approach, stakeholder interviews	3. Investigate whether the existing TDM policies are adequate to encourage public transport use in Riyadh City. 4. Identify the potential effectiveness, acceptability and applicability of a set of proposed interventions that could influence people's travel behaviour. 5. Consider the wider impacts of the new public transport system in Riyadh City on urban form, economics, environment, social norms and culture.
Quantitative approach, a general public Survey	6. Analyse individual perspectives and attitudes towards the current travel conditions in Riyadh City 7. Investigate considerations and behavioural intentions to use Riyadh's new public transport system 8. Identify the potential barriers and facilitators for using the metro and bus in Riyadh 9. Explore public reactions towards various TDM strategies in order to encourage car users to use public transport 10. Explore the relationships between participants' behavioural intentions and the various factors that affect travel choices

8.2 Addressing the research question and objectives

8.2.1 Stakeholder's perspective

A series of semi-structured interviews was conducted during June and July 2015 with 25 stakeholders, including transport experts and representatives of Riyadh City authorities to address three of the study's objectives (see Table 8.1, objectives 3-5).

Overall there was a consensus among stakeholders that there are currently no direct transport-policy measures that may encourage Riyadh's residents to use public transport due to poorly performing current public transport system. High income, lack of coordinated city planning, low car operational costs, culture and climate were key barriers that would prevent uptake of public transport ridership. Stakeholders strongly emphasised the city's needs for a competitive public transport system handled with relevant TDM strategies to overcome these barriers and encourage car users to switch to public transport.

As shown in Table 8.2, this study also found that good level of service, comfortable seats and cleanliness would be highly effective in attracting public transport users. Security measures, personal safety, and pedestrian-friendly surroundings across public transport premises were also mentioned by stakeholders as highly effective strategies.

The strict gender segregation is an important aspect in Saudi society which is fully enforced by the country's rules and religious life (Ezzi et al. 2014; Alhazmi and Nyland 2015). From stakeholders' point of view, it became clear that allocating exclusive space for females in buses, gender separation at bus stops and waiting areas in transit stations, and separate carriages for families would be effective in improving public transport ridership in Riyadh City.

Table 8.2 summarises the qualitative approach findings in terms of effectiveness and acceptability of a number of TDM strategies examined in the study. It also contrasts findings with prior evidence reported in the literature. The 'expected' sign for Riyadh in brackets is [✓] for positive effectiveness and acceptability by the general public and [X] for negative.

Table 8.2: Riyadh findings compared to general findings from elsewhere in the world

Themes	Proposed TDM strategies	Affect	Accept	References
Planning and Physical changes	Improve infrastructure for walking	[✓]✓	[✓]✓	(Wu and Murray 2005; Garling and Schuitema 2007; Meek et al. 2008)
	Park and ride schemes	[✓]✓	[✓]✓	
	Transit stations/stops within acceptable walk	[✓]✓	[✓]✓	
	Limit supply of road space	[✓]✓	[X] X	(Kenworthy 2006)
	More space to park in station car parks	[✓]✓	[✓]✓	(Rietveld 2000)
	Dedicated bus lanes	[✓]✓	[✓]✓	(Basso et al. 2011)
	Luxury metro stations	[X]	[✓]	
Legal policies	Banning car traffic in crowded areas	[✓]✓	[X] X	(Ison 2000; Loukopoulos et al. 2005a)
	Increase enforcement in urban areas	[✓]✓	[X]✓	(Garling and Schuitema 2007)
	Updating the rules for issuing new driving licences	[✓]✓	[✓]✓	(Chapman 2007)
	Operating and monitoring parking demand	[✓]✓	[✓]✓	(Garling and Schuitema 2007)
Economic policies	Parking charge	[✓]✓	[✓]X	(Ison and Wall 2002)
	Increase fuel price	[✓]✓	[X] X	(Gallo 2011; Khalilikhah et al. 2016)
	Road pricing	[X]✓	[X] X	(Small 2004; Dieplinger and Fürst 2014) and Ison (2000)
	Low public transport fare	[✓]✓	[✓]✓	(Garling and Schuitema 2007; Santos et al. 2013)
	The chance of winning prizes	[✓]✓		
	Discounts for families and students	[✓]✓	[✓]✓	Seattle Department of Transportation (2008)
	Awareness of the environmental impacts	[X]✓	[✓]✓	(Chapman 2007; Howarth and Ryley 2012)

Social and culture measures	Separate family carriages	[✓]✓	[✓]✓	(Ezzi et al. 2014; Alhazmi and Nyland 2015)
	Promote the safety of public transport	[✓]✓	[✓]✓	(Delbosc and Currie 2012)
	Comfortable seats and cleanliness	[✓]✓	[✓]✓	(Ison 2000; Beirão and Cabral 2007)
	Frequency of public transport service	[✓]✓	[✓]✓	
	On-board facilities such as entertainments	[✓]✓	[✓]✓	(Ahern and Tapley 2008)
	Station facilities such as utilities offices	[✓]✓	[✓]✓	
	Encourage public school commuters	[✓]✓	[✓]✓	(Moser and Bamberg 2008; Bamberg et al. 2011)
	School programmes to entice PT use	[✓]✓	[✓]✓	(Garling and Schuitema 2007; Moser and Bamberg 2008)
	Security and personal Safety	[✓]✓	[✓]✓	(Hamilton 2007; Delbosc and Currie 2012)
Information and technological measures	Public information campaigns	[✓]✓	[✓]✓	(Institute for Transport Studies 2010; Matsumoto and Hidaka 2015)
	On-board facilities such as Wi-Fi	[✓]✓	[✓]✓	
	Mobile tickets app	[✓]✓	[✓]✓	
	Pre-trip, wayside and on-board information	[✓]✓	[✓]✓	
	Provide written directions for reaching sites by public transport	[✓]✓	[✓]✓	(Balcombe et al. 2004)
	Journey plans app	[✓]✓	[✓]✓	

8.2.2 General public perspectives

The study also involved a quantitative survey of the general public using a sample of Riyadh's residents to address five of the study's objectives (see Table 8.1, objectives 6-10). The survey comprised four sections including perceptions of current traffic status, attitudinal statements regarding public transport, a discrete choice experiment and socio-demographic questions.

As shown in Chapter Six, 250 participants (33.7% of the invited target group) completed the survey questionnaire including Saudis and non-Saudis living in Riyadh City.

Generally, survey respondents were dissatisfied with the current road traffic conditions in Riyadh City. The issues highlighted included congestion, increase of road casualties and aggressive driving behaviour. Respondents were in favour of possible counter measures most notably new public transport service. Almost all respondents were dependent on private cars for their daily travel. The study also found that the majority of respondents expressed a

willingness to walk up to 300 metres (equivalent to 7-minute walk) to catch a public transport service when in operation. In Sydney, Australia, a study by Daniels and Mulley (2013) found that people are different in their acceptability of walking distance to transit station. Their study concluded that people would accept to walk more distance to train station but not to bus stop. They also added that there are other factors which would affect walking distance such as individual demographic characteristics and trip characteristics such as trip purpose, time of day and week. The following sub-sections summarise the key findings from the general public survey.

8.2.2.1 Attitudes towards public transport

Investigating Riyadh's residents' perceptions around travel involves several stages of analyses such as exploratory, factor analysis, structural equation and modelling (see Chapters Six and Seven).

The attitudinal statements explored participants' reactions to planning and physical changes interventions such as transit stops, improving infrastructure to enhance the accessibility to public transport services and dedicated bus lanes. The above interventions were important measures that would encourage people to use public transport.

Legal transport policy measures such as banning car traffic in crowded areas, prohibiting parking at certain destinations, on-street parking control and monitoring illegal parking would be appropriate strategies to shift travel choices towards public transport.

It was also found that increasing fuel prices, introducing road tax, parking charges, stricter penalties for traffic violations, competitive public transport fee, offers for students and families and discounts in malls and local shops for public transport users were among the economic transport policy measures motivating elements to encourage the use of public transport in Riyadh City.

For future planning of the public transport system in Riyadh City, authorities have to consider lifestyle, social and cultural perspectives of its citizens; for example, introducing separate carriages for families with standard seats and first-class seats on metro compartments, encouraging travel to school by

public transport. The security and privacy were very important elements highlighted by respondents.

In terms of factors relating to public transport, a considerable number of respondents expressed concerns about car accidents and confirmed their willingness to use public transport for safety reasons. High-quality public transport elements such as comfortable seats, air conditioning and cleanliness would encourage use of public transport, even if journeys took longer than driving.

Factor analysis of respondents, attitudinal statements helped classify respondents into three groups: those concerned with conditions of travel, others placing emphasis on financial and a group highlighting cultural perceptions towards public transport aspects of travel (see, Table 8.3 and Chapter Six, Section 6.5.2 for more details).

Table 8.3: Summary of statements emerging from the factor analysis

Factors	Attitudinal statements
Conditions of travel	• Public transport journey plan application in smart devices • Separate families' carriages • Use public transport to avoid traffic accidents; Public transport is safe • Public transport provides women access to transport • Punctuality, clear and efficient passenger information on Public transport • Public transport safety and security • Ease of reaching metro stations
Financial considerations	• Use Public transport to avoid traffic violations • Discounts in malls and local shops for public transport users • Increase fuel price • Introducing road tax • Introducing parking charge
Cultural perceptions towards public transport	• Use Public transport I have taken a step down in the world • Mixing with others in Public transport • Public transport would make me cancel some activities • I would use the metro but I would not use buses • I have negative impressions about bus use

Note. Statements with factor loadings less than 0.4 were omitted.

Structural equation modelling also pointed towards a positive association between participants' income, conditions of travel and financial considerations (see Chapter Six). The results showed that respondents who earned less than 15,000 SR (≈ $4,000) per month were more likely to score higher on the scales/statements related to conditions of travel. These respondents were

more likely to accept efficiency, provision for family carriages and safety and security.

Also, respondents' education qualification was positively associated with respondents' placing higher scores onto scales related to financial considerations and cultural perceptions about public transport. In other words, individuals holding a bachelor's degree or higher were more likely to take into account elements around pricing, public transport tickets and fuel prices. Most importantly, those holding a higher education degree were more likely to score higher on the 'cultural aspects about public transport' factor and thus felt strongly that taking public transport would be 'taking a step down in the world', 'dislike mixing with others', 'having negative impressions about bus use' and would rather use metro instead of bus.

8.2.2.2 Choice analysis

As shown in Chapter Seven, the second part of the general public survey was a discrete choice experiment. Respondents were offered scenarios that showed two travel alternatives (car and public transport) with various attributes at different levels. Out of the 250 respondents, 207 respondents were included representing 1890 observations.

MNL models were estimated to examine the effect of travel time, travel cost and number of transfers in-between public transport modes into respondents' choice between car and public transport (metro, metro&bus and bus). The choice analysis also examined the interactions between these attributes combined with trip-based and respondents' socioeconomic characteristics.

The key findings were that metro provides the highest utility to respondents across all Models followed by a car, metro & bus and bus. In Model 1, the results confirmed that the likelihood of people shifting from private cars to public transport in Riyadh City would increase by a reduction in public transport costs, decreased number of transfers in-between public transport modes and increased frequency of service. As indicated in Table 8.4, in the MNL model estimation value of time coefficients were 35.65 SR (≈ $9.50, €8.34 and £7.33) per hour. For comparison the estimated value of time is relatively close to the value of time estimated in the United Arab Emirates which was 28.5 Arab

Emirates Dirham, equivalent to 29.1 SR and $7.60 (Clarke et al. 2007). According to the Victoria Transport Institute (2017) travel time value estimated in the UK about £5.00 per hour for commuting time and £4.37 per hour for other travel purposes, in other Europe countries at €6.00 for commuting time and €4.00 leisure / holiday, and in USA the average travel time value estimated around $12.50.

As shown in Table 8.4, Model 2 included the interaction between income and travel cost. It was found that the value of time was significantly different for different income groups in which as income increases value of time also increases.

Model 3 also examined the associations between socio-economic characteristics such as age, gender, education and number of children and the choice of car. The results showed no effect of age and gender in the probability of choosing car among survey participants. However, all else being equal, respondents with higher qualifications were more likely to choose car. Finally, respondents with less than three children were more likely to choose car than others with three children or more.

As shown in Table 8.4, in Model 3, the difference in the estimated value of time between Models 2 and 3, was very small.

In Model 4a, the effect of total travel time was estimated for two travel purposes, commuting and shopping. In contrast with a study by Mackie et al. (2001), it is worth noting that as shown in Table 8.4, the absolute value of time for shopping was higher than commuting, and subsequently the value of time for shopping was higher than the value of time for commuting (see Chapter Seven).

In Model 4b, there was a slight increase observed in the absolute value of time among all categories considered in modelling estimations between the error components model and the classical Model 4a.

In Model 5a, the utility specification included the interaction between total travel time, the purpose of the journey and travel mode. The estimated coefficients for both (commuting and shopping) and travel mode (car and public transport) had negative signs and were statistically significant at 99%

(see, Chapter Seven). All coefficients were negative implying that an increase in travel time would reduce the likelihood of a given mode being chosen.

Also, in Model 5b, mixed logit models were account for the panel effects in the repeated observations of stated choice data. As shown in Table 8.4, there was a slight increase in the value of time compared to Model 5a.

Table 8.4: Value of time estimated based on MNL and mixed MNL specifications.

Models	Attributes and socio-demographic	Value of time (SR) ≈ $
Model 1: MNL Base	A fixed value for all decision makers	35.65 ≈ $9.5
Model 2: Considering the interaction between income and travel cost	Income < 15,000 SR	29.70 ≈ $7.9
	Income > 15,000 SR	48.90 ≈ $13.1
Model 3 (MNL): Considering socio-economic characteristics (age, gender, education and number of children)	Income < 15,000 SR	28.8 ≈ $7.68
	Income > 15,000 SR	48.3 ≈ $13.0
Model 4 (MNL): Considering travel purpose	Income < 15,000 SR: Commuting	23.2 ≈ $6.18
	Income > 15,000 SR: Commuting	38.0 ≈ $10.13
	Income < 15,000 SR: Shopping	31.8 ≈ $8.48
	Income >15,000 SR: Shopping	52.1 ≈ $13.90
Model 4b (Error Component MNL): Considering serial correlations in the data	Income < 15,000 SR: Commuting	26.0 ≈ $6.93
	Income > 15,000 SR: Commuting	42.0 ≈ $11.2
	Income < 15,000 SR: Shopping	31.5 ≈ $8.18
	Income >15,000 SR: Shopping	50.9 ≈ $13.6
Model 5a (MNL): Considering the interaction between total travel time, journey's purpose and travel mode	Income < 15,000 SR: Commuting , Car	22.6 ≈ $6.10
	Income < 15,000 SR: Commuting , PT	24.8 ≈ $6.61
	Income > 15,000 SR: Commuting , Car	33.9 ≈ $9.04
	Income > 15,000 SR: Commuting , PT	37.2 ≈ $9.92
	Income < 15,000 SR: Shopping, Car	29.7 ≈ $7.92
	Income < 15,000 SR: Shopping, PT	29.6 ≈ $7.92
	Income >15,000 SR: Shopping, Car	44.4 ≈ $11.84
	Income >15,000 SR: Shopping, PT	44.3 ≈ $11.83
Model 5b (Mixed logit): Considering the panel effects in the repeated observations of stated choice data	Income < 15,000 SR: Commuting, Car	25.6 ≈ $6.83
	Income < 15,000 SR: Commuting , PT	26.7 ≈ $7.12
	Income > 15,000 SR: Commuting , Car	39.8 ≈ $10.61
	Income > 15,000 SR: Commuting , PT	41.5 ≈ $11.10
	Income < 15,000 SR: Shopping, Car	30.5 ≈ $8.13
	Income < 15,000 SR: Shopping, PT	30.4 ≈ $8.13
	Income >15,000 SR: Shopping, Car	47.4 ≈ $12.64
	Income >15,000 SR: Shopping, PT	47.2 ≈ $12.59

8.3 Consolidation and Discussion of Findings

This section consolidates similarities and differences across all study findings. As shown in Table 8.5, with regard to planning and physical changes, findings agreed with previous studies such as Garling and Schuitema (2007), Agarwal and Collins (2016) and Wake (2016) that public transport ridership in Riyadh City may be encouraged by park and ride schemes, improving infrastructure for walking and car parks in public transport stations. Other planning strategies such as TOD sites (Cervero and Murakami 2008; Newman 2012), transit stops within acceptable walking distances (Wu and Murray 2005; Aljoufie 2016) and dedicated bus lanes (Basso et al. 2011) were felt as effective to motivate public transport ridership in Riyadh City. Thus, authorities should take into consideration any future demand for these facilities and be willing to provide more if needed.

On the other hand, while stakeholders were in agreement with Wallström (2007) in favour of limiting supply of road space to discourage car use, general public opinion opposed this strategy.

From the stakeholder interviews and general public survey findings it became clear that interventions relating to legal policy measures were imperative in reducing private car travel thereby providing additional benefits to the city. For example, studies maintain that an improper parking service leads to traffic congestion, longer travel times and lower levels of accessibility (Verhoef et al. 1995; Ison and Wall 2002). In line with Litman (2006) and Vianna et al. (2004), results of this study confirmed the importance of promoting parking management in Riyadh City including illegal parking control, monitoring the parking demand, and an integrated parking management system. These findings were also consistent with a study by Javid et al. (2013) conducted in Auckland City, who reported that parking management reduced the rate of private car trips between 8% and 18%. Furthermore, in this study, other legal policy measures including speed management and penalties for driving without a driving licence were rated as effective strategies to encourage public transport ridership in Riyadh City.

A recent study by Bliss and Breen (2012) aimed at improving road safety outcomes in developing countries, reports that measures to reduce unsafe vehicle speeds can also result in less air pollution and improved physical well-being. In line with Schlag and Teubel (1997), prohibiting car traffic in city centres and congested locations was effective but less acceptable by general public compared to other legal policies. The general public felt this strategy would be ineffective and unacceptable. A study by Wang et al. (2014) investigated the effectiveness and acceptability of the driving restriction policy in Beijing, China, introduced in 2007 using data from a household survey and travel diaries. The study found a rule-breaking behaviour and that almost 50% of the commuters drive illegally to their destination places.

In terms of the frequency and reliability of public transport, in line with studies by Ison (2000), Balcombe et al. (2004), Dell'Olio et al. (2011) and the Transit Cooperative Research Program (2007) stakeholders and the general public were in agreement that high frequency of public transport, punctuality, comfortable seats, air conditioning and cleanliness would attract them to use public transport. These results were also intuitive and consistent with a number of studies on travel behaviour, for example Redman et al. (2013) conducted a systematic review of studies regarding the quality of public transport services and found that public transport attributes such as service reliability and frequency were effective in attracting car users and linked to individual perceptions, motivations and contexts.

As shown in Table 8.5, with regard to cost, stakeholders reported that increasing fuel prices (Gallo 2011; Khalilikhah et al. 2016) and road taxes (Small and Gómez-Ibáñez 1997; Buehler and Pucher 2012; Dieplinger and Fürst 2014) would be major factors to reduce private car attractiveness and increase public transport ridership. However, the stakeholders also confirmed that the public might be against pricing measures (Loukopoulos et al. 2005b; Schuitema et al. 2010) and might lead people to believe that public transport would contribute to decrease the negative aspects of car use.

From the perspective of the general public and in line with the conclusions of reported by Gallo (2011) and Khalilikhah et al. (2016), increasing car operation costs such as fuel price and road taxes were seen as more effective strategies

to shift the public to public transport use. However, in consistent with Ison (2000) road pricing felt less acceptable by both study respondents groups compared to other economic strategies.

Nevertheless, stakeholders and the general public both agreed that introducing parking charges was an important element to encourage public transport ridership (Ison and Wall 2002). Other motivation strategies welcomed by the general public included offering discounts or special offers in malls and local shops for public transport users, discounts for families and students and the chance of winning prizes such as smartphones and tablets every month through a raffle draw. The elements have not be investigated nor reported in the literature.

Given the social and cultural context of the study area, strict gender segregation is an important aspect in Saudi society. Therefore, in agreement with studies by Horii and Burgess (2012), Delbosc and Currie (2012) and Aljoufie (2016) stakeholders and the general public agreed that, allocating exclusive space for females in buses, ensuring gender separation at bus stops and waiting areas at transit stations, and separate metro carriages for families were motivation strategies to make public transport compete with dominant car reliance in Riyadh City.

Nevertheless, studies in the UK found that addressing security and safety would make 10% of the people reconsider using public transport (Crime Concern 2004). In this study, stakeholders felt that security measures, personal safety and pedestrian-friendly surroundings in all public transport premises would be highly effective strategies. Delbosc and Currie (2012) used a survey sample from Melbourne, Australia, and found that safety has a significant influence on public transport ridership. A survey by Stradling et al. (2007) analysed influences on satisfaction with bus journeys in Edinburgh and found that feeling unsafe was one of the main underlining factors that discourage respondents from using the bus. In agreement with these studies, in this study the general public expressed their willingness to shift to public transport if it offers a high level of safety and security. Moreover, other incentives such as metro carriages provided with standard seats and first-class seats were welcomed by both study groups of participants.

Stakeholders and the general public agreed for some school travel initiatives that might be considered by teachers, parents and governors to reduce car travel and promote public transport ridership. For example, in agreement with the school travel advisory group report by Osborne and Pontefract (1999) travel awareness campaigns in schools, school travel plans and new school sessions for all age groups to teach pupils the main benefits of proven of public transport in the city and how to use it were highlighted by stakeholders and the general public to be appropriate initiatives to persuade people to switch to public transport. They also highlighted that encouraging high school pupils to use public transport rather than school buses would entice them to use public transport in the future. Moser and Bamberg (2008) synthesised results of 141 studies on soft transport policy measures to promote voluntary reduction of car use. The study included 25 school travel plans studies and indicates that school travel plans is one of the 'mature' soft transport policy measures.

With regard to information and technology strategies to persuade people to change mode, in conformity with the studies by Nelson and Mulley (2013) conducted as a comparative analysis of Intelligent Transport Systems policy between Europe and Australia, stakeholders and general public agreed that implementing a clear and accurate passenger information strategy using the appropriate media would make public transport more attractive such as a smart ticketing system, mobile tickets app, journey planner app providing up-to-date information on public transport options and wireless Internet would simplify journeys. In line with a study by Grotenhuis et al. (2007, p. 28), both of the study groups' participants stressed that travel information is an important factor of public transport quality such as pre-trip, wayside and on-board information that helps people to plan and execute travel.

Table 8.5 summarises the evidence collected via stakeholder interview and the general public survey in terms of effectiveness of a number of TDM strategies to persuade people to switch mode. Also it contrasts what is reported in the literature review with. The 'expected' sign is ✓ for positive effectiveness, X for negative effectiveness by both study methods findings and evidences elsewhere in the World. The 'expected' sign for Riyadh in brackets [X] is for negative acceptability by the general public.

Table 8.5: Study's findings compared to general findings from elsewhere in the world

Themes	TDM strategies	Effectiveness and acceptability			References
		Stakeholders	General public	Literature review	
Planning and Physical changes	Improve infrastructure for walking	✓	✓	✓	(Wu and Murray 2005; Garling and Schuitema 2007; Meek et al. 2008; Aljoufie 2016)
	Transit stations/stops within acceptable walk	✓	✓	✓	
	Limit supply of road space	✓	X[X]	✓[X]	(Kenworthy 2006)
	Stations car parks	✓	✓	✓	(Rietveld 2000)
	Dedicated bus lanes	✓	✓	✓	(Basso et al. 2011)
	Luxury metro stations	X	X		
Legal policies	Banning car traffic in crowded areas	✓	X[X]	[✓] X	(Ison 2000; Loukopoulos et al. 2005a; Wang et al. 2014)
	Increase enforcement in urban areas	✓[X]	✓[X]	✓	(Garling and Schuitema 2007)
	Updating the rules for issuing new driving licences	✓	[X] X	✓	(Chapman 2007)
	Parking demand management	✓	✓	✓	(Garling and Schuitema 2007)
Economic policies	Parking charge	✓	✓	✓	(Ison and Wall 2002)
	Increase fuel price	[✓]X	✓	[✓] X	(Gallo 2011; Khalilikhah et al. 2016)
	Road pricing	[✓]X	[X] X	[✓]X	(Small 2004; Dieplinger and Fürst 2014) and Ison (2000)
	Low public transport fare	✓	✓	✓	(Garling and Schuitema 2007; Santos et al. 2013)
	The chance of winning prizes	✓	✓		
	Discounts for families and students	✓	✓	✓	Seattle Department of Transportation (2008)
Social and culture measures	Awareness of the environmental impacts	[X]✓	[X]✓	✓	(Chapman 2007; Howarth and Ryley 2012)

	Separate family carriages	✓	✓	✓	(Ezzi et al. 2014; Alhazmi and Nyland 2015)
	Promote the safety of public transport	✓	✓	✓	(Delbosc and Currie 2012)
	Comfortable seats and cleanliness	✓	✓	✓	(Ison 2000; Beirão and Cabral 2007)
	Frequency of public transport service	✓	✓	✓	
	On-board facilities and luxury services	✓	[X] ✓	✓	(Ahern and Tapley 2008)
	Station facilities such as utilities offices	✓	✓	✓	
	Encourage public school commuters	✓	✓	✓	(Osborne and Pontefract 1999; Moser and Bamberg 2008; Bamberg et al. 2011)
	School programmes to entice PT use	✓	✓	✓	(Garling and Schuitema 2007; Moser and Bamberg 2008)
	Security and personal Safety	✓	✓	✓	(Crime Concern 2004; Hamilton 2007; Stradling et al. 2007; Delbosc and Currie 2012)
Information and technological measures	Public campaigns	✓	✓	✓	(Institute for Transport Studies 2010; Gripsrud and Hjorthol 2012; Nelson and Mulley 2013; Matsumoto and Hidaka 2015)
	On-board facilities such as Wi-Fi	✓	✓	✓	
	Mobile tickets app	✓	✓	✓	
	Pre-trip, wayside and on-board information	✓	✓	✓	(Balcombe et al. 2004; Nelson and Mulley 2013)
	Journey plan app	✓	✓	✓	

8.4 Contributions to the body of knowledge

This is the first study of its kind to look into the potential public transport demand in Riyadh City, Saudi Arabia. The main contributions of this research work are summarised below:

1. **Academic contributions**

- A comprehensive review of the literature placing emphasis on the planning and physical change, economic, legal, social and cultural, and information and technological aspects toward adopting public transport.
- A comprehensive research design to enable systematic collection of evidence resourcing the views and opinions of key stakeholders and the public. The proposed design can be adopted by practitioners and academics in similar contexts across urban areas in Saudi Arabia and the Gulf countries.

2. **Contributions to policy and decision-making**

- This study provides the evidence base on how stakeholders and the public perceive different strategies that would encourage uptake of public transport (metro and bus) in Riyadh City. It proposed recommendations for implementing TDM strategies to improve the current transport challenges such as congestion and encourage public transport ridership in 2018. It presented real world numbers that show positive changes in public transport ridership due to the implementation of various pro-transit strategies can be very encouraging for Riyadh authorities to adopt some of those strategies, the most effective and suitable for Riyadh and its new public transport system.
- Examines how different segment of the population perceive public transport and shows that education, income and age are important factors, which imply the need for different information and awareness campaigns to be launched in order to encourage public transport use. For example, this study found that highly qualified individuals were more likely to perceive public transport as a 'taking a step down into the World' and

this is a point in which public transport authorities need to focus in order to ease this perception.

- For the first time, this study reports on the analysis of the potential demand for public transport in Riyadh based on a stated choice experiment when considering three important – according to previous studies – attributes of public-transport operations; namely, travel time, cost and number of transfers in-between public transport modes. It is also the first time to derive estimates of the value of travel time saving for Riyadh City. Interestingly, and contrary to findings in the UK by Mackie et al. (2001), this study found that in Riyadh City the value of travel time for shopping purposes is slightly higher than for commuting.

3. Methodological contributions

This study follows a comprehensive approach involving both qualitative and quantitative methods and engages key stakeholders and the general public. The research also makes a contribution for transport authorities and academic research organisations at the country of Saudi Arabia or the Gulf countries with similar regimes that may adopt similar approaches, for example, by consolidating stakeholder view and general public perspectives.

- Qualitative, semi-structured interviews with stakeholders, including transport experts and representatives of Riyadh City authorities.
- A quantitative, general public survey of a sample of Riyadh's residents using a social network-based survey tool as a methodology. With the absence of a sampling and data collection framework, the study adopted a Social Network-Based Survey tool in Riyadh City as a promising way for collecting general public responses. There are several reasons that made recruitment of participants in Saudi Arabia challenging. Addresses and phone numbers are not yet systematically listed, postcode and postal services provide little opportunity for a mail survey and the Saudi society is gender-segregated, largely conservative and religious, making participant recruitment – especially women – through random talk, extremely challenging.

To address these challenges this study tested a social network-based survey tool. The social network-based survey recruitment process was conducted over the Internet using principles of the RDS method in that participants used their social networks to invite their friends or relatives to participate in a study (Heckathorn 2011).

The findings reveal that the survey methodology presented a successful experience in terms of collecting high quality data at minimum cost.

8.5 Limitations of the research

Regarding the limitations, due to the cultural context of the society all interviewees in this study were males. There is a lack of secondary data about the reality of the current transport policy measures of the city of Riyadh with respect to sustainability. Moreover, there is no prior information about the public transport operational criteria such as the ticket prices and the service frequencies.

In the general public survey, the study has faced a few limitations worth noting. First, males, respondents in full-time employment and Saudis were over-represented in the sample. In Saudi Arabia, people do not regularly check their email account which made a delay in the data collection process and decrease in the number of participants in the survey. The low proportion of non-Saudi participants could be explained by a number of factors. The majority of expatriates in Saudi Arabia are blue-collar workers with basic qualifications (Al-Dubikhi 2007) unable to access the Internet and in many cases do not speak Arabic or English. The dominant private car and lack of experience of public transport use among study participants would affect their underlying attitudes and interest.

Finally, another aspect relates with the potential to reach a much larger sample size. The use of a social-networking tool to recruit respondents performed fairly well. It helped establish the right level of trust among respondents so that they could recommend the survey to friends and family following the completion of the survey. However, the key issue discovered during the testing and main survey stages was that a lot of the potential respondents did not regularly check their emails. Unlike other countries, email is not part of

everyday communication. If the data collection were to be repeated in the future it is crucial for the referral system to include means of communication centred on the use of mobile phone. That is, the referral system should include options to refer the survey via mobile text or personalised text via other social-network platforms such as Facebook, WhatsApp or Twitter. This way would help to reach a significantly higher number of referral by different modes.

8.6 Recommendations for future research

Future studies have to build on the benefits of avoiding the current study limitations discussed in the previous section. A similar study could be conducted in the future after the public transport system is in operation in Riyadh City and follow incorporated comparison in a before–after people being familiar with the public transport service.

The same method could be applied using other social media instead of email, such as WhatsApp or Twitter which are widely spread in the study area. Thus, future research may benefit from the knowledge gained from conducting this research work with its associated techniques whether in Saudi Arabia or internationally.

Future research may include the use of weights or quotas to ensure that the sample would be representative relative to the general population. This could be done by obtaining Census data on gender and age, nationality and occupation for the whole population of Riyadh, and using this information to calculate weights and running the same models using a weighted sample. However, it is not fully expected that the general population sample would be representative of that involving regular commuters should the models' purpose be to explain future uptake of public transport.

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APPENDIX 1: Semi-structural interview

Dear Sir,

This interview is a part of my doctoral research in the School of Planning and Geography at Cardiff University in the United Kingdom. Our meeting and interview address one of my research questions namely: *"what are the procedures and approaches that have to be undertaken to ensure public transport uptake in Riyadh City?"*

The research looks into transport challenges in Riyadh City and how these may be overcome, also hopes to find out the potential barriers and facilitators for using metro and public transport, in general. Undoubtedly, your views and opinions will help obtain the desired objectives of this study.

The contribution of this research is to produce evidence and inform travel strategies and regulations to reduce private car use and encourage shift to public transport.

All responses will be anonymised and will be treated confidentially. Findings by combining all responses will be made publicly available via my thesis and research articles.

Yours sincerely,
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Section One: Existing Travel Strategies in Riyadh City

1. What do you think, on the whole, are the current status of Riyadh travel demand management policies, measures and incentives adequate for encouraging public transport ridership? And why?

……

……

2. In your point of view, to what extent you agree or disagree with introducing public transport services in Riyadh City now?

    1. Not necessarily □
    2. Welcome change □
    3. High priority □

Add comments, please explain, why?

……

……

3. How favour are you about implementing travel demand management strategies with incentives to change Riyadh residents' travel behaviour?

    1. Extremely favour □
    2. Very favour □
    3. Somewhat favour □
    4. Slightly favour □
    5. Neither Agree nor favour □

Add comments, please specify:

……

……

4. Is our society ready for a wide use of public transport? If no what are the barriers?

    □Yes □ No

……

……

5. Please, what priority should be given to the following dimensions in reshaping travel demand management strategies in Riyadh City?

Table 1: Priority of themes

(A) Highly Priority, (B) Very Priority, (C) Somewhat Priority, (D) Slightly Priority (E) Not at all Priority

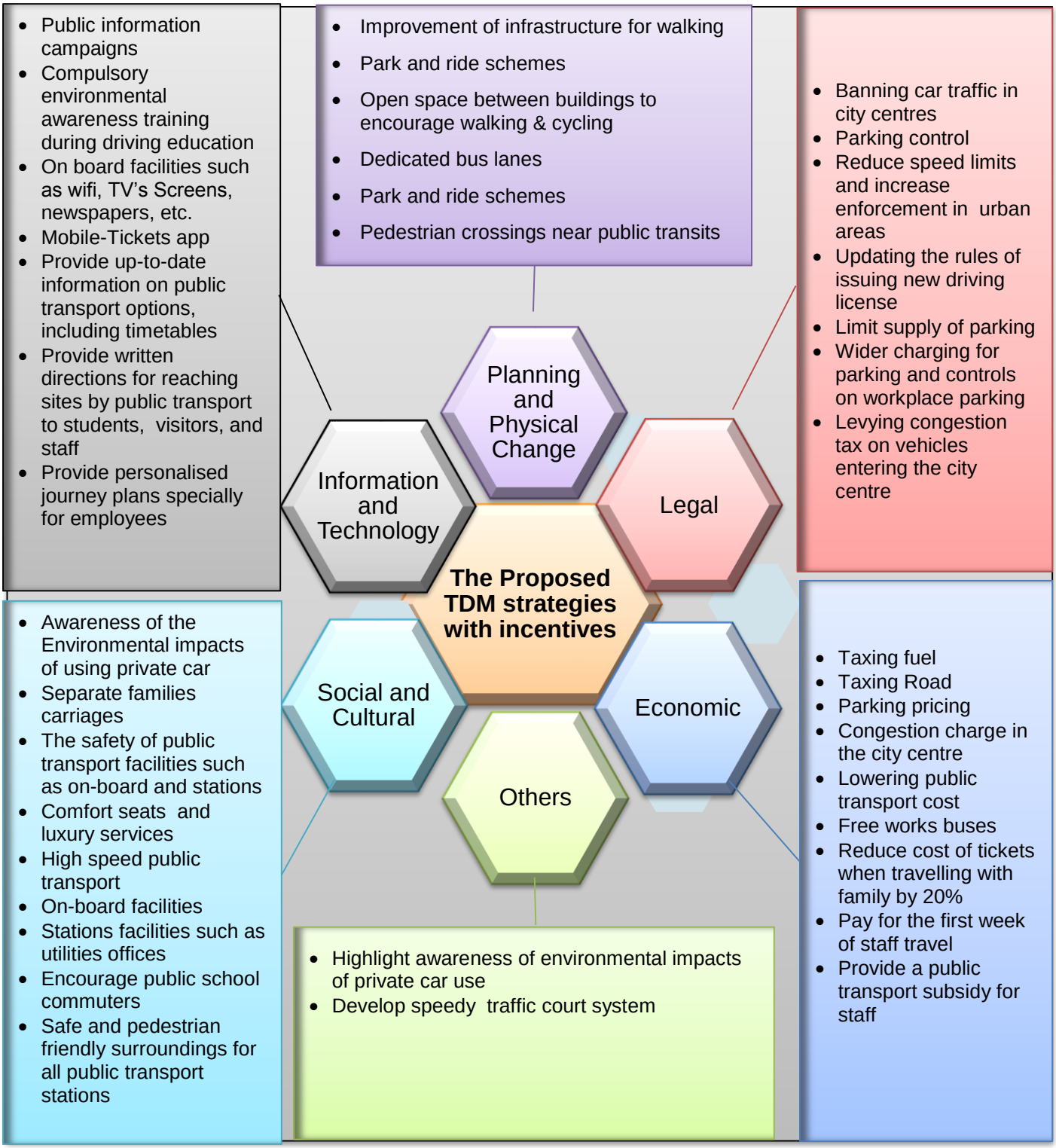
Implications	Rank	A	B	C	D	E
1. City Planning and physical change	□	□	□	□	□	□
2. Legal policies	□	□	□	□	□	□
3. City Economic	□	□	□	□	□	□
4. Social and culture	□	□	□	□	□	□
5. Information and Technology	□	□	□	□	□	□

Add comments, please specify:

……

……

Figure 1.The proposed framework suggests examples of Travel Demand Management policies and measures with incentives to reduce private car use and encourage shift to public transport in Riyadh City, Saudi Araba



Section Two: The potential effectiveness, acceptability and applicability of a set of proposed TDM strategies

The initial framework is presented in Figure 1, and amalgamates relevant studies, experience from other countries, and theories regarding sustainable transport in both developed and developing countries.

As illustrated in Figure 1, the study proposes a framework containing a set of suggestions of policies, measures, and legislations aiming at shifting Riyadh's residents from private car to public transport. The framework covers six dimensions namely:

1. Planning and Physical Change
2. Legal
3. Economic
4. Social and Cultural
5. Information and Technological, and
6. Other policies and measures.

These areas need to be integrated to accomplish the required goal of the framework. Each one of these areas includes a number of criteria.

Could you comment upon the following criteria and the corresponding travel strategies with regards to;

- Effectiveness (in shifting travel behaviour)
- The level of acceptability by general public
- Level (degree) of applicability (to local context)

1. Please indicate to what extent you believe the following planning and physical changes measures will be effective to reduce private car use and encourage shift to public transport in Riyadh City?

Table 2: The Planning and Physical Change

(A) Highly Effective, (B) Very Effective, (C) Somewhat Effective, (D) Slightly Effective (E) Not at all Effective

Planning and physical changes	Rank	A	B	C	D	E
1. Improvement of infrastructure for walking such as open space between buildings	□	□	□	□	□	□
2. Park and ride schemes	□	□	□	□	□	□
3. Transit stations/stops located centrally within acceptable walking distances	□	□	□	□	□	□
4. Limit supply of road space in key locations	□	□	□	□	□	□
5. More space to park in stations car park	□	□	□	□	□	□
6. Dedicated bus lanes	□	□	□	□	□	□
7. The luxury metro stations	□	□	□	□	□	□

2. How acceptable do you believe these changes would be in Saudi society and why?
3. How applicable do you believe these changes would be in Riyadh and why? Please add comments and specify:

……

4. Please indicate to what extent you believe the following legal policies will be effective to shift Riyadh society from private car to public transport?

Table 3: The Legal policies

(A) Highly Effective, (B) Very Effective, (C) Somewhat Effective, (D) Slightly Effective (E) Not at all Effective

Strategies	Rank	A	B	C	D	E
1. Banning car traffic crowded areas	□	□	□	□	□	□
2. Operating and monitoring parking areas	□	□	□	□	□	□
3. Increase enforcement in urban areas	□	□	□	□	□	□
4. Updating the rules of issuing new driving license	□	□	□	□	□	□
5. Limit supply of parking	□	□	□	□	□	□
6. Wider charging for parking and controls on workplace parking	□	□	□	□	□	□

5. How acceptable do you believe these changes would be in Saudi society and why?
6. How applicable do you believe these changes would be in Riyadh and why? Please add more activities, policies, and comments:

……

7. Please indicate to what extent you believe the following Economic policies will be effective to shift Riyadh society from private car to public transport?

Table 4: The Economic policies

(A) Highly Effective, (B) Very Effective, (C) Somewhat Effective, (D) Slightly Effective (E) Not at all Effective

Strategies	Rank	A	B	C	D	E
1. Taxing fuel	□	□	□	□	□	□
2. Taxing Road	□	□	□	□	□	□
3. Parking Pricing	□	□	□	□	□	□
4. Congestion charge in crowded areas	□	□	□	□	□	□
5. Lowering public transport cost	□	□	□	□	□	□
6. Reduce cost of tickets for family ,students, special needs, and seniors	□	□	□	□	□	□
7. Provide a public transport subsidy for staff	□	□	□	□	□	□

8. How acceptable do you believe these changes would be in Saudi society and why?
9. How applicable do you believe these changes would be in Riyadh and why? Please add comments, and specify:

……

10. Please indicate to what extent the following Social and Cultural Measures will be effective to shift Riyadh society from private car to public transport?

Table 5: Social and Cultural Measures

(A) Highly Effective, (B) Very Effective, (C) Somewhat Effective, (D) Slightly Effective (E) Not at all Effective

Strategies	Rank	A	B	C	D	E
1. Awareness of the Environmental impacts of using private car	□	□	□	□	□	□
2. Separate families' carriages	□	□	□	□	□	□
3. The safety of public transport facilities such as on-board and stations	□	□	□	□	□	□
4. Comfort seats and luxury services	□	□	□	□	□	□
5. High speed public transport	□	□	□	□	□	□
6. On-board facilities	□	□	□	□	□	□
7. Stations facilities such as utilities offices	□	□	□	□	□	□
8. Encourage public school commuters	□	□	□	□	□	□
9. Schools programs to encourage public transport use	□	□	□	□	□	□
10. Safe and pedestrian friendly surroundings for all public transport stations	□	□	□	□	□	□

11. How acceptable do you believe these changes would be in Saudi society and why?
12. How applicable do you believe these changes would be in Riyadh and why?

Please add comments, and specify:

……

13. Please indicate to what extent the following Information and Technology Measures will be effective to shift Riyadh society from private car to public transport?

Table 6: The Information and technology measures

(A) Highly Effective, (B) Very Effective, (C) Somewhat Effective, (D) Slightly Effective (E) Not at all Effective

The Information and technology measures	Rank	A	B	C	D	E
1. Public information campaigns	□	□	□	□	□	□
2. Compulsory environmental awareness training during driving education	□	□	□	□	□	□
3. On board facilities such as wifi, TV Screens, newspapers, etc.	□	□	□	□	□	□
4. Mobile-Tickets app	□	□	□	□	□	□
5. Provide up-to-date information on public transport options, including timetables	□	□	□	□	□	□
6. Provide written directions for reaching sites by public transport to students, visitors, and staff	□	□	□	□	□	□
7. Provide personalised journey plans specially for employees	□	□	□	□	□	□

14. How acceptable do you believe these changes would be in Saudi society and why?
15. How applicable do you believe these changes would be in Riyadh and why? Please add comments, and specify:

Section Three: The potential effectiveness, acceptability and applicability of a set of proposed TDM strategies

16. Please, if a set of policies is implemented to shift people toward public transport in Riyadh, to what extent do you believe the following will be impacted:

Please feel free to add other dimensions you think it is missed, strategies, and comments, specify:

……

Table 7: City main aspect

(A) Highly impacted, (B) Very impacted, (C) Somewhat impacted, (D) Slightly impacted (E) Not at all impacted

Key Dimensions	Rank	A	B	C	D	E
1. City Form	□	□	□	□	□	□
2. City Economic	□	□	□	□	□	□
3. City Environment	□	□	□	□	□	□
4. Social Norms	□	□	□	□	□	□
5. Saudi Culture	□	□	□	□	□	□

17. In your opinion, do you think there are other factors need to be taken into consideration within the framework in Figure 1?

□Yes □ No □ Not Sure

Please add comments, and specify:

……

18. Does this framework need to be reshaped/modified in order to be relevant to Riyadh?

□ If Yes, how and why? □ If No, how and why?

……

Finally, please kindly provide the following information:

Personal Information
Name
Institution
Address
E-mail Address
Telephone No.

APPENDIX 2: General-Public Survey

Dear

As you may have recently heard/read, six lines of Metro with 85 stations integrated with bus network will be in operation in Riyadh City by 2018. The metro network will cover most of the densely populated areas, public facilities, and the educational, commercial and medical institutions.

This survey forms part of a doctoral research in the School of Geography and Planning at Cardiff University in the United Kingdom. The research is aimed to find out the potential barriers and facilitators for using the Metro and Bus in Riyadh.

It only takes **25 minutes** to complete this questionnaire.

Please note that at the end of the survey, you will be asked to forward the survey to five friends or family members and for this, you will be asked to provide their email addresses.

All responses will be anonymized, and all data will be treated with confidentiality. Findings of combined responses will be made publicly available via doctoral thesis and research articles.

Should you require any further information about this survey please contact the researcher

Omar Alotaibi at AlotaibiOM@cardiff.ac.uk

Tel: 00966556666694/00447474252777

Web: http://www.cardiff.ac.uk/cplan/about-us/phd/omar-alotaibi

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Please click here to complete the survey

Thank you for agreeing to complete the survey

Prior to completing the survey, please, take a look at the following video, which provides some more details on Riyadh's public transport system

Please click here to proceed with the survey

Section 1: Perceptions of traffic problems

1- How satisfied or dissatisfied are you with the current road traffic in Riyadh city?

☐1 Very Satisfied ☐2 Satisfied ☐3 Neutral
☐4 Dissatisfied ☐5 Very Dissatisfied

2- Have you previously used any kind of public transport?

☐1Yes ☐2 No ☐3 Not sure

3- Have you previously heard of the new public transport in Riyadh City?

☐1Yes ☐2 No ☐3 Not sure

If yes, how?

☐1 In TV advertisement

☐2 Campaigns

☐3 From construction works and roads' signs

Elsewhere? Please, specify……

4- In your view, to what extent you agree or disagree with new public transport service in Riyadh City?

☐1 Strongly Agree ☐2 Agree ☐3 Neutral
☐4 Disagree ☐5Strongly disagree

Add comments, please explain, why?

……
……

5- How likely is it that you would have used Riyadh public transport had it been in operation?

☐1 Very likely ☐2 Likely ☐4 Unlikely
☐5 Very unlikely ☐3 Don't know

Add comments, please explain why?

……

6- What do you think would be the acceptable walking distance to the nearest station for you to travel by Metro or Bus?

☐1 Less than 200 meters (up to 5 minutes walk)

☐2 200-300 metres (5-7 minute walk)

☐3 300-400 meters (7 -9 minute walk)

☐4 400-500 meters (9-11 minute walk)

Next
Back

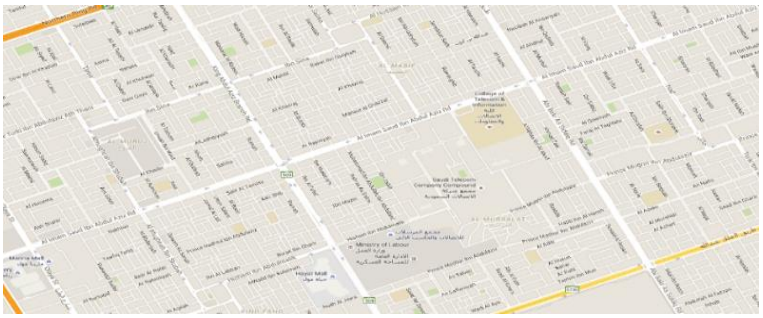
Section 2: About your travel

7- What is your employment Status? [Tick more than one when applicable]

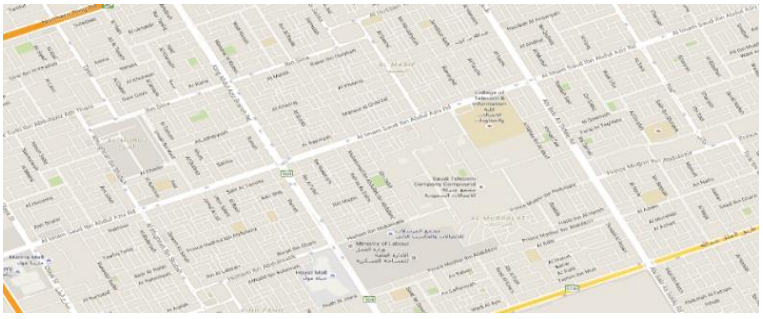
☐1 Full-time employed ☐2 Part-time Employed ☐3 Self-employed
☐4 Unemployed ☐5 Student ☐6 Retired
☐7 Looking after the home ☐8 Other

8- Geographic locations

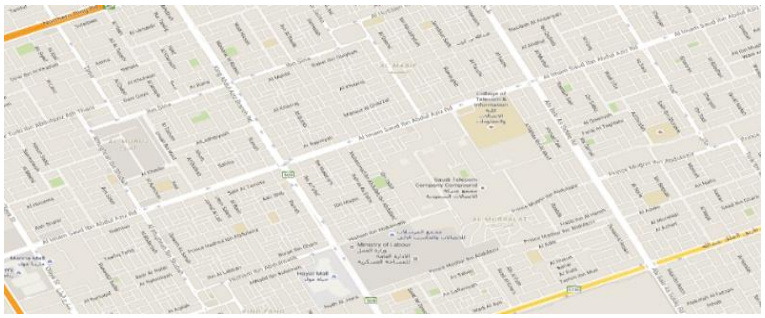
- Could you please click on the district where your home is located on the map below?



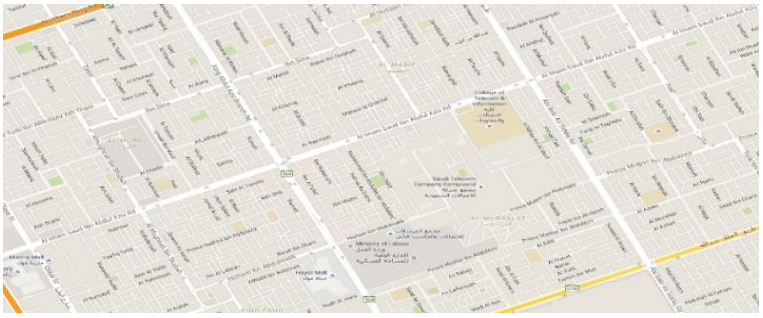
- Could you please click on the district where your work is located on the map below?



- Could you please click on the district where you study institute is located on the map below?



- Could you please click on the district where you usually shop on the map below?



Next
Back

9- What time of the day do you usually travel to and from your regular travel destination?

Time when you leave your home

Time when you leave from work

Time when you leave your place of study

10-What is your most common way of getting to and from your regular travel destination?

☐1 Driving alone
☐2 Driving with someone else
☐3 As a passenger in family vehicle
☐4 As passenger in someone else's vehicle
☐5 Other

Next
Back

Section 3: Attitudes, beliefs, and transport behaviour

11-For each of the following statements, please check the response that best expresses your opinion:

Express your opinion for the following statements	Strongly agree	Agree	Neutral	disagree	Strongly Disagree
1. Road congestion makes me more open to using public transport	☐1	☐2	☐3	☐4	☐5
2. I prefer high quality public transport such as comfortable seats, air conditioning, and cleanliness even if it takes longer than driving	☐1	☐2	☐3	☐4	☐5
3. Obtaining a transport journey-plan application on my computer and phone will encourage me to use public transport	☐1	☐2	☐3	☐4	☐5
4. Punctuality, clear and efficient passenger information on the public transport system is very important	☐1	☐2	☐3	☐4	☐5
5. I will allow and encourage my children and family to use public transport because there are separate families' carriages in Riyadh metro and buses	☐1	☐2	☐3	☐4	☐5
6. I will use public transport if the main stations have shops and utilities offices such as Telecom offices	☐1	☐2	☐3	☐4	☐5
7. I always worry about traffic accidents when I travel, so I am willing to use public transport because it will be safer than driving a car	☐1	☐2	☐3	☐4	☐5
8. Public transport will be a major solution to provide women access to transport, since they don't drive in our society	☐1	☐2	☐3	☐4	☐5
9. I would be willing to use public transport to avoid paying road tax and/or parking charges in the future	☐1	☐2	☐3	☐4	☐5
10. I am willing to be a public transport commuter if there is a chance of winning prizes such as, smartphones and tablets every month through a raffle draw	☐1	☐2	☐3	☐4	☐5
11. The price of fuel should be raised to encourage public transport ridership and reduce congestion and air pollution	☐1	☐2	☐3	☐4	☐5
12. I like to buy tickets for public transport which offer discounts or special offers in malls and local shops	☐1	☐2	☐3	☐4	☐5
13. I like driving because I don't like mixing with others when I am travelling	☐1	☐2	☐3	☐4	☐5
14. If I take public transport, I feel like I have taken a step down in the world	☐1	☐2	☐3	☐4	☐5
15. I would use the metro but I would not use buses	☐1	☐2	☐3	☐4	☐5
16. My decision to switch to public transport depends on its safety and security	☐1	☐2	☐3	☐4	☐5
17. I have negative impressions about bus use	☐1	☐2	☐3	☐4	☐5
18. I will opt to use the metro, because carriages are provided with standard seats, family carriages, and first class seats	☐1	☐2	☐3	☐4	☐5
19. Taking more pupils to school by public transport rather than school buses in Riyadh,	☐1	☐2	☐3	☐4	☐5

	will help familiarise with public transport and use it in in the future					
20.	Limited parking at destinations, coupled with on-street parking control will make me use public transport	☐1	☐2	☐3	☐4	☐5
21.	Ease of reaching metro stations and stops, particularly on foot will make me more open to using public transport	☐1	☐2	☐3	☐4	☐5
22.	I would use public transport because I do not have access to a car	☐1	☐2	☐3	☐4	☐5
23.	I feel that metro compartments with a variety of entertainment such as videos and Wi-Fi will attract me to ride it	☐1	☐2	☐3	☐4	☐5
24.	If I use public transport instead of my car, I have to cancel some activities.	☐1	☐2	☐3	☐4	☐5
25.	If public transport modes were introduced in Riyadh, I would choose to use it rather than my car and not having to be worried about traffic violations such as Saher cameras.	☐1	☐2	☐3	☐4	☐5

Section 4: Travel mode choices

12-Imagine that, you are about to go to your work and shopping. There are two options of travel, private car that you normally drive and public transport comprising Metro and bus.

12- Imagine that, you are about to go to your work and shopping. There are two options of travel, private **car** that you normally drive and public transport comprising **Metro And Bus**.

Please carefully review the available options and their characteristics and choose the one that you would like to travel the most to your work and shopping

Note: The prices of public transport tickets are for standard seats.

Scenario 1: Travel to Work

Please consider the following two options and tick your preferred preference

Attributes	Car	Public Transport
Cost of travel/fare [SR]	3	8
Parking Charge [SR/7 hrs]	Free Parking	-
Waiting Time (min)	-	1
Travel Time (min)	31	30
Walking time (min)	-	8
Number of changes	-	0
Transport Mode	-	Metro Only
Total Journey time (mins)	**31**	**39**
Total Cost (SR)	3	8
Please choose one option	○	○

13- Thanks for completing these exercises. Please tell us how easy or difficult it was to understand the options and decide your preference between them?

☐1 Easy ☐2 Fairly Easy ☐3 Difficult ☐4 Extremely Difficult

Please indicate why:

Section 5: About you

15- Finally, we would like to ask a few questions about you, this is quite important to understand how peoples' choices may differ. So please tick the appropriate box for the following questions:

a. Are you?
○ Male
○ Female

b. Which of the following age groups do you fit into?
○ 16-24 ○ 25-34 ○ 35-44 ○ 45-54 ○ Over 55

c. Marital status
○ Married ○ Single

d. How many adults and children live in your household including you?
Number of Adults | Number of Children

e. Which of the following best describes your monthly household income?
○ Less than 5000 SR
○ 5000-10000 SR
○ 10000-150000 SR
○ 150000-200000 SR
○ Over 200000 SR

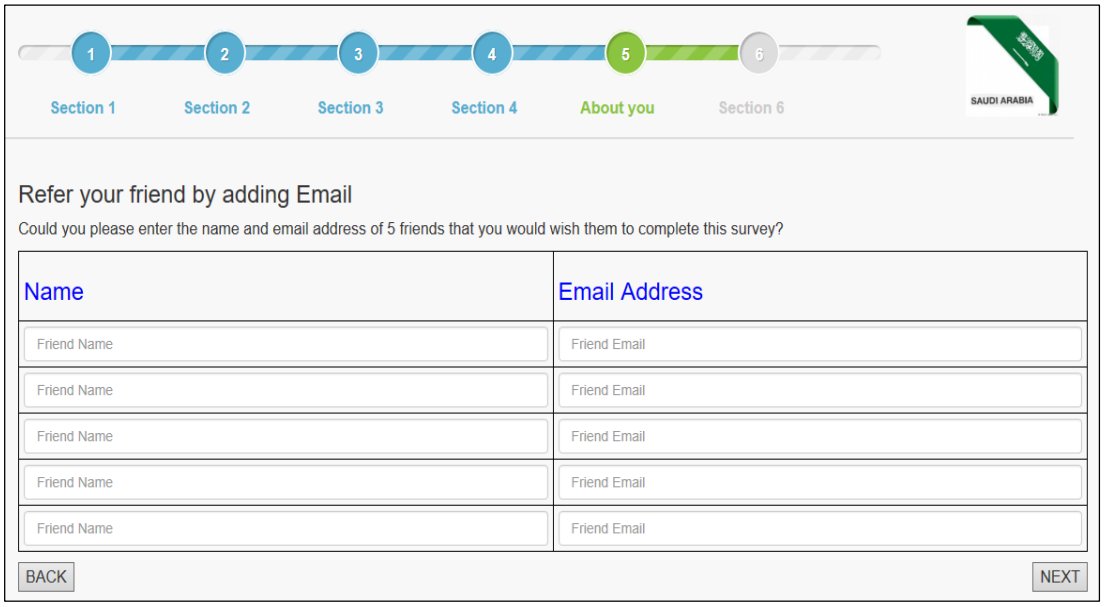
f. Your Nationality:
○ Saudi ○ Non-Saudi

g. Level of Education:
○ Primary ○ Intermediate ○ Secondary ○ Bachelor ○ Post-graduate

h. How many personal cars/vans does your household have?
Number of Vehicle

Refer your friend by adding Email

Could you please enter the name and email address of 5 friends that you would wish them to complete this survey?



Please if there is anything you would like to add about barriers to using public transport or walking to stations or other suggestions you would like to be made with introducing public transport in Riyadh City, use the space below e.g. reasons why you would not use public transport:

Thank you very much for completing this questionnaire.

Submit