RP2021e: Greening Inner-urban Travel with Sharing Economy Mobility Services

Servicing the needs of Major Inner-urban Trip Generators

Final Report

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The author(s) confirm(s) that this document has been reviewed and approved by the project's steering committee and by its program leader. These reviewers evaluated its:

- originality
- methodology
- rigour
- compliance with ethical guidelines
- conclusions against results
- conformity with the principles of the Australian Code for the Responsible Conduct of Research (NHMRC 2007),

and provided constructive feedback which was considered and addressed by the author(s).

Executive Summary

This report explores the role of commercial shared mobility services in supporting the needs of major trip generators, using the inner urban Adelaide as a case study. The commercial shared mobility services covered in this report are characterised by carshare (such as GoGet), rideshare (UBER), bicycle share (dockless within the context of Adelaide provided by OfO and OBike) and shared e-scooters (such as provided by Lime, Beam and Ride). Major trip generators described in this report are characterised by festivals, sporting events or public facilities (such as hospitals, universities and transport interchanges) that attract relatively high numbers of participants and workers.

During the preparation of this report, shared mobility services underwent cataclysmic upheaval in late 2018, with the effective collapse of the dockless share bike business model locally and the withdrawal of dockless bikeshare systems in many cities internationally. However, car share and ride share schemes continue, and dockless share micro-mobility options continue in Adelaide in the form of e-scooters (currently provided by Beam and Ride).

During the research phase of this project, OfO had just commenced trial operations of a dockless share bike scheme in Adelaide in 2017, but a year later had effectively ceased to operate as a business locally, and exited in controversial circumstances in Australian cities with dockless bikeshare being discredited because of the clutter they created in city streets. When the travel behaviour survey of over 400 participants for this study was conducted in early 2018, it was within the context of dockless bikeshare just having been introduced in Adelaide, with bright prospects for universal uptake across metropolitan Adelaide and as an enduring 'active transport' micro-mobility option, particularly suited to short urban trips and solving the 'first mile-last mile' conundrum of urban travel. Hence, interpretation of the survey results needs to be viewed within the context of shared mobility being seen as a viable transport choice.

This project focused on the role of major trip generators in supporting shared mobility services and vice versa, because successful transport services are most viable where there are large numbers of trips generated. For the sake of simplicity in the research design, the choice of major trip generators (and conversely, trip attractors), was determined by areas of the City of Adelaide that create the largest flows of participants (specifically Rundle Mall, Adelaide Oval, the Royal Adelaide Hospital, The University of Adelaide, Adelaide Central Railway Station and the Adelaide Central Markets) rather than districts or zones of high density commercial and residential developments. It should also be noted that at the time the survey was conducted, the North Terrace tram extension was not yet complete and its opening was delayed by more than 6 months into 2018 which may have influenced survey respondents' perceptions regarding public transport accessibility to and from the University of Adelaide. The remainder of this Executive Summary describes the content of the 5 Chapters contained within the report.

Chapter 1 provides a rationale for the choice of Adelaide as a case study for investigating shared mobility, reviewing the policy environment, its socio-economic background and contemporary travel behaviour. The inner suburban areas of Adelaide and its CBD are shown to present a jurisdiction with considerable potential for innovative shared micro-mobility solutions to succeed because of its concentrated dense population within a compact CBD, its younger and well educated demographic, its wealth, its abundance of amenity of metropolitan-wide significance, the concentration of varied employment opportunities, and its high density of public transport provisioning.

Chapter 2 provides a comprehensive literature review covering the concept of shared mobility in urban settings, the evolution of bike share systems, car and ride share systems, the emergence of autonomous vehicles and electric cars, culminating in discourse on modal shift towards sharing mobility services.

Chapter 3 provides an overview and comparison of international and local data on the rapidly emerging phenomenon of sharing-mobility. Bike-sharing and other forms of mobility sharing are not a particularly new phenomenon, however, what is new is the incredible computing processing power, high data handling capacity and the geo-positioning capability afforded by today's smart devices (such as smart phones), which has enabled complicated customised apps with powerful 'on the fly' processing power that can manage commercial transactions in real-time.

Chapter 3 provides an international perspective of the rise and rise of the bike-share phenomenon and provides international case studies of bike share, such as London's 'Cycle Hire', Chicago's 'Divvy' and Budapest's MOL Bubi. Bikeshare is a global phenomenon, however, 2019 has proven to be a watershed year for shared micro-mobility with many dockless bikeshare companies withdrawing from many cities both in Australia and internationally or switching their business focus to micro e-mobility services, predominantly in the form of e-scooters, and in some cases e-bikes. The dockless bike share phenomenon survives in Sydney (Mobike and Lime e-bikes), but it is a shadow of its former self when it was launched with much fanfare in 2017. The failure of dockless share bike schemes may be due to problems with the business model, however, vandalism in all of the Australian city markets and community hostility to the random parking of share bikes created a challenging operation environment. It is probably too early to say whether the bikeshare phenomenon can survive in the longer term or whether micro e-mobility in the form of e-scooters and e-bikes (which are much more easily controlled by the share mobility operator), will be the way forward for dockless share micro-mobility in Australian cities. Chapter 3 provides an overview of the types of users and usage patterns for dockless share bikes based on international experience. Chapter 3 then concludes with an overview of carshare and its current state of operation in Adelaide. Service provider GoGet's penetration and acceptance in the Adelaide market is relatively limited compared to what has been achieved in Sydney and Melbourne. However, with the legalisation of UBERX in the Adelaide market, ride share has achieved significant success to the extent that it is challenging aspects of the local taxi industry.

Chapter 4 examines six major trip generators within the Adelaide Central Business District in the context of shared mobility services: Adelaide's Rundle Mall; Adelaide's Central Market; Adelaide Oval; the new Royal Adelaide Hospital; the Adelaide Railway Station; and the University of Adelaide. The analysis undertaken includes: a network analysis (employing Hillier's space-syntax analysis); a pedshed analysis; a participant questionnaire survey; a survey of potential users' visitations to these major trip generators, their origins, travel behaviours, travel attitudes and travel preferences; a survey of Bikeshare System (BSS) users; and a survey of carshare users exploring current attitudes to carshare, preferences and interest in shifting to carshare away from private car usage.

Chapter 5, the final chapter in this report, presents the discussion and conclusion. The key challenge for dockless bikeshare services in Adelaide is that it did not appear to achieve any greater community acceptance as a modal choice than was the case for conventional commuter cycling (at around 2 percent) (ABS, 2017). The collapse of dockless bikeshare services suggests that the brief experiment in Adelaide has at the very least been a commercial failure, and to a lesser extent a transport failure. The current trial of e-scooters which is proposed to end in October 2019, may present a more popular and commercially successful pathway for micro-mobility services going into the future, and based on international experience with micro e-mobility this mode appears to have a better chance of achieving success than was the case for dockless bikeshare schemes. The Chapter presents findings for carshare and rideshare schemes, which suggests that UBER is succeeding, however, Adelaide's low density urban environment and plentiful parking has yet to present a convincing case for GoGet to provide a substantial share of mobility needs. This may change as residential development in Adelaide's CBD becomes denser and parking becomes scarcer and more expensive. The Chapter concludes with discussion on the likely policy implications, particularly with regard to planning changes, infrastructure improvements and facilitating modal shifts to more environmentally sustainable travel modes.

By itself, shared mobility in the context of Australian cities may not attract sufficient market share to provide significant carbon emissions reduction, however, when combined with medium to long term changes in urban form (particularly the creation of transit oriented developments), shared mobility in denser, space constrained cities may begin to make a lot of sense as an efficient, practical and affordable way to satisfy mobility needs for major trip generators.

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Project Overview

RP2021e Greening Inner-urban Travel with Sharing Economy Mobility Services

The sharing economy is undergoing massive expansion, with exemplars like the car sharing market expected to involve millions of consumers globally by 2020. Increasingly, consumers consider public sharing systems a viable alternative to product ownership, a paradigm that competes with the dominant logic of private ownership and control. Sharing systems have evolved as a disruptive technology driven business concept on the premise of providing end-users with access to the benefits of product ownership, but without the commitment to capital expenditure.

This research project is designed to investigate the potential social, economic and carbon benefits of the sharing economy mobility services by answering the question: To what extent can sharing economy services deliver the low-carbon mobility needs of those who live, work or play within inner-urban precincts?

The project has four main parts:

- Work Package 1: Barriers to the provision of sharing economy mobility services
- Work Package 2: Servicing the needs of major inner-urban trip generators
- Work Package 3: Mapping demand for sharing economy mobility services
- Work Package 4: Quantifying the carbon abatement impact

The following represents the Final Report of Work Package 2, and draws on local and international data to explore, in-depth, the role of sharing economy mobility services in addressing the mobility needs of major trip generating events and public facilities.

Introduction

Australia's metropolitan areas including Adelaide, have high levels of car dependency compared to wealthy Asian and European cities (Kenworthy & B Laube, 1999). There were 18.8 million registered motor vehicles in Australia as of 31 January 2017 and the country's vehicle fleet increased by 2.1 percent from 2017 to 2018 (ABS) (2018). Over 90 percent of the Australian population lives in a household with access to a car. This car dependency trend has significant impacts on society including a high dependency on oil and fossil fuel energy resources, air pollution, carbon induced climate change and social segregation (Amphlett, 2011).

Personal vehicles are a major cause of global warming, as road transport accounted for 84 percent of emissions from the transport sector and over 12 percent of all greenhouse gas emissions produced in Australia (Department of the Environment, 2013). The high reliance on motorised transport such as private cars and motorbikes has resulted in numerous transportation issues have arisen creating considerable impacts on human beings. Today, traffic congestion, poor air quality, in conjunction with catastrophic events that are created by climate change, threaten both developed and developing nations. Whilst zero emission motor vehicles in the form of electric vehicles are now available in the Australian market, their high purchase cost and lack of financial incentives from the government has suppressed sales, with the result that electric vehicles have less than 0.1 percent market share. Given the extensive range of problems linked with car-dependent cities, there is an ongoing debate about the best pathway forward: is it land use change, or a modal switch to public transport, or active transport and sharing-mobility modes, or is it technologically driven (i.e. changing to electric vehicles (EVs) or is it related to travel behaviours? Whether it is a combination of responses or a particular policy choice forward, it is apparent that an alteration of Australia's urban travel habits is essential and unavoidable.

With increasing awareness of car dependency, several strategies have been offered to help in restricting private vehicle usage. Possible policy solutions are: improving public transit systems in both coverage and quality; enhancing facilities of non-motorised modes of transport; travel demand management measures such as cordon pricing; road pricing; a CO2 and congestion tax; increasing public awareness and education; parking supply management; and more lately sharing-economy mobility systems (Department of the Environment, 2013). Adelaide is recognised as one of the most car-dominated Australian capital cities (Mees, O'Connell, & Stone, 2008; Nguyen, Soltani, & Allan, 2018), and car or ride sharing schemes could potentially make a contribution to reducing Adelaide's level of car dependency and high travel related carbon emissions. Car or ride sharing potentially has an important contributory role in fulfilling City of Adelaide's quest to become a carbon neutral city.

To mitigate the consequences of the dependency on private vehicles, transport policy to encourage and simulate active travel like cycling has been made by national governments and local authorities of diverse countries in the world. Of these policies, bike sharing has been widely discussed among transportation researches because it is identified as one of the fastest growing modes of transport (Campbell, Cherry, Ryerson, & Yang, 2016) with an annual growth at 37 percent (Meddin, 2015). Since its first introduction in Amsterdam under the White Bikes Program in 1965, Bikeshare is now in its fourth generation (Parkes, Marsden, Shaheen, & Cohen, 2013),and it is now an entrenched global trend with over 700 bikeshare programs and more than 940,000 bicycles in operation (Fishman, 2016; Fishman, Washington, Haworth, & Watson, 2015). In 2019, shared micro-mobility is perhaps transitioning into its fifth generation with a dramatic shift to share micro-e-mobility in the form of e-scooters and to a lesser extent, e-bikes. In the Australian context, the rise of bikeshare began when Melbourne and Brisbane both launched their bikeshare programs in 2010 (Bonham & Johnson, 2015). However, previous studies indicate that bikeshare has been underdeveloped due to the low level of usage recorded in these two major cities (Transport, 2011). This may be associated with the fact that Australia has one of the lowest level of cycling participation among Western nations (Pucher & Buehler, 2008). With the almost complete collapse of dockless Bikeshare in Australia's capital cities and many other cities internationally, shared micro-mobility has entered a new phase of e-micro mobility, which has largely displaced share bikes with a new system centred on e-scooters, and to a lesser extent, e-bikes. This new phenomenon of e-micro mobility, appears to be the new model of shared mobility, and whilst docking bikeshare systems continue in Brisbane and Melbourne, dockless share bikes appear to have run their course in Adelaide and are no longer available. Interestingly, Bike SA purchased OfO's 500 plus fleet of share bikes with a view to their re-introduction under local branding, management and ownership, but a year on from their withdrawal, they are still absent from Adelaide's local streets (personal communication, Christian Haag, 2019)

Sharing-mobility offers cities new opportunities to address crucial challenges such as improving physical health, air quality and traffic congestion. Car and bike share are becoming progressively evident in cities across the world, whether in the more conventional docked bike form as found in Paris or London or the more recent dockless technology facilitated via smartphone apps.

Such systems offer people a car or bike to use without the hassle of ownership or storage and, for car or bike owners that are away from home without their own car or bike, these systems offer convenient affordable access to a car or bike. They therefore promise to make car use and/or cycling an option for a wider population and for more journeys. They offer a possible solution to the elusive “first mile-last mile” local transport riddle that can make public transport difficult and make cycling into a visible and attractive option for many.

The project, carried out from September 2017 to December 2018 as the second module of the CRC Low Carbon project on Greening Inner Travel (project e2021), comprised three surveys included one intercept/online survey from potential users of sharing mobility (I.e. those who made a trip to six major destinations) and two street surveys of actual users of sharing mobility services undertaken inlate February 2018 and March 2018.

The objectives of this project include:

- To identify and quantify the multiple benefits associated with the provision of sharing economy mobility services in Australian cities (with a particular focus on City of Adelaide)
- To determine their role in meeting the needs of different types of major trip generators (I.e. main destinations or origins).

Three bikesharing services were active in Adelaide while two international competitor schemes Singaporean OBike and Chinese OfO (both of which launched in South Australia in October 2017) had been operating in the city for approximately one year, and the rationale for this research project was to find out more about who was making use of their bikes, why they chose to use them, for what purpose and their significance in reducing travel related carbon emissions. We wanted to understand how these bikes fitted into contemporary travel patterns and whether they were becoming a regular part of how people get around.

Shortly after our fieldwork data collection was completed , the first dockless bikeshare company to Adelaide, Singaporean O’Bike withdrew from Adelaide due to its failure to renew its permit with Adelaide City Council and a couple of months later, OfO company locally managed by Alex Hender removed their service with its 500 distinctive yellow bikes from the Adelaide with the overall strategic purpose of redirecting their efforts on priority international markets, citing operational issues including vandalism and theft as the main challenges OfO raced operating in Adelaide. OfO has now been overwhelmed by its financial problems and its business collapsed. This research assisted in understanding the operation of this model of bikeshare operations, particularly with regard to what were the major influences of consumer usage of the scheme.

Figure 0-1 a) OfO bikes distributed randomly throughout Adelaide City boundary; b) Adelaide Council Free bike provided in UniSA City East campus

This report also discusses and analyses surveys of user experiences of two rapidly expanding car sharing and ride sharing models: GoGet and UBER X which expanded their operations into Adelaide in 2014 and 2016 respectively. UBER works much like a taxi service, except that rides are booked through a smart device app rather than flagged in the street. GoGet is the equivalent of short term car rental and the user (i.e. the hirer), must have a membership with GoGet, they must have a driving license and be able to drive themselves for the trip they wish to make.

This study also assisted in understanding the correlation between sharing vehicles and owning vehicles more broadly. For instance, while car-sharing (and/or ride-sharing) may decrease the barriers such as ownership and storage, it adds new barriers such as having access to a smartphone. The other two alternatives that operate as sharing business are EcoCaddy and e-scooters (initially trialled with Lime e-scooters for the Adelaide Fringe Festival in 2019 and then with Beam and Ride e-scooters for the second and third trials which Adelaide City Council extended up to October 2019).

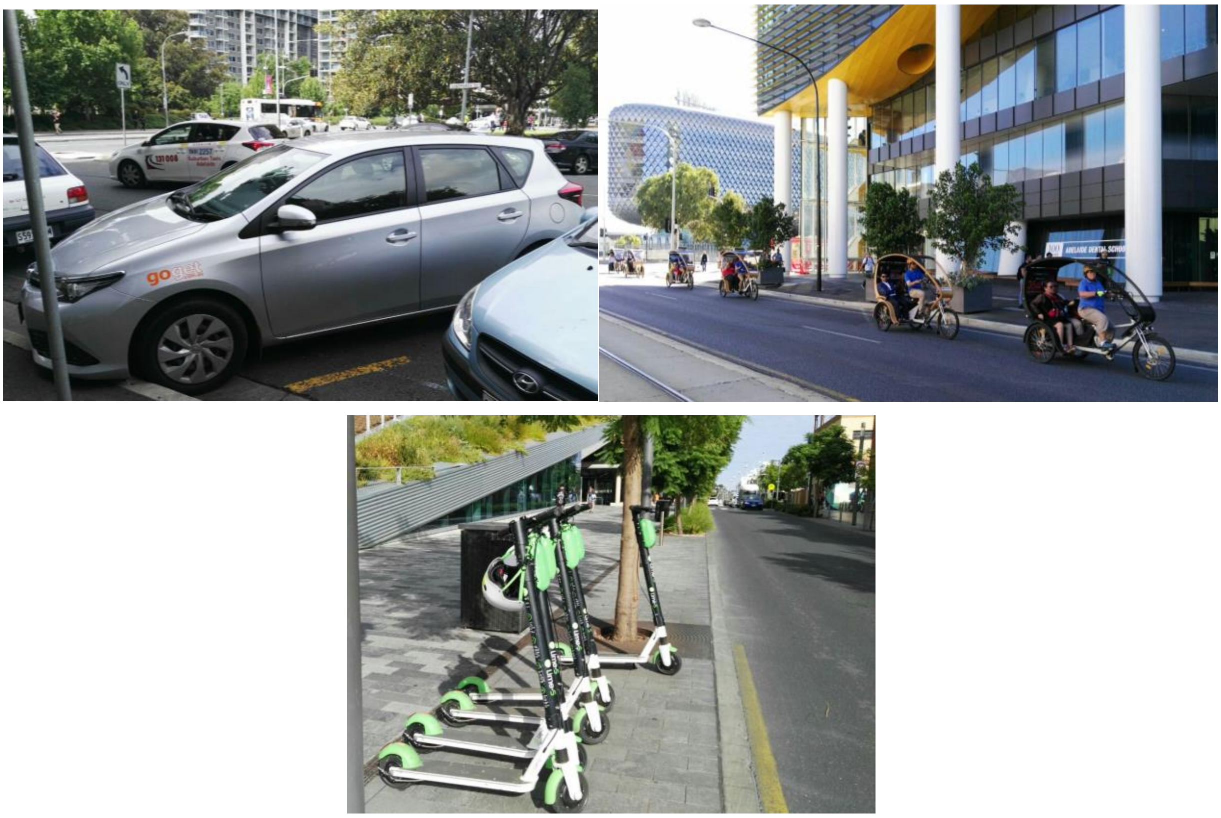


Figure 0- 2 a) The GoGet share car; b) EcoCaddy fleet of pedal-assisted electric trike; c) Lime e-scooters

This report provides new evidence of experiences and perceptions of car and bike share in the City of Adelaide. It explores whether, to what extent and in what forms car or bike share can contribute to the usual mode of travel to major city destinations, the number of journeys they make and the health and environmental benefits that follow.

In this way, the focus of the study was on six major trip generators which have the highest rates of trip attractions from either Adelaide city residents or suburban areas. The location of the six major trip generators are identified in Figure 0-3.

Figure 0-3 The selected six major trip generators in the City of Adelaide

The structure of the report is set out below: the first chapter introduces Adelaide as the case study area, its specific characteristics in terms of transport network and facilities for the residents and workers to move around, in addition to an introduction to its socio-economic profile. The chapter justifies why the City of Adelaide is regarded as an appropriate context for establishing and running a sharing mobility business. The second chapter included the literature review of sharing mobility, the successful business plan, the benefits of sharing mobility, different types of sharing mobility and the barriers to this emerging type of transport business. The third chapter is about introducing and analysing the sample data from an international perspective as well as some data from Australian cities including Adelaide. Chapter four provides a description of the methods of data collection within the City of Adelaide for this project and the results of descriptive and inferential statistical analysis on the data collected. Chapter five concludes with some policy directions extracted from the results of this research. It also includes directions for further research on this topic.

Chapter 1: The Rationale for Choosing Adelaide

1.1. Why the City of Adelaide is ideal for developing sharing-mobility services?

Global climate change has resulted from the impact of humanity on nature. The evidence shows that the frequency of weather and climate related disasters such as heavy storms, extreme heatwaves, and severe flooding has increased within last two decades. According to the United Nations Office for Disaster Risk Reduction (UNISDR, 2015) the number of weather and climate related disasters has doubled from 1996 to 2015 compared to the period of 1976 to 1995.

Australia is one of the most vulnerable industrial nations around the globe to the impacts of climate change. Australia experiences a great diversity of climatic extremes, including heatwaves, floods, droughts and frosts (Westra, White, & Kiem, 2016). The increase in mortality is expected due to high temperatures for capital cities. The data from the Climate Council indicates that the number of hot days has increased to almost double in comparing with the recent half century and is expected to more growth. Adelaide and other Australian capital cities such as Melbourne and Canberra, in the period between 2000 and 2009, have suffered increased risks from heat waves weather, and these risks are predicted to increase dramatically over future decades (Steffen, Hughes, & Perkins, 2014).

Australia is a country with low urban densities, and because of this, most Australian households rely on private motor vehicles for their daily traveling which releases greenhouse gas emissions to the atmosphere (Allan, 2010).The main contributor of global warming and carbon induced climate change is CO_2 of which the transport sector is a major contributor. It is estimated that CO2 accounts for a 25 percent share of average of world carbon emissions (Agency, 2017). Currently the transport sector contributes to 14 percent of global carbon emissions, mainly in the form of passenger and freight road transport (Hensher & Environment, 2008).While the technology of the car industry in relation to vehicle emissions and fuel consumption has improved within last two decades, road transport has remained a growing source of carbon emissions. Having said that, there has been rapid development of the electric car segment, with the emergence of Tesla's electric vehicles in the United States and commitments from major automotive companies such as Volkswagen to electrify automotive offerings within the next decade. France, the UK and China have also set in place policy commitments to move towards zero emissions vehicles within the next 20 years. The transport sector was ranked second in contributing to greenhouse emissions with a growth rate of 23.4 percent in Australia, between 1990 and 2004 (ABS, 2007). The main growth reason for the growth of transport emissions during this time period was due to the increase in private vehicle usage in urban areas. In Australian capital cities, the emissions from cars has resulted in air pollutants well above EU standards, which is partly a function of higher rates of motor vehicle usage in its cities (12500km/passenger vehicle and of some of the highest fleet fuel consumption rates in the world (at 10 litres/100km) (ABSa, 2018; ABSb, 2018)

Currently 14 percent of global carbon emissions are generated by transport, predominantly produced by road transport, both passenger and freight (Hensher & Environment, 2008).In Australia, between 1990-2004, transport was the second highest contributor of greenhouse emissions with an increase of 23.4 percent (ABS, 2007). The Australian Bureau of Statistics (ABS) has stated that the leading cause for the increase of transport emissions in this period was due to greater usage of private vehicles with cities continuing to sprawl and people having less access to public transport. Transport is a source of growing carbon dioxide (i.e. CO2) emissions, which in 2007 was 17 percent of CO2 emissions, increasing in 2017 to 27 percent. This has occurred in response to a growing population, increased low density urban sprawl and increased reliance on personal fossil fuel powered private vehicles (many being SUVs, the most popular segment of vehicles in Australia), resulting in a 71 percent share of transport emissions, or 21 percent of total carbon emissions in 2017 (Adelaide City Council, 2017).

Australia's metropolitan areas and in particular Adelaide, are amongst the highest car dependent cities internationally with car dependency 31 percent higher than in European cities and 77 percent greater than in Asian cities (Kenworthy & B Laube, 1999). Over 90 percent of the Australian population lives in a household with access to a car. This car dependency trend has its own impacts including an excessive reliance on non-renewable oil and fossil energy resources, high levels of air pollution and a key contributor to carbon emissions that induce climate change and social segregation (Amphlett, 2011). Personal motor vehicles are a major cause of global warming, as road transport accounted for 84 percent of emissions from the transport sector and over 12 percent of all greenhouse gas emissions produced in Australia (Department of the Environment, 2013). Given the extensive range of problems linked with car-dependent cities it is apparent that an alteration of Australia's urban travel habits is essential.

The journey to work trips compromise over 40 percent of total travel within Australia's cities and regions. According to 2016 ABS Census data, driving is the dominant method of journey to work in Australia, which resulted in 70 percent of the working population (more than 6.5 million persons) commuting to employment by car (ABS, 2017). On the other hand, the share of commuting by public transport increased significantly in Melbourne and Sydney but decreased significantly in Perth and Brisbane, and remained nearly constant in Adelaide between 2011 and 2016. A partial explanation for these modal changes is due to the job decentralisation and the changing distribution of jobs within the metropolitan areas (Loader 2018).

According to the job distribution data extracted from ABS (2016), it is evident that Adelaide is relatively mono-centric city where over a third of jobs (34 percent) are located within 4 km of the Adelaide's CBD. Furthermore, comparing the share of outer jobs (66 percent) with 2011 (65 percent) shows that a minor decentralisation of employment occurred between 2011 and 2016 (ABS, 2011, 2016). The distribution of all jobs versus distance from Adelaide's CBD is detailed in Figure 1 (note, active transport has not been included due to the total of commutes being too low: less than five percent across non-CBD areas).

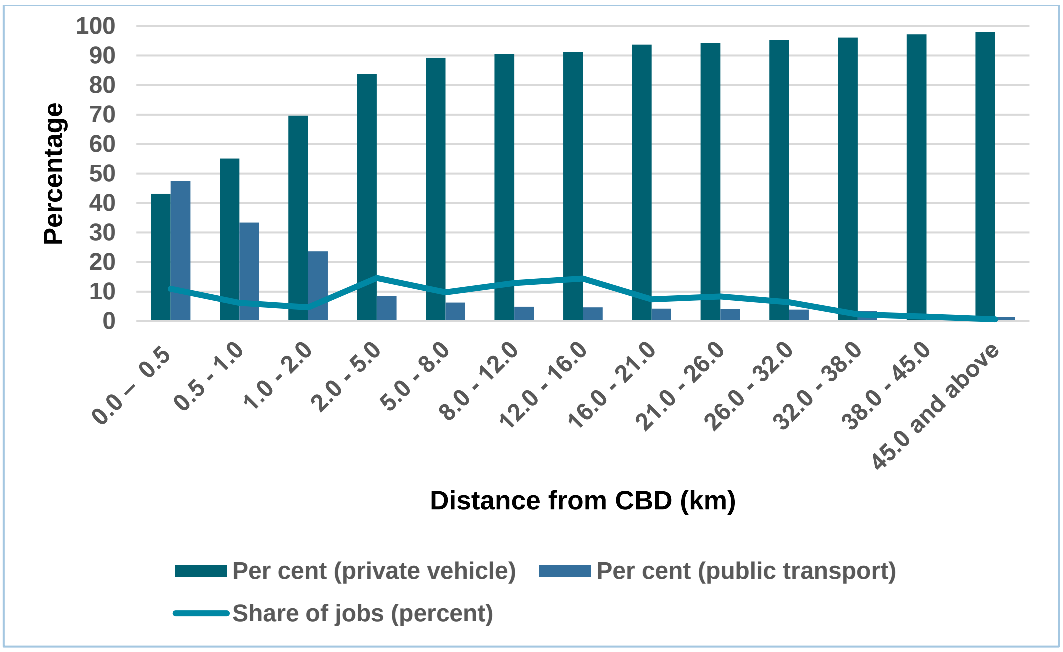


Figure 1-1 Distribution of jobs and the mode of commuting in Adelaide (Adapted from ABS 2016)

From Figure 1-1 it is clear that private mode share is lower in areas closer to the CBD, with about 70 percent of modal share dominating in Adelaide as close as 2 km from the city centre. Public transit usage decreased dramatically beyond 2 km from city centre. The time-series ABS data (Figure 1-2) illustrates the changes in commuting mode since 1976, with very little change in modal share patterns since 2005.

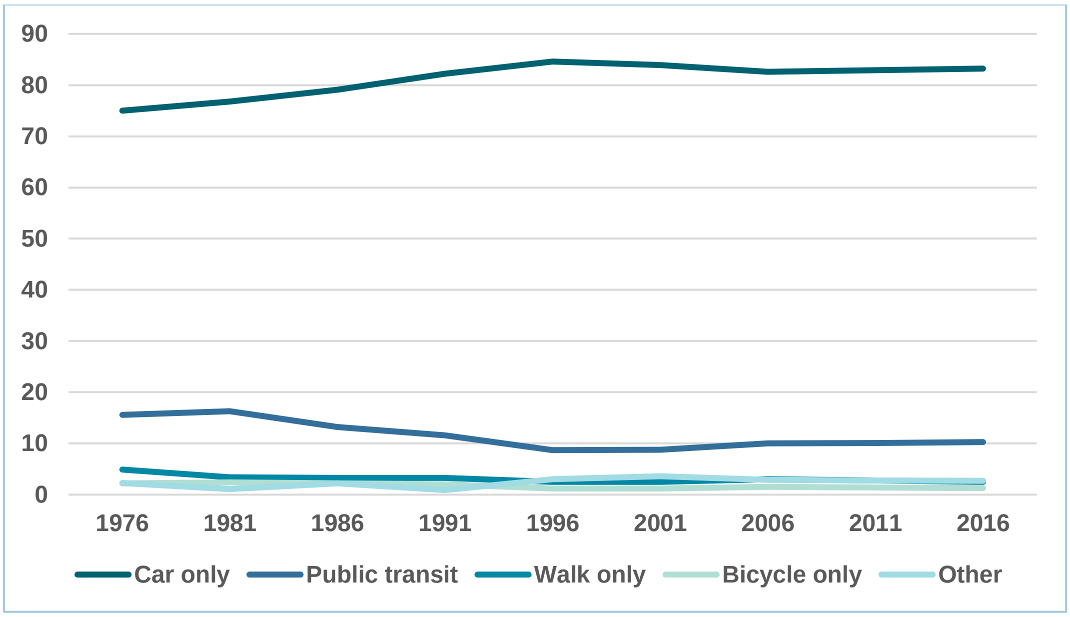


Figure 1-2 Modes of commuting in Adelaide, 1976-2016 (Adapted from ABS 2016)

For those 7,560 workers living in central Adelaide (as the main hub of employment) where 61 percent worked full-time and 37 percent part-time, using a private vehicle was still the dominant mode. The ABS data shows that using a car as driver (43.0 percent) was the most preferable mode of going to work (ABS, 2016), followed by walking (32.9 percent) and using the bus (9.99 percent). The figure for bike usage is also significant (4.6 percent). The relatively high usage of non-motorised modes (37.5 percent) and public transit (13.1 percent) illustrates the suitability of the urban environment for walking/cycling and the closeness of working places to residential areas for those living in central Adelaide.

The volume and congestion of vehicular traffic in the City of Adelaide are increasing due to a gradual growth of population with a preference for residing either in or closer to the city. Despite the fact that the urban road network and infrastructure have attracted large investments within the last two decades, this has failed to offset the massive increase in traffic congestion in Australia's major cities. Furthermore, due to perceptions (and very often the reality) of low frequency, limited value and relatively poor utility of public transport, people have been unwilling to substitute personal car usage for public transport.

Figure 1- 3 Car parking space provision in City of Adelaide (Adelaide;, 2017)

The evidence shows that public transport usage for commuting to work is less popular than four decades ago. Moreover, there is still a large proportion of public transport vehicles that use diesel fuel which is regarded as a source of air pollution.

For inner suburbs and CBD area, sharing mobility provides an advantageous alternative over other modes of transport especially personal car usage and public transport. Sharing mobility is widely regarded as a cost-effective, affordable and fast-growing industry which has the potential to be sustainable in the longer-term, either through shared cycling or micro e-mobility solutions. However, for active transport solutions (as characterised by bikeshare) or low speed e-mobility solutions (such e-scooters or e-bikes) to succeed, it is essential that the speed of motor vehicle traffic is reduced to a speed that is compatible with these modes, particularly cycling (Pucher and Dijkstra (2003).

Adelaide City Council, is now pro-active in pursuing its goal of becoming a Carbon Neutral City. The Action Plan for Carbon Neutral Adelaide (2016-2021) has the target of doubling the number of cycling trips within the boundary of Adelaide City by 2020.

The term Carbon Neutral refers to the state of an organisation, business or individual having zero net impact on the level of operational greenhouse gases, such as carbon dioxide or methane, that is produced annually (City of Adelaide, 2016). 'Adelaide is a major contender in the race to become the world's first carbon neutral city'. Carbon Neutrality is achieved when the community act in order to eliminate their contribution to global warming by adapting the way we live, work, travel, and socialise. The Carbon Neutral Adelaide initiative is the brainchild of The Adelaide City Council and the Government of South Australia are working together with the community to ensure that "the state develops resilience to the changing economy and is proactive about warding off the devastating effects of climate change" (City of Adelaide, 2016).

The South Australian government and Adelaide City Council formalised their commitment in 2015 with short-term action plan spanning 5 years that is well on the way to being implemented. The City of Adelaide has consistently managed to reduce their carbon emissions each year. Officially titled the Carbon Neutral Adelaide Action Plan 2016-2022, the Plan outlines a course of actions needed to establish vital partnerships with businesses and institutions in Adelaide and the surrounding suburbs as well as a five-tier approach to achieve carbon neutrality where the first tier is 'changing our approach to our daily commute'(City of Adelaide, 2016). This goal is part of a larger plan of action that is South Australia's Climate Change Strategy 2015 - 2050, a long-term vision for the state that outlines a state-wide goal to produce net zero emissions by 2050.

The Carbon Neutral Adelaide Action Plan 2016-2021, outlines a course of actions required establishing active co-operation with institutions and business units in Adelaide and its surrounding suburbs in order to achieve carbon neutrality. This goal is part of a larger action plan that is South Australia's Climate Change Strategy 2015-2050 that outlines a state-wide objective to yield net zero emissions by 2050.

The City of Adelaide has constantly managed to reduce their carbon emissions each year. Indeed, a reduction of 15 percent in the 10 years from 2007 to 2017 has been achieved. The main contributor of CO_2 in 2007 was from stationary energy, which is energy production and energy use, while this share decreased to 52 percent in 2017, largely due to the use of renewable energy. This reduction occurred despite an increase in GDP and population for the City of Adelaide. On the other hand, the transport sector has experienced an increasing trend: from 17 percent in 2007 to 30 percent in 2017. This increase appears to be associated with an increasing population and urban sprawl encouraging car dependency (City of Adelaide, 2016). The high level of long-stay commuter parking provisioning within Adelaide's CBD is also a significant contributor to car usage in Adelaide's CBD.

Table 1- 1 Energy use in Adelaide (City of Adelaide, 2016)

Energy use	**2007**	**2017**
Stationary energy	**72**	**61**
Transport	**17**	**30**
Waste	**5**	**8**
Product use	**6**	**1**
Total	**100**	**100**

1.2. Government Policies related to Mobility

Several planning documents have addressed the issue of car dependency and sustainable transport which reflect the government's visions on this subject. They include:

1- The "30 Year Plan for Greater Adelaide (2017 update)" is part of the state planning strategy that provides strategic policy directions for urban and regional development, with a key objective of transforming Adelaide into a world-class, sustainable and liveable city (DPTI, 2017). According to 30 Year Plan, car dependency is regarded as the main barrier to achieving urban sustainability and effectively addressing the climate change crisis. The Plan proposed directions to improve non-motorized and public transport through developing transit-oriented projects and communities. It also aims to introduce a network of approximately transit oriented developments, many connected by high capacity public transit corridors, with urban densities increased to around 35 dwellings/hectare to help to ensure the functional viability of public transit.

2- The State Government's "Integrated Transport and Land Use Plan (2015)" provided by the State Government. The vision of the Plan is based on aligning transport development with urban land use in order to decrease car usage while increasing public transport and non-motorised transport. According to this plan, the most critical challenges in the areas of urban and transportation development were growing car dependency with its consequent carbon emissions. For addressing these challenges, it recommended reductions in the volume of car travel across metropolitan Adelaide. Indeed, the City of Adelaide's vision of Carbon Neutral City will need the development of alternative to car travel such as public transit, non-motorised transport and shared-mobility especially within the boundary of Adelaide CBD area.

3- Adelaide City Council's "The City of Adelaide Strategic Plan (2016-2020)" is a medium-term strategic plan which is works within the guiding frameworks of the State Government's overarching plans mentioned above. The 2016-2020 Strategic Plan recommends providing incentives for the usage of low-carbon or zero emission vehicles in order to achieve the zero-emission vision plan as outlined by the plan.

4- Adelaide City Council has released two 'Smart Move' reports following its 2012-2016 strategic plan to further advance and actuate its vision. Council's "Transport and Movement strategy (2012-2022)" outlines the needs for transport and movement outcomes, and the required actions to achieve the vision of the Plan. This document gives priority to creating a pedestrian-friendly city through giving higher consideration to non-motorised and public transport. Shared-mobility is regarded as an option for affordable transport and reducing carbon emissions, however, no clear direction was provided to support establishing and maintaining this alternative system.

5- The City of Adelaide had also developed "The Smart Move Interim Action Plan (2016-2018)" as a connected framework between the Smart Move 2012 and the forthcoming Adelaide 2040 Plan. This Plan provided updates on achievements from 2012 to 2016 in addition to identifying new influences and outlining several directions for the change.

6- A critically important local government policy initiative in the area of mobility is "The Carbon Neutral Adelaide Action Plan 2016-2021" which was a joint work between the local and state government with the key objective of transforming Adelaide city into the first carbon free city in the world. For achieving this objective, the plan offered a set of policy directions that included increasing the share of low emission vehicles, electric cars, and encouraging carbon-free modes of transport. The plan targets a growth of 15 percent in electric and hybrid vehicles registered by 2021 and up to 30 percent by 2025. One important policy is increasing sharing-car services within the boundary of Adelaide City. The plan targets an increase of registered members to over 10,000 by 2021. This policy will be followed in parallel with promoting walking, cycling and public transport. While promoting green transport, Adelaide City Council will implement increased greenery through planting additional trees, creating green walls, and neighbourhood gardens to offset carbon emissions that it currently creates. It is expected that over 100 thousand square metres of built-up areas would be covered by green surfaces.

Figure 1- 4 Development Plans discussing mobility issue for South Australia and/or City of Adelaide

From the review of these plans, it is evident that there is potential for more direct and targeted policies that could be developed and implemented to achieve the environmentally sustainable future for the City of Adelaide, some of which include:

- Restricting the entry of high emission vehicles into the City of Adelaide realm;
- Ensuring affordable access to electric vehicles and scooters service (such as a shared mobility service) for those social groups that cannot afford a car such as tourists, students and low-income groups;
- Restricting parking within the City of Adelaide for high emission vehicles;
- Substituting existing parking capacity for conventional petrol and diesel vehicles to parking for electric vehicles and a progressively increasing scale at the rate of 7 percent per annum, which within 10 years, would result in 50 percent reduction in petrol/diesel vehicles being parked in the city centre.
- Placing a cap on parking provisioning at a pre-determined level related to the ultimate development potential for the City of Adelaide and the maximum traffic network capacity for that development potential.
- Making cycling environment safer and more pleasant by restricting the speed limit of vehicular traffic to 40km/h or less and allocating dedicated routes for cyclists;
- Removing on-street parking spaces and replacing the space created to accommodate active transport modes (i.e. cycling and walking) and landscaping;
- Developing and allocating more on-street parking spaces for sharing-vehicles and mobility policies to favour shared-mobility. Whilst e-scooters in small numbers are currently required to use Adelaide's sidewalks, this transport mode is severely restricted in high pedestrian traffic areas and requires dedicated safe routes within the road space.
- Mandating all development to provide secure bicycle parking that is aligned with the targeted modal share for active transport. For residential development, it should be mandated that all homes are provided with secure bicycle parking.
- Providing explicitly discounted council rates for ratepayers that do not have car-parking bundled with development.
- Mandating travel related carbon emission limits per person throughout the City of Adelaide and preventing development that does not comply with these limits and introducing financial penalties (i.e. fines) for existing development that does not comply. This policy suggestion would require improvements to public and active transport and modelling to determine what are achievable limits and how these might be lowered over time.
- A mobility carbon emissions trading scheme (at the local level) could be a useful way of encouraging the uptake of alternative zero or low carbon emission mobility options.
- Adelaide's CBD currently lacks mass transit that offers competitive service speeds and travel times. The tram service along North Terrace and King William Street averages less than 10km/h even in off-peak periods, and it does not cover large areas of Adelaide. Its bus services perform marginally better, but unless they are substituted with electric buses, they will exacerbate noxious emissions in the city. Extension of the tram service into Adelaide's northern, western, eastern and southern inner suburbs (a now abandoned strategy by the current State Government, having dropped the previous Government's AdeLink tram network) would be desirable, however, in the longer term, Adelaide would benefit from an underground metro loop with links to key transit oriented development hubs in Adelaide's suburbs, particularly if current population growth trends continue. Metropolitan Adelaide in 2050 with population growing at the rate of 2 percent per annum over the period 2019-2050 could become a city of 2.5 million, at which point a metro becomes almost a necessity, particularly if that population outcome is achieved through a much denser inner urban Adelaide, as proposed in its current metropolitan Planning Strategy.

1.3. The City of Adelaide: Physical Characteristics and Socio-economic Profile

The City of Adelaide covers 15.57 square kilometres, and is a mix of different land uses, including residential, institutional, commercial, cultural, and entertainment land uses. The Adelaide City Council are contains the central business district (CBD), North Adelaide and the Adelaide Park Lands, and is one of the 19 local government areas (LGAs) located within metropolitan Adelaide. The City of Adelaide had a total residential population of 22,064 people according to the 2016 Census, with a gross population density of 14.2 persons per hectare. This density reflects the large area of parklands, and the North Adelaide precincts which are dominated by large areas of low density heritage housing. Net residential densities are significantly higher within the Adelaide CBD with several apartment towers of 30 or more storeys now built or under construction.

According to the ABS (2017), the City of Adelaide was estimated to have a total of 11,669 dwellings. Over recent years, government and urban planners have supported and promoted the implementation of greater housing choices, to help accommodate a rapidly growing population, including the demand for more affordable housing and accommodation in closer proximity to major urban destinations (ABS, 2016).

Separate houses accounted for 11 percent (1,315 dwellings) of the total dwellings that exist in the City of Adelaide – these are dwellings with a space of least half a metre from other dwellings – whereas most total dwellings were made up of high-density housing. Units, flats and apartments, characterised by a shared common entrance foyer or stairwell, were the main contributors to the large proportion of high density housing (52 percent or 6,031 of total dwellings). Semi-detached, row/terrace houses and townhouses, which are dwellings attached to each other while having their own private grounds accounted for about one-third of dwellings (33 percent or 3,871 dwellings). The relative ratios of separate houses to high-density dwellings are not unexpected as the CBD uses a large proportion of land for commercial and business purposes. By its very nature, the CBD would contain little separate housing compared to suburban areas – therefore having more high-density housing leaves space to fit necessary/additional commercial and business structures.

The data has been presented below as a population pyramid and illustrates the distribution of males and females residing in the City of Adelaide, in 5-year age intervals.

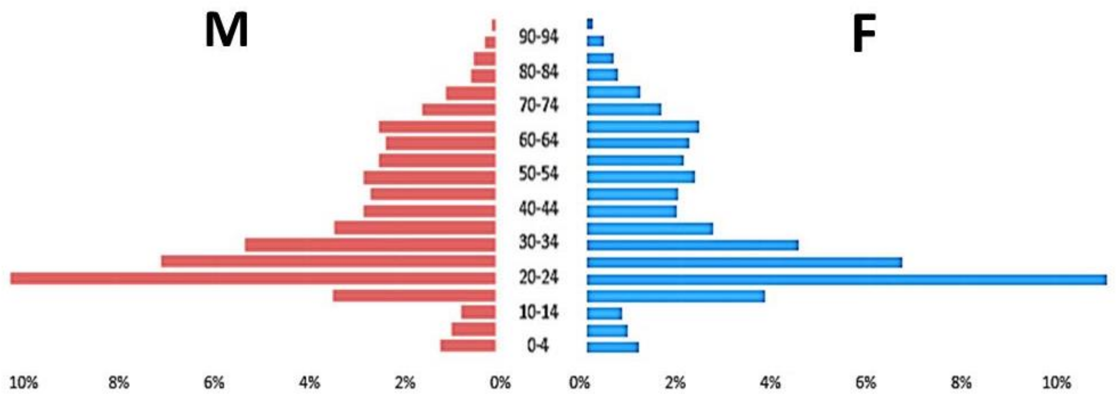


Figure 1- 5 Distribution of age and gender in City of Adelaide, ABS 2016

The above figure shows that the highest proportion of residents were between 20 and 24 years of age in 2016, making up 21 percent (4,969 persons) of the population, followed by those aged 25-29 years (14 percent or 3,044 persons) and 30-34 years (10 percent or 2,157 persons). These three age groups together represented a proportion of 45 percent (9,897 persons), almost half of the total population of the area.

By contrast, the age groups with the lowest population proportions were those aged 95-99 years (0.2 percent or 37 persons), 90-94 years (0.5 percent or 120 persons) and 85-89 year (1 percent or 220 persons), together representing 1.7 percent (377 persons) of the population.

Because the area of interest coincides with the CBD, the number of families living in the area would be much less compared to a more suburban setting. In fact, many of the residents would be those who had commuted to the CBD for work and/or study – and this could explain why a large proportion of the population is in employment, compared to the young and elderly. It could be further suggested that the elderly population above working age would be mostly long-term residents, while many of the younger and more middle-aged population were only temporary residents.

Moreover, because Adelaide CBD provides employment and education opportunities to residents from across the wider metropolitan Adelaide area, the daily temporary influx of commuters would account for the vast majority of the ebb and flow of commuters in the Adelaide CBD. Unfortunately, it is these commuters who are most likely to commute by motor vehicle and exert the largest impact on the carbon emissions generated by transport activities within the Adelaide CBD. According to Adelaide City Council (2017), the Adelaide CBD is an employment destination for approximately 129,000 employees, representing 92 percent of jobs in Adelaide's CBD, and many of the over 40,000 tertiary and high school students in the council area originate from outside council area.

In terms of gender distribution, the data displays a fairly even balance of males and females; the male proportion was slightly greater than the female proportion, with 51 percent (11,311 persons) and 49 percent (10,755 persons) respectively. The figure shows relatively similar proportions between males and females below 15 years of age and a higher proportion of females between 15-24 years of age. The proportion of males to females then remained higher across all age groups between ages of 25 years and 69 years, after which the graph shows a higher proportion of females compared to males.

The "place of work" refers to the location of where people worked a week prior to the Census night (ABS, 2016). Information regarding place of work is used to examine the work patterns of people getting to and from work and to assist in planning for the development of public transport systems(ABS, 2016). The following two data sets illustrate the work location distribution of people residing in the City of Adelaide, and the residential location of people who work in the City of Adelaide.

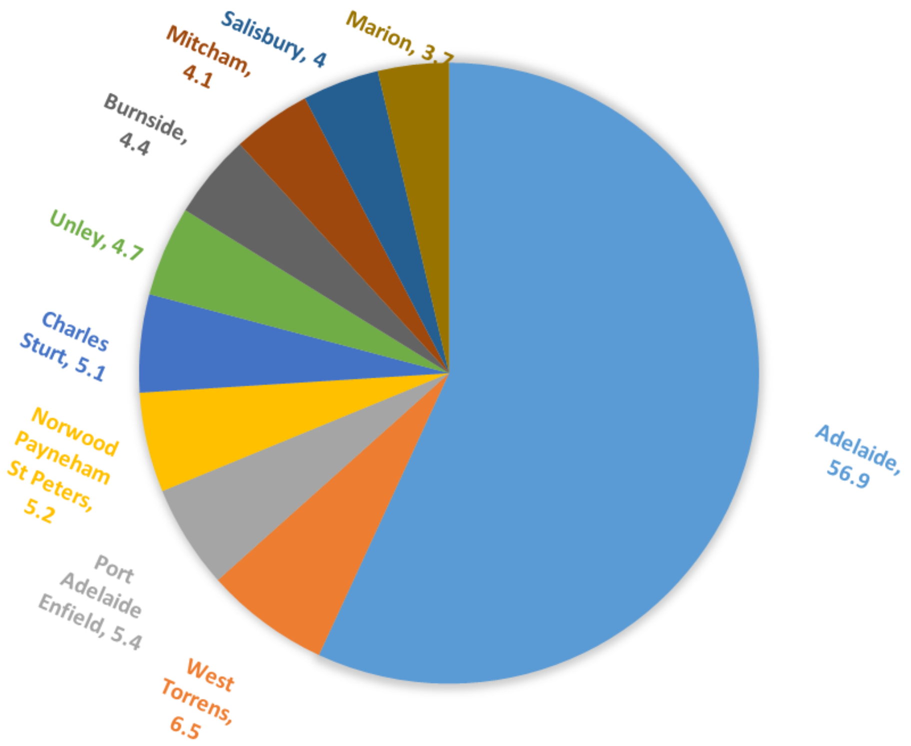


Figure 1- 6 Place of work of people who reside in Adelaide, ABS 2016

Of the 9,060 workers living in the City of Adelaide district who reported their work location, there were a total of 40 suburbs to which people travelled for work. Figure 6 shows the top ten places of work, with over half of the population (56.9 percent) working in their own LGA, followed by work places located in West Torrens (6.5 percent), Port Adelaide Enfield (5.4 percent) and Norwood, Payneham and St Peters (54.2 percent). These areas are all generally close to the CBD; even areas that are further away such as Salisbury (4.0 percent) are easily accessible via public transport. The distribution of employment is depicted below.

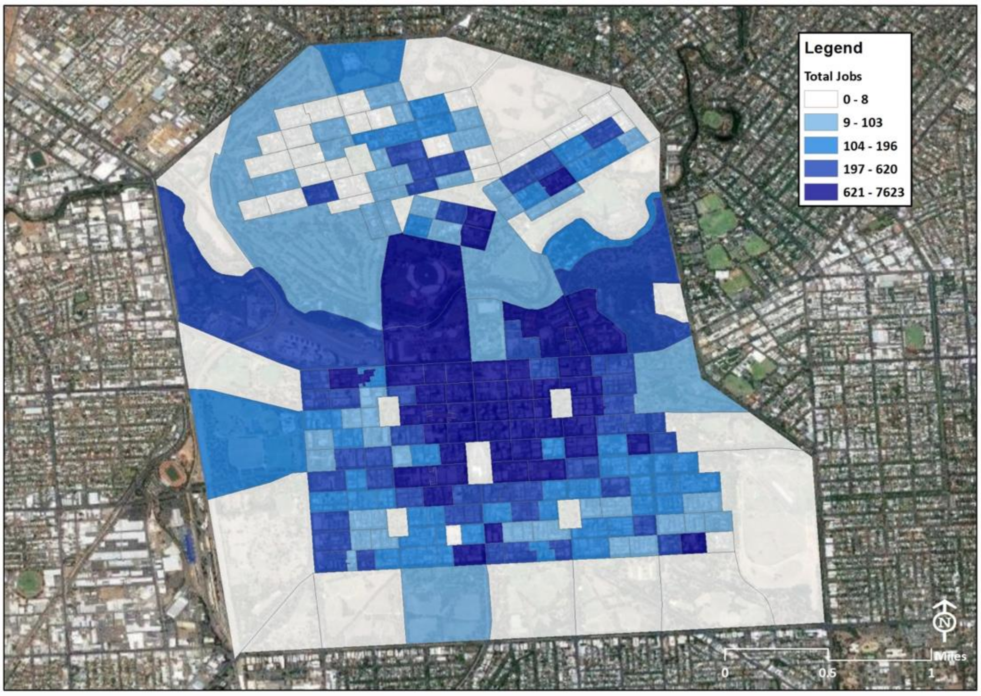


Figure 1- 7 Distribution of employed residents in Adelaide, ABS 2016

In 2016, a total of 116,958 persons worked in the City of Adelaide, the largest number for any local government jurisdiction in Adelaide's metropolitan area, making it the most common work destination. This is most likely due to it being located in a city centre that is able to provide a great range of economic activity and opportunities for employment (Adelaide City Council, 2014).

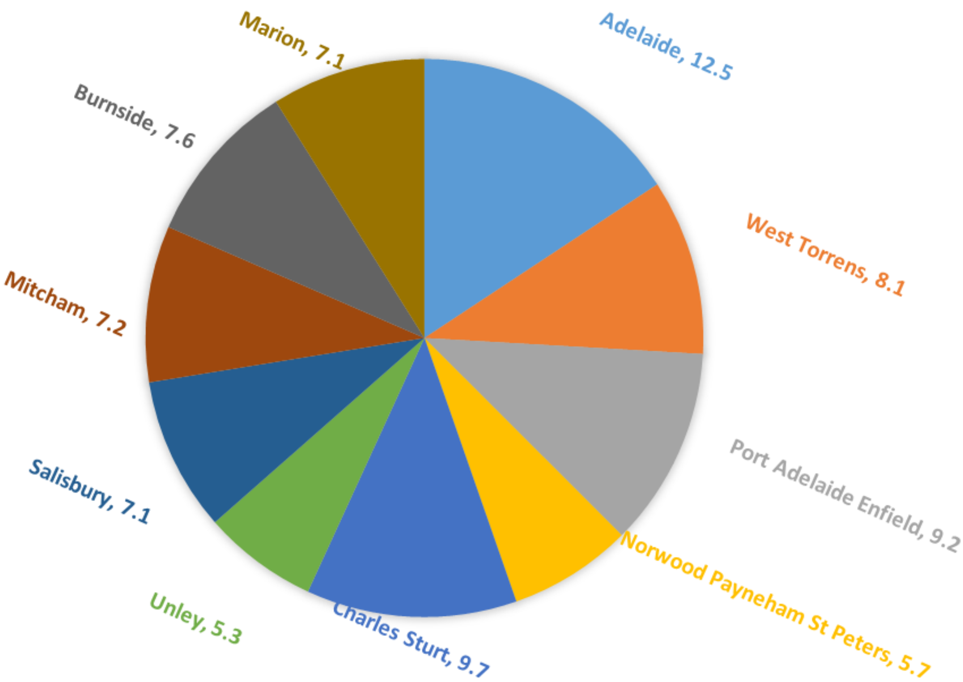


Figure 1- 8 Usual residence of people who work in Adelaide, ABS 2016

These people travelled from 19 different LGAs to the City of Adelaide for work. Figure 1-3 shows high proportions of workers with their usual residence being Charles Sturt (9.7 percent or 11,311 workers), followed by Port Adelaide Enfield (9.2 percent or 10,759 workers), and Onkaparinga (7.4 percent or 8,694 workers). Workers that resided in the City of Adelaide only accounted for 4.5 percent of these workers (5,250 workers).

The Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD) for Adelaide (ABS, 2011) clearly indicates that the City of Adelaide is an LGA with high levels of socio-economic advantage, which is defined by the ABS "in terms of people's access to material and social resources, and their ability to participate in society" (ABS, 2016). A high score indicates greater advantage such as high rather than low incomes, more people in skilled, rather than low-skilled occupations, few unemployed people, and higher rates of residents with higher levels of completed education. The metrics for Adelaide's central area for the Index of Relative Socio-economic Advantage and Disadvantage were a score was 1036 (Decile =9); for the Index of Relative Socio-economic Disadvantage the score was 1013 (Decile =8); for the Index of Economic Resources the score was 874 (Decile =1); and for the Index of Education and Occupation the score was 1170, (Decile =10).

In households, income is usually shared amongst partners and/or children, helping to improve access to goods and services (ABS, 2016). The proportion of households decreases as the amount of weekly household income increases; 24 percent of households (2,807) generated an income of less than $999 per week, while less than a quarter of households earned $4,000 and over (5.3 percent or 614 households). The high proportion of households making less $1,999 per week (43 percent) suggests that many "households" in the City of Adelaide were made up of apartments or flats, housing only a small number of people. This reinforces the suggestion that much of the population of Adelaide only have temporary residence, living in the city mainly for reason related to work and study.

The results of ABS statistics suggest some distinct characteristics of the population residing in the City of Adelaide when compared with many of the surrounding suburbs in South Australia. Some of the key findings highlighted in this analysis of population include the high proportion of the working population, with the assumption that many reside in the area for work and/or study purposes. Being in a commercial and business area, high-density housing is more likely to occur. A higher proportion of the population are temporary residents, as reflected by the high proportion of rented dwellings.

Furthermore, household incomes were lower, reflecting a strikingly larger younger age cohort who would be less likely to commend higher wages. Lastly, because of the large proportion of the population that work and/or study in the area, many people were either unemployed or not seeking employment in the labour force.

Table 1- 2 Socio-economic characteristics of residents of City of Adelaide, ABS 2016

		Adelaide (C)	Greater Adelaide	South Australia	Australia
Employment and job	Professionals and managers job	52.80	33.80	32.90	35.20
	Labourers	5.1	9.8	11.1	10
Industry type	Cafes and Restaurants	6	2.3	2.1	2
Dwelling internet connection	Internet accessed from dwelling	86.7	82.3	80.6	83.2
Dwelling structure	Separate house	12.2	74.8	77.8	72.9
	Semi-detached, row or terrace house, townhouse etc.	34.9	16.9	14.8	12.7
	Flat or apartment	50.9	7.8	6.6	13.1
Ethnics diversity	Birth country of father: Australia	45.60	52.20	56.90	52.30
Age	Median age	30	39	40	38
	20-24 years	21.3	6.9	6.4	6.7
	25-29 years	13.8	6.8	6.4	7.1
	30-34 years	9.8	7	6.6	7.3
	75-79 years	2.2	3	3.2	2.8
	80-84 years	1.2	2.3	2.3	2
	85 years and over	1.7	2.6	2.7	2.1
Education	University or tertiary institution	57.9	19.3	16.2	16.1
	Highest educational attainment: Bachelor degree or above	37.2	21.2	18.5	22
	Highest educational attainment: Year 12	24.6	16.5	15.5	15.7

With regard to car ownership, the City of Adelaide has a relatively low level of car ownership in comparison to South Australia and Australia. About one third residents of City of Adelaide, do not own a motor vehicle compared with 7.5 percent in South Australia and Australia. For households with three vehicles or more, only 3.7 percent (ABS 2016) of households own a vehicle compared with 17.5 percent in South Australia. South Australia's vehicle ownership rates closely mirror those for Australia.

Table 1- 3 vehicle ownership level of City of Adelaide, ABS 2016

Number of registered motor vehicles	Adelaide (C)	Percent	South Australia	Percent	Australia	Percent
None	2,631	30.3	47,848	7.5	623,829	7.5
1 motor vehicle	3,897	44.9	228,940	35.8	2,881,485	34.8
2 motor vehicles	1,498	17.3	229,930	36.0	2,999,184	36.2
3 or more vehicles	318	3.7	112,047	17.5	1,496,382	18.1

Furthermore, the ABS data on method of travel to work for 7,560 workers living in central Adelaide and using one method for going to work indicates that using a car as driver (43.0 percent) is the most preferable mode of going to work. This is followed by walking (32.9 percent) and using the bus (10.0 percent). The figure for bike usage is also significant (4.6 percent). The relatively high usage of non-motorised modes (37.5 percent) and public transit (13.1 percent) together shows the appropriateness of the urban built environment for walking/cycling and the closeness of working places to residential areas for those living within central Adelaide (ABS 2016).

Table 1- 4 Method of travel to work in City of Adelaide, ABS 2016

Mode of travel (one method)	No of travellers	Share (percent)
Train and tram (and light rail)	235	3.11
Bus	755	9.99
Car as driver	3254	43.04
Car as passenger	295	3.90
Taxi and UBER	36	0.48
Motorbike/scooter	60	0.79
Walking	2487	32.90
Cycling	349	4.62
Other	89	1.18

According to above socio-demographic information, Central Adelaide is an ideal place to establish sharing mobility services due to following reasons:

- Relatively low car dependency comparing to the rest of the Greater Adelaide region.
- Higher share of non-motorised and public transit usage.
- A younger population which could be more open to using active transport modes, particularly cycling.
- A large share of students, visitors and temporary residents (of Australia).
- A large share of middle-income households with the disposable income needed to be economically active and physically mobile.
- A mix of dwelling types that is conducive to using micro-mobility transport solutions and restrictions on parking and motor vehicle mobility.
- A concentration of employment, retail, community services and amenities, where motor vehicle parking is at a premium, and access for local residents is more practical by micro-mobility solutions.

This is consistent with the literature, for example in an international study across four global cities that included London, Paris, Madrid, and Tokyo, a key finding was that the city centre is the best location within which to recruit new users of car sharing services (Prieto, Baltas, & Stan, 2017).

In this regard, the promotion of the use of more affordable and sustainable transportation modes such as bikeshare and carshare is argued as a vitally important transport policy initiative that should be incorporated into future Development Plans, Local Government Strategies and Local Area and State Transport Strategies/Plans. It is interesting to note that Adelaide introduced one of the first bikeshare schemes in Australia with the introduction of Adelaide Free Bikes in 2005 (BikeSA, 2018). Adelaide City Council supported expansion of Adelaide City's bikeshare market when OfO and O'Bike operated in Adelaide during late 2017 and early 2018 (Adelaide City Council, 2018). This has now transitioned to (micro) e-mobility share mobility services, intially in a trial during the 2018 Adelaide Fringe Festival with Lime e-scooters and then later in 2019 with further trials with Beam (a shared mobility service operating out of Singapore) and Ride e-scooters (an Australian shared mobility service based in Melbourne). With the strong support of both local government (City of Adelaide, 2016), and the public (Elliot Fishman & Martin von Wyss, 2017), share systems (including bikeshare and e-scooters) not only offer a relatively low cost and sustainable travel option for Adelaide's city dwellers but it could be a catalyst for the future increase of Adelaide's low cycling levels which is now a mere 1.5 percent of commuter modal share (Pojani, Butterworth, Cooper, Corcoran, & Sipe, 2018). Although sharing mobility has been an intense and controversial topic of public interest since its first introduction, it does appear that Adelaide's current bikeshare and carshare systems have not had their potential realised. The remainder of this report examines why this potential may not have been fully realised to date through discussion of a major market research survey conducted in 2018 of community attitudes within the inner suburbs of Adelaide to rideshare services.

Chapter 2: Literature Review

2.1. Shared mobility

There have been increasing concerns regarding the energy and environmental impacts of the transportation sector, which have motivated governments and related actors to consider different strategies to deliver a more sustainable and efficient transportation future (Huwer, 2004); (Clewlow, 2016). The sharing economy is an outcome of those efforts, which is defined as 'any marketplace that brings individuals together to share or exchange otherwise underutilised assets' (Yanwei, Araz, & Martin De, 2018). The sharing economy enables consumers to interact with potential suppliers via innovative technologies (Yanwei et al., 2018). Within various concepts of sharing economy, the notion of sharing mobility – the shared utilisation of a car, bike or other modes that allows customers to have short-term access (on an on-demand basis) to transportation vehicles – has emerged and aroused wide debates from international scholars (Shaheen & Chan, 2016b).

The development of sharing mobility systems is mostly affected by high fuel costs, scarce and costly parking, internet access, smart technologies and increased demand for personal vehicle access (S. A. Shaheen & Cohen, 2007). Shared mobility refers to the shared use of a car, bike, or other vehicle which provides trip-makers short-term access to travel modes on an on-demand basis (Shaheen & Chan, 2016a). Sharing mobility systems have shown to result in a significant reduction in energy and GHG emissions through saving on parking infrastructure demand, and lower fuel use which are associated with reduced car ownership, shifted modes, and more efficient vehicle technology (Baptista, Melo, & Rolim, 2014; J. J. Chen, Kwak, & Fan, 2016; J. Firnkorn & Müller, 2015; Martin, Shaheen, & Lidicker, 2010)

This chapter discusses two forms of shared-mobility included bike-sharing and car-sharing (and ride-sharing) extensively and a brief explanation on autonomous vehicles (AVs) and electric cars. It also includes a discussion on the modal shift and the factors influencing it in order to highlight the ways to shift from personal vehicles to shared-mobility alternatives.

2.2. Bike share systems (BSS)

2.2.1. History and evolution of BSS

The emergence of bikeshare schemes (BSS) explained by its history, implications, performances, and factors that influence the use of BSS, are presented in this section to provide a theoretical framework of this study. The introduction of bikes was firstly in the 19th century in Europe as a simple means for transport. Australia has its own long history of cycling, especially for the purpose of facilitating local urban mobility. On the other hand, due to the rapid development of cars after 1910, culminating in domestic manufacture of motor vehicles in the in 1948, bike usage for daily travel and work commuting has decreased in Australia (Bonham & Johnson, 2015). Unfortunately cycling became a less attractive, less convenient and less safe means of urban transport as cities expanded with transport infrastructure in the form of high speed roads focused on meeting the needs of personal car travel.

In essence, a bikeshare scheme is defined as 'the shared use of a bicycle fleet' (Shaheen, Guzman, & Zhang, 2010). Several distinct features are characteristic of a seamless BSS system in relation to the provision of bicycle between places (i.e. docking stations), applied technology used for BSS management, rental duration, and payments method. Firstly, BSS offers the provision of bicycles for cyclists' travel from his/her origin to their destination. In this regard, after registering a ride or commencing a hire, users are able to pick-up and drop-off bikes between different self-service docking stations within a short-term rental (less than 30 minutes) (Fishman, 2016).

Additionally, the system is designed to incorporate smart device or internet based applications that allow BSS's operators tracking docking stations and users' movements thorough the network (Fishman, Washington, & Haworth, 2013). In terms of pricing and the payment methods, the services are normally free for the first 30 minutes (DeMaio, 2009). After that, users can use credit cards to pay for the additional time of using the services.

Although the principles of BSS operation seem to be simple, it has evolved through a long development process to create the comprehensive bike sharing systems that are currently available. Interestingly, whilst many dockless bikeshare schemes have now collapsed and given way to dockless e-scooters and e-bikes, docking bikeshare schemes continue, albeit often in heavily subsidised arrangements, supported by either local government jurisdictions within which they operate (as in Melbourne and Brisbane) or with corporate sponsors (as in New York's CitiBike Scheme in its initial launch phase, which is now operated on a commercial basis by Motivate).

Table 2- 1 Notable bikeshare schemes all over the world

BSS program	City/country	Operator(s)	Year of operation	Capacity
Hangzhou	Hangzhou, China	Hangzhou Public Transport Corporation	2008	60,600 bicycles; 2,416 stations
BIXI	Montreal, Canada	PBSC/Bixi	2009	5,000 bicycles; 400 stations
Capital Bikeshare	Washington DC, US	ABS/Motivate	2010	120 bicycles ; 10 stations
Bicing	Barcelona, Spain	BSM	2007	4,852 bicycles; 420 stations
Vélib	Paris, France	JCDecaux	2007	20,600 bicycles; 1,451 stations
Samba	Rio de Janeiro, Brazil	Serttel	2008	80 bicycles; 8 stations
Melbourne Bike share	Melbourne, Australia	RACV, Public Transport Victoria, Victoria State Government	2010	600 bicycles ; 51 stations
CityCycle	Brisbane, Australia	JCDecaux CityCycle Australia	2010	2,000 bicycles; 150 stations
CitiBike	New York, USA	New York Department of Transport/Citibank/Motivate	2013	12,000 bicycles; 706 stations

Adapted from (de Chardon, Caruso, & Thomas, 2016; Shaheen, Guzman, & Zhang, 2010)

Since its introduction in the late 1960s, BSS has undergone different generations. DeMaio (2009) identified three generations of BSS with each generating heralding changes in the principles of controlling and managing such systems. More specifically, the first generation of BSS emerged with Amsterdam's White Bike program. The White Bike BSS provided free access to the public and was designed without docking stations to securely store bikes or tracking features of the movements of users (Parkes et al., 2013). Consequently, it led to the failure of the program because bikes were either used inappropriately or vandalized by the users (DeMaio, 2009). Despite this unsuccessful program, bike sharing schemes were still developed across Europe with subsequent introductions of BSS in La Rochelle, France, and Cambridge, UK (Shaheen et al., 2010).

The second generation of BSS was developed in Copenhagen with the addition of a coin deposit system, and the appearance of docking stations (Fishman, 2016). However, as with the first generation, due to the lack of security functions to track customers' movements and customer anonymity (Shaheen et al., 2010), the second generation was also compromised by loss through thefts (DeMaio, 2009). Therefore, significant improvements were applied with the introduction of technological applications in the third BSS generation. Users' experience with BSS was improved by the provision of an automated system which allowed hirers the use of credit cards to pay for their BSS usage. Additionally, several technologies have also been applied to the system to enhance bicycle tracking, thereby decreasing vandalism or theft (Shaheen, Martin, & Cohen, 2013). Besides these three distinct generations throughout the development of bike sharing, recently, the fourth generation of BSS has evolved and discussed widely in the literature (DeMaio, 2009; Fishman, 2016; Parkes et al., 2013; Shaheen et al., 2010). In this regard, these contemporary BSS researchers believed that although the development of this generation has still been unclear, cutting-edge technologies could be utilized to create seamless bike sharing systems.

Although BSS has now passed through over five decades of development, this kind of active travel has just emerged in Australia in the past two decades. As noted, both Melbourne and Brisbane introduced their BSS in 2010, with Melbourne Bike Share (i.e. MBS) and Brisbane's CityCycle (Fishman, Washington, & Haworth, 2012). Notably, these BSS serve city centres and inner suburbs of both cities. Adapting the principles of BSS's generations, MBS could be hired for a short time (few hours), a whole day or even a week (Melbourne;, 2018). In addition, there are over 600 bikes that could accessed from 51 different docking stations across Melbourne's inner metropolitan area. Free helmets are also provided for hirer. Similarly, CityCycle in Brisbane has a fleet of 2,000 bikes across a network 150 stations with the availability of 24/7 services (CityCycle, 2018). In the Australian examples of BSS, schemes are only made available within inner metropolitan areas (i.e. within 5km of the CBD), with no attempt made to extend BSS into the heart of car dominated suburbia in the middle to outer suburbs. This partly reflects metropolitan governance arrangements, with multiple local government jurisdictions cross the wider metropolitan area in Melbourne which may frustrate the introduction of a broad based metropolitan-wide BSS. Brisbane's larger BSS system is an interesting contrast to the Melbourne BSS which was established at the same time, in that despite Melbourne characterised by largely flatter terrain that is more conducive to cycling and having double the metropolitan population than Brisbane, Brisbane has managed to have a much larger BSS system. Brisbane's sub-tropical climate may also partly explain its larger scheme, however its unitary metropolitan local governance arrangement would have made it easier to manage and regulate BSS.

Figure 2- 1 The supply site of OfO and Mobike as two service providers in China (Economist, 2017)

2.2.2. The implications of bike sharing

As a key form of non-motorised transport, bike sharing brings significant benefits to its users and the society. Susan Shaheen et al. (2010) concluded that the three main benefits of BSS, are the potential impacts on car use reduction, the positive effects on the environment, and health benefits.

The impacts of bike sharing on car use are indicated through an in-depth study of (Fishman, Washington, & Haworth, 2014) about BSS programs in five different cities worldwide, including Melbourne and Brisbane (Australia), Washington DC, Minneapolis-St.Paul (the US), and London (United Kingdom). Interestingly, this study presented contradictory findings where Melbourne and Minneapolis-St. Paul were recorded as having an annual reduction of nearly 90,000 kilometres of motor vehicle travel as a result of bikeshare usage. Likewise, it was evident that over 243,000 kilometres of motorised transport have been reduced in the case of Washington DC. By contrast, there was an additional 766,000 kilometres of motor vehicles usage with regard to London's BSS due to the low substitution rate of car use (only two percent). Indeed, the potential shift of car users to bikeshare has still been modest in several bikeshare programs worldwide. Besides the example of London's BSS as mentioned in research of (Fishman et al., 2014), other cities also witnessed a low level of mode substitution from cars to bike sharing, such as Montreal (2%), Lyon (7%), and Barcelona (9.6%) (Bachand-Marleau, Lee, & El-Geneidy, 2012; Fishman et al., 2013) Riojas-Rueda et al., 2011). Similar findings were also supported in studies by Murphy (2010) and Midgley (2011) with findings that bikeshare had minimal impact on car use in Dublin and Paris.

Corresponding to the impacts of bike sharing on car use, (Fishman et al., 2014) also demonstrated positive influences on the environment of chosen BSS in Melbourne, Brisbane, Minneapolis- St Paul and Washington DC. However, in the case of London's bikeshare, this study suggested that if the rate of car substitution was at 10 percent, then positive impacts on the environment could be created. Ricci (2015) noted that although several studies have put effort into identifying the significant influences on the environment of bikeshare usage, a research gap still exists due to the lack of reliable evidence associated with usage data or the implementation of surveys with real users.

There is a growing interest in researching health impacts of bike sharing in recent years. Fuller, Gauvin, Kestens, Morency, and Drouin (2013) and Woodcock, Tainio, Cheshire, O'Brien, and Goodman (2014) both carried out studies about the health impacts of BSS in Montreal and London. The findings of two studies both concluded positive effects on bikeshare users' health conditions. In particular, physical activity was believed to be increased significantly among London's bikeshare users, thereby helping to reduce ischaemic heart disease among male users and depression levels of female counterparts. In addition, users' lower level of exposure to air pollution (i.e. PM 2.5) was also recorded by the research team of Woodcock. Additionally, bikeshare usage has also led to a reduction of the Body Mass Index amongst undergraduate students at University of Valencia (Spain), a finding that is backed by a study of Molina-Garcia et al. (2013) and which helps to promote user's healthy weight as found in the research of Shaheen et al. (2014) in relation to Capital Bikeshare in Washington DC.

2.2.3. Performances of bikeshare

Bikeshare performances are presented by two important indicators, which are usage rates, and user frequency. First of all, usage rate is a common metric used for evaluating performances of BSS in different cities (Fishman, 2016). Normally, trips per day per bike (TDB) are calculated to represent the usage rates of a bikeshare system. Studies in the literature found that the average TDB for BSS is between 3 and 6 trips per day per bike (de Chardon et al., 2016; Meddin, 2015; Rojas-Rueda, de Nazelle, Tainio, & Nieuwenhuijsen, 2011) undertook a study with 75 different BSS worldwide and they found that TDB are recorded higher in European cities as compared to both North American and Asian cities. Indeed, European cities dominated in the ranking of the top 10 cities which have the highest TDB for bikeshare systems. In particular, Barcelona has ranked at the top of TDB performances with 8.4 trips per day per bike, followed by other European cities such as Dublin (8.0) and Turin (7.9). None of North American or Asian cities were in the top 10. Similarly, Melbourne and Brisbane are the only two BSS in Australia that were evaluated in this study; however, the performances of TDB for these two cities are relatively low, at 0.71 and 0.32 trips per day per bike respectively. Notably, these findings agree with Fishman's study (2016), which used the same TDB data for those cities.

Similar to the usage rates of the bikeshare system, user frequency is also an important indicator that has been mentioned in studies of different scholars. To explain, the common findings of previous studies noted that members of BSS do not utilize bikeshare services frequently. Indeed, BSS's members in London (Transport for london, 2014), Washington D.C (Buck et al., 2013a) or Australian cities such as Melbourne and Brisbane (Fishman et al., 2014), did not frequently use bikeshare services for a typical month. This could be explained by the fact that users considered bikeshare as 'an occasional adjunct' to the primary and secondary modes of transport (Fishman, 2016), thereby leading to the low user frequency of BSS.

In the case of BSS in Adelaide, the lack of having a study which provides better understandings about performances of bike sharing system has existed. Efforts have been made by Fishman and Wyss (2017), and Pojani et al. (2018). The former just focused on undertaking a feasibility study for the future of bikeshare in Adelaide; however, researchers failed to provide an in-depth study with the current users of bikeshare. Therefore, this study did not justify the current situation of bikeshare performances in Adelaide based on its users' opinions. Likewise, the recent research of Pojani and her colleagues just emphasised the current situation of cycling in Australian cities but they omitted to acknowledge the evaluation of bikeshare's performances in these cities. Based on these analyses, this provides justification for this study to investigate the current performances of BSS in Adelaide.

2.2.4. Factors affecting bikeshare use

There is a growing body of work investigating influential factors on the use of Bike share worldwide. The common findings of previous studies in the literature pointed out the role of important attributes such as convenience and financial (or cost) savings (Fishman, 2016). Moreover, gender is also a notable factor in which men have been indicated utilizing bikeshare more frequently than women counterparts. Absent from the literature is discussion on the carbon emissions reduction impact of BSS, although to some extent, the localised nature of BSS provisioning, the spatial extent of BSS and the rate of car trip substitution allows crude inferences to be made about its likely role in reducing car travel related carbon emissions.

It is also interesting that debate continues about the effect of mandatory helmet legislation on the level of bike share usage due to the perceived inconvenience, hair style concerns, sanitary issues, punitive legal penalties for non-helmet wearing cycling and the difficulty in sourcing a helmet when many go missing in BSS. However, bicycle helmet wearing legislation was originally introduced in Australia in response to a high rate of catastrophic head injuries within the context of cycling occurring in a hostile car dominated urban road environment. The work of Martin, Cohen, Botha, & Shaheen (2016) Fishman & Schepers (2016), Fishman and von Wyss (2017), Fishman et al., (2012) and VicRoads (Melbourne, Australia) advocated the voluntary use of bicycle helmets for bikeshare cyclists as a means of increasing bikeshare on the basis that the low speed urban road environment of inner city areas and dedicated cycling infrastructure can offset the risks of cycling that helmets are designed to minimise.

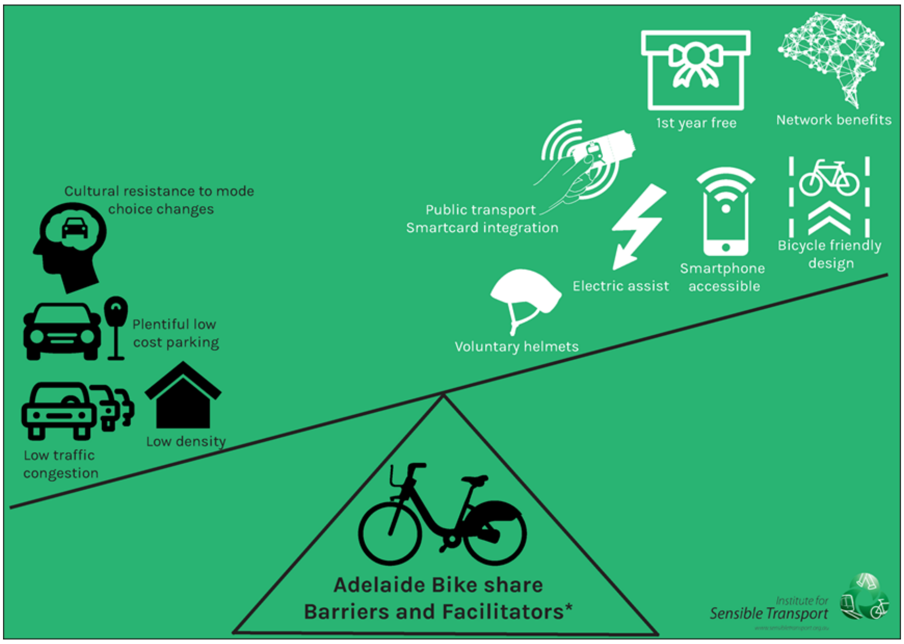


Figure 2- 2 Barriers and facilitators of bikesharing in Adelaide (E. Fishman & M. von Wyss, 2017)

2.3. Car share/ride share system (CSS)

2.3.1. The growth of CSS

Carsharing (also known as commercial ridesharing) is a major suite of services under the umbrella concept of shared mobility. Carsharing first appeared in North America from World War II onwards as 'carsharing clubs' or 'car clubs' (Morency, Trépanier, Agard, Martin, & Quashie, 2007; S. Shaheen et al., 2010; Yanwei et al., 2018). As a new mode of urban transportation, carsharing is described as the utilisation of a shared pool of vehicles (Clewlow, 2016; Huwer, 2004; Schaefers, 2013). Within carsharing models, customers do not need to own physical cars; however, they can rent cars for a short period, pay for the time that they utilise the cars (or the distance they drive the cars) while all the maintenance and servicing of the cars are delivered by the operators (Baptista et al., 2014; Ferrero, Perboli, Rosano, & Vesco, 2018). The first practical CSS initiatives began in the late 1980s in Germany and Switzerland with small businesses run by pro-environment groups. At present, there are two crucial models of car-sharing, which are: station-based (where customers have to return vehicles to an available fixed station) and free-floating (vehicles can be accessed and returned anywhere within the operating areas) (Becker, Ciari, & Axhausen, 2017; Terrien, Maniak, Chen, & Shaheen, 2016). Moreover, three existing key carsharing models that have emerged in recent times are: (1) peer-to-peer carsharing (shared utilisation of privately possessed vehicles provided by a third-party company/organisation), (2) roundtrip carsharing (vehicles are approached and returned to the same place), and (3) one-way carsharing (shared utilisation of vehicles that are free-floating through a designed urban area)(S. A. Shaheen, Chan, & Micheaux, 2015).

Along with carsharing, recent studies in the transportation field have also pointed to the concept of commercial ridesharing. Ride-sharing is a growing form of movement because of its lower cost for short distance and occasional trips when compared with conventional vehicle ownership. The process of ride-sharing involves consumers gaining access to shared private vehicles, which are positioned at different locations such as residential areas, CBD's, university campuses, etc., and this creates the benefits of private vehicle usage, without the costs of ownership (Shaheen et al., 2013).

The current versions of ride-sharing models include peer-to-peer applications, one-way applications, or connected applications to public transport. Rayle et al. (2016) indicate that ridesharing aims at matching supply and demand dynamically and provides an ongoing arrangement where passengers can request car rides through utilising a smartphone application provided by potential suppliers (for instance, UBER, Grab or Gocatch). Furthermore, ridesharing drivers can use their own car to transport customers for a payment, and generally provide rides that are not incidental to their personal trips.

Generally, ridesharing is claimed to be different from traditional taxi cabs because of the use of smart device matching platforms, different pricing mechanisms as well as the accountability of a user controlled drivers' rating system (Rayle et al., 2016).

2.3.2. The Pros and Cons of CSS

Contemporary studies suggest that carsharing has certain pros and cons to both individuals and society. On the positive side, carsharing models have great potential to curb travel demand as well as its associated energy and environmental impacts (Clewlow, 2016). For further clarification, carsharing offers commuters an additional transport option, increasing mobility and encouraging multi-nodal communities in which people can reach destinations inaccessible by other means of transport (including walking, biking or public transit) (Ferrero et al., 2018). Additionally, carsharing allows users to access the benefits of private vehicles utilisation without bearing all of its inherent costs, which creates considerable scope to reduce car ownership, the total amount of car trips, total vehicle miles travelled, which in turn supports more sustainable travel behaviours (Huwer, 2004; E. Martin & S. Shaheen, 2011; Martin et al., 2010; Schaefers, 2013).

Car sharing also encourages appropriate and efficient car usage by encouraging users to opt for the right modal choice transport and facilitating improved travel efficiency through trip-chaining and inhibiting impulsive trips (Stefano de Luca and Roberta Di Pace (2015).

Research has demonstrated that carsharing may contribute to reducing carbon emissions, pollution, congestion, and demands for parking spaces (T. D. Chen & Kockelman, 2016; Furuhata et al., 2013; Rabbitt & Ghosh, 2013; Stiglic, Agatz, Savelsbergh, & Gradisar, 2016). In a report published in 2018, the European Federation for Transport and Environment gathered empirical data showing the impacts of carsharing on travel behaviours, which is summarised in table 2-2.

Table 2- 2 Examples of carsharing/ridesharing programs and their impacts on travel behaviours

City/Country	Sharing system	Established date	Fleet / Users no.	Impacts on travel behaviours
North America	Zipcar	Mid-2000s	777000 members with nearly 10000 vehicles	-Carsharing vehicles released 20% less CO2/km than normal cars -41% users eliminating car ownership used public transport more frequently and 41% customers walked more
Germany, Italy and some other countries	Car2Go	2008	350000 customers with 6000 conventional and alternative vehicles	-Private automobiles were purchased 30,000 less due to the operation of carsharing -42% customers utilised carsharing together with public transport
Paris, France	Autolib	2011	1750 Electric Vehicles, with 4000 charging points and has more than 65000 registered subscribers	-Declining 15,000 tons CO2 emissions since the launch of Autolib
US, Europe and Australia	Hertz	2008	150000 users	
London, UK	UBER	2012	Not stated	28% of UBER users who possessed automobiles no longer did so since they could utilise UBER alternatively
Lisbon, Portiguo	MobCarsharing	2008	12 vehicles in 9 locations, 300 members	

Source: Adapted from Transport and Environment 2017 (Annual Report), European Federation for Transport & Environment, April 2018 accessed at www.transportenvironment.org

Moreover, Kent (2014) argues that car-sharing can overcome the social justice shortcomings in urban mobility that are often characteristic of car dependent societies by providing more equitable access to mobility for broader socio-economic groupings (especially poorer residents), through the adoption of autonomous mobility (Kent, 2014). Furthermore, car-sharing is also claimed to have the potential to enable commuters to communicate with other people, and thus increase social capital (van Meerkerk, Koppenjan, & Keast, 2015).

Along with the above listed benefits, there are also certain debates on the negative side of car-sharing and ridesharing programs. From an economic perspective, car-sharing (and ridesharing) are causing disruption to the existing conventional taxi markets worldwide (Rogers, 2015). Additionally, there are concerns regarding service quality, the privacy as well as safety of users and unfair competition raised by the emerging carsharing and ride-sourcing industry (Nielsen, Hovmøller, Blyth, & Sovacool, 2015; Taeihagh, 2017). For example, in a recent study conducted by Yanwei et al. (2018) in Singapore, a taxi driver, social media writer and newspaper correspondent, and government officials and researchers working on the sharing economy and transportation policy were interviewed to determine five key risks involved in ridesharing (see table 2 – 3).

Table 2- 3 Five key risks involved in ridesharing in Singapore

(1) Privacy: Carsharing and ridesourcing programs can collect sensitive information of their users, including geolocation data, phone numbers or credit card numbers. A massive data breach of UBER in November 2017 raised serious concerns about privacy policy and the inappropriateness of gathering these data implemented by ridesharing companies.

(2) Safety: Customers might feel unsafe when using ridesharing as drivers are not licensed and professionally trained like in traditional taxi companies. Safety concerns also come from the fact that vehicles utilised for ridesharing might not be rigorously inspected (some drivers in Singapore buy second-hands vehicles to work for Grab and UBER to save costs and earn more money).

(3) Influence on incumbent industries: Ridesharing companies generally do not have to comply with consumer protections or pricing policy (for example: UBER has a ‘surge price’ charging more money when demand is high), thus have unfair benefits. Therefore, taxi drivers in Singapore claims that these companies can negatively impact their businesses.

(4) Liability: Interviewees raise concerns about who would take legal responsibility when ridesharing vehicles involve in accidents, as there is no clear policy framework for this situation. For example, UBER denied their responsibility in an accident involved UBER car in Singapore in 2016.

(5) Automation: Along with the development of carsharing and ridesharing, automation is also making remarkable progress in Singapore. For instance, Grab collaborated with nuTonomy or Honda to develop autonomous vehicles (AV) in 2016. However, AV can raise certain challenges for policy makers as it may result in unemployment for taxi and existing ridesharing drivers or concerns regarding the real safety of these vehicles.

Source: Adapted from the study of Yanwei et al. (2018))

In terms of the characteristics of carsharing users, in a survey conducted in North America in 2008, Martin and Shaheen (2011) found out that carsharing users were relatively well-educated, young and had moderate incomes (Clewlow, 2016). In addition, Schaefers (2013) utilised laddering interviews with carsharing users of a United States [US] provider and identifies four key motivational patterns as: value-seeking, convenience, lifestyle and environmental motives. Firstly, the value-seeking motive stems from the result of saving money when utilising carsharing due to its relatively reasonable pricing (spending less than owning a car) and free parking. Secondly, the convenience motive refers to the users' feelings that carsharing services make their life easier, through flexible use, time-saving, reduced responsibility, values of security (high degrees of reliability and availability). Thirdly, lifestyle motive refers to the symbolic desire of carsharing users, particularly the desire for status (or recognition) via joining, utilising and talking about carsharing programs, interacting with other users and a feeling of belonging to a carsharing community. Finally, the environmental motive refers to users' desires for indirect benefits obtained via carsharing, particularly environmental awareness regarding the car's characteristics (fuel efficiency or size) and the possibility of users being able to go carless (Schaefers, 2013).

2.4. Autonomous Vehicles (AVs)

The existing pattern of private car usage is enormously inefficient in terms of time and energy consumption. The estimations show that most private cars spend over 90 percent of their life unused and within the denser urban areas, approximately 40 percent of the total fuel used is exhausted when searching for a parking space. The rapid growth of information and communication technology (ICT) and the requirement of supplying an aging population has potentially made AVs as an emerging business paradigm (Hong et al., 2008). Significant changes in travel patterns are expected by considering the safety and congestion-reducing impacts of AVs. This technology can provide more feasible alternatives for youth, senior adults, the elderly and the disabled, thereby generating new roadway capacity demands. Furthermore, parking patterns could be altered as AVs self-park in less-expensive zones. It would help in expanding car- and ride-sharing programs, as AVs serve multiple individuals on demand (Fagnant & Kockelman, 2015). AVs may also create extra benefits such as improving accessibility and mobility and even improving land use. On the other hand, there might be substantial pitfalls associated with AVs, however, it is generally believed that such disadvantages are outweighed by the benefits (Bagloee, Tavana, Asadi, & Oliver, 2016).

Based on the level of automation control, six types of vehicle automation are recognised:

- Level 5 (full automation): All driving tasks under all conditions that a human driver could execute them, are taken by the automated system;
- Level 4: While the driving and monitoring the driving environment are taken by the automated system, however, it works only in particular environments under certain circumstances;
- Level 3: While the automated system may both take driving task and monitor the driving environment, however, the human driver must be prepared to take back control when required;
- Level 2: while the automated system takes some parts of the driving task, the human driver monitors the environment and conducts the rest of the driving task;
- Level 1: the human driver performs the driving task but can get assistance from the automated system if required;
- Level 0: There will be no intervention from the automated system on the vehicle and the human driver does every job (Bagloee et al. 2016).

AVs have several benefits in terms of saving parking space, saving time, reduction of congestion and improving human and vehicle safety. Initially popularised by Elon Musk during his time as CEO of Tesla Motors and Google with their completely autonomous cars, the concept of AVs is now at the forefront of almost all major automotive engineering research efforts. The technical advances in the car manufacturing industry globally by major motor manufacturers such as Ford, General Motors, Volkswagen, Nissan-Renault, Mercedes Benz, Volvo and BMW utilising advanced road network mapping, vehicle to vehicle communication, road infrastructure to vehicle communication, pedestrian/cyclist to vehicle communication, centrally managed road network traffic management, coordinated and linked traffic signals network, and on-board vehicle artificial intelligence to interpret real-time data collected by the vehicle's sensors (in the form of on-board lidar, radar and ultra-high definition camera systems) during autonomous driving to provide navigation and collision avoidance. A study by Fildes et al.(2015) showed about 60 percent decline in collisions was achievable using an automated collision avoidance system.

The second benefit of AVs in using autonomous communication systems such as vehicle to vehicle (V2V) communication and vehicle to infrastructure (V2I) communication is that it allows sharing of information between two vehicles or more and transport physical infrastructure which consequently reduces the potential collision points and facilitates improved and more efficient traffic flows.

This technology not only manages traffic flow at intersection points but also has other benefits such as reducing traffic congestion, space efficiency on roads through reducing gaps between vehicles and in reducing fuel consumption and GHG emissions. Furthermore, the capability of AVs to manoeuvre in close proximity to one another, allows reducing parking space requirements. However, perhaps the most significant benefit of using AVs was in a study by Zhang et al. (2015) that demonstrated a reduction by 90 percent in parking demand if an autonomous ride-sharing system is used. Unfortunately, if AVs are acquired under a private ownership model, whilst non-home based parking requirements could be greatly reduced, vehicle mileage could double if owners adopt a 'back to base' operational strategy to minimise parking fees, although the vehicle's computers would provide the optimal balance of destination parking against the 'back to base parking' operational strategy, assuming that the rational operational strategy would be to minimise costs by finding the 'sweet spot' between parking and travel costs.

AVs when combined with shared mobility models have the potential to shatter the traditional private car ownership paradigm that has dominated consumer societies in the advanced national economies of the world throughout the 20th century. From a technological standpoint too, powerful technological synergies are possible in combining AVs with electric automotive drivetrains, particularly in terms of refuelling since electrons are easier and safer to move and manage than hydrocarbons in a completely automated transport system. More importantly from a carbon emissions reduction point of view, the introduction of AVs, if mandated by regulators to have only electric drivetrains, would allow a seamless, rapid and total transition to independent vehicle e-mobility, assuming that the world fully embraces AVs on the basis of improving safety, reducing emissions and providing people with time that they would otherwise spend behind the wheel driving a conventional internal combustion engine (ICE) vehicle.

2.5. Electric Cars

The first electric cars were produced before the mass introduction of combustion engines in the late 19th century. The penultimate electro-mobile wave took place in the 1990s, when the California Environmental Protection Agency announced ZEV Zero–Emissions Vehicle (ZEV) initiative. The result was the development of several electric vehicles from Chrysler, Ford, GM, Honda, Nissan and Toyota. Developed cars were later withdrawn from the market (Høyer, 2008). The two most notable examples were lead acid battery EV1 by General Motors in the US in 1996 and Honda's EV Plus in 1997 which were introduced to allow these car companies to sell cars into the Californian car market. At that period in time, the Californian Air Resources Board required the production and sale of zero emissions vehicles which would result in credits that could offset the production of conventional vehicles and conversely, in the absence of zero emissions vehicles, a manufacturer would incur financial penalties. The Scheme was to eventually ramp up the share of zero emissions vehicles to reach 10 percent of vehicles by 2010, however, this provide to be too ambitious in terms of the technology, the scalability of production to those levels and the lack of market awareness and acceptance of EVs.

The latest wave of electric car development was launched in 2008 with the launch of Tesla Roadster (4 years of development). Further development of electric vehicles now includes common brands such as Volkswagen, Hyundai, Nissan began. The European Commission and individual Member States are now pushing for electric cars to become dominant by the mid-21st century. The Tesla Club, Association for Electro-mobility of the Europe and the Civil Electro-mobility Association have already been established in many European countries, with these organisations host electro-mobility meetings at an international level.

2.6. Modal shift towards sharing-mobility

2.6.1. Importance of modal shift

Modal shift is defined as the shift from private cars to more sustainable modes of transport such as public transport, or walking and cycling (Graham-Rowe, Skippon, Gardner, & Abraham, 2011)Two types of modal shift can occur: one is long-term changes which are due to structural changes in a socio-economic profile, physical built environments or the transport supply system. This type of change takes time and can be referred as macro-dynamic effects. The second type is associated with temporary or instant changes such as changes in travel route or departure time, and these can be called micro-dynamic effects (Cherchi & Cirillo, 2014). In this section, we will focus on the first type: macro-dynamic effects.

Long-distance movers are affected not only by built environment qualities but also by city-wide transport and mobility attributes such as the general level of car-dependency or pedestrian/cyclist-friendliness (Klinger, 2017). Long-term changes in modal choice especially from car usage to low-carbon bus, cycling and walking are possible to some extent through either pull or push measures or a combination of both. Push measures are those which restrict traveller's opportunities, while Pull measures provide them with more options, including either improved choices or freshly created choices (Steg, 2007).

Pull measures generally encourage non-car alternatives such as making changes in transport infrastructure and facilities (e.g. establishing new public transit routes and vehicles; improving of walking and cycling networks); land use planning (e.g. bringing workplaces closer to residential zones, enhancing the quality of built environment for non-motorised transport and improving accessibility to facilities for residents). By contrast, push measures are those actions (largely economic), which render car travel either harder or more expensive (Eriksson, Garvill, & Nordlund, 2008). Examples include: vehicle taxation; fuel taxation; congestion charging and road pricing schemes (Sammer & Saleh, 2009). Some cities have adopted restriction of/auctioning license plates; removal of car-oriented subsidies and organising distance-based car insurance schemes to discourage car ownership and usage; integrating transport and land use master plans; promoting car-free city zones and low emission areas; and parking management. Pull measures are more likely to be advocated by the public than push measures (Eriksson, Garvill, & Nordlund, 2006). However, it is worth noting that the combination of both 'push and pull' measures is significant as a transport demand management approach (Creutzig, Mühlhoff, & Römer, 2012; Sammer & Saleh, 2009)

Drivers of individual modal shift have been discussed in different disciplines included sociology, psychology and transport planning. The utility of a mode is a function of cost, value for money, punctuality and reliability, frequency of the mode, comfort/cleanliness, travel time, and any facilities attached to a mode. Understanding the factors likely to motivate behaviour change is of crucial importance (Consultancy, 2005). Previous studies can be divided into three groups based identifying the main drivers of modal change: a) relocations of job or housing place; b) changes in transport infrastructure and physical (built) environment; and c) changes in personal/family characteristics or his/her attitudes/habits.

2.6.2. Causes of modal shift

The relocation of workplace or residence is one of major causes of modal shift (Oakil, Ettema, Arentze, & Timmermans, 2011). There are several examples showing this: for instance, about 18 percent of commuters in the UK changed their commuting mode between years (Dargay & Hanly, 2007). This figure was 28 percent for those who moved house, 33 percent for those that had a workplace change and 45 percent for those that relocated residence and workplace both. According to a study by Chatterjee et al. (2016), changes in commuter modal choices over a three month period were affected by job-related characteristics, access to mobility resources, satisfaction with current commuting, awareness of sustainable transport measures and changed life circumstances. A qualitative survey of a limited number of residents in Richmond, London who had made a shift towards walking/cycling/public transit within one year showed that influential factors driving modal shift included both negative and positives aspects. Positive aspects are exercise and health benefits and spending time with family members, while negative aspects were stress and the cost of using existing modes. Some factors such as the familiarity with the current modes, and the logistics of shifting to new modes emerged as barriers to change. Moving to a new house and retirement were two major factors affecting modal choice as stated by interviewees (Transport for London, 2014).

Clark et al. (2016) by using panel data from the UK Household Longitudinal Study on commuting modes found that about one fifth of workers have changed their commuting mode from one year to the next. The modal shift is more likely where journey to work distance changed dramatically especially in cases of job or home displacement (Oakil et al., 2011). In the longitudinal study using a panel model of 200 participants in Utrecht to indicate influential factors of modal shift to and from cars, Oakil's research team found that job change was one of important factors leading to modal shift. A similar finding emerged (but with the focus on modal shift associated with residential change), in a study of 295 respondents in Halifax used with a retrospective survey using a random parameters logit model (RPL) that clearly identified the modal shift of those who had relocated their house. Over half (57.09 percent) of surveyed participants stated that they switched to new travel modes along with their residential change. It is consistent with the fact that residential displacement leads to changes in the built environment which motivates people's use of public and active transport, thereby decreasing their car usage (Cao, Mokhtarian, & Handy, 2009). Using a structural equation modelling for analysing household survey data of ten areas within Cologne, Scheiner and Holz-Rau (2013) concluded that residential relocation and the changes in respondents' socio-demographic profile as well as the built environment significantly affected the travel behaviour of people particularly modal change. Most recently, Klinger and Lanzendorf (2016) explored changes towards car use, rail-based transit and bicycle participation of 1,450 sampled respondents who changed their residential locations in five German cities. The findings of this study revealed that the changes of the modal choice of surveyed respondents were for car use, rail-based transit and bicycle participation. Most importantly, a clear association between the mobility cultures of each city defined as 'travel-related socio-physical context' and the likely shift of people towards three travel modes was clearly justified. Furthermore, pro-environmental attitude leads to shifting from motorised transport to more environment-friendly modes. Moreover, the provision of reliable and efficient public transit or provision of daily necessities close to home would encourage switching away from car usage.

The modal shift of people as a result of the operation of new transport infrastructure has been widely discussed among transport researchers. Babakan et al. (2015) study on the simulation of modal shift after adding a highway and a new BRT line in Tehran (Iran) showed that the new highway led to an increase in private car use in commuting of households while adding a BRT line changed their commuting mode from the private car to public transit. However, these changes are more evident among households with low incomes without a private car. By contrast, households with high incomes and higher rates of car ownership were less likely to change their commuting mode from the private car to BRT.

Heinen et al. (2015) studied the commuting behaviour of 470 employees in Cambridge after establishing a guided busway with a designated walking/cycling route in 2011, which showed that although net changes in modal transition were minor, the new infrastructure promoted an increase in the share of commuting trips involving active travel and a decrease in the share made entirely by car (the usage of public transit remained constant). In relation to new tram services, studies of Pradono et al. (2015), and Termida et al. (2016) revealed individuals' preferences of shifting away from car to tram transit. Most recently, a study about the likely modal shift of car users to trams from a new city tramline extension in Adelaide concluded that more than 60% of sampled respondents would switch to the new tram service (Nguyen & Allan, 2017).

The cross-sectional study by Heinen et al. (2017) in Cambridge made an in-depth exploration of travel behaviour change in five categories: (1) no changes; (2) a complete modal shift; (3) a partial modal shift; (4) non-stable; and (5) random patterns. The study found no specific evidence that introduction of changes in physical environment was correlated with definite modal shifts, or with fitting in with any of the categories of change patterns.

Panter et al. (2013) by selecting 655 commuters in Cambridge, UK asked them to report their personal and household information, psychological audits relating to car usage and environmental settings on the way to workplace. They then tested for any statistically significant association between these characteristics and their willing to change their mode of commuting by applying multivariate logistic regression. The results showed that a combination of practices in parallel would be effective in switching from car use to non-motorised and public transport. These include improving the quality of cycling routes and walking paths in addition to making restrictions on workplace parking. On the other hand, Goodman et al. (2014) found that the intervention in the built environment had not had a significant effect after one year, but after two years, exposure to the intervention predicted changes in travel behaviour. Therefore, future studies collecting follow-up data for a longer period after the intervention may result in additional insights.

As noted by Oakil et al. (2011), mode change is significantly associated with changes in family status. The authors emphasized that households with new born baby are likely to shift to car usage as the needs of baby-related maintenance activities arise such as regular health check, kindergarten, or playgrounds. This is also confirmed by study of Lanzendorf (2010), who conducted qualitative retrospective interviews with 20 young parents of small children in Leipzig (Germany). In this regard, almost all sampled mothers stated that the private car was preferred because of increased convenience. However, the authors also acknowledged other attributes that determined the shift towards other modes of transport among sampled mothers as their maternal leave, income reduction, biographic reasons after the birth, and their 'strong emotional ties' to other transportation options.

Redman et al. (2013) using a qualitative systematic review, concluded that while public transport service frequency and reliability are crucial, the features that are most influential in car usage are mostly linked with personal perceptions, background and inspirations. Webb, Netuveli, and Millett (2012) concluded that the introduction of a free bus travel for senior adults on the weekends in Victoria, Australia had dramatically increased the modal share of public transit and received positive feedback from customers. In a similar experience in Austin, Texas, USA, the offering of free public transit service resulted in a 75% increase in ridership. However, it is argued that attributes such as comfort and safety has a greater impact on shifting modal share than offering free travel(Perone & Volinski, 2003). Thøgersen (2006) analysed the impact of free public transit pass card for those who had moved either their work or home place during the past three months, and the results confirmed that public transit usage increased significantly. In fact, the impacts of relocation on changing commuting patterns become more apparent if such incentives are offered after relocation.

In fact, although decreasing (or removing) fare price may encourage and give support to intentions to take public transit, other reliability and quality features will determine whether such intentions are implemented and maintained (Perone & Volinski, 2003). Furthermore, any fare reduction incentives or habit-interrupting policies will be successful in the longer-term if other quality attributes of public transport are being sustained for the target market(Redman et al., 2013).

Some modes of travel such as walking and cycling complement other modes, because they act as access and egress modes. Therefore, it is expected that a car user who infrequently cycles may be expected to shift to public transport than someone who just uses the car (Perone & Volinski, 2003).The study by Ramadurai and Srinivasan (2006) proved an inherent rigidity (inertia) among people to shift their mode of travel. This effect was especially solid for those used to cycling or walking. Furthermore, a transitional state-dependence was observed between public transport and car usage. In fact, those who used a car for the previous trip were less likely to select public transport or a cycle. Similarly, those who selected a bicycle in the former trip are more likely to choose walking among the set of alternatives within the present journey. Diana and Mokhtarian (2009) noted that single-mode travellers generally have dissimilar expectations and attitudes toward different choices than multi-modal travellers. For instance, car drivers normally have biased judgments toward the cost and time imposed by public transport. According to Diana (2010), multi-modal travel habits affects modal switching. In fact, those who are aware of multiple choices are more likely to have modal shift.

Kenyon and Lyons (2003) studied the potential contribution of information to modal change and showed that information can play significant roles in modal change cycle. It is recommended providing travellers with the information about 'softer' alternatives, such as convenience and comfort, in addition to the usual aspects of journeys that included cost and travel time. According to Idris et al. (2015) car drivers stated that on average they used a car for 87.4% of their non-commute activities (73.6% as car driver and 13.7% as car passenger), in comparison with only 3.8% who used public transport and

9.3% that used walking/cycling options. This level of strong habit formation towards car driving makes it hard to change the mode they are already habituated to. The study concluded that while improving transit service performance is crucial to surge modal shift, transport planning policies should also emphasis breaking the strong habits linked with the car.

2.6.3. The impacts of sharing-mobility on modal shift

In recent years, the emergence of new transportation modes, especially shared mobility options highlight the potential of these new mobility trends to shift people away from motorised transport. Fishman et al. (2014) compared the shift from cars to shared bikes in five different cities of the US, UK and Australia and found that bike share programs brought positive influences in the reduction of motor vehicles use in Melbourne, and Minneapolis where private cars are the dominant mode of transport. By contrast, an opposite trend was revealed in case of Washington D.C. and London where the car substitution rates were quite low (at 2% and 7% respectively), which is in line with the low car usage in these cities. The authors concluded that the modal shift from car to bikeshare was higher in cities with greater car usage. Sharing the same objectives, research by Shaheen et al. (2013) also noted the benefits of bike sharing in switching people from car usage in Toronto. This is consistent with the research results of Fuller, Gauvin, Kestens, Daniel (2013), who stated that the percentage of car users that shifted to the new Montreal's BIXI bike sharing program ranged from 7.9 percent to 10.1 percent between 2009 and 2010. A later study of Shaheen and Martin (2015) confirmed the potential of shared bike schemes in shifting people in North American cities away from private cars. Therefore, bike share schemes could be utilised as an effective alternative travel option of motorised transport.

Chapter 3: International and Local Data on Sharing-mobility

3.1. Introduction

Shared mobility schemes have attracted the consideration of scholars in various fields including urban and regional planning, transport and traffic engineering, sociology and psychology, and marketing and business. A large bulk of the existing research to date is about shared mobility systems based on Revealed Preference (RP) data from survey research in North America, Europe and Asia, whilst empirical studies on shared mobility schemes in Australian cities are limited. Reviews are provided by Meijkamp (1998), Katzev (2003), Litman (2000), Shaheen et al.(2006,2009) , Barth et al. (2007), Shaheen and Cohen (2007) and Shaheen and Cohen (2013a).

Whilst the modern car sharing idea was introduced in the 1990's, its history dates back to the middle of the twentieth century. The first car sharing scheme developed in Switzerland in 1946 included a small car share arrangement in a housing cooperative company based in Zurich. A sharing scheme called White Bikes later started in Amsterdam in 1965. The idea was developed by a young anarchist group struggling against car usage. With White Bikes, riders at the conclusion of their ride would leave the bike unlocked anywhere for other riders to use. The extraordinary and rapid advances GPS and smartphone technology within last two decades has had a significant impact on the sharing mobility market.

This chapter reviews sources of secondary data on sharing-mobility schemes from different countries and regions. It also includes a detailed comparison of two internally well-known bikesharing systems of Chicago and Budapest as exemplars of successful bikeshare schemes. The second section is a description of data examining shared mobility in Adelaide, which has in the past few years become joined the growing ranks of cities that have either consciously implemented shared mobility schemes or experienced opportunistic share mobility companies start up schemes ahead of the authorities or regulators approving or controlling their implementation and operation.

3.2. International data for bike-sharing

The distribution of shared-bike companies across the five continents shows that America (36 percent) and Europe (35 percent) have the highest share followed by Asia (26 percent). The share of Australia (2 percent) and Africa (1 percent) is negligible. Furthermore, USA (21); China (16); France (8); Hungry (5) and Great Britain (5) are the top five countries around the world in establishing bike-sharing companies. The trend of establishing bike-sharing companies around the world (1998-2015) shows an interesting fluctuation with a dramatic growth in 2011. While the industry started growing from 1998, a significant increase occurred after 2005 (Mátrai & Tóth, 2016)

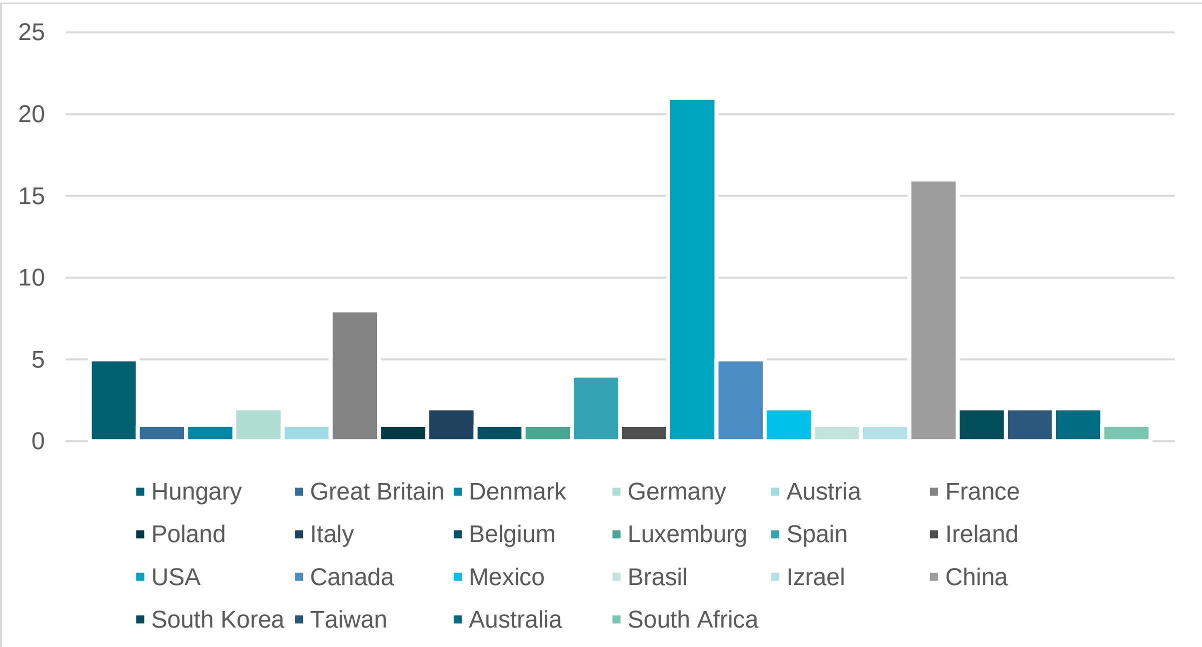


Figure 3- 3 Distribution of shared-bike companies across the countries (Mátrai & Tóth, 2016)

The distribution of number of shared-bike companies against city size shows that interestingly the medium-sized cities with a population between 1 and 5 million had experienced the highest rate of shared-bike companies.

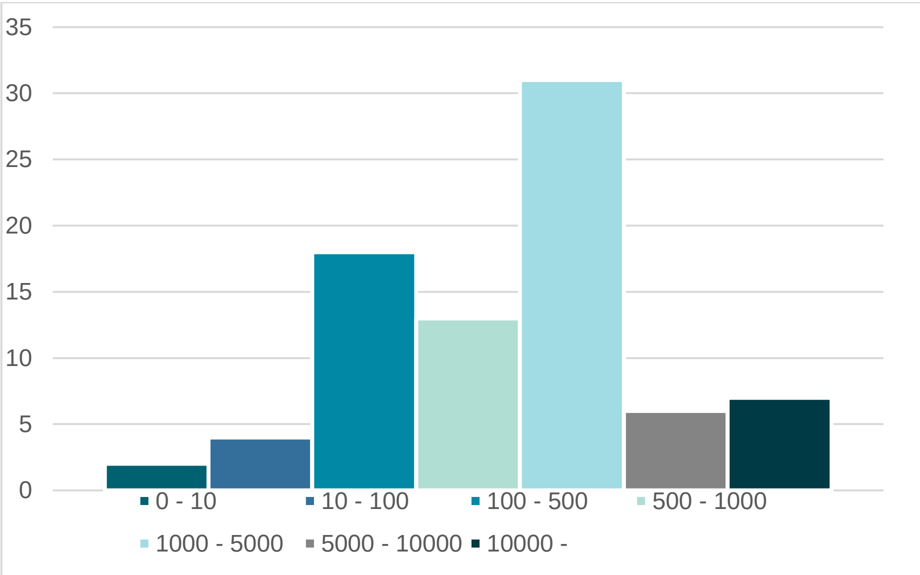
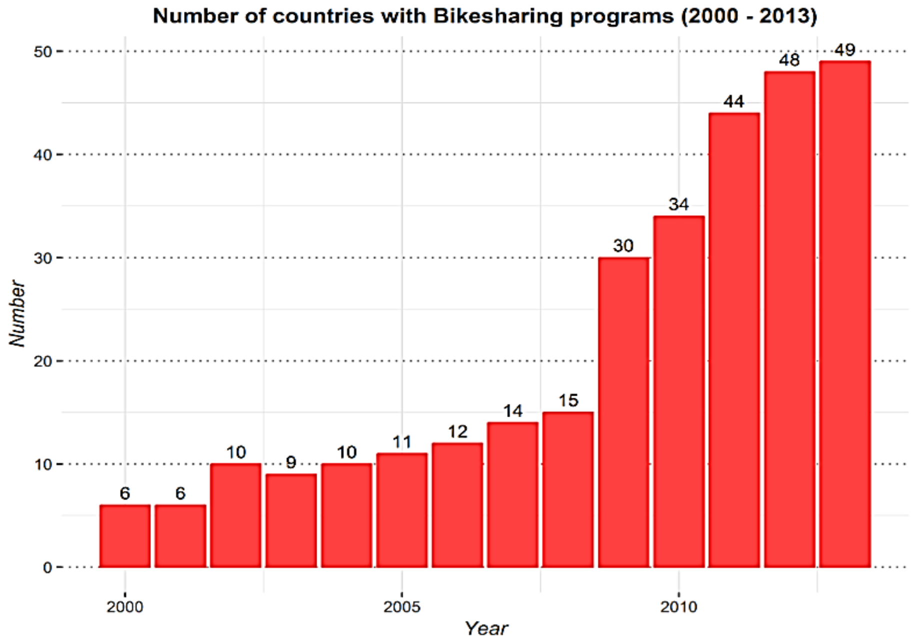


Figure 3-4 City population and number of shared-bike companies (Mátrai & Tóth, 2016)

Since its emergence from the 1960s, bikesharing programs (BSPs) have developed into a global phenomenon. According to Figure 3- 5, the number of cities with BSPs increased gradually from 2000 to 2008 before reaching a new peak of 49 countries in 2013. In this regard, it was evident that Europe was the leading region in the number of BSPs, followed by Asia and Pacific. Lower numbers of BSPs were recorded in other continents, including North America, Latin America, and Middle East.



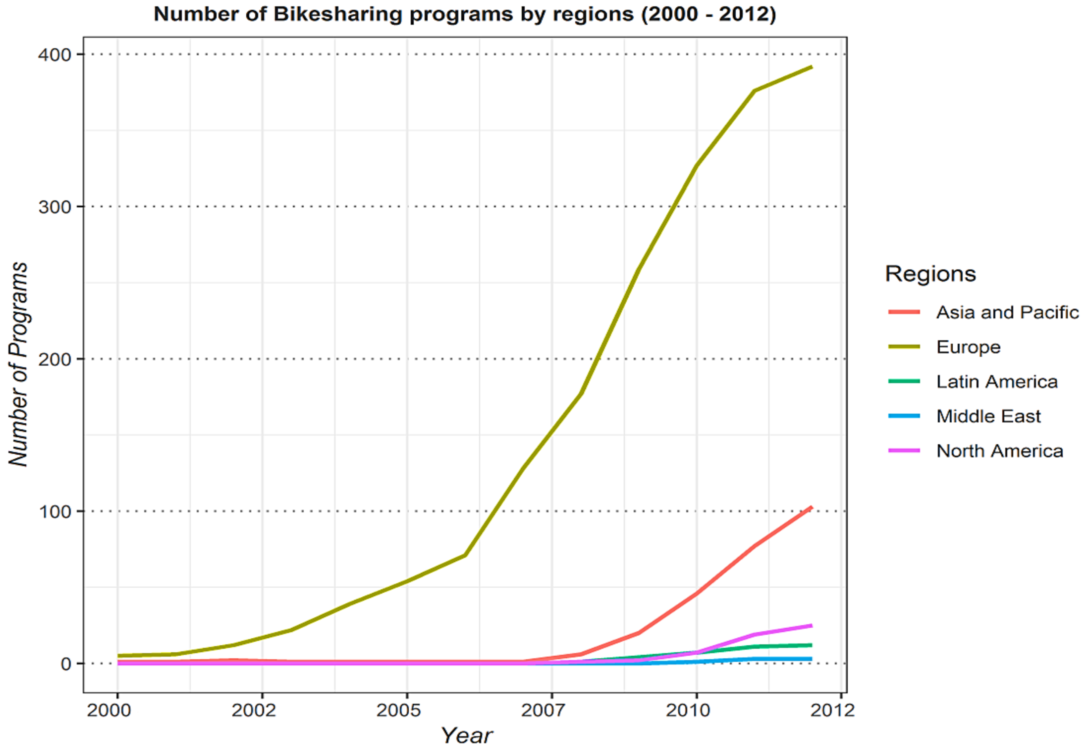


Figure 3- 5 A) Statistics on the numbers of Bikesharing programs worldwide; B) Number of BSPs by regions from 2000 to 2012 (Larsen, 2013)

These above-mentioned figures were strongly linked to the statistics of the countries with the highest number of BSPs in 2012. Four out of five leading nations were in the Europe, including the world number one, Spain (132 programs), followed by Italy (104 programs) and other two were Germany and France (43 and 37 programs respectively). China, the Asian leader, was World no.3 for BSPs, with 79 different BSPs (Figure 3- 6).

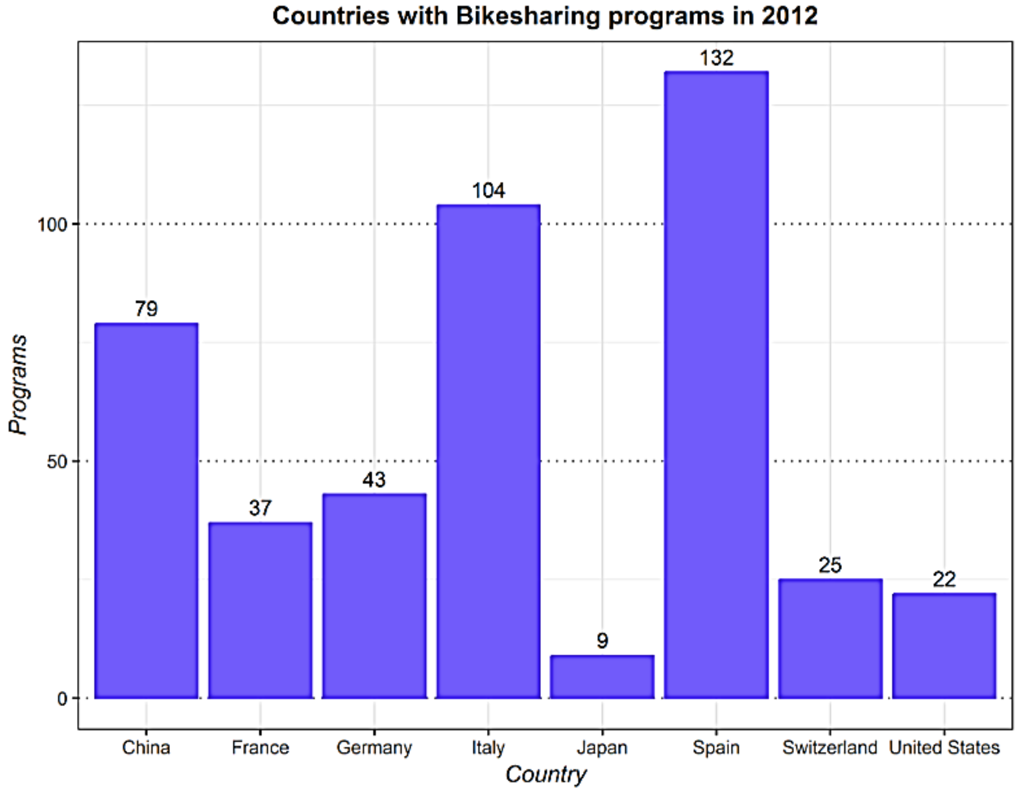
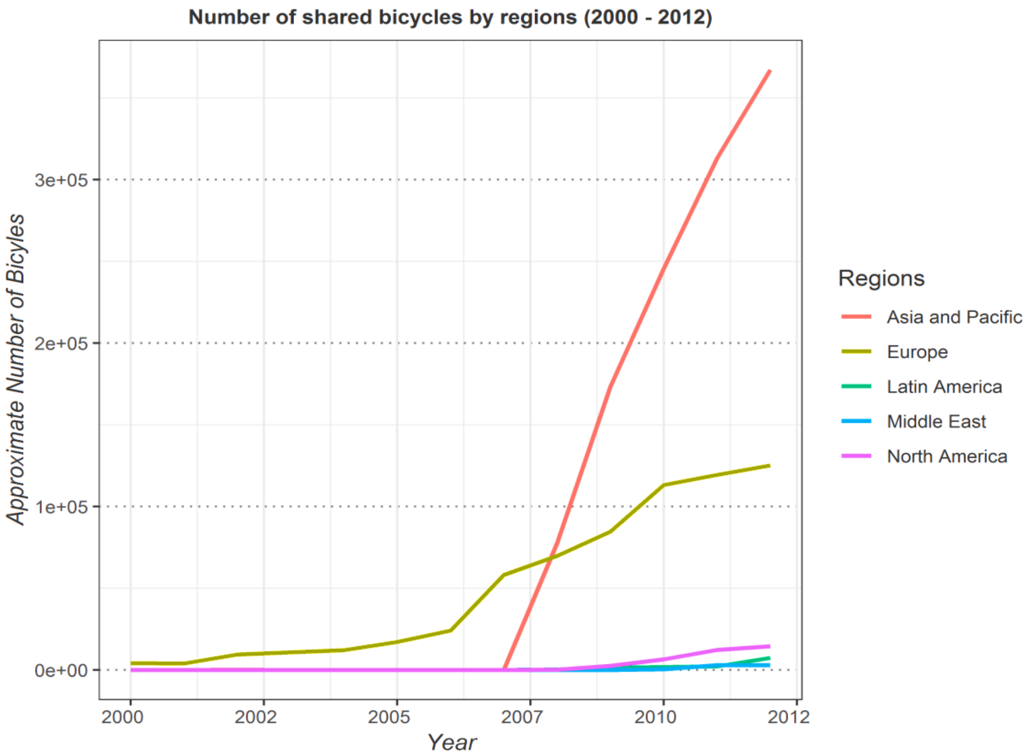


Figure 3- 6 Top countries with BSPs in 2012 (EPI, 2013)

It is interesting to note that Europe was not listed as the world largest bike-sharing fleet in the period of 12 years from 2000 to 2012. This phenomenon had its modern genesis in Asia and the Pacific, with more than 367,000 bicycles in 2012, three times higher than European counterparts. Meanwhile, there were negligible recorded numbers of shared bikes in other continents such as Latin America, Middle East and North America (Figure 3- 7). Undoubtedly, China eclipsed other countries with the highest bikeshare fleet, with over 351,000 bicycles in 2012, followed by four other European nations. Research into the reasons for this phenomenon emerging out of China are poorly explored in contemporary research, however, it may reflect China's traditional affinity with the bicycle as a dominant mode of transport in its cities prior to motorisation and its economy opening up to the world. The growing entrepreneurial spirit emerging in China in recent times, together with a large urban domestic market requiring cheap, affordable transport and a protected digital eco-system created the preconditions for shared bicycles to expand into the phenomenon that they have currently become.



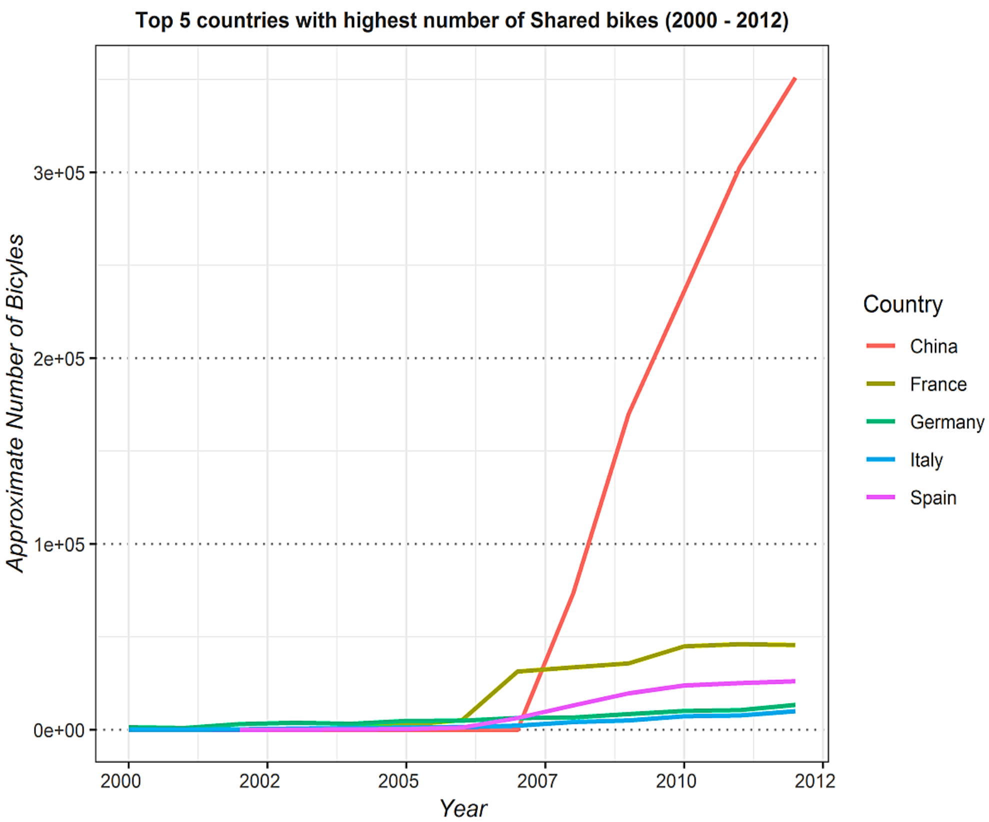


Figure 3- 7 A) Number of shared bikes by regions from 2000 to 2012; B) World leading nations of bikeshare ownership between 2000 and 2012 (Larsen, 2013)

Although ranked highest in the number of BSPs, Europe was not listed as having the world largest bikesharing fleets in the period of 12 years from 2000 to 2012 (Figure 3- 7). As such, Asia and the Pacific ranked more highly with more than 367,000 bicycles in 2012, three times higher than its European counterpart. As noted by S. A. Shaheen, Zhang, Martin, and Guzman (2011), Asia came behind in the investment in BSPs, this is still the fastest growing market for this type of sharing mobility. Indeed, shared bikes in Asia and the Pacific witnessed a sharp uptake from the late 2006 to 2012. Most of the BSPs have presented in East Asia with the dominance of bikeshare schemes in China (Midgley, 2011). Meanwhile, there were negligible recorded numbers of shared bikes in other continents such as Latin America, the Middle East and North America.

Undoubtedly, China was the country with the largest bikeshare fleets, with over 351,000 bicycles in 2012, followed by four other European nations (Figure 3- 7). This could be seen as the result of a large-scale BSPs that have been implemented across China since 2008 (S. A. Shaheen et al., 2011). The development of station-based bikeshare (or docked bikeshare), and then the replacement of dockless bikeshare has contributed to the large number of bikeshare in China (Gu, Kim, & Currie, 2019). France, Germany, Italy and Spain trailed China in the list of world leading bikeshare fleets but the order of these nations changed. France (45,650 bicycles) had the highest bikeshare ownership in the Europe, followed by Spain (26,210), whilst bikeshare in Germany and Italy were half that of Spain (13,440 and 10,030 bicycles respectively).

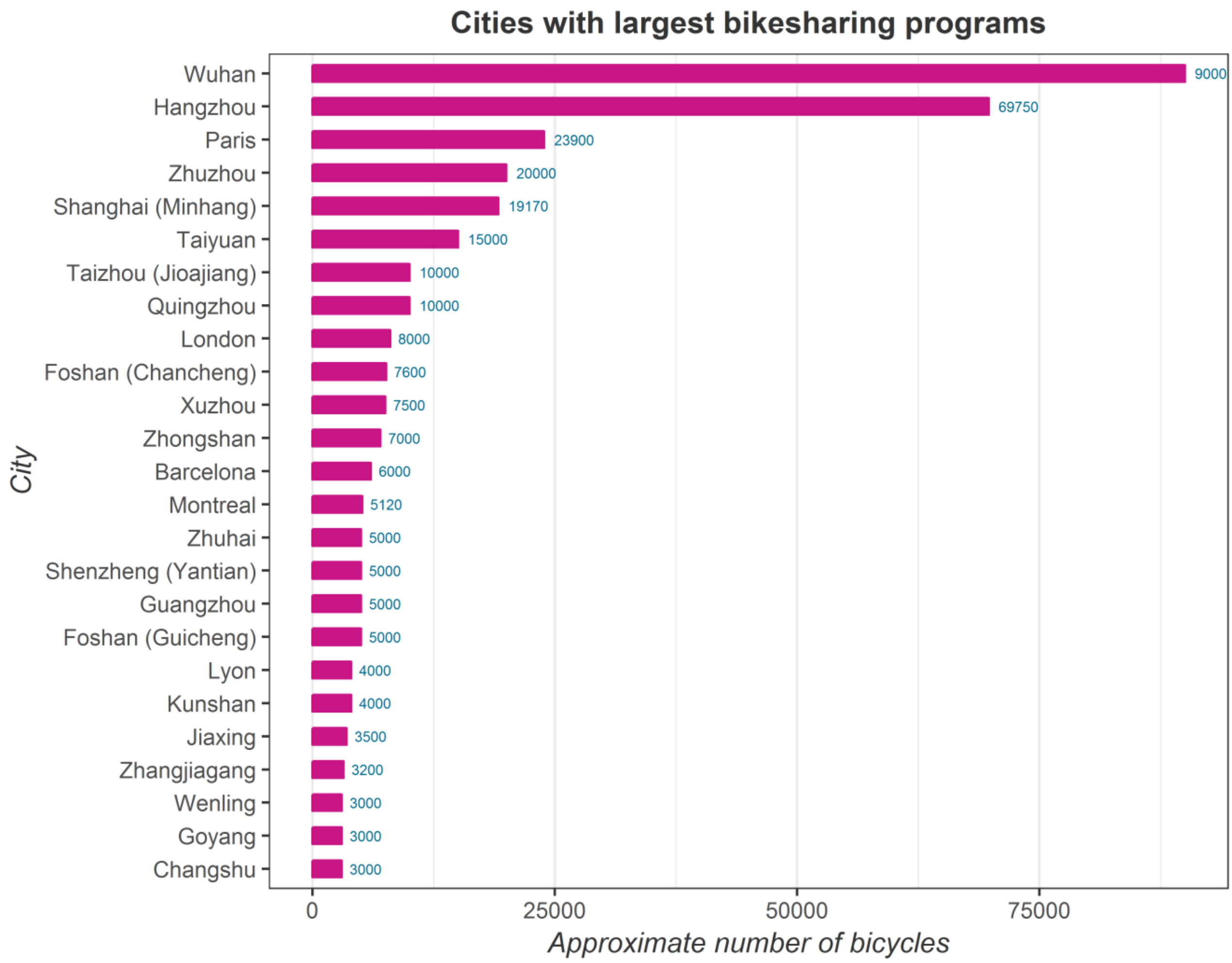


Figure 3- 8. Cities with largest bikesharing programs in early 2013

As illustrated on Figure 3- 8 Asian cities (80 percent) dominated the statistics for the largest BSPs in early 2013. Of these Asian cities, only one city was outside China (Goyang, Korea), highlighting the impressive dominance of China in the Asian bikesharing market. With 90,000 bikeshare ownership, Wuhan city had the largest

BSPs in the world, followed by Hangzhou with roughly 70,000 shared bicycles. Four European cities were notable for bikeshare, including Paris, London, Barcelona, and Lyon, however, in the case of North America, Montreal was the only city with significant BSP.

3.2.1. The Case of London (Cycle Hire)

The London Cycle Hire scheme is the local name for the bicycle sharing system that was launched in London in July 2010. The scheme operates 24 hours a day, 365 days a year, and initially comprised of 5000 bicycles located across 315 docking stations in central London. Following an eastern extension in March 2012, the scheme grew to comprise 8000 bicycles at 571 docking stations. Users could either register online for an access key (registered users) or pay by credit or debit card at docking stations (casual users). Users initially pay for access to hire bicycles (prices in 2020-11 were for £1 for 1-day access, £5 for 7-day access or £45 for annual access). After paying the access fee, trips of under 30 minutes were free but longer trips incurred additional usage charges at a progressively faster rate. Users had to be 18 years old or over to register and 14 years old or over to use the bicycles.

The level of bike-sharing usage from 2010 to 2012 increased dramatically from 2 million to nearly 10 million trips. However, since 2012, the rate of usage has plateaued at a rate of 10 million trips.

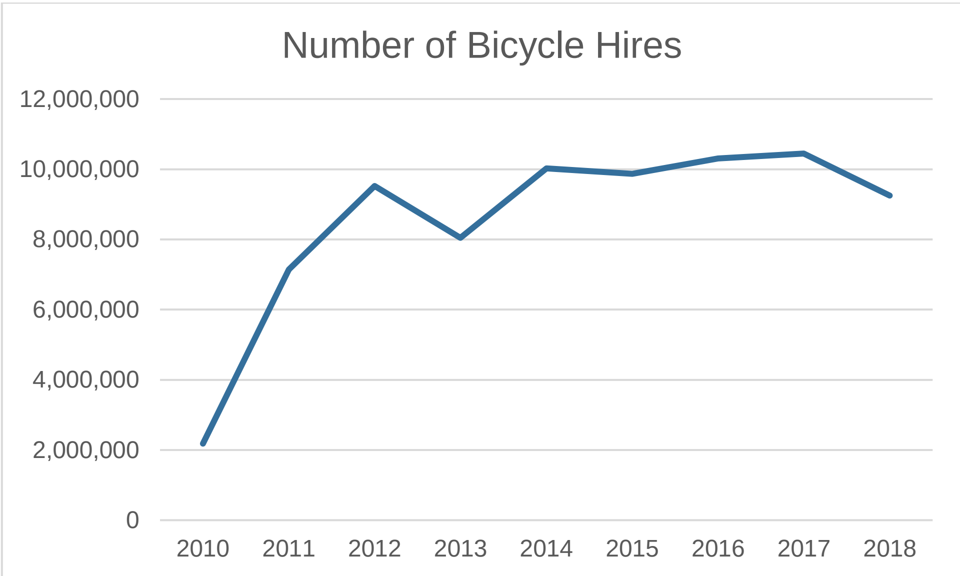


Figure 3- 9 Number of bicycle hires, London from 2010 to 2018

The fluctuations in hiring rates over the year (see figure 3-8) demonstrates the effects of seasonal weather changes where cold wet winters dampen demand by more than 50 percent, particularly amongst recreational users. The average hiring time was about 20 minutes. On average London bike hiring has had a 0.47 percent increase from 2010 to 2018. The numbers of bicycle hires for different seasons show that June was the best season for bike hiring while the winter months of December, January and February were the months with lowest levels of bike hiring. On average, approximately 800,000 bikes were hired by cyclists in London in each month.

Furthermore, cycle hiring on weekdays was twice as popular as on weekends, and Tuesday followed by Monday were the two days with highest frequency of cycle hiring. The encouraging finding is that the higher rates of bicycle hiring on weekdays (when compared to weekends), suggests that weekday commuter based cycling could conservatively account for a third of bike hires which provides a strong baseline commitment to frequent regular cycling. Recreational cycling might be infrequent and enjoyed for its novelty value, but over the longer term, the strategic value of recreational users is that they may be inspired to modify their lifestyle to eventually incorporate cycling.

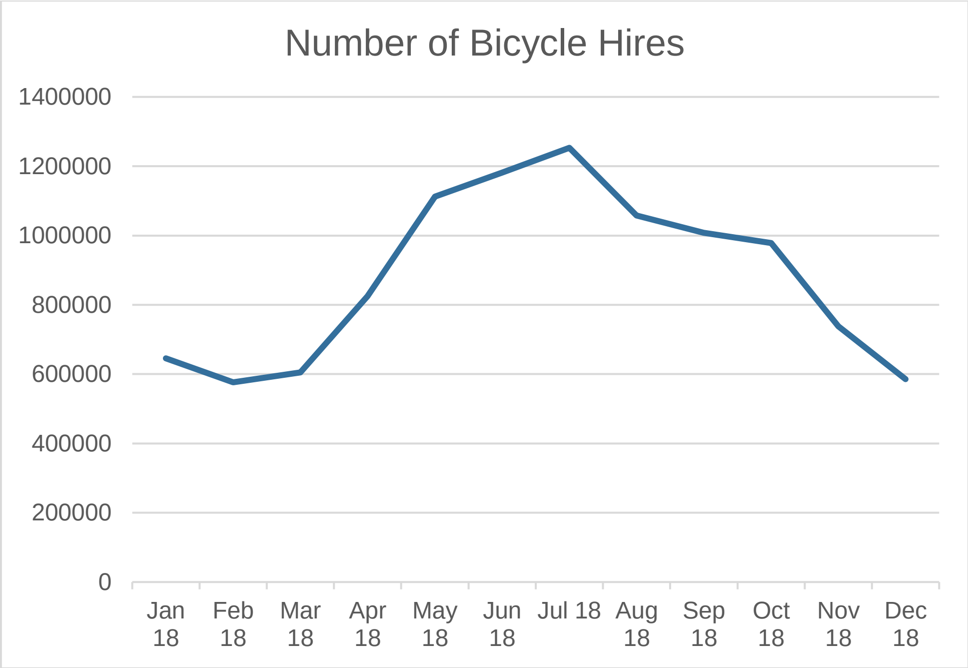


Figure 3- 10 Number of Bicycle Hires, Seasonal change, London, Jan to Dec 2018

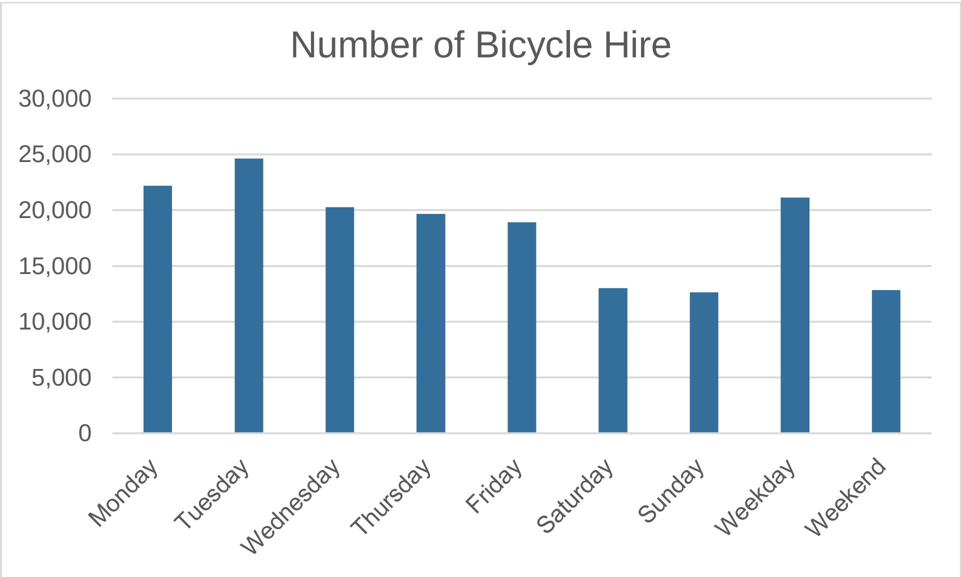


Figure 3- 11 Number of Bicycle Hires, daily change, London, Dec 2018

3.2.2. The Case of Chicago (Divvy)

The City of Chicago has a successful story in running its bike-sharing program, called Divvy. Chicago covers an area of 60,0km2 and sits 176 metres above sea level, on the southwestern shore of Lake Michigan. The city is traversed by the Chicago and Calumet Rivers. Chicago's extensive parklands (about 3,000 hectares) attract an estimated 86 million visitors annually. Chicago is also recognized across the United States as a very passionate sports town.

Divvy is a BSS in the City of Chicago and two adjacent suburbs, operated by Motivate for the Chicago Department of Transportation. The name "Divvy" is a playful reference to sharing ("divvy it up"). Divvy's light-blue colour palette and four stars evoke Chicago's flag.

Currently, using a bike for a single trip costs $3, while if the user takes it for a day, the price will be $15. The fare for annual membership is $99. The first 30 minutes of each ride are included in the membership or pass price. However, if the user keeps a bike out of any docking station for longer, extra fees are applied. The payment is by credit card, and no up-front payment is required to rent a bike.

Once a user joins the system for the first time, the actual use of the bicycle is pretty straightforward: after paying the fees as a new customer, he/she gets a ride code or can use the member key to unlock the bike. Users are allowed to use the vehicle for as many short rides they want, within the time window they have paid for. The bicycle can be dropped off in any Divvy station with empty racks; the system map, displayed on the Divvy app, shows in real-time the station locations, with the available bikes and racks for each of them. The service provider expects the users to respect and obey any common rule of the road, such as ride with vehicular traffic while keeping the safe distance, obey traffic signals, stay away from sidewalks and give way to people walking.

3.2.3. The Case of Budapest (MOL Bubi)

Budapest has a population of 1.75 million inhabitants; around 3 million citizens live within this agglomeration, and around 800,000 people commute to Budapest on a daily basis. Budapest is the political, cultural and commercial centre of the country, and the city is popular tourist destination. It is situated on the two sides of the Danube River, covering an area of 525 square kilometres. One side of the city is flat and easy to cycle, while the other side is hilly.

MOL Bubi is the public bike sharing system of Budapest owned by the city. The name MOL originates from the sponsoring Hungarian petrol company, while Bubi refers to "Budapest Bike". It was launched in 2014 as a new form of public transport solution. The main objective at the time was to encourage more and more passengers to opt for cycling when reaching their destinations within a short distance in Budapest. The system was not designed to provide an alternative solution for mass public transport, but rather to provide an extension to it.

The MOL Bubi system guaranteed access for bikes via different tickets and passes, which were valid from 24 hours for $US 2.5 to 365 days for $US 58. Three short-time access alternatives (tickets) to the system – 24 hours, 72 hours or 7 days – were offered. When buying a ticket, a deposit of $US 120 per bike would be held in the hirer's bank account. Tickets could be purchased by bankcard from the touchscreen terminals at the docking stations, or alternatively on the molbubi.bkk.hu website, or via the mobile application.

The MOL Bubi passes provided long-time access options (3 months, 6 months or 12 months) to the shared system. A pass could be purchased at any Budapesti Közlekedési Központ (BKK) customer service centre, on the website, or via the mobile app. Although it did not require a deposit, after the purchase, the hirer would need to visit a customer service centre in person in order to finalize their hiring.

For hirers in possession of a valid ticket or pass, the system could be used free of charge for up to 30 minutes per trip. If the bike was not parked in any docking station by the end of the 30 minutes, additional usage fees were applied, with a progressive increase according to the actual minutes of usage.

Whilst one ticket unlocked one bike, a single user could buy up to four tickets at the same time: in this case, the deposit amount was charged for each bike. The same conditions applied to MOL Bubi passes, where up to four bikes connected to a registrant (i.e. purchased pass) can be used by four users at the same time.

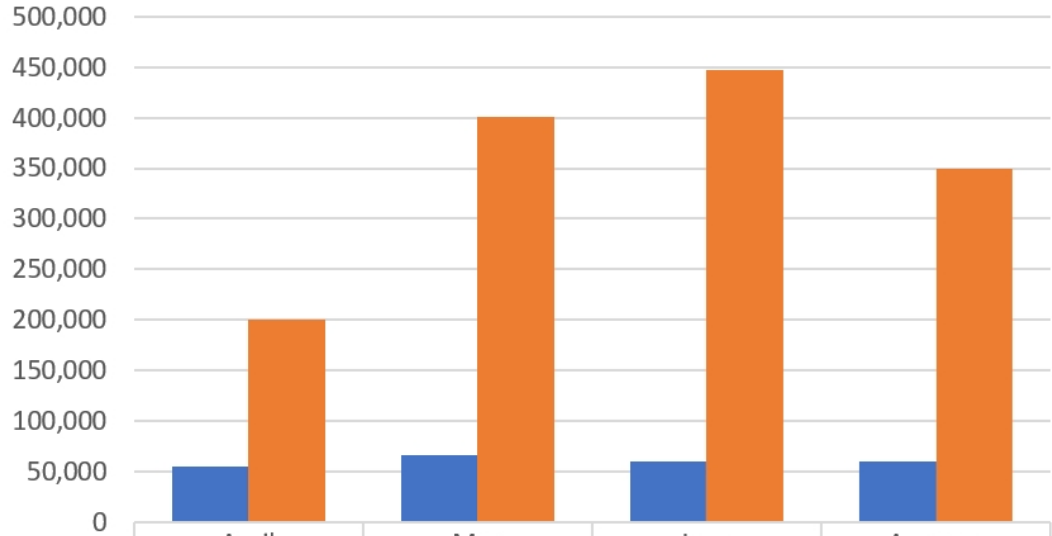
3.3. The Comparison of the two successful systems: Divvy versus MoL Bubi

Divvy owns 6,500 bikes registered for its sharing program, and data from 6,400 bikes were reported on its data file. The shared bicycles were distributed across 577 docking stations; on average, according to the collected travel behaviour data, each station had been used 605.7 times over one month, with an average riding time of 24.21 minutes.

The MOL Bubi system in November 2018 operated with 126 docking stations and roughly 1600 bikes. All stations were functional during the analysed 3-month period, which means that on average each station had been used

478 times in a month, with an average trip duration of 14.64 minutes. This proves that not only is Divvy a larger system, but also that is more utilized than MOL Bubi.

In both cities, most of the trips were undertaken during the weekdays (76.4 percent in Chicago, 74.1 percent in Budapest), while the remaining one-fourth of trips were undertaken on weekends. The start and end time of each ride shows that shared bikes were mainly used for social trips, and were less regularly used for commuting to work. Based on that, in both cities, the PM trips were two times more frequent than the AM trips.

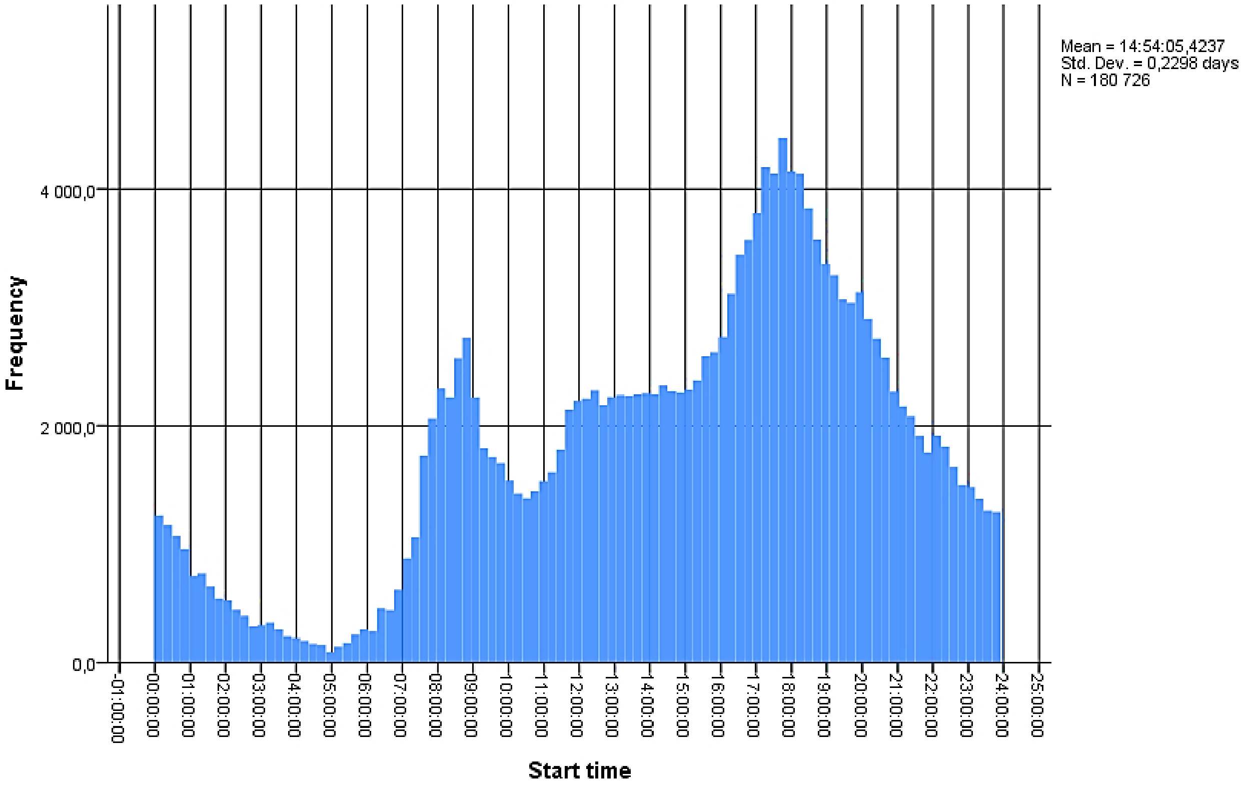


	April	May	June	Average
Budapest	54,557	66,403	59,766	60,242
Chicago	200,112	401,149	447,314	349,525

Figure 3- 12 Monthly distribution of trips [source:(BKK, 2018; DIVVY, 2018)]

According to Figure 3- 12, June was the most popular month for bike users in Chicago; the increasing trend from April to June, reflects improving and warming weather that is more conducive to cycling.

According to historical weather data, May and June have very similar meteorological conditions in Budapest. Moreover, the number of rentals declined in June, suggesting that in this city the main user group may be regular commuters.



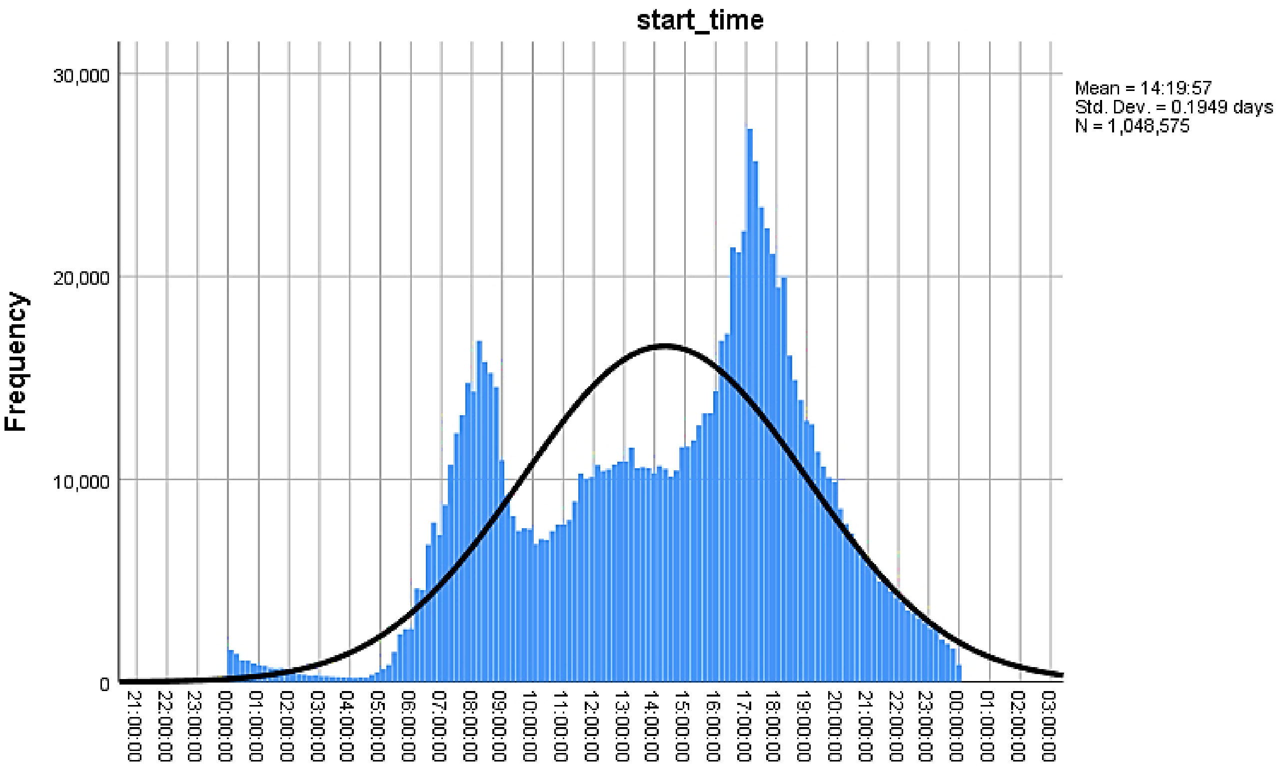


Figure 3- 13 Usage frequency of bike against start time for Budapest (upper graph) and Chicago (lower graph); source:(BKK, 2018; DIVVY, 2018))

In both cities, the start time distribution (Figure 3-13) showed an AM peak hour between 8:00-9:00 AM, probably associated with work purposes.

The afternoon peak was between 17:00 to 18:00 PM. However, the share of trips during the PM peak hour was about 1.5 times higher, showing the capacity of shared bicycles in servicing the afternoon and evening trip demands, mostly linked to social/recreation and exercise activities. Furthermore, the evening usage of the bikes was as high as the morning peak. This indicates that the main purpose of the trips could be associated with commuting as bike riders return home in the afternoon.

In the Divvy system, two types of usage are reported: subscribers, who already joined as a member (834,295); and customers (214,282), such as tourists or casual users without an interest in joining as a member. This implies that one-fifth of the users were non-subscribers.

The MOL Bubi database provides the registered user IDs in an anonymized way; 3,782 passes and 5,089 tickets were used in the selected period; 82 percent of the trips were purchased with a subscription. The average usage among ticket users declined over the 3-month period. On average, there were 5 trips per day using a 24h ticket, while there were only 1.9 trips per day with the weekly ticket.

In Chicago, the gender composition of BSS users corresponded to 20.9 percent females, 60.8 percent males and 18.3 percent not declaring their gender. Females prefer to be a subscriber rather than a casual user: over 42 percent of subscribers were female, although only 6 percent of the total customers were female.

In Budapest, as anticipated previously, the gender and age distributions for pass users could not be ascertained because this information was not compulsory. However, 1824 ticket users provided this information out of 3288.

It can be stated that the main age group for short-term bike sharing usage is between 19 and 39 years old in Budapest. In Chicago, the youngest bike customer was born 2003, and the average age of users was 34.5 year. The two main age groups using shared bikes amongst 50 percent of bike users were 25-29 years (27.7 percent) and 30-34 years (22.5 percent). The share of bike share use for 35-39 year users was 13.5 percent, and 10.8 percent for 20-24 years. Bike share usage was minimal for the age categories 17-19 years (1 percent) and those aged 70 years and over (1.3 percent).

With regard to the distribution of bike trips in Chicago across weekdays and weekends, Wednesdays had the highest frequency, followed by Thursdays. The lowest share was on Sundays, showing a globally lower demand for bikes during the weekends. However, this pattern can vary during the summer, as shown in Figure 3- 14. For example, in April 2018, Monday was the most popular day, while Saturday the least popular. In May 2018, Tuesday was the most popular day for bike users, whilst Sunday was the least popular. In June 2018, there was a relatively equal share for all week-days. This daily/monthly variation can be mainly explained by the variable summer weather conditions included rainfall, temperature, humidity, and wind. The distribution of bike trips across different days in Budapest shows an approximately equitable pattern. However, the weekends have a somewhat lower share, which again points out the fact that the BSS is mainly used by locals, possibly for commuting.

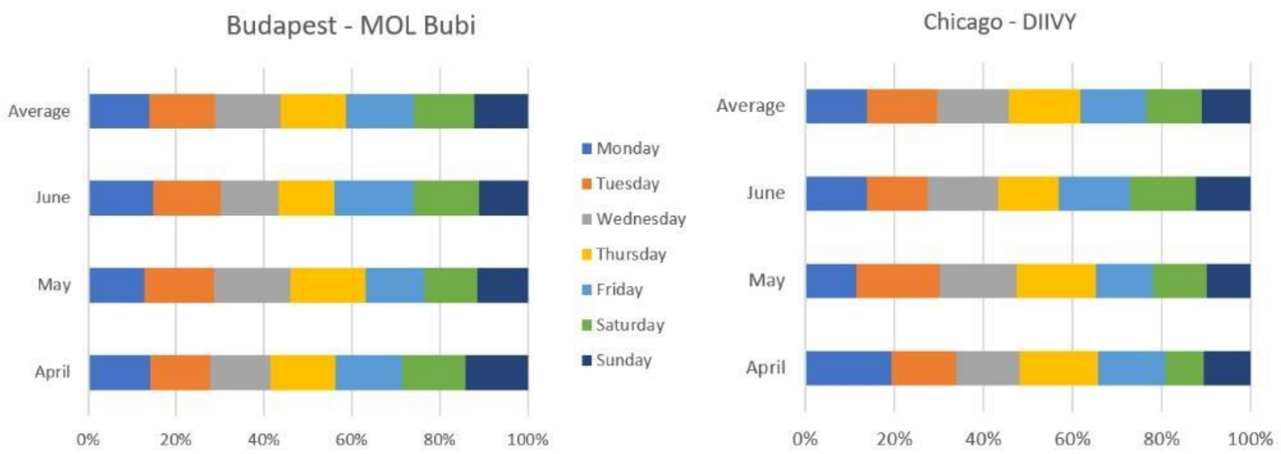


Figure 3- 14 Daily variation in shared bike usage; source: (BKK, 2018; DIVVY, 2018)

Figure 3- 14 illustrates that the highest shares of trips in both cities coincide basically with two time-windows: the PM peak (39 percent in Budapest, 34 percent in Chicago); and the Midday peak (30 percent in Budapest, 32 percent in Chicago). In both cases, the lowest share was in the early morning; however, data show that the MOL Bubi system was better integrated with the nightlife in Budapest, considering that more than 30 percent of trips were registered in this period of the day. Given that more than one bike can be rented by the same user at the same time in Budapest implies that the usage of BSS is a social activity (i.e. perhaps hired as for a family outing). In the analysed 3-month period, 27 percent of the trips were made with somebody else using the same account, 26 percent originated from the same station, while 22 percent had the same origin and destination.

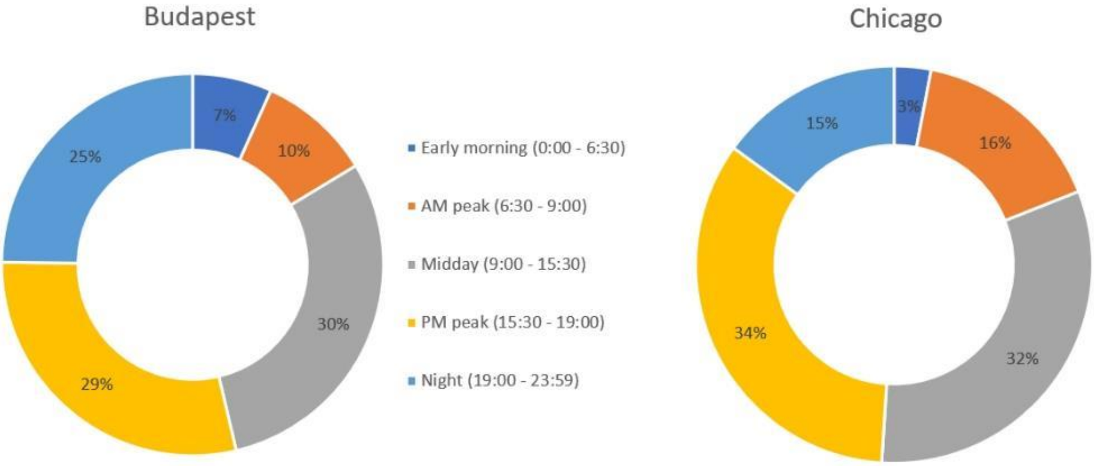


Figure 3- 15 Peak and off-peak variation in bike usage; source: (BKK, 2018; DIVVY, 2018)

Another interesting finding from the data is the geographical distribution of bike stations (depicted below) which highlights the most popular origin and destination locations. The 10 most popular localities for both origins and destinations have been reported in Table 3-1 and Table 3-2. These stations alone account for 12.8 percent of origins and 12.4 percent of destinations and are critically important in the trip generation of BSS users because of their proximity to major trip generators.

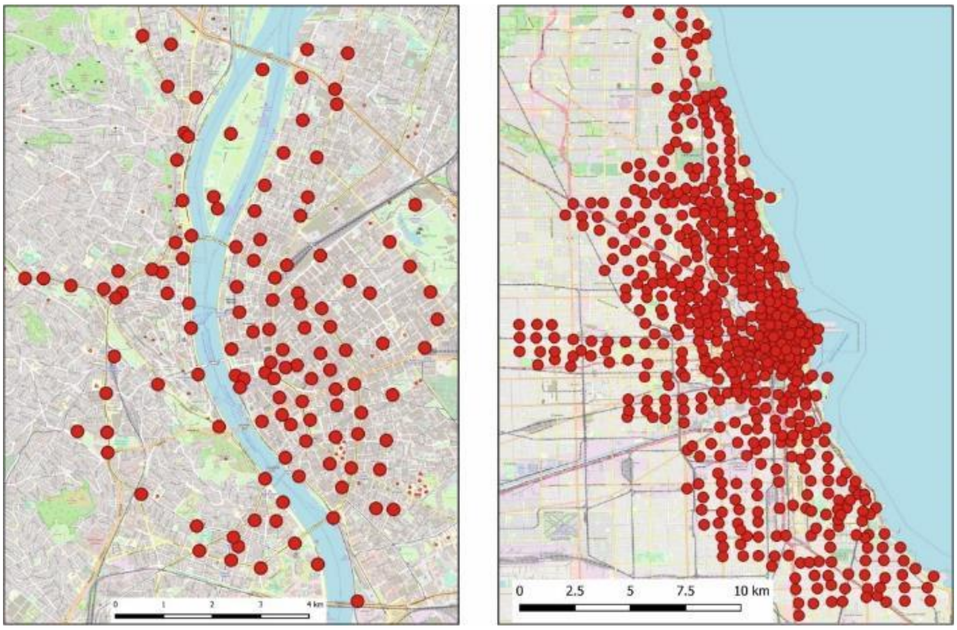


Figure 3- 16 Peak and off-peak variation in bike usage; source: (BKK, 2018; DIVVY, 2018)

Table 3- 1 10 main locations for trip origin and destination in Budapest; source:(BKK, 2018)

No.	Station address		Frequency in origin	Frequency in destination	Rank in origin	Rank in destination
1301	Jászai Mari tér	PT connection to the recreational area	4952	4645	1	2
1304	Margitsziget	Main recreation area	4669	4753	2	1
1101	Szent Gellért tér	University	4267	4136	3	3
0905	Kálvin tér	University, downtown	3737	3792	4	4
0515	Fővám tér	University, downtown	3640	3735	5	5
0101	Batthyány tér	Main PT hub	3242	3621	6	6
0508	Erzsébet tér	Downtown	3159	3177	7	8
0517	Városháza Park	Downtown	3026	2804	8	13
0607	Oktogon	Downtown	2949	2886	9	10
0611	Nyugati tér	Shopping centre, PT hub, main train station	2928	3236	10	7
0802	Astoria	Downtown	2771	2833	11	12
0103	Clark Ádám tér	Tourist attraction	2653	2891	12	9

Table 3- 2 10 main locations for trip origin and destination in Chicago; source:(DIVVY, 2018)

No.	Station address		Frequency in origin	Frequency in destination	Rank in origin	Rank in destination
35	Streeter Dr & Grand Ave	Park, shopping, restaurants, waterfront	25587	21108	1	1
192	Canal St & Adams St	Metro, restaurants, banks	17158	17724	2	2
91	Clinton St & Washington Blvd	Metro, working area	12767	13836	4	3
77	Clinton St & Madison St	Resturants, banking	14014	13200	3	4
76	Lake Shore Dr & Monroe St	Waterfront, park	10212	12779	9	5
43	Michigan Ave & Washington St	Park, cultural, sport	11064	10788	8	6
90	Millennium Park	Park, waterfront	11457	10424	7	7
177	Theatre on the Lake	Park, waterfront, cultural	11474	10276	6	9
81	Daley Center Plaza	Shopping	10182	9996	10	10
133	Kingsbury St & Kinzie St	Work office area, warehouse	9888	9864	11	11

The Budapest system's top 10 locations produce 20.2 percent and attract 20.4 percent of all trips. Further investigation about the function and character of the adjacent areas of these stops may show more clearly the reasons for their popularity, and the effects of built environment factors on the trip generation processes

(Vogel, Greiser, & Mattfeld, 2011; Y. Zhang, Thomas, Brussel, & van Maarseveen, 2017).

3.4. International data for car-sharing

With respect to the development of carsharing, the first worldwide carsharing system was recorded in Zurich, Switzerland from 1948 to 1998 (Susan Shaheen et al., 2013). Earliest carsharing experiences in North America were identified as the Short-Term Auto Rental (STAR) (California, between 1983 and 1985) and Mobility Enterprise (a research program of Purdue University, from 1983 to 1986). There were also similar carsharing programs in Europe, including Procotip (France, 1971), Witkar (Netherlands, 1973), Green Cars (United Kingdoms, late 1970s) or Vivalla Bill (Sweden, 1983) (Gianni 2016). From those first practices, over the past two decades, the carsharing industry has grown significantly and now operates in more than 30 countries serving over five million users across five continents: North America, Asia, Europe, Australia and South America (Greenblatt & Shaheen, 2015; Shaheen et al., 2013; Wang & Zhou, 2017). North America is by far the largest carsharing region occupying 50.8 percent of global car-sharing membership, following by Europe constituting approximately 38.7 percent (S. de Luca & R. Di Pace, 2015). Additionally, it is forecasted that worldwide, carsharing industry's revenue will increase from $1.1 billion to $6.5 billion between 2015 and 2024 (Navigant Research, 2015). Examples of contemporary carsharing organisations/companies operating around the world include GoGet, BlaBlaCar, Zipcar (with more than 900,000 users and 11,000 vehicles) or Car2Go (with approximately 2,000,000 users and 14,000 cars in different countries)(Dowling & Kent, 2015; Ferrero et al., 2018; Yanwei et al., 2018).

Germany is one the most progressive countries in terms of developing car-sharing services. The comparison of 22 different cities in Europe and North America shows that Berlin (3774), Hamburg (2066) and Munich (1527) have the highest number of vehicles allocated to car-sharing services. In terms of trip duration, New York (54.9 min) has recorded the highest figure followed by Copenhagen (44.6 min) and Dusseldorf (44.2 min). On the other hand, three top cities with the distance travelled include: Munich (6 km); Berlin (4.2 km) and Cologne (4.2 km). Another measure of comparison is the number of trips per vehicle per day which was maximized in three cities included Madrid (9.6); Hamburg (5.5) and berlin (5.3). Based on these findings, the utilization rate was calculated by the total times all cars were used each day divided by how many minutes they can be potentially driven per day. The calculation of utilisation rate shows that Madrid (21.6) has the highest rate and was considerably higher than the average of other cities (approximately two time greater). It is followed by New York (12.2) and Hamburg (11.7). The three cities with lowest utilization rate were Arlington (4); Columbus (4.1) and Miami (4.9).

Table 3- 3 International sharing car usage (Habibi et al., 2017)

City	Number of vehicles	Average duration of Trip	Average distance of Trip	Number of trips vehicle per day	Utilisation rate*
Amsterdam	614	35.4	3.3	4.6	11.3
Arlington	96	29.7	2.5	1.9	4
Austin	362	24.6	3.3	3.3	5.7
Berlin	3774	29.8	4.2	5.3	11
Cologne	703	34.9	4.2	4.5	11
Columbus	199	22.6	2.8	2.6	4.1
Copenhagen	399	44.6	3.1	2.2	6.8
Düsseldorf	685	44.2	3.3	3.6	11.1
Florence	219	26.8	2.9	3.4	6.4
Frankfurt	597	28.1	3.8	3.1	6.2
Hamburg	2066	30.2	4	5.5	11.7
Madrid	500	31.9	2.8	9.6	21.6
Miami	296	29.4	4	2.4	4.9
Montreal	455	29.4	3	3.8	7.8
Munich	1527	32.5	6	3.3	7.7
New York	525	54.9	3	3.3	12.2
Portland	612	25.8	3.3	4.9	8.8
Stockholm	545	30.2	4	2.4	5
Stuttgart	515	35.1	3.8	4.3	10.5
Toronto	498	38.6	3.3	3.1	8.5
Washington DC	1011	29.6	3	3.6	7.5
Wien	446	33.7	3.9	4.5	10.5
Avg	757	33	4	4	9

The hourly distribution of trips for Madrid, Stockholm, Copenhagen, Berlin, Amsterdam and New York shows that car-sharing is generally more popular in the afternoon rather than morning hours showing its capability for non-work trips. According to these graphs, the peak hour for shared-car usage was different among different cities: for Madrid, the hours of 1300 hours and 1400 hours were recorded as the afternoon peak, while for the other cities listed, the PM peak hours were between 1700 hours and 2000 hours. This fact shows that car-sharing in those cities were mostly used for recreational and social trips instead of work commuting. The other interesting finding is the higher frequency of long-time trips with distances over 1.5 km.

According to graph 3-17, Paris (3,827); London (2,800); Berlin (2,070) and Milan (2,062) are four major European cities with large fleets of shared-cars in 2016.

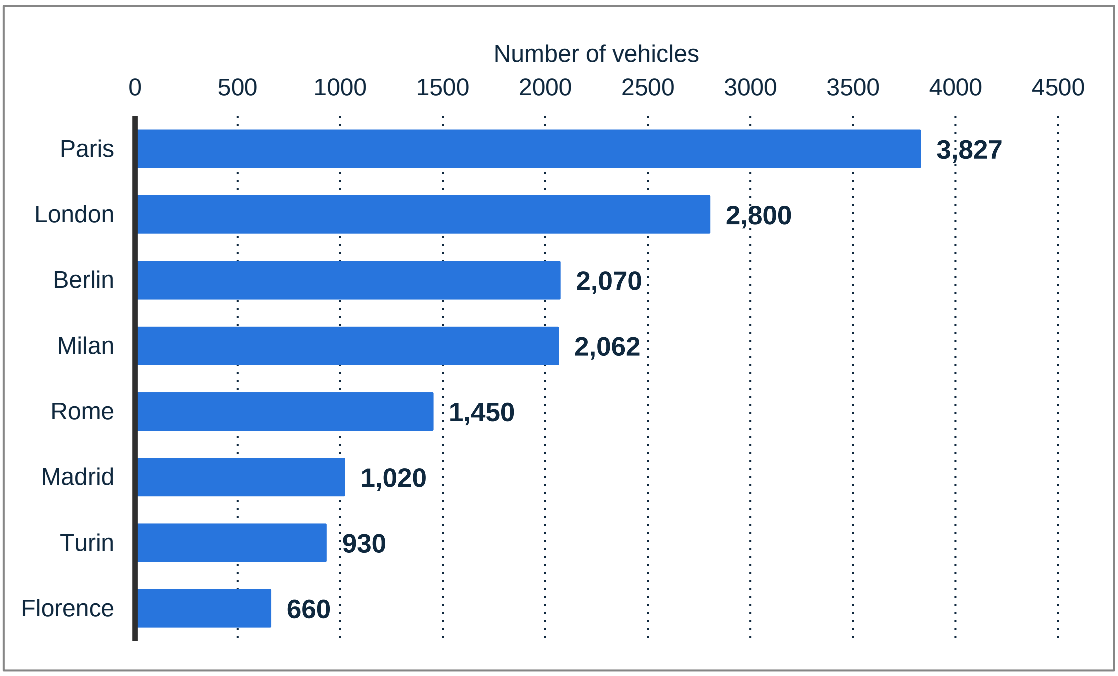


Figure 3- 17 Car sharing: number of vehicles in selected European cities 2016, Source:(Statista, 2019)

3.5. Sharing mobility in Adelaide

3.5.1. Bike Sharing in Adelaide

BSS in Australia first commenced in Melbourne in June 2010, with the introduction of a docking bikeshare system by the City of Melbourne. Brisbane followed in September of 2010 with their version of a docking bikeshare system. These docking bikeshare systems were similar in technology to docking bikeshare systems introduced in other large cities around the world such as New York's CitiBike scheme and in various Chinese cities such as Beijing. OBike commenced operations in Sydney and Melbourne in June of 2017 and were available in Adelaide in late 2017. OfO quickly followed, setting up operations in Sydney and Adelaide in October of 2017. Both OFO and OBike were set up on a trial basis overseen by Adelaide City Council, with a cap of around 1000 share bikes in operation. Other dockless share bike operations included Reddy Go (setting up in Sydney in July 2017), Mobike (Sydney in November 2017 and the Gold Coast in February 2018) and AirBike (Canberra in March 2018). By July of 2018, dockless Bikeshare was reduced to Mobike with the departure of OfO, OBike and Reddy Go. Lime, a US company, introduced a dockless E-bike share scheme to Sydney in 2019. Hence, the introduction of dockless micro-mobility in Australian cities was part of a world-wide phenomenon.

BSS of Adelaide included two types of bikeshare systems, one being a conventional bike sharing called Adelaide Free Bikes, and two dockless bike schemes that were operated by private companies namely OfO and O'Bike (Table 3-4)

Table 3- 4 Main features of three bikeshare schemes in Adelaide

Name of BSS	Operator(s)	Year of operation in Adelaide	Number of stations/bikes	Cost of usage	Payment method	Availability of Smartphone apps	GPS trackers
Adelaide Free Bikes	Adelaide City Council, Bike SA	2005	- 27 stations (20 city center locations; 7 suburbs locations) - Over 200 bikes	Free (A$25 charge applied if bikes are not returned).	-	No	No
OfO	OfO company (China)	2017	- No docking stations - 50 bikes with an increase to 200 bikes in 2018	A$2 for 30 minutes, A$5 charge per ride	Available functions to pay via mobile app using Credit cards/debit cards, PayPal, cash	Yes	Yes
O'Bike	O'Bike company (Singapore)	2017	- No docking stations - 100 bikes	A$2 for 30 minutes; A$69 Refundable deposit	Available functions to pay via mobile app	Yes	Yes

Source: (BikeSA, 2018)

3.5.1.1. Adelaide Free Bikes

Adelaide Free Bikes (AFB) was the first BSS in Australia when it was launched in 2005 in partnership between Adelaide City Council and Bike SA. This scheme is a type of conventional bike sharing program which provides free services during the daylight hours for users at bike stations allocated across city centre and some outer suburbs (Figure 3- 18). At present, the bikeshare system consists of over 200 bikes and AFB are available for hiring at 20 different locations in the city centre and North Adelaide, as well as at other 7 locations in the suburbs (BikeSA, 2018).

Notably, the introduction of the AFB is considered as a part of Smart Move strategy regulated by the Adelaide City Council aimed at encouraging cycling activity in Adelaide. The AFB has become a popular travel option for tourists and city visitors throughout its 14 years of operation. However, the key drawback of AFB is that users need to collect a bike helmet at the point of hire and return bikes, their bike helmet and retrieve their legal identification at the original point of hire during business hours. By comparison, dockless bikes can be hired wherever they are located and at the conclusion of the hire left in any legal public space at any time within the bike operator's designated area of operation.

Table 3- 5 Free bike location in city of Adelaide

Adelaide City	Address	Work hours
Bicycle SA	53 Carrington St, Adelaide	Open 7 days 9am - 4:30pm
Adelaide City Council	25 Pirie Street Adelaide	Open Mon - Fri 8.30am - 5pm
Adelaide Gaol	18 Gaol Road, Thebarton	Open 7 days 10am - 4pm
Connect Convenience (in Adelaide Central Bus Station)	Bowen St, Adelaide	Open 7 days, 8am - 6pm
Jarvis Subaru	190 West Terrace, Adelaide	Mon-Sat 8am-5pm
Peter Pan's Adventure Travel	119 Waymouth Street, Adelaide	Open Mon - Fri 10am - 6pm
Golf Links Par 3	War Memorial Drive, North Adelaide	Open 7 days, 10am - 4pm
Adelaide Travellers Inn	220 Hutt St, Adelaide	Summer: Open 7 days, 8am - 7pm/Winter Open 7 days 8am - 5pm
Adelaide Meridien	21-39 Melbourne St, North Adelaide	Open 7 days 9am - 5pm
Hostel 109	109 Carrington Street Adelaide SA, Adelaide	Open 7 days
North Adelaide Community Centre	176 Tynte Street, North Adelaide	Open Mon -Fri 10am to 4pm, Sat 11am - 2pm
Royal Adelaide Zoo	Frome Road, Adelaide	Open 7 days, all year round, 9.30am - 4pm
University of South Australia	Phillip Street, Adelaide	Open 7 days,
City West Campus	Jeffery Smart Building (Security Office)	8am-8pm (Summer)
University of South Australia	Corner North Tce and Frome Street, Adelaide	Open 7 days,
City East Campus	Barbara Hanrahan Under-croft	8am-8pm (Summer)
Adelaide South West Community Centre	171 Sturt St, Adelaide	Mon - Fri 9am-5pm

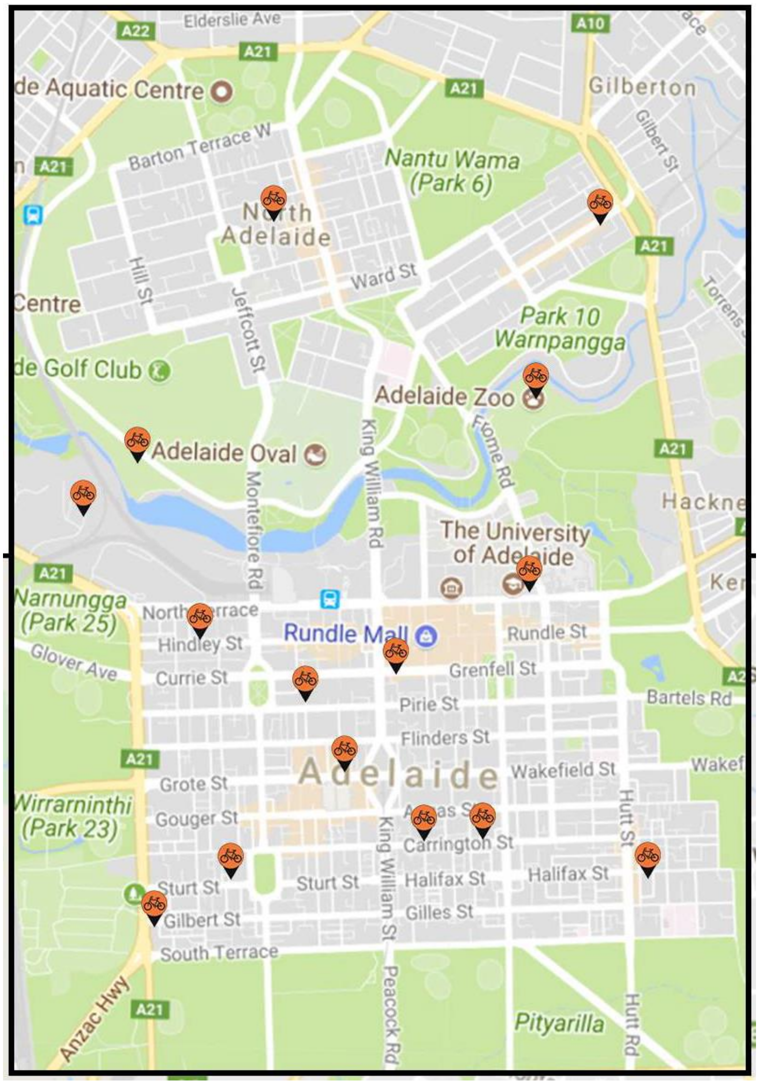


Figure 3- 18 Locations for hiring Adelaide Free Bikes (Source: BikeSA, 2017)

The one-year data for Adelaide City's Free Bikes shows that overseas visitors had the highest share of bike usage (42.8 percent) followed by metropolitan Adelaide residents (28.3 percent). The shares of CBD residents (11.3 percent) and interstate visitors (16.3 percent) were similar, while country residents (1.4 percent) had the lowest rates of hire of Adelaide City Bikes.

The significant proportion of overseas visitors using shared-bikes showed that the potential of this system both as a tourist attraction and source of satisfaction for city residents and visitors alike from the viewpoint of marketing and business opportunities. The other important point from the graph is the seasonal change in using bike-share. Figure 3-17 demonstrates that the summer months in Adelaide, from December to February, are the optimum season for cycling tourism. Part of this period (15 Febuary to 15 March) is the season of Adelaide's ambitious Fringe Festival time which is one the world's largest annual arts festival. According to Wikipedia (2018) Adelaide Fringe Festival, features more than 5,000 artists from around Australia and the world, featuring world premieres, hit shows and new artists. The Adelaide Fringe Festival attracts interstate and overseas visitors and attracted $29.5 million into South Australia in 2018. In addition to the Fringe Festival, the annual classic Santos Tour Down Under Bicycle Race events which are run from the 16th-26th of January each year, attracts international interest and is classified as a UCI World Tour Event. The focus on cycling in the Tour Down Under does have help to generate increased interest in cycling which may translate into increased local interest in cycling, including for recreational, sporting and commuting purposes. The festival theme continues with the international themed music festival of WOMADelaide in early March and the city street circuit Adelaide 500 car race in early April, which attracts large volumes of foot traffic with an increased propensity to make use of bikeshare.

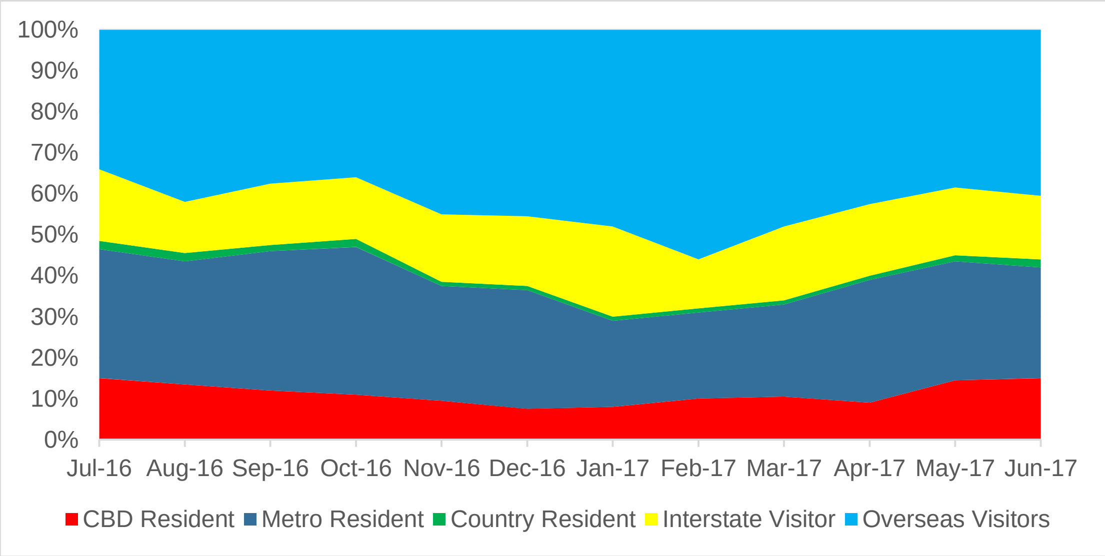


Figure 3- 19 Adelaide Free Bike, users, 2016-2017

The seasonal pattern of usage for other groups of users differed as CBD residents were more likely to use shared-bikes during the winter months of May, June and July. By contrast, December and January were two months with lowest share of bike usage for CBD residents, which may be due to the sometimes extreme heat experienced in Adelaide during these months or period of school holidays. Interestingly, metropolitan residents used shared bikes most often during September and October. As with CBD residents, December, January and February were the months with the lowest shares for metropolitan residents.

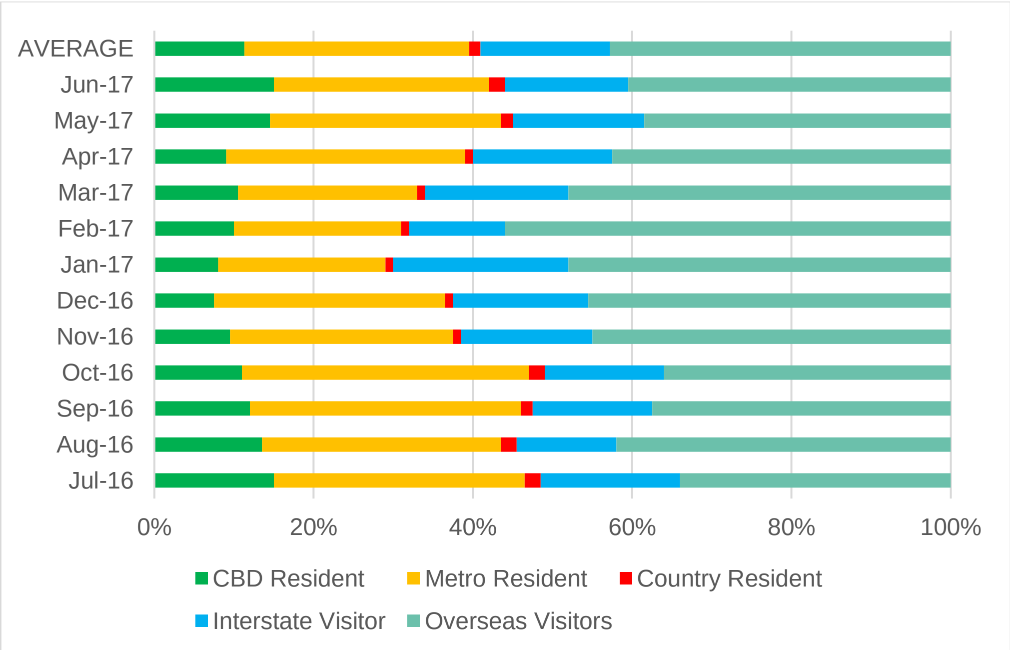


Figure 3- 20 The seasonal change pattern for different groups of users

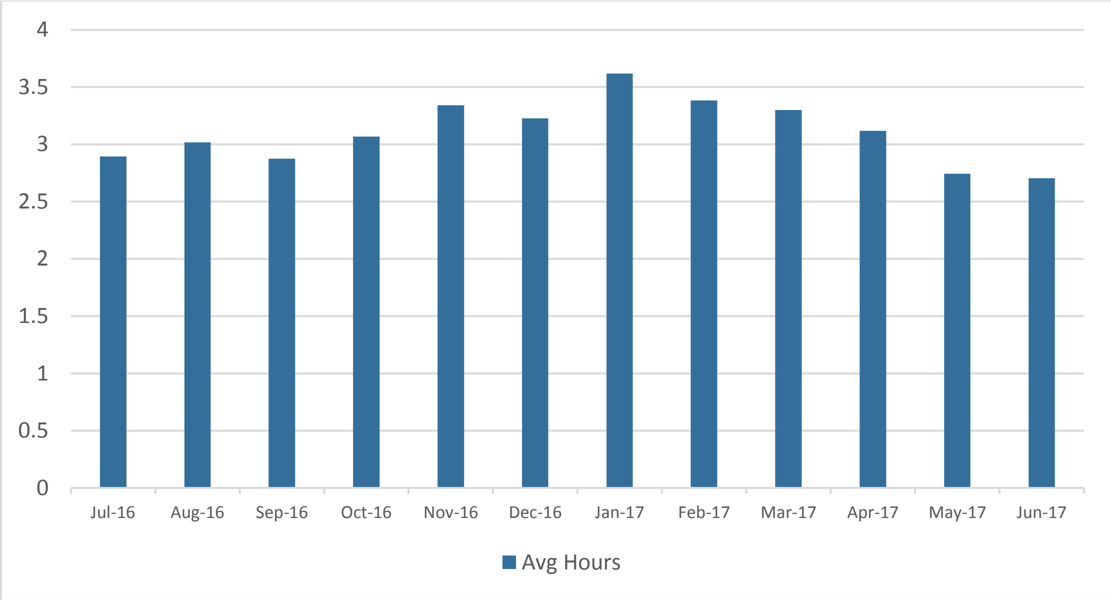


Figure 3- 21 Usage average duration of Adelaide Free Bike, 2016-2017

The other interesting point is that the bike hire duration in January (3.5 hours) and February (3.4 hours) was for a longer period which is partly because of the suitability of weather conditions and complementary social events. By contrast, May and June (2.7 hours) had the lowest hire duration. Considering the two factors of the frequency of hiring and hire duration, the Summer period of December to February had experienced the highest contribution in shared-bike usage as shown in Figure 3-22.

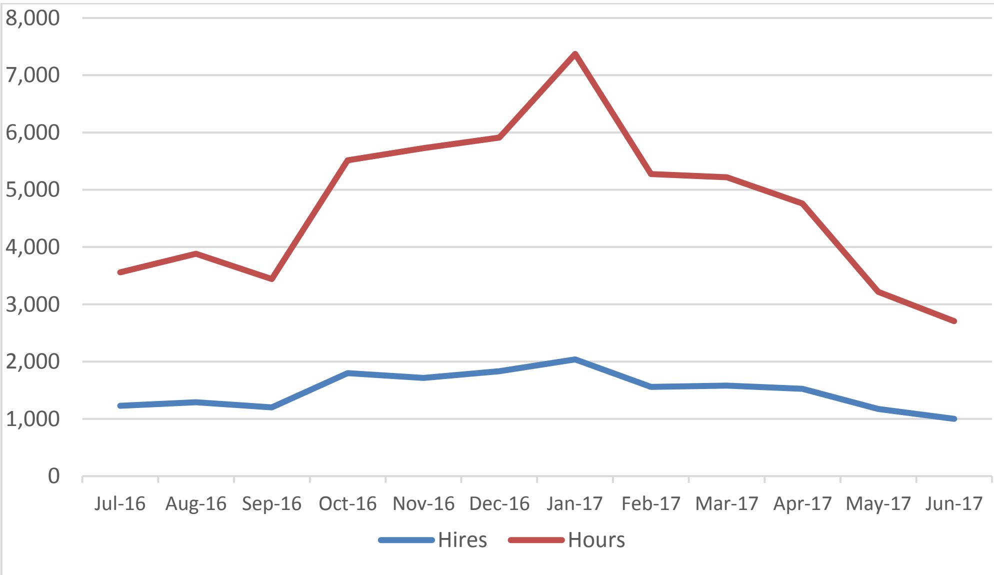


Figure 3- 22 Usage duration time and frequency of Adelaide Free Bike, 2016-2017

Whilst the Adelaide free bike system is available in several spots, Bike SA, Adelaide Travellers Inn and Backpack Oz were three main hiring locations to pick up the bikes. The latter two are the major accommodation choices of foreign tourists. The details of bike hiring statistics are provided in Table 3-6 (and noted in the related map in figure 3-21).

Table 3- 6 The main hiring locations for Adelaide Free Bikes

Station	Hires	Hours	Avg hours
Bike SA	6114	20922	3.4
Adelaide Travellers Inn	1578	4770	3
Backpack Oz	1390	4664	3.4
Peterpans	1096	3856	3.5
Adelaide Zoo	975	2333	2.4
Pirie St (Adelaide City Council)	834	2608	3.1
Convention Centre	770	2230	2.9
Conservation council	709	2815	4
Uni SA - City west	661	2314	3.5
Bonython park kiosk	624	1167	1.9
Urbanest bank street	578	1936	3.3
Par 3	567	1225	2.2
Meridian	516	1685	3.3
Uni SA - City East	495	1447	2.9
North Adelaide community Centre	197	586	3
Tandanya	98	246	2.5
South West Community Centre	52	165	3.2
Subaru (West Terrace)	33	69	2.1
Adelaide Gaol	20	57	2.825

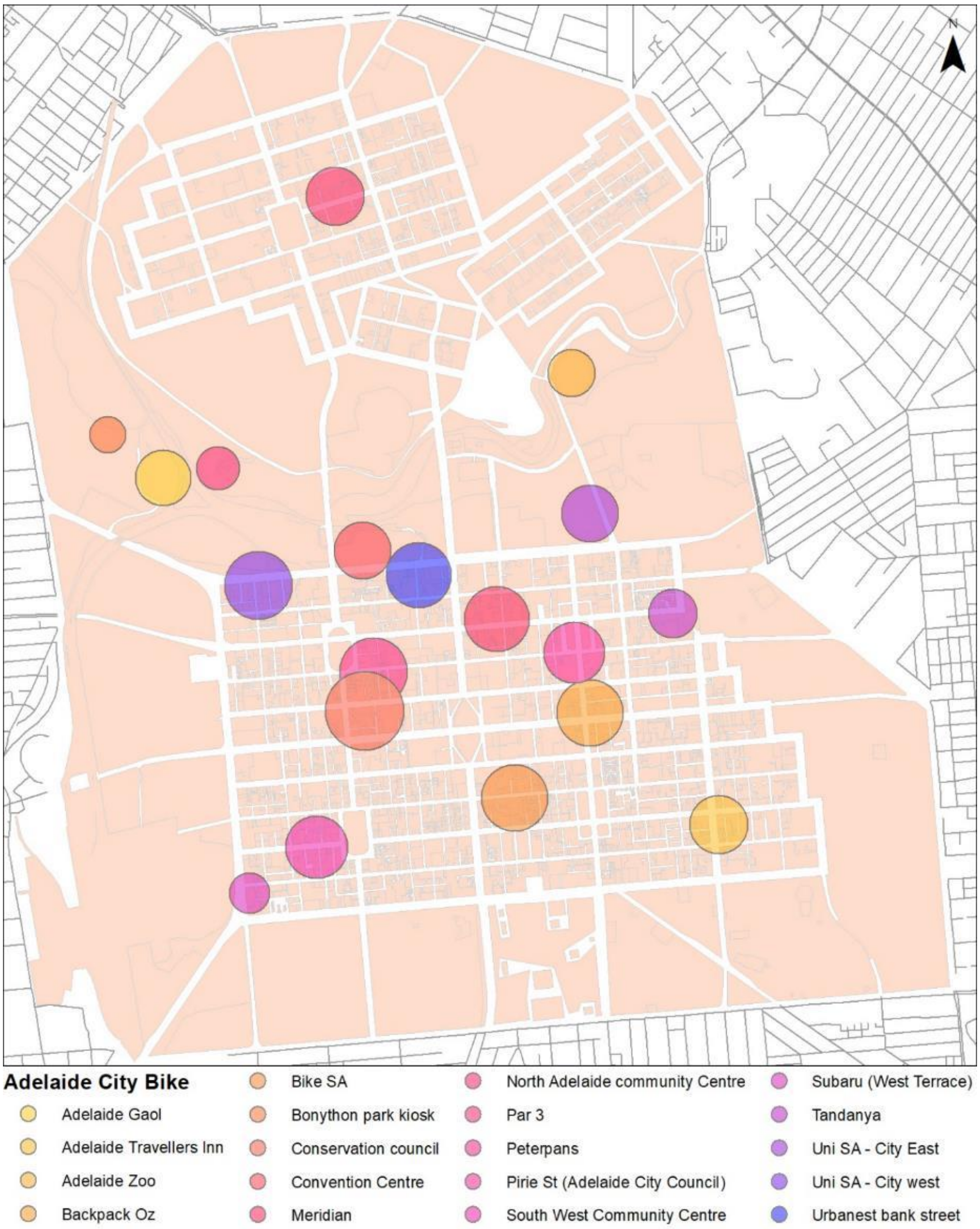


Figure 3- 23 The locations of main hiring points of Adelaide Free Bike

Limited studies have been conducted to investigate factors that influence the usage of bikeshare in Adelaide. So far, the only study about Adelaide's BSS was conducted by the Institute of Sensible Transport in 2016. More specifically, it provided an evaluation for the feasibility of future BSS in Adelaide. The research team led by Dr. Elliot Fishman employed two research methods, including a review of the literature on bikeshare, and included a professional workshop with the involvement of transport planners from different local government areas in Adelaide (Elliot Fishman & Martin von Wyss, 2017).

3.5.1.2. Dockless bikeshare schemes – OfO and O'Bike

Under the global trend of developing the fourth generation bikeshare which was designed with the application of cutting-edge technologies such as smartphone apps and wifi enabled GPS tracking, two new Dockless BSS namely OfO and O'Bike launched their businesses in Adelaide in late 2017. These two dockless schemes have distinct characteristics that provide users with a different experience of using bikeshare as compared to the conventional scheme provided by AFB. These services both employed a customised smartphone app to to facilitate usage of the service from initial registering (usually initiated with downloading of the app), arranging payments digitally via credit card, locking and unlocking of bikes and tracking their rides. In addition, both schemes were supported by GPS trackers that helped to reduce theft and vandalism. The key advantage over the AFB and conventional docking bikeshare systems, is that riders can leave the bikeshare in any legal public space at the conclusion of their hire. The available share bikes were typically shown on the mobile apps (see below). Although both schemes only operated in Adelaide for a short period of time, the flexibility of these two dockless bikeshare may help to vary travel options and create opportunities for further expansion of BSS in Adelaide.

Share-bikes in Australian cities generated extreme controversy, particularly in Sydney and Melbourne, where share bikes were dumped in waterways, abandoned in deliberately in accessible places or vandalised. Although the volume of share bikes in Adelaide was restricted to less than 1000 for the two private bikeshare operators, OfO was still plagued by vandalism, with around 60 share bikes cut in half, and OBikes often ended up a long way from where they were likely to be rehired. OBike in particular, were lax in retrieving wayward share bikes which particularly annoyed Adelaide's residents, and this ire eventually led Adelaide City Council to withdraw OBike's permit to offer share bike services at the end of 2017. OBike's share bikes were also very poor quality cheap bicycles (reputedly worth about the same as the $69 deposit required of users), and were a dismal cycling experience with only a single gear, solid rubber tyres and a poor ergonomic arrangement for riders.

OfO soldiered on for a few months longer, but was forced to withdraw from Adelaide on its own volition in early 2018 as a result of financial liquidity problems with its parent company, which eventually ceased operations internationally in early 2019. On departing Adelaide, OfO sold its share bikes (numbering around 400) to BSA, a local bicycle advocacy group in Adelaide, which intended to refurbish these for later release as a rebranded local bikeshare operation. OfO's share bikes, were quality bicycles (worth approximately $500 each), with sturdy construction, three speed gears, pneumatic tires, quality brakes, however, the service has not been relaunched since their withdrawal.

Instead, Adelaide City Council has now opted for several consecutive trials of e-scooters in 2019, commencing with Lime Scooters (which ended after the 2019 Adelaide Fringe Festival), and progressing to trials with e-scooter brands of Beam and Ride, which are currently still in operation. Setting aside the international problems that bedevilled bike rideshare companies, it is likely that bikeshare would have failed anyway in Adelaide, for several reasons:

- The initial launch of bikeshare did not have a compact geo-fencing for the preferred operational area (i.e. around the City of Adelaide). This meant that hired bicycles could be dispersed to far flung locations around metropolitan Adelaide. Retrieval of share bikes in this situation would have rendered any income derived from a hiring completely uneconomic, since each trip would only yield around $2. Over time, OfO did attempt to use a credit point system to encourage hirers to return share bikes to preferred locations, but this had limited success. The lesson from this is that in an area of low urban density, bikeshare will not work because share bikes end up being dispersed too widely in one way hirings and rebalancing this, is economically inefficient and functionally clumsy.

- Adelaide City Council in an attempt to avoid the debacle of abandoned and trashed share bikes that characterised bikeshare schemes in Sydney and Melbourne, allowed only a very limited distribution of share bikes in Adelaide (i.e. less than 500 in total), which were inadequate to meet demand in the City of Adelaide, because even within Adelaide's CBD, the share bikes would be dispersed to widely to provide a satisfactory locally accessible transport system. Indeed, neither OfO, or OBike or any of E-scooter companies satisfactorily redistributed share bikes or share e-scooters to where demand is, and often they would accumulate in popular locations resulting in over-supply.

- To have adequate cost recovery, share bikes would not have been competitive with public transport, and would struggle to attract clientele. E-scooters have dealt with this issue more successfully, however the high cost of them is unlikely to attract users on a regular basis beyond their initial novelty value. The $1 flag fall for the Beam e-scooter with a time based fee of $0.30 every minute means that a typical trip across Adelaide's CBD (assuming 15 minutes to negotiate a distance of 2km including waiting time at intersections), would cost around $6, which is more expensive than catching a bus. Without competitive pricing, it seems doubtful that shared mobility of this nature will be attractive to consumers for regular travel in an enduring manner.

- Whilst share bikes had the advantage of being able to be operated on public roads, e-scooters in the Adelaide trial cannot be legally operated on a public road because they are classified as a powered vehicle, which would require vehicle registration. A compromise solution introduced by the South Australian Government is that they could be operated on public footpaths (whilst giving way to pedestrians and vehicles) at speeds of 15km/ or less. However, Adelaide City Council placed further restrictions on their use, such as excluding them from major pedestrianised precincts such as Rundle Mall (the major east-west pedestrian corridor through the Adelaide

CBD), which has hobbled the already mobility utility of e-scooters to the point of uselessness.

- Often mandatory safety helmets were missing from many share bikes and e-scooters, which meant that hirers risked prosecution by police for a traffic offence. None of the bikeshare or e-scooter share companies appear to have come up with a suitable lock that secures the helmet to the bikeshare or e-scooter, when it is not in use. The absence of a safety helmet would have deterred some hirers from commencing a hire, and indeed perhaps set the scene for permanent disdain of these otherwise useful and appealing local mobility options.

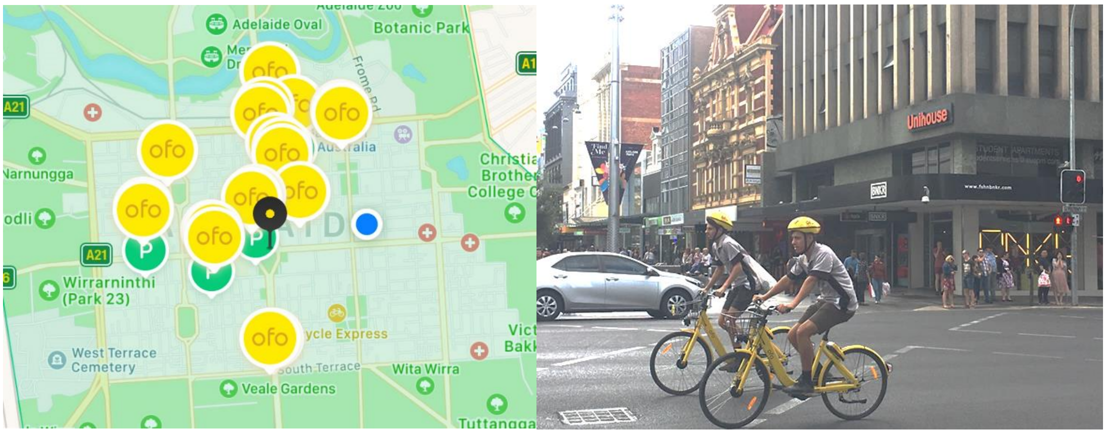


Figure 3- 24 a) Available bikes are shown on OfO's mobile app; b) OfO riders at Rundle Mall, Adelaide

Figure 3-25 a) Parked dockless OfO Bike in Adelaide showing basket and other features; and b) OfO Bike locking mechanism and unique QR Code

3.5.2. E-scooters

E-scooters (currently Ride and Beam), have addressed one of the key criticisms of bikeshare schemes in that because they are powered vehicles (albeit limited to 14km/h), because they are geo-located at any given point in time, operation of the electric motor can be controlled remotely by the Company Operator. Their design makes e-scooter unwieldy to operate manually, and whilst they can be manually pushed across a street or in a restricted zone, they are not able to ridden under power in restricted areas. Illegal or inappropriate use results in a spoken and potentially embarrassing warning being issued. The ability of the operating company to "geofence" the operational area of the e-scooter, and display this on a map on the e-scooter application on the hirer's mobile phone means that the risk of abandoned e-scooters is minimized. Incentives to park an e-scooter in an appropriate place can also be programmed into the app (such as Beam refunding a hirer's cost if a new hiring commences within an hour of the completed hiring).

E-scooters are a clever physical design in that they require a minimal footprint and the stance adopted by the rider is not very different to that of a pedestrian, despite the slight increase in elevation relevant to other pedestrians. The range of e-scooters is also impressive at around 25km, with most short urban trips well within its scope. Their operation is simpler than riding a bicycle, and more akin to driving a car, which most adults in a modern car dependent city could relate to. A right hand twist grip on the handle bar operates the throttle and a similar arrangement on the left of the handle bar operates a front brake, with a manual heel brake used to clamp down on the rear wheel.

The Ride brand, an Australian operator, uses a disc brake on the rear wheel. A small digital display provides the rider with information on the state of the battery charge, the speed and the range in km. At night, a small brilliant white LED Headlamp and twin LED red lamps on the back wheel mud-guard provides good visibility and they appear quite futuristic. A warning bell on the right side of the handle bar provides some piece of mind to the rider and other users, although few riders appear to avail themselves to this safety feature.

Other observations on the usability of e-scooters include:

1. They are somewhat unstable being susceptible to upsets in sharp turns, uneven ground or sudden front wheel braking.

2. Limiting the speed to 13-14km/h works relatively well around pedestrians, but it does require skill and in heavy pedestrian densities, the e-scooter has to be dismounted and walked. Hence, it is unlikely that e-scooters would work well in areas with high pedestrian densities or when travelling in swarms. Having said that, unlike share bikes, around Adelaide, social groups of young people (up to 6) on a recreational trip are not unusual to see.

3. The lack of linear progressiveness in the braking and throttle action, despite the modest speeds, is problematical in dense pedestrian/e-scooter situations. The strong acceleration can be quite surprising and take others around the e-scooter by surprise. However, the e-scooters do have a coast function (i.e. freewheel) after application of the throttle, that eases the rider's stress by not having to constantly judge the optimum throttle position, and mimics the experience of driving a conventional fossil fuel powered motor vehicle.

4. The mobile phone app is quick and easy to use, allowing a hiring within a few minutes, and displaying the necessary warnings for safe use and the responsibilities of the rider.

5. Unlike share-bikes with their handle-bar carry baskets, e-scooters have no provision for a rider carrying items. A rider therefore has to come prepared with their own backpack in order to travel safely with a secure load.

6. The safety of e-scooters is an emerging concern, although Brisbane's experience of them has resulted in a large number of casualty accidents (80 within a 2 month period for Lime Scooters in early 2019 according to Toby Crockford and Sabrina Walker of the Brisbane Times (8-5-2019)). Because e-scooters are classed as a powered vehicle, they do not fall under the road rules that regulate e-bikes, which are allowed to operate as bicycles, providing the rider contributes to the motion of the bicycle by pedalling. To circumvent existing restrictions on the use of e-scooters, the South Australian Government created an exemption to allow their use on footpaths, but speed limited to 14km/h. The particular danger in Adelaide's streets is that because their use is legally restricted by the State Government to footpaths (unless otherwise banned), driveway crossings and intersections present significant traffic hazards. As with Adelaide's Share-bikes, the availability of helmets was a somewhat hit and miss affair, and effectively curtailed the availability of around 25 percent of e-scooters, although with Share-bikes, in the case of Adelaide, around 50 percent of share bikes where "sans helmet". At night, the visibility of the e-scooters was high with their bright and distinctive LED lighting. The warning bell provided some measure of warning to other footpath users, but its awkwardness inhibited use. Perhaps the most concerning aspect of the E-scooter safety was in crossing intersections, where powering into an intersection without stopping was possible provided the rider did not stop mid-intersection, however, stopping mid-intersection would cut the power meaning the scooter would have to be walked out of the intersection to the kerb, which could result being stranded in the roadway if the rider had left it late to enter the intersection. It did appear that the Operator had created a geofence to prevent start-up operation within a roadway, which could cause significant anxiety to a rider wondering about its reliability and ability to power out of harm's way from approaching traffic. Their safety performance in wet weather is somewhat of an unknown, but one suspects that ridership would be poor in inclement weather.

7. As a means of transport, the functionality of e-scooters is only moderate when used legally. Unless they align directly with the intended path of travel, they offer less transport utility than share bicycles because in Adelaide they are restricted to footpaths which prevent smooth and uninterrupted travel. A brisk walk can achieve 6-7km/h, with the speed advantage of an E-scooter only 7km/h above this which can be deeply compromised by waits at intersections, the risk of unexpected egress of pedestrians from building entrances and pedestrian congestion. By comparison, a geared share bike (such as the OfO share bike was

capable of road speeds of 18-25km/h in either a dedicated bicycle lane or on-road, allowing significantly faster point to point travel times. The geo-fencing of e-scooters is problematical, because in the case of Rundle Street/Rundle Mall/Hindley Street, a linear corridor extending approximately 2km along the east-west axis of Adelaide's central retail and commercial precinct, the geofencing means that the detours needed to access the e-scooter and operate them on a parallel legal transport corridor (i.e. the footpaths along Grenfell/Currie Streets of North Terrace), results in a negligible time-saving of a few minutes for a 20 minute e-scooter trip over walking, partly due to the unrestricted passage for pedestrians along the 600m length of the pedestrianised Rundle Mall.

8. The fun factor of e-scooters has a number of intangibles, however, a feeling of smugness afforded by their slightly elevated position, together with an ability to zip around pedestrians at 3 times their typical walking pace with minimal physical effort does make them fun to use, if somewhat unnerving for unsuspecting pedestrians. E-scooters are not active transport and do little to exercise limbs apart from mild exertion of a calf muscle to push off from a standing start or the exercise associated with remaining in a standing posture, which could become surprisingly tense and tiring after 15 minutes. Share-bikes have an advantage over e-scooters in this regard in that part of their fun derives from providing the physical motivation and the road craft needed to successfully make a trip. Observations of users of e-scooters around Adelaide indicates popularity amongst a younger demographic (i.e. under 40 years of age) and a male bias, although the gender split appeared to be equal (under 25 years of age) in the use of e-scooters.

9. Ultimately, economics are an important factor in determining the uptake of a share transport service, and unfortunately, e-scooters perform poorly compared Share-bikes. Costs can escalate quickly with a $1 flag fall and time based of $0.30/minute. A 2km trip can easily cost $7 in Adelaide which makes it less competitive than Adelaide's public transport over the same distance. Riders are therefore expected to pay a high premium for convenience (assuming geofencing doesn't prevent direct door-to-door travel) and the fun, individualistic factor. In inclement weather, e-scooters lack appeal and comfort. Unlike the dockless share bikes with a physical manual lock on the back wheel, e-scooters require the rider to end the hire through the phone app. One pitfall that can occur is that mobile phones that default to the use of wifi networks when in range, is that the network may block access to the app, thereby preventing ending of the hire. UniSA's wifi network does this, which could result in a hefty bill because the meter is continually ticking over until the hirer ends the hiring, and this can only be done through the app. Most of the share mobility apps do not have a phone number connection to a service operator to assist where there are technical difficulties. A flat phone battery that prevents access to the app partly into the hiring, or a battery exhaustion with the E-scooter, could result in fees of hundreds of dollars or an E-scooter replacement fee (of around $1000 not including penalty and recovery charges).

10. As with Share-bikes, the brilliant branding and iconic visibility of e-scooters, provides a high recognition factor, which over time may improve take-up of them through simple reinforcement of their iconic shape and branding. This also works in favour of improving safety in public spaces since large numbers of identical e-scooters provides safety in numbers with every E-scooter rider reinforcing the commonality of this mode of transport, so that road users in particular are not surprised by their presence. With over 500 e-scooters in service, a continual presence should contribute to this mode becoming a significant and visible urban transport mode over the longer term.

11. Maintenance (specifically recharging), is a significant undertaking with e-scooters compared to the maintenance of Share-bikes. Nevertheless, the robust nature of the E-scooter mechanicals and electrics means that the only significant maintenance challenge is in ensuring that they are sufficiently charged (which could be a daily task), whereas with Share-bikes, these would only be brought in for maintenance when there is a mechanical failure (apart from lubrication and brake adjustments over the longer term). The novel feature of e-scooters, is that in theory, anyone with their own premises with an electrical outlet can earn extra income by recharging e-scooters on behalf of the E-scooter operator, thereby spreading the economic benefit to the wider community (i.e. not just the riders and the rideshare operator). The issue of limited battery range could have posed a major impediment to their take-up, is limited because whilst battery charging in public places for e-scooters is non-existent in Adelaide, all premises in the areas served are potentially recharging points, assuming that there are those in the community willing to recharge e-scooters. The current trial should help to determine whether this service model is practical.

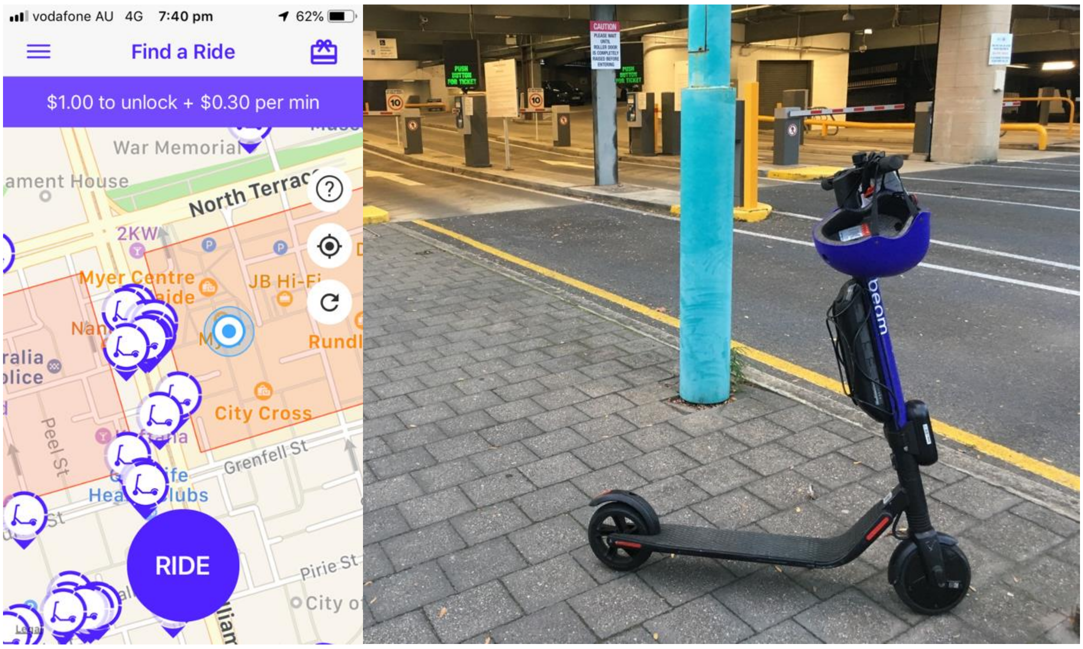


Figure 3- 26 a) Singapore based Beam e-scooter screen grab from app highlighting availability in Adelaide's CBD, geofenced areas and ride activation button; and b) Beam E-scooter parked outside an Adelaide City Council UPark carparking station.

Figure 3- 27 a) Rival Australian Melbourne e-scooter 'Ride' showing height adjustable handle bars, bell, throttle and brake controls, rider instructions and b) E-scooter in parked position with footstand under footplate activated.

3.5.3. EcoCaddy

EcoCaddy is an unusual zero emissions service based in Adelaide that offers rides for unique local tourist experiences and during major events (such as during the Adelaide Fringe Festival, Adelaide Oval events and city street circuit Adelaide Superloop 500 car race). Since its inception in 2015 by founder Daniels Langeberg the small fleet of three wheel electric 3 person covered rickshaws have travelled over 150,000km, provided over 120,000 rides and saved 26.6 tonnes of carbon emissions. The average ride length for an EcoCaddy is 1.25km/trip reflecting its utility, value and efficacy as a 'first mile-last mile' transport solution. This boutique business is privately run and its small fleet of around 10 operational eco-caddies complete an average of 7 trips per day. Eco-caddies are not classed as motor vehicles, however, the Australian road rules that regulate the use of e-bikes also applies to Ecocaddies. This means that their road speeds are limited to 25km/h with the operator required to provide pedalling input. Whilst they can be legally operated on urban streets (apart from freeways), they are not particularly well suited for travelling in high speed motorized urban traffic, particularly given that increased girth (to accommodate 2 seated passengers on the rear bench), is wider than on-road cycling lanes. However, for short trips on congested low speed urban streets, Ecocaddies fulfil their remit of providing short carbon free trips effectively, and their modest operational speeds are competitive with other modes of motorized travel in traffic congested city streets. Although EcoCaddy is upheld as an outstanding small business model that has been lauded in the media, it has not shown any signs of expanding beyond a tourist style novelty experience in Adelaide and it has remained the same size since its establishment. Part of the challenge in doing this is that it is an expensive service (at around $120/hour or $2/minute), meaning that a typical short trip (i.e. of around 1km), could cost approximately $10, which is similar in cost to an UBER ride. Eco-Caddies are presented as all-weather rides, nevertheless, whilst there is complete weather protection with side flaps, their design does not suggest that they would present an appealing travel experience in Adelaide's cold and wet winters. Where EcoCaddy succeeds brilliantly is in providing awareness of an eco-friendly urban travel experience and in raising the awareness of carbon free mobility.

Figure 3- 28 Daniels Langeberg, Founder and CEO at EcoCaddy

3.5.4. Car/ride share schemes

3.5.4.1. GoGet and UBER

In the Australian context, popular car-sharing companies include GoGet, GreenShareCar, Flexicar, Popcar, Hertz 24/7 and ridesharing such as as UBER, GoCatch (Dowling & Kent, 2015). A report conducted by Philip Boyle and Associates [PBA] (2016) reveals that the car share services in Australia support approximately 66,000 customers accessing 2,200 vehicles with roughly 90 percent of members and vehicles concentrated in Melbourne and Sydney. According to that report, the City of Sydney had the largest carsharing network in Australia with nearly 20,000 customers utilising 805 vehicles.

GoGet is Australia's biggest car-sharing scheme and has 2200 vehicles across the country and 66,000 members, with growth of 40 percent year on year. In metropolitan Sydney alone, 20,000 users — 15 percent of the total population— accessed more than 800 GoGet cars, 162 of which are parked in off-street locations that a single privately-owned car would otherwise get parked (Simpson, 2018). For ride sourcing, a survey conducted by the Institute of Transport and Logistics Studies (ITLS, 2016) showed that in 2016 there were 23 percent of Australian that had already experienced UBER services, and about 42 percent of Australians were interested in utilising these services in the future.

Figure 3- 29 GoGet vans awaiting hirings at Adelaide's IKEA store

With regard to the City of Adelaide's particular circumstance, the most popular form of carsharing was identified as fix-based car share services, which began in 2008 with two cars in Sturt Street and then grew to 14 vehicles located in 11 nodes in 2016 (PBA, 2017).

A survey conducted in December 2016 also showed that fix-based car share services supported 446 private and business customers, in which more than 66 percent of users were between 25 and 54 years old (Philip Boyle and Associates, 2017). At the beginning, there was only one carsharing company in Adelaide – GoGet; however, in early 2017, General Motors (GM) started the operation of Maven Gig to serve Adelaide (Maven Gig, 2017). This model works in a similar manner to UBER, except GM provides the vehicle for a weekly rental charge (ranging from $245-$310 per week for a minimum of 28 days) that includes the cost of maintenance, insurance, registration and roadside break-down assistance. The key difference of Maven Gig when compared with car rental agencies, is that providing rideshare services will not void insurance protection. This model of carshare has experienced viability problems in the US, with contraction of the service to 9 North American metropolitan markets (originally 17 at launch in January 2016). Part of this may reflect a shift by GM redirecting scarce capital into costly autonomous vehicle and electric vehicle technology and an intensely competitive automotive carsharing business environment, but it may also be due to weak consumer demand, particularly in car-oriented metropolitan markets where there isn't a convincing personal reason to dispense with a privately owned vehicle. Carsharing tends to work best in inner city metropolitan markets such as San Francisco and Manhattan in New York with car-less households (Wayland, 2019).

UBER works much like a taxi service, except the entire commercial transaction is managed through a smart device app. GoGet is the equivalent of short term rental and the user (i.e. the hirer) must have a membership with GoGet, must have a driving license, and be able to drive themselves for the trip that they wish to make.

For clarification, "car sharing" is a service like GoGet, where the actual vehicle is booked or hired by the driver as the sole hirer. Although there may be passengers in the vehicle with that driver, they are there as non-paying guests of the driver. Charges (i.e. fees) and responsibility for the vehicle accrue to the driver. The passengers in a car-sharing situation have no legal connection with the use of the vehicle, except in the case of accident insurance cover. The service is akin to short term car rental/hire.

With "ride sharing", it can work several ways. UBER is an example of ride-sharing. An UBER driver provides a service to a person/s wanting to travel under a single booking (in much the same way that a person uses a conventional taxi). Another possibility is for several hirers wanting to travel in a similar direction, to book the same car, but get off at different locations, whilst paying a share of the total cost. Car-pooling is a non-commercial type of ride-sharing, with a token payment limited to sharing the costs of fuel, and the driver is not paid a salary or reward. In this paper, for the sake of consistency, we use the term "shared-mobility" as a unique term for both types of commercial services: car-sharing (e.g. GoGet) and ride-sharing (e.g. UBER).

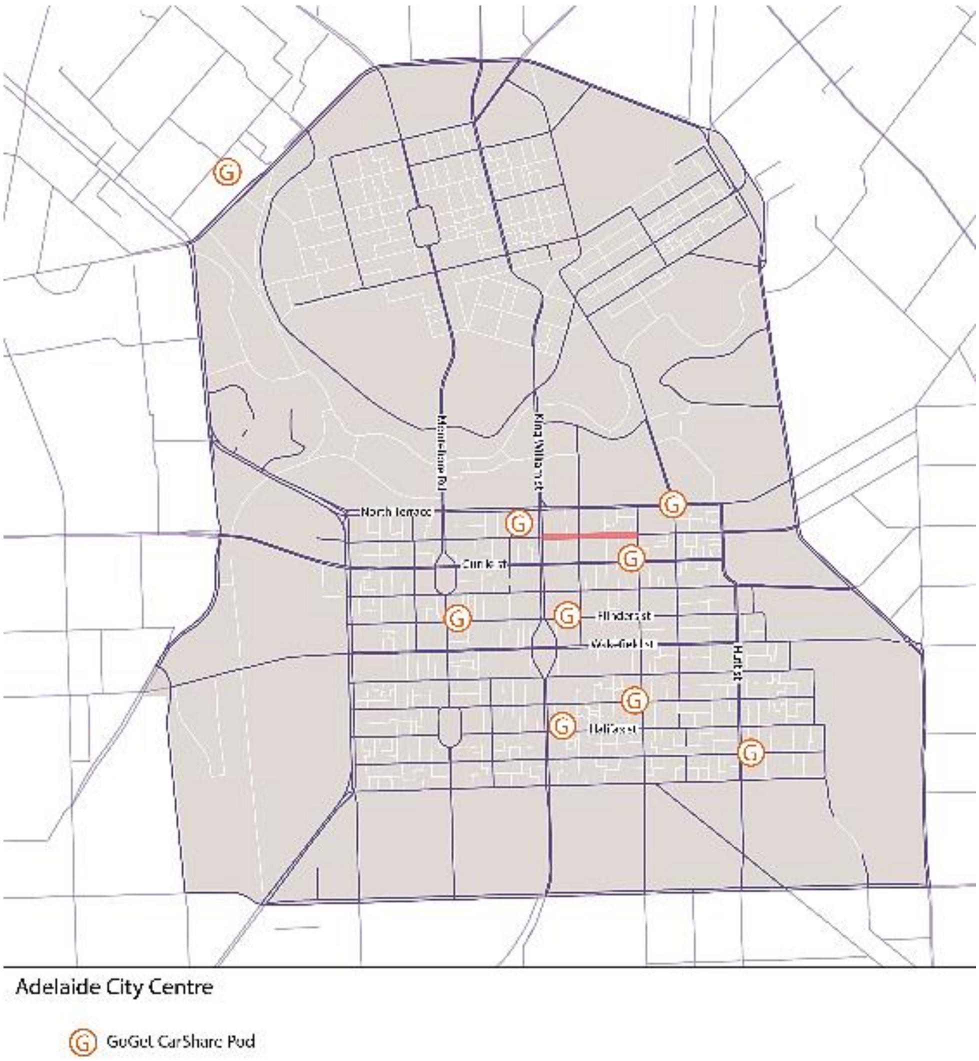


Figure 3-30 Map of the City of Adelaide and the locations of GoGet sharing cars, ABS 2016

3.5.4.2. Carpooling

Carpooling as a type of transport demand management (TDM) strategies is an informal type of commuter ride-sharing which may mitigate traffic congestion and parking demand. The core concept of carpooling is stressing travel behaviour alteration using exist transport resources and facilities. Carpooling achieved its peak use in US in the 1970s because of the energy crisis in regard to fuel shortages and climbing petrol prices. By contrast, carpooling experienced an on-going reduction in modal share throughout the next three decades. In comparison with other TDM approaches such as improving public transport or facilitating non-motorised transport, carpooling provides a substitute travel choice without asking people to give up their cars and without needing as major an infrastructure investment. Each empty seat in every traveller's car constitute a significant resource for transport planners to discover (Park et al., 2018).

Carpooling is currently operating in Adelaide and several companies based in the City of Adelaide now participate in carpooling. Below is the list of business units which participated in carpooling activities. This data shows that the University of South Australia (83); DPTI (51) and University of Adelaide (38) as the top three institutes that use carpooling services.

Table 3- 7 Carpooling information registered by company in Central Adelaide

Company name	No. of members	Company name	No. of members
Adelaide Airport Ltd	1	Hutt Street Centre	1
Adelaide Casino	17	HYLC Joint Venture	1
City of Adelaide	12	Jurlique	8
Adelaide Convention Centre	2	Macquarie Bank	1
AGD	1	MGI Adelaide	1
Aldinga Arts Eco-Village	8	Optus	19
APA Group	1	Orlando's	4
ATO	16	Pernod Ricard Wines	1
Attorney-General's Department	6	RAA	9
Bendigo and Adelaide Bank	7	RAH	9
Business SA	1	SAFECOM	2
DC Yankalilla resident	2	SES	1
DC Yankalilla Staff	7	St Andrews Hospital	1
DCSI	11	Southern Cross Care	3
Department of Premier and Cabinet	24	Super SA	4
Department of State Development	3	Uniting Communities	7
DEWNR	14	University of Adelaide	38
District Council of Yankalilla	3	University of South Australia	83
DMITRE	3	William Light Foundation	2
DPTI	51	Women and Children's Hospital	19
Environment Protection Authority	8	Yankalilla Community Member	13
Haigh's	1	Yankalilla Netball Club	7

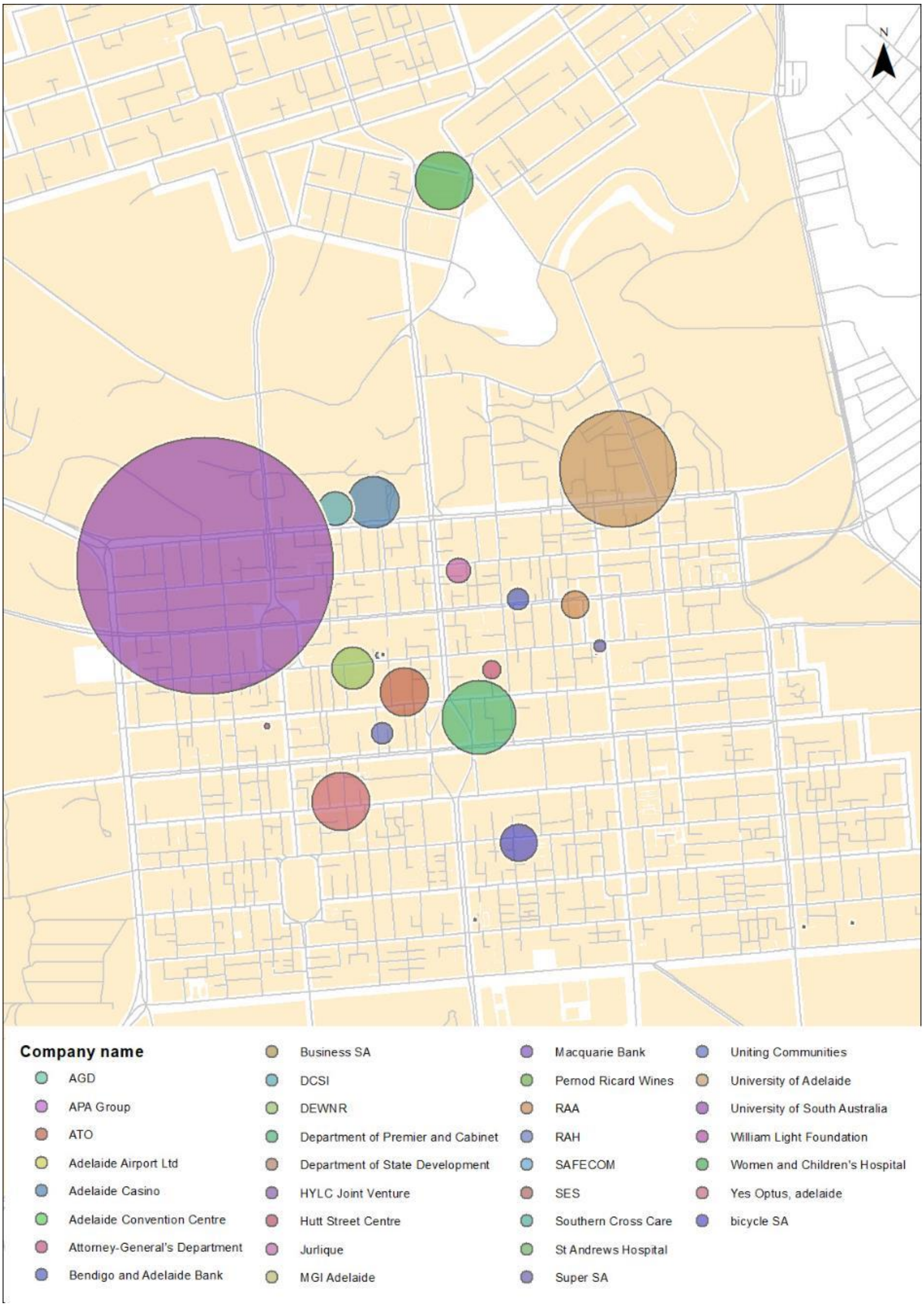


Figure 3-31 The location of companies involved in carpooling program in Central Adelaide

Chapter 4: Data Collection and Analysis

4.1. Introduction

This chapter introduces the methods of data collection and presents descriptive and inferential analyses from the collected data. Two approaches were taken to collect the data on sharing-mobility. First, a combined field and online survey was undertaken of those who attended one of the six major destinations (i.e. identified as major trip generators) in February and March 2018 in central Adelaide The survey sample size was n = 410. The respondents were then asked to report the history of their trip including travel mode, travel time and distance and also express their opinion and attitudes (e.g. attitudes towards the environment; safety; cost; independence; image and status, etc.) and any suggestion to improve the current schemes and what personal (e.g. health issue with using bikes) or external (e.g. about the quality of infrastructure) barriers they perceived towards sharing-mobility. By means of open-ended questions in the questionnaire survey instrument, all participants were also requested under what conditions they would be eager to use sharing-mobility alternatives. The second survey then collected data from those that had already used one of the sharing-mobility alternatives. They were then asked to report their personal experience and rate the detailed aspects of the system. This chapter includes a statistical description of the data and its quality and draws conclusions from the bivariate graphs in order to explore the potential relationships between the frequency of choosing a mode and the socio-economic characteristics of the traveller.

4.2. Six major trip generators

As noted earlier, six major trip generators in the City of Adelaide were chosen as the case studies for this research project. By trip generation, we mean the number of trips going into and coming out of a land use area (which implies two-way trips). These six locations are well-known as major trip generators and for their higher attractiveness to visitors that consequently plays a major role in trip generation. The locations of the six target destinations are shown below. These include: the Adelaide Oval; Royal Adelaide Hospital; Adelaide Railway Station; the University of Adelaide; Rundle Mall and the Adelaide Central Market.

Figure 4- 1.The locations of six major trip generators

Below is a description of each major trip generator and its transport capacity and functionality.

Rundle Mall: the Rundle Mall Precinct is the heart of the City of Adelaide's retail precinct, claiming to be the centre for fashion, beauty, lifestyle and food in the City of Adelaide. Bounded by the southern side of North Terrace, the eastern side of King William Street, the northern side of Grenfell Street and the western side of Pulteney Street, the precinct has Rundle Mall along the east-west axis of the Adelaide CBD as its centrepiece. As one of the longest and busiest outdoor pedestrian malls in Australia, Adelaide's Rundle Mall attracts more than 400,000 visitors and locals each week. Rundle Mall is home to more than 1,000 retailers and services and its businesses employ over 5,000 people, ensuring that Rundle Mall is a hive of activity in Adelaide's CBD seven days a week. More than 85 percent of tourists to Adelaide visit the precinct and annually there are over 24 million visitors to the Mall. Rundle Mall is a key destination in Adelaide's CBD and its characteristics and location create strategic positioning opportunities for events, pop-ups, brand activations and marketing to reach out to tourists and locals. Since Rundle Mall's creation as a pedestrianised thoroughfare in 1976 through the closure of Rundle Street between King William and Pulteney Streets, retailers have focused on developing parking capacity to attract customers. The Mall has undergone two major refurbishments since its inception, but neither of these upgrades have changed the transport functionality of the Mall, and have instead focused on lighting, landscaping and aesthetic improvements. Located at the core of Adelaide's CBD, it has the advantage of being immediately parallel with Adelaide's preeminent cultural boulevard, North Terrace, which now accommodates a new tramline (completed in 2018) with wide footpaths that facilitate active transport. It is also parallel with Grenfell/Currie Street, which is the major east-west corridor for public transport buses accessing the Adelaide OBahn in the north-east and bus routes to the north-west, west and south of Adelaide's metropolitan area. King William Street which forms the western boundary of the mall has a tram stop connecting Rundle Mall to Glenelg, Bowden, the old Royal Adelaide Hospital (now Lot 14), Adelaide's Festival Theatre, the city's two major universities and the new Royal Adelaide Hospital. It also is the major thoroughfare for the majority of Adelaide's north-south bus routes. Unfortunately, cycling options are limited with cycling and small wheeled personal transport banned in the Mall and few dedicated cycle-lanes in the vicinity, apart from an east-west bicycle route along Pirie Street (about 250m south of and parallel to the Mall) and a north-south bicycle route along Frome Road, 200m distant from the eastern entrance to the Mall. Public bicycle parking options are limited and not secure. The following off-street parking spaces are available for visitors: Wilson Adelaide Central Plaza Car Park (enter via North Terrace); Wilson Centrepoint Car Park (enter via Rundle Street); UPark on Rundle Street (enter via Rundle Street); UPark on Gawler Place (enter via North Terrace and Gawler Place); UPark on Wyatt Street (enter via Wyatt St or Hyde St); UPark on Frome St /North Tce (enter via North Tce or Frome St); The Myer Centre Car Park (enter via North Terrace); Secure Parking Rundle Place Car Park (enter via Grenfell Street). For many visitors, access by car is the dominant transport modal choice, although the co-location of Rundle Mall with the densest commercial areas and the nearby universities (the University of Adelaide and the University of South Australia's City East Campus, contributes significantly to visitations during normal business hours. Increasingly, the massive densification of Adelaide's central core with high rise residential buildings of up to 40 storeys, will result in a large increase in the local residential population. The City of Adelaide's current population is around 25,000, up from 17,000 in 2006, with a targeted population is around 40,000 (i.d.community, 2018). Interestingly, Adelaide City Council in their last publicly available user profile survey of 2005 respondents for the City of Adelaide in 2017, found that cars as a modal choice amongst 'users' in their choice of travel to the City had declined from around 45 percent in 2007 to 34 percent, whilst it had increased from 41 percent to nearly 50 percent for public transport. Of some concern is that the choice of active transport remained static at around 14 percent. Trams attract approximately 5 percent of visitors to the CBD, and it is likely that Rundle Mall would attract a significant share of these visitors, given that the Rundle Mall tram stop is one of four major tram stops (City of Adelaide, 2017)

Adelaide Railway Station is the central terminus of the Adelaide Metro railway system. Above ground suburban lines extend north to Gawler, north-west to Port Adelaide and Grange, south to Seaford and Belair. Approximately 11 percent of visitors to the City of Adelaide travel by train (City of Adelaide, 2017). This grand structure has served railway passengers arriving in the city for more than 80 years. A tram stop is co-located with the Railway Station entrance on North Terrace, facilitating easy transfers that provide access to the old Royal Adelaide Hospital site, the new Royal Adelaide Hospital, the two universities, the Botanic Gardens and both ends of Rundle Mall. However, unless one was seriously mobility impaired, walking would be the quicker option due to the proximity of the Mall. There is negligible provisioning for cycling, either in terms of secure bicycle parking or cycling infrastructure, apart from indirect access from the Torrens Linear Park on the northern back-side of the Railway Station. The significant limitation of Adelaide's heavy commuter rail network is that the Adelaide Railway Station does not have a through line and there is no railway loop within the central city area, in the manner that Sydney and Melbourne have with their commuter rail networks. This means that the Railway Station only serves commuters accessing the city from the suburbs (and vice versa). There is a large car parking station attached to the Adelaide Convention Centre and a smaller car-park serving the Adelaide Casino and Adelaide Festival Centre, however, the use of these car parks is unlikely to be related to the use of the Adelaide Railway Station.

Adelaide Central Market is one of Australia's largest fresh produce markets providing a wide range of fresh and products in a multi-cultural setting. It is also a popular tourist attraction in the heart of Adelaide and is often referred to as the Central Market. The Central Market sells a wide variety of goods, including fruit & vegetables, meat & seafood, cafes, breads and much more. It has a vibrant atmosphere and is one of Adelaide's best-known landmarks. It is also one of the most visited places in South Australia with approximately 8 million visitors per year. Its location on Victoria Square where there is a major tram stop and its proximity to major bus routes using King William Street (for north-south routes) and Wakefield Street (for east-west routes), positions it in a highly accessible location. Unfortunately, despite this proximity to public transport, the Central Markets appear to be configured to accommodate shoppers mostly arriving by car. Its undercover carpark has over 1,000 parking spaces available in the UPark Central Market, located directly above the Adelaide Central Market which are easily accessible from both Gouger and Grote Street. The other parking station that is available is Adam Parking, located off Gouger St between Witcombe Street and Talbot Lane. Parking is also available in other nearby undercover parks, within walking distance of the Market. Limited on-street parking is also available around the precinct. Whilst there are on-street cycle lanes catering to cyclists in the vicinity, secure bicycle parking catering to the casual cyclist is practically non-existent, making it difficult to complete one’s shopping by bicycle. The visual message to the visitor accessing the Central Market, both from the on-street parking presence on Gouger Street and the off-street parking provisioning is that motorists are the dominant and most valued clientele.

Adelaide Oval: Adelaide Oval is the premier sports ground in Adelaide, South Australia, located in the parklands between the city centre and North Adelaide. The venue is predominantly used for cricket and Australian Rules Football (AFL), but has also played host to rugby league, rugby union, soccer, tennis among other sports as well as regularly being used to hold concerts. Adelaide Oval has been headquarters to the South Australian Cricket Association (SACA) since 1871 and South Australian National Football League (SANFL) since 2014. The stadium is managed by the Adelaide Oval Stadium Management Authority (AOSMA). It has catered to a record crowd of 55,317 people in its current guise, which was completed in 2014. During AFL events, bus based public transport is included as part of the match ticketing arrangements, with the result that the bulk of patrons access the Oval via the SANFL used a stadium at West Lakes in Adelaide’s western suburbs for its major matches. The redevelopment of Adelaide Oval was based partly on the desire by the then Labor State Government to reinvigorate the Adelaide CBD and to have the event in a more central location, with maximum accessibility and less reliance on private cars for patrons to attend the event. As part of the project, a new wide high capacity footbridge over Torrens was built, the Riverbank Footbridge, to provide a more direct link between the Oval and North Terrace for capacity AFL crowds accessing and leaving events at the Oval. This foresight allowed the Oval direct pedestrian connections to the Adelaide Railway Station, tram stops and bus routes. Whilst car-parking for events was discouraged, disability drop off and pick up zones for event days are located on: War Memorial Drive, in front of the Next Generation Health Club and Tennis SA. This drop off zone is accessible from the western side via Montefiore Road or Morphett Street Bridge. On-street parking spaces are extremely limited in the vicinity with 2 hour blanket parking restrictions applying to most streets within a 15 minute walking distance of the Oval. Adelaide Oval operates two car parks on non-event days. These car parks are open to all visitors including guests attending functions at Adelaide Oval: the East car park with access via King William Road (north-bound lanes only) and the North car park which can be accessed via Pennington Terrace. Cycling is the forgotten mode in Adelaide Oval’s mobility arrangements, and whilst the oval management are open to the idea of cycling parking for events, they are not likely to take concrete actions to provide bicycle parking or other shared mobility solutions. Their main concern is that whatever parking is provided for cycling (either for private users, dockless bicycles, docking bicycles or e-scooters), that these are managed in an orderly manner. Adelaide Oval’s lack of will to cater to bicycles partly reflects the reality of the impracticality of accommodating wheeled vehicle movements within capacity crowds accessing or leaving the Oval. The proximate position of the Oval on the northern bank of the Torrens River does however provide it with direct access to the Torrens Linear Park Trail (cycleway) that spans the width of Adelaide’s metropolitan area from the foothills of the Mount Lofty Ranges in Athelstone to West Beach on the coast, a distance of 47km. Whilst this cycleway captures only a narrow corridor across the metropolitan area, it provides outstanding cycling access for residents who are able to access this Trail. For the most part, the

Trail has grade separated road crossings, allowing a continuous and uninterrupted ride for cyclists.

New Royal Adelaide Hospital (RAH): The new RAH is one of Australia's most technologically advanced healthcare facilities, integrating the latest innovations across health, education and research to deliver high-quality care. As South Australia's flagship hospital, the RAH provides a comprehensive range of complex care across medical, surgical, emergency, acute mental health, outpatient and diagnostic fields. The Royal Adelaide Hospital is located at the corner of North Terrace and West Terrace, at the west end of the city. The RAH site incorporates a total of 3.8 hectares of landscaped environment, including more than 70 internal themed courtyards and sky gardens across the 9 levels. This creates a 1.6 hectare footprint of greenspace within the hospital. It has 2,300 car spaces on-site with 50 parking spaces for disabled persons. It also has short-term 15-minute patient pick-up and drop-off areas on levels 2 and 3 of the carpark. Whilst the new hospital has made a modest effort to accommodate cyclists with secure undercover bicycle parking for around 300 bicycles (largely for hospital staff) and some shared use pathways within its grounds, access to the hospital is strongly oriented to facilitating arrival by car. The hospital is co-located to a tram stop, and there are bus routes running along North Terrace to bring passengers as close as possible to the RAH, however, the RAH's integration with public transport makes heroic assumptions about its visitors personal mobility. It appears to be a regressive design compared to the public transport convenience afforded by the old RAH, which had bus-stops virtually on the hospital's doorstep. Security concerns influenced the relative isolation of the hospital from its public transport services or it may be a handicap of a very awkward site on a corner that should have remained as parklands, if the design had been true to Colonel Light's original plan for Adelaide.

North Terrace, University of Adelaide (UoA): North Terrace is the home of many of Adelaide's most important cultural institutions including: Government House; the War Memorial; the ANZAC Centenary War Memorial Walk; the State Library of SA; the Migration Museum; the South Australia Museum; the Art Gallery of South Australia, the University of Adelaide and the University of South Australia (UniSA). The highest concentration of Adelaide's monuments and memorials can be found on this section of North Terrace. The precinct is easily accessible by numerous bus routes and since 2018, tram services now travel along the complete length of North Terrace, although this has been at the expense of numerous bus services due to the narrowing of North Terrace. North Terrace is no longer suitable for safe cycling due to the high speed limit (50km/h) and the removal of on-street parking to accommodate two lanes of traffic in each direction. Parking activities previously provided some friction to traffic speeds, however paradoxically, the protected right of way for trams appears to be have transformed North Terrace into a speedway that renders it hazardous for cycling. However, for those using a car, North Terrace is well provided for with parking stations mostly on the south side of North Terrace, albeit associated with the retail and commercial activities on that side of North Terrace, rather than catering to visitors intent on patronizing cultural venues. There is short-term on-street car parking available on Kintore Avenue and Victoria Drive. Within the university and cultural precinct bounded by Kintore Avenue, North Terrace, Frome Road and Victoria Drive, parking is largely limited to on-site staff. The old RAH site (now Lot 14), does have a massive multi-deck parking station, which is now significantly underutilised. The university campuses (UoA and UniSA) do have significant provisioning for undercover bicycle parking, although compared to the student and staff populations on these sites, it is modest and reflects the modal split of cycling (i.e. around 2-3 percent). These campuses are a long way off mimicking the Dutch or Danish cities love of cycling, with cycling often viewed by campus management as a nuisance to be curtailed. UniSA's City East Campus had provided a drop-off and collection point for Adelaide City Council's limited Share Bike Scheme (which only allowed back to base hiring rendering them useless for point to point commuting), but with only a maximum of 4 bicycles available their utility was limited. The Adelaide Bike-Share Scheme tended to suit tourists who did not mind returning the bicycle to where the hiring commenced. None of the university campuses created situations conducive to shared mobility (either in the form of the dockless share bikes of OfO or OBike, or the new e-scooters) because these were banished from campus locations. With e-scooters, the UniSA's Information Technology Services obstructs access to ride-share apps.

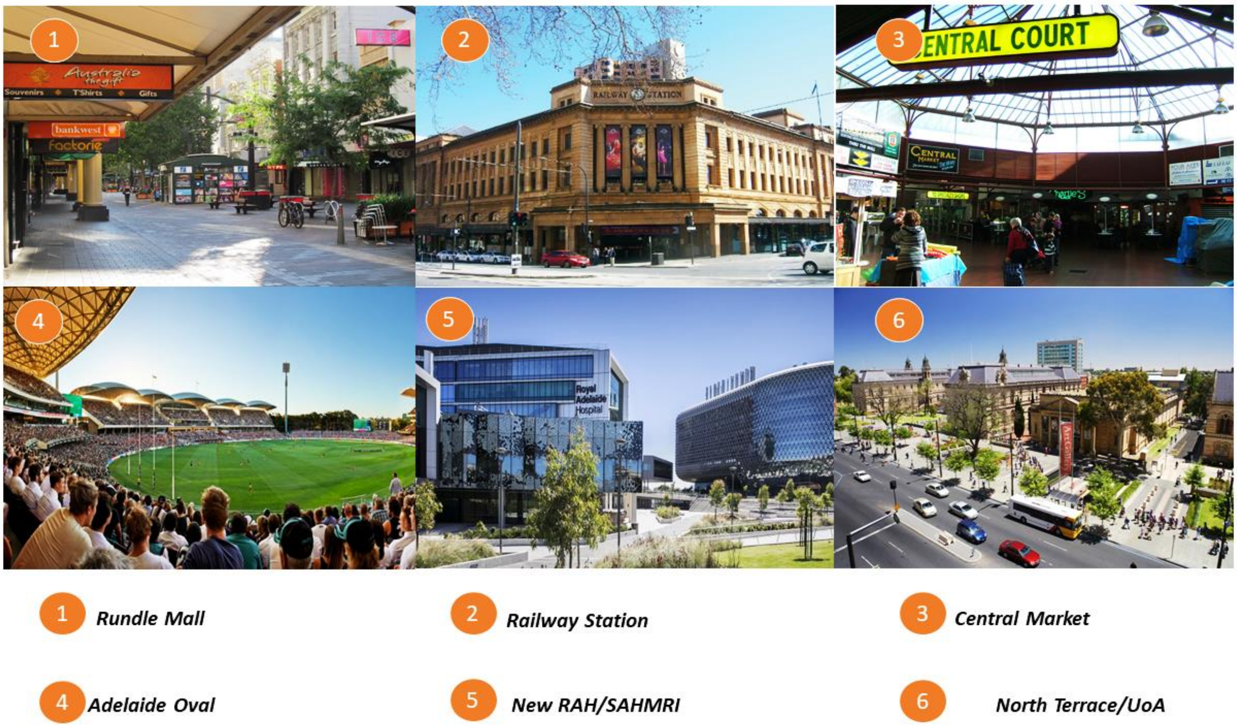


Figure 4- 2 The six major trip generations

4.3. Network Analysis

4.3.1. Space Syntax Analysis

The street network in vicinity of each six major destinations was analysed using the Space Syntax method. Space Syntax is the name given to a set of theories and techniques concerned with the relationship between complex spatial structures and the societies producing/inhabiting them. In urban network analysis (UNA) using the space syntax approach, the streets are represented as edges and intersections as nodes (in a topological representation). Three main syntactic measures (Hillier, 2007) were used which are:

- Connectivity (degree) measures the number of immediate neighbours that are directly connected to a space. This is called local measure.
- Integration (availability): The global integration measure shows how deep or shallow a space is in relation to all other spaces. It is a variable that refers to how a space is connected with other spaces in its surroundings. Integration is a static global measure. It indicates the degree to which a line is more integrated, or segregated, from a system as a whole;
- Depth as a global property. It tells us how an element is far away from all the other elements. A global property can only be experienced from moving through space. Depth is a topological distance in a graph. It counts the least number of syntactic steps that are needed to reach one from another. If two lines are directly connected, the distance between them is equal to one, and the distance of lines which are not directly connected is the shortest path between them.

The following figures compare three measures space syntax across six major trip generators:

Figure 4- 3 The quality of connectivity across six major destinations (vicinity of 800 metres)

Figure 4- 4 The quality of integration (global) across six major destinations (vicinity of 800 metres)

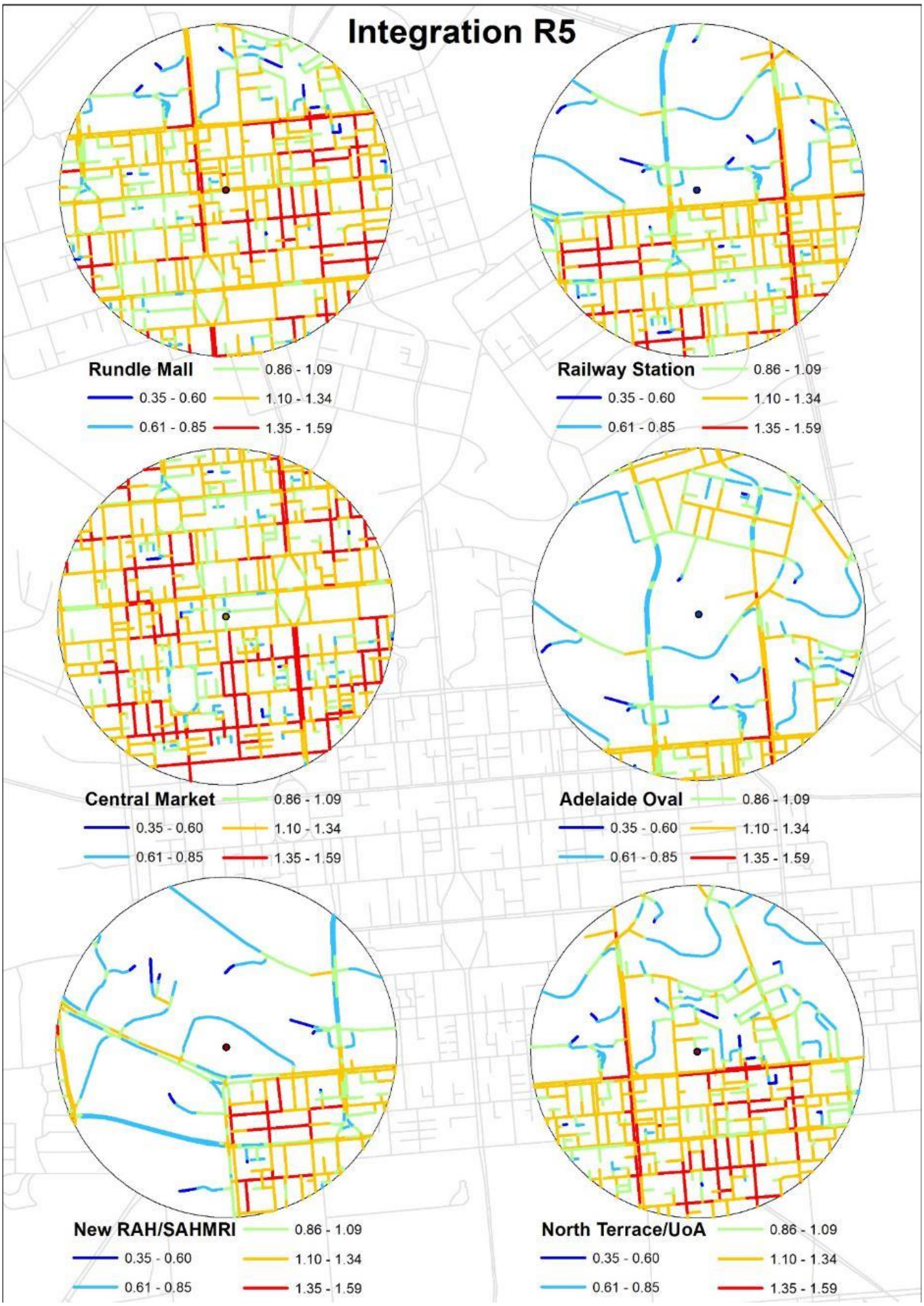


Figure 4- 5 The quality of integration (local) across six major destinations (vicinity of 800 metres)

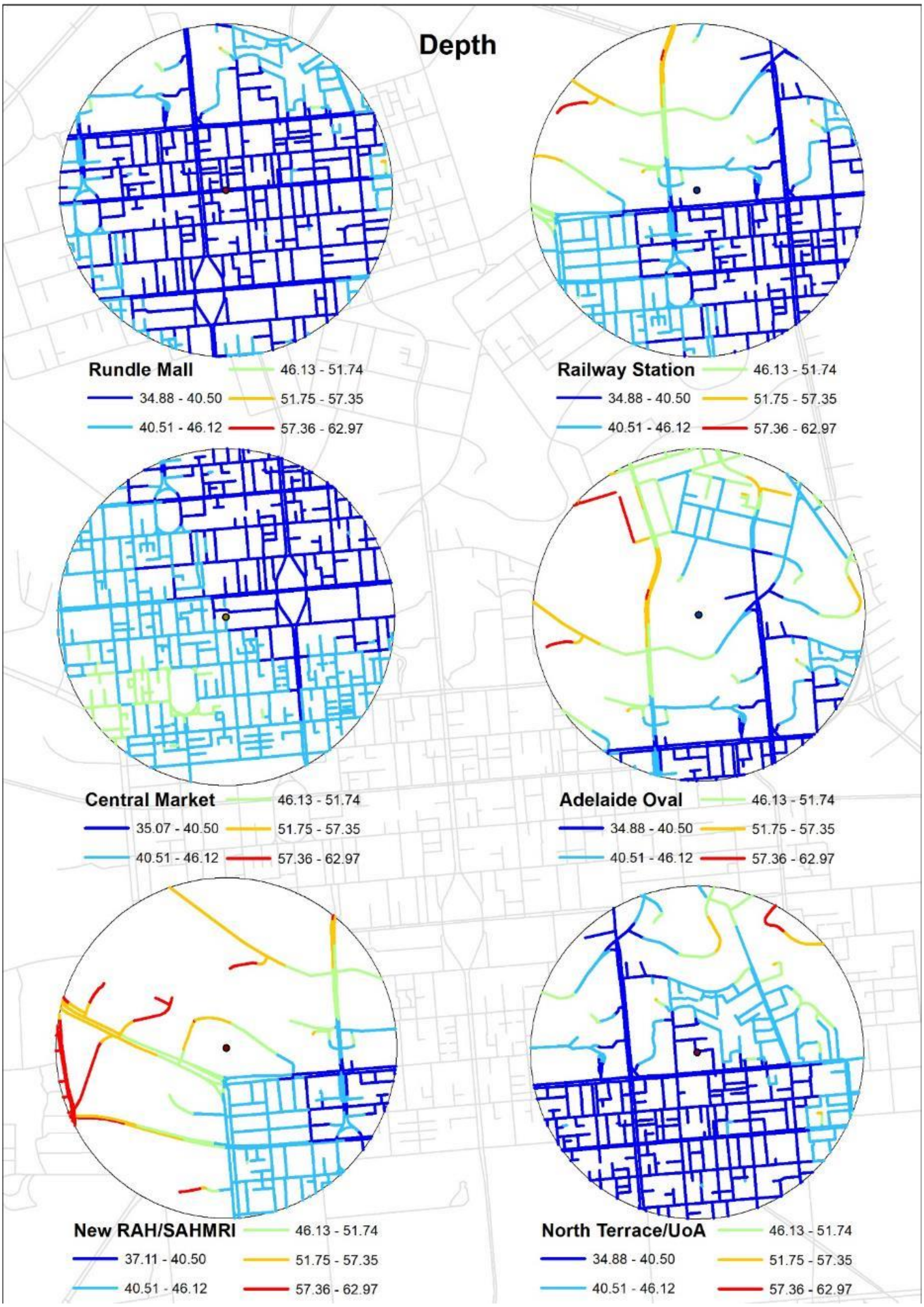


Figure 4- 6 The quality of depth across six major destinations (vicinity of 800 metres)

Figure 4- 7 The quality of depth (R5) across six major destinations (vicinity of 800 metres)

4.3.2. PedShed Analysis

The mapping of a 'PedShed' or walkable catchment enables an assessment to be made about the interconnectedness and accessibility of the street network for pedestrians. To map the PedShed, a 400- and/or 800-m circle is usually drawn around a transit stop, which assumes a 5 and 10 min walk, respectively. The PedShed shows the percent of the circle that is truly accessible based on safety, sidewalk connectivity, and street layout. The PedShed analysis technique is used as a tool to assess the walkability of a neighbourhood and to assess street layouts for new developments and existing areas, to consider improvements which can be made to connectivity. It can also be used to compare locations for walkability and connectedness.

The PedShed index is expressed as the actual area within a five minute walking distance and as a percentage of the theoretical area within a five-minute or ten-minute walking distance. The higher the percentage obtained, the better the walkability and the likely energy efficiency of any urban area. A good target for a walkable catchment is to have 60 percent of the area within a five minute walking distance, or 10 minutes in the case of railway stations.

The PedShed maps for six major destinations are shown below (Figure 4- 8). As seen in

Table 4- 1, North Terrace/UoA and Rundle Mall are slightly more walkable than four other destinations within a five minute walking distance. Similarly, Rundle Mall is substantially more walkable than the five other destinations.

Table 4- 1 The PedShed index for six major destination

Major destination	Radius of 400m (%)	Radius of 800m (%)
Adelaide Oval	39	41
New RAH/SAHMRI	47	28
Railway Station	53	58
North Terrace/UoA	63	43
Rundle Mall	61	65
Central Market	45	57

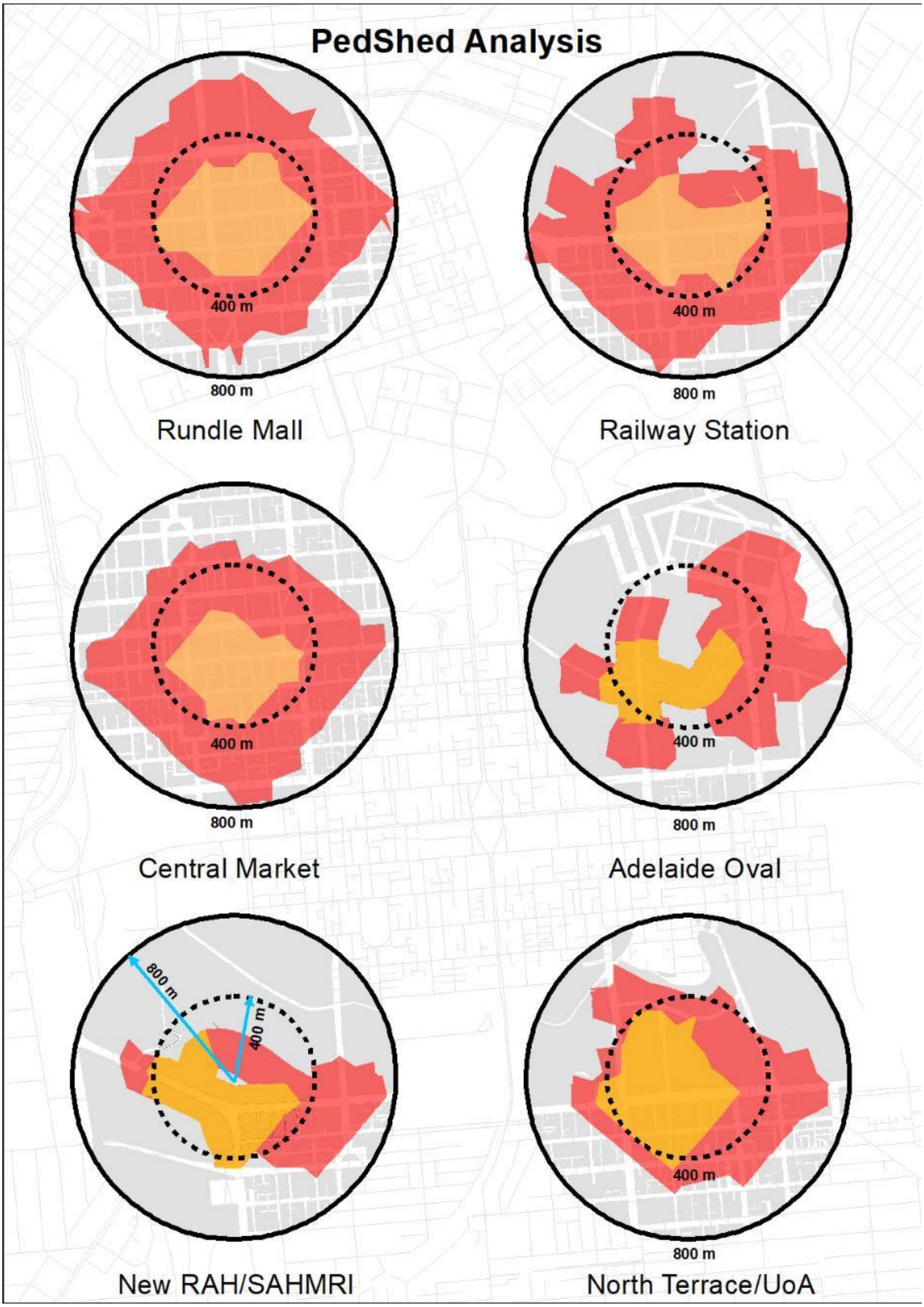


Figure 4- 8 PedShed maps of six major destinations for a 5- and 10-min walk

4.4. Data collection on potential users

4.4.1. The administration of the survey

Since the potential customers (trip makers) of selective sites are in excess of 50,000 the following formula was used to arrive at a representative number of respondents when population estimate is known (Godden, 2004).

Where:

$$n = \frac{Z^2 \times p\,(1-p)}{M^2}$$

n = Sample Size for infinite population

Z = Z value

P = population proportion (expressed as decimal)

M = Margin of Error

If we assume that one in two of Adelaide's population are likely to attend at least one of those 6 places, then we can use a population proportion (P) of 50 percent (0.5) to determine a sample size (n) of an infinite population of those potentially attend in MTGs. On the other hand, we consider the confidence level of 95 percent, therefore, we can consider Z value of 1.96. Also, the margin of error is assumed to be 5 percent.

Considering the above assumptions, the optimum sample size is 384. If we consider 10 percent extra in case of incomplete or unreliable answers, then the sample size will be increased to 422. Because we have 6 destinations to survey, for each MTG, the goal was 70 questionnaires from each location.

- The survey undertaken by ActionResearch under contract to UniSA which included both the intercept street survey and online panel interview. Intercept Interviewing took place between 20-24 March 2018.
- 8 interviewers participated in the intercept work
- The online interview took place between 27 March – 9 April, 2018.

Table 4- 2 The process of the field survey

Task	Undertaken date
Stage 1: Project Set Up and Approvals	
• Agree on Schedule/Terms of Reference (UniSA)	Friday 9 March
• Cost Centre approval for costs including invoicing details (UniSA)	Friday 9 March
• Confirm six locations and provide project description (UniSA)	Friday 9 March
• ACC Approvals to conduct research (UniSA)	w/c 12 March
• Provide Questionnaire draft (UniSA)	Friday 9 March
Stage 2: Questionnaire Review, Programming and Testing	
• Review questionnaire and suggest any changes to skip logic, content and question design (Action)	13-16 March
• Program online questionnaire (Action)	w/c 19 March March
• Length test questionnaire and advise timings (Action)	w/c 19 March March
• Final approval sign-off of questionnaire (UniSA)	Monday 26 March
Stage 3: Online Interviewing	
• Launch online interview to Adelaide Metro Residents within 10km who have visited 1 of the 6 locations (Action)	w/c 26 March
• Monitor fieldwork and check data, provide regular updates to client (Action)	26 March – 9 April (2 weeks)
• Complete n=200 online interviews (Action)	9 April (end fieldwork)
Stage 4: Intercept Interviewing	
• Undertake intercept interviewing at n=6 locations in the CBD (Action)	22-25 March*
• Recruit n=400 participants to online interview (to achieve n=200 completes) (Action)	22-25 March*
• Email list of recruits to complete interview and follow up with reminder calls (Action)	w/c 26 March
• Completed n=200 recruit to online interviews	9 April (end fieldwork)
Stage 5: Delivery of Data File	
• Provision of data (Excel/SPSS) (Action)	COB Wed 10 April
• Random selection of 4 x winners for $50 incentive prize and payment completed by voucher (Action)	13 April

The average interview length for the survey was 16 minutes 30 seconds (median length 11 minutes 21 seconds) for those interviewed via the panel. For those interviewed by recruitment at the intercept interview, the average interview length for the survey was 20 mins 29 seconds (median length 14 minutes 34 seconds). A total of 408 interviews were completed, which provides an accuracy level of +/- 4.85 percent for these results at 95 percent confidence (in 95 out of 100 surveys, we would expect the result to be within +/- 4.85 percent, so we can be 95 percent confident the 'true' result lies within this range).

The number of participants for each of six major destinations were as below. We achieved the required minimum of n=40 in each location for the purposes of this study.

Table 4- 3 A sample outlook of a surveyor activity

Date	Start time	End time	Location	Work description	Number of hours
21/03/2018	3pm	5pm	City West campus & Hindley street	Street interview	2 hours
22/03/2018	4.30pm	6.30pm	Chinatown	Street interview and taking photos of bike parking (OfO)	2 hours
23/03/2018	4pm	6pm	City East campus	Campus interview	2 hours
24/03/2018	2pm	4pm	Rundle Mall	Street interview	2 hours
27/03/2018	4.30pm	6pm	City	Street interview and taking photos of bike parking (O-bike)	1.5 hours
28/03/2018	3.30pm	5.30pm	North Terrace	Street interview	2 hour
29/03/2018	3.30pm	6pm	City	Going to GoGet Carshare Pod in Franklin Street and Hindmarsh Square to take photos and street interview around those areas	2.5 hours
03/04/2018	3.30pm	5.30pm	Chinatown	Street interview	2 hours
04/04/2018	2.30pm	5pm	Rundle Mall	Street interview	2.5 hours
05/04/2018	3.30pm	5pm	Riverbank Precinct and surrounding areas	Street interview	1.5 hours
Total					**20 hours**

Specific limitations were placed on the survey. Limited quotas were applied on age, gender, and other demographic items so this data does not show a truly representative sample of South Australian residents (typical of the nature of intercept work). Time of intercepts was done during the day time at best available busy times so there is a possible bias in the results due to timings of intercept work and the types of respondents that were recruited. Intercept work relies on the willingness of people to provide their personal contact details at a time of increased scrutiny around privacy awareness and personal data security issues so people might have been less willing to participate in the survey as a result. The following map and graph show the geographical distribution of the respondents. The majority of respondents (91.9 percent) lived in council areas other than Adelaide City Council area. The residence suburb of those attending the 6 major centres shows the higher share of inner suburbs and middle-ring suburbs.

Table 4- 4 The number of collected samples

Location	Online	Intercept	Total
Rundle Mall	48	34	82
Train Station	63	23	86
Central Market	39	29	68
Adelaide Oval	24	40	64
New RAH/SAHMRI	14	30	44
North Terrace/UoA	20	44	64
TOTAL	208	200	408

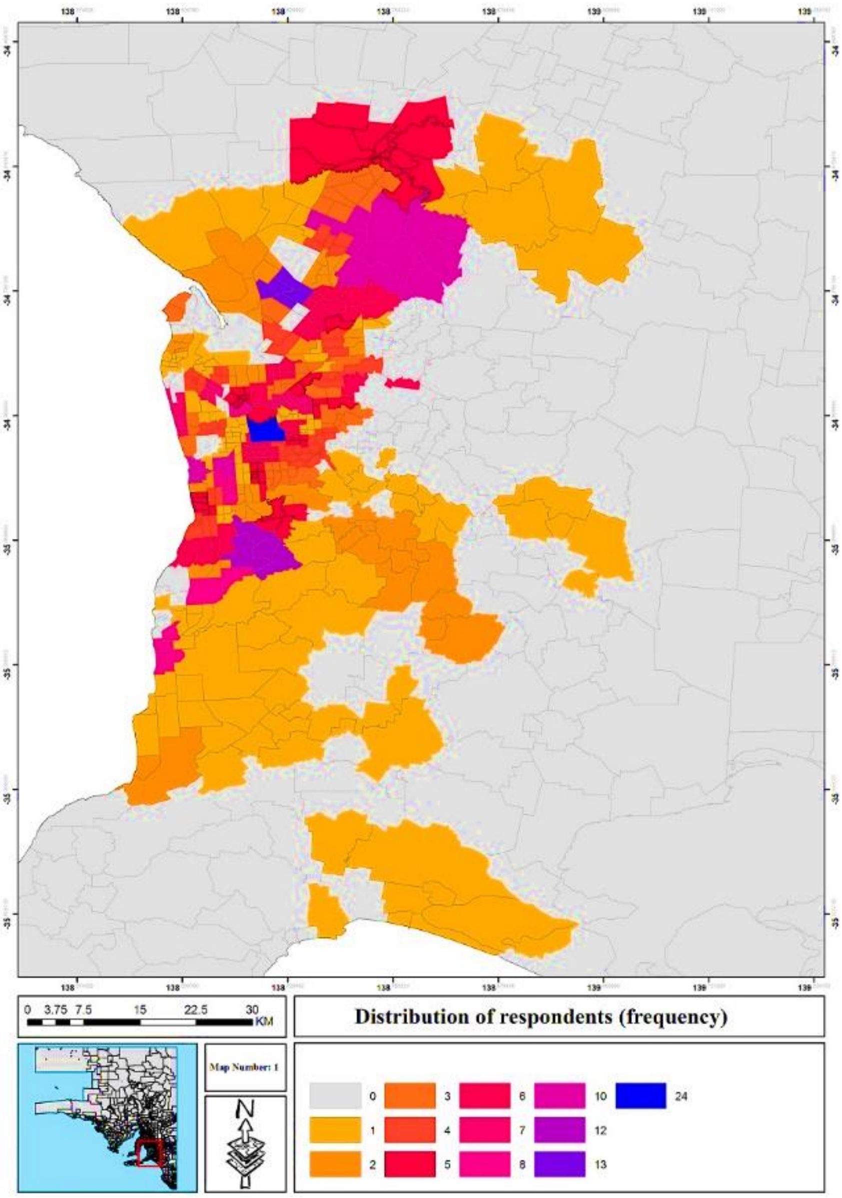


Figure 4-9 Distribution of respondents based on residential suburb

4.4. Data analysis on potential users

Not all of six major destinations have the same trip attraction. In fact, the function, services and facilities provided, and accessibility affected the level of trip generation for each destination. The frequency of travel for 11 major destinations in Adelaide City was investigated by asking two questions: "S1: Which of the following have you visited in the last week?" and "A1: Approximately how often do you take trips to each of the following destinations in central Adelaide?" The results of these questions are illustrated in the following graph and table respectively.

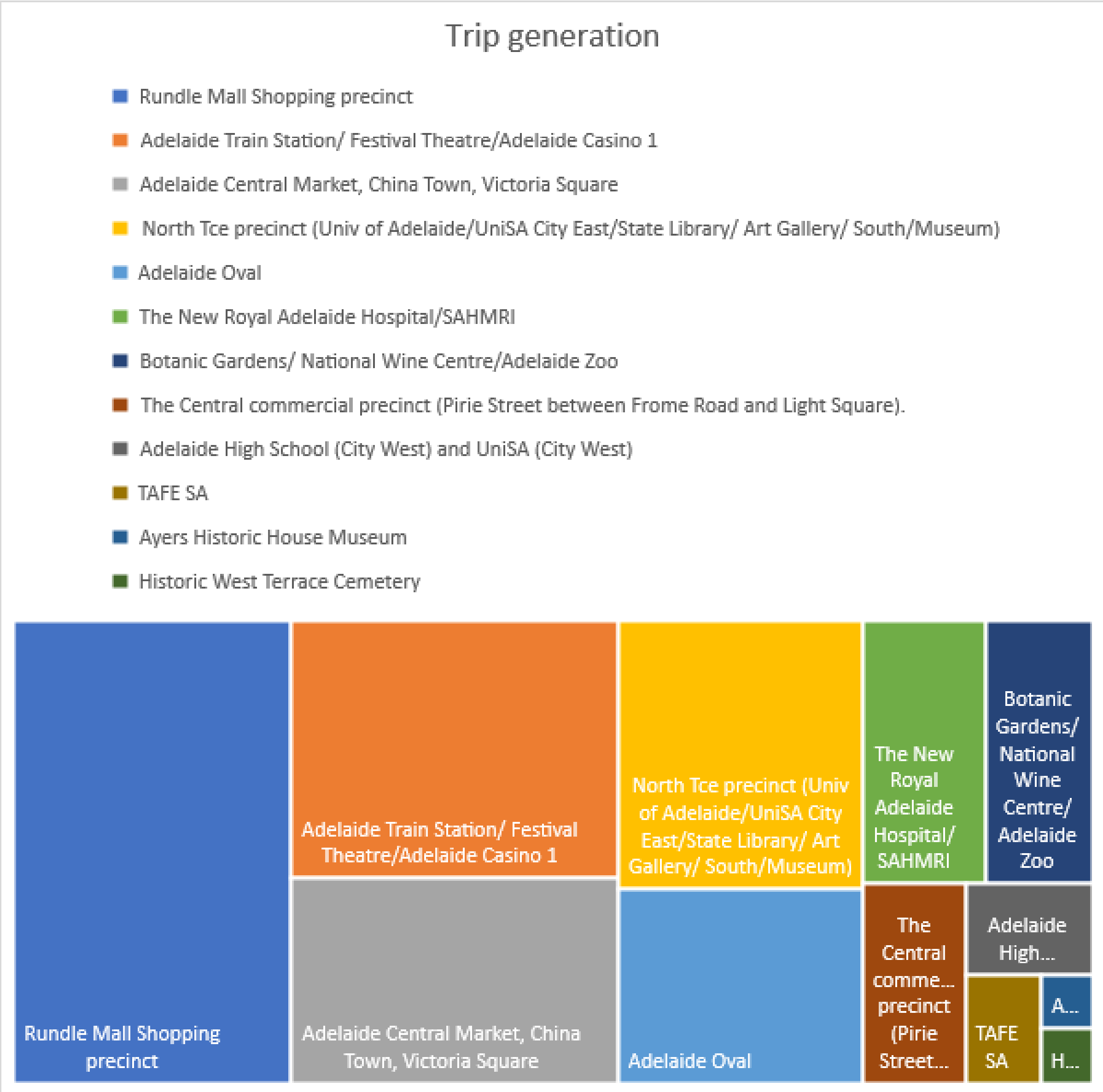


Figure 4- 10 Trip generation by major destinations in City of Adelaide

Table 4- 5 Frequency of attendance at one of major trip generation spots

	Rundle Mall Frequency	Train Station	Central Market	Adelaide Oval	Royal Adelaide Hospital	North Tce precinct	Botanic Gardens	Adelaide High School	Central commercial precinct	Ayers House Museum	TAFE SA	West Terrace Cemetery
Daily	34	37	8	1	21	50	1	6	13	1	1	0
A few times a week	69	39	33	2	9	34	7	13	22	1	5	1
Once a week	78	39	61	30	10	24	14	4	21	3	4	3
Once a month	89	63	84	62	15	50	39	8	58	7	10	2
A few times per year	133	191	185	184	98	151	255	47	142	52	29	39
Never	5	39	37	129	255	99	92	330	152	344	359	363
Frequency index (FI)	0.28	0.24	0.23	0.19	0.18	0.23	0.14	0.13	0.17	0.10	0.15	0.09

Based on the above information, the six major destinations within the City of Adelaide include:

- Rundle Mall (FI= 0.28)
- Train Station (FI= 0.24)
- Central Market (FI= 0.23)
- Adelaide Oval (FI= 0.19)
- New RAH/SAHMRI (FI= 0.18)
- North Terrace (FI= 0.23)

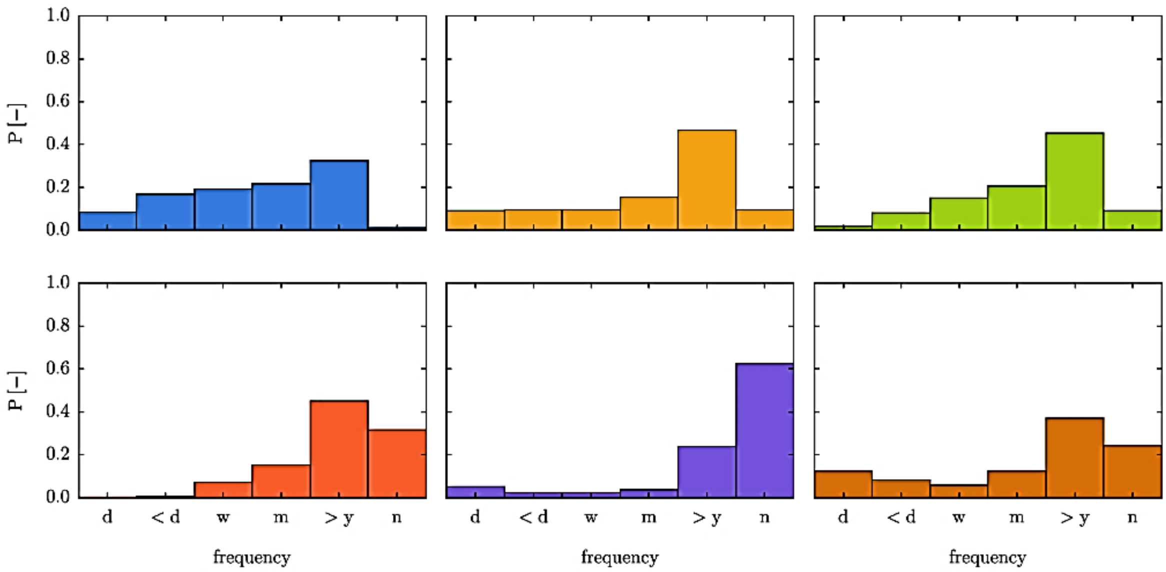


Figure 4- 11 Frequency of attendance at six major trip generation spots

Each of these destinations has a distinct role in addressing the needs of metropolitan Adelaide residents, therefore, different trip purposes are expected. The survey showed that shopping (21.1 percent) had the highest share followed by going to work (17.6 percent), social activities (13.7 percent) and education (10.8 percent). In fact, these four functions comprise over 60 percent of trips targeted Adelaide's central area. If work and education trips are considered as non-arbitrary trips, then a large share of trips for other purposes (68.7 percent) are associated with some degree of flexibility make their management easier by transport planning authorities (home return trips excluded).

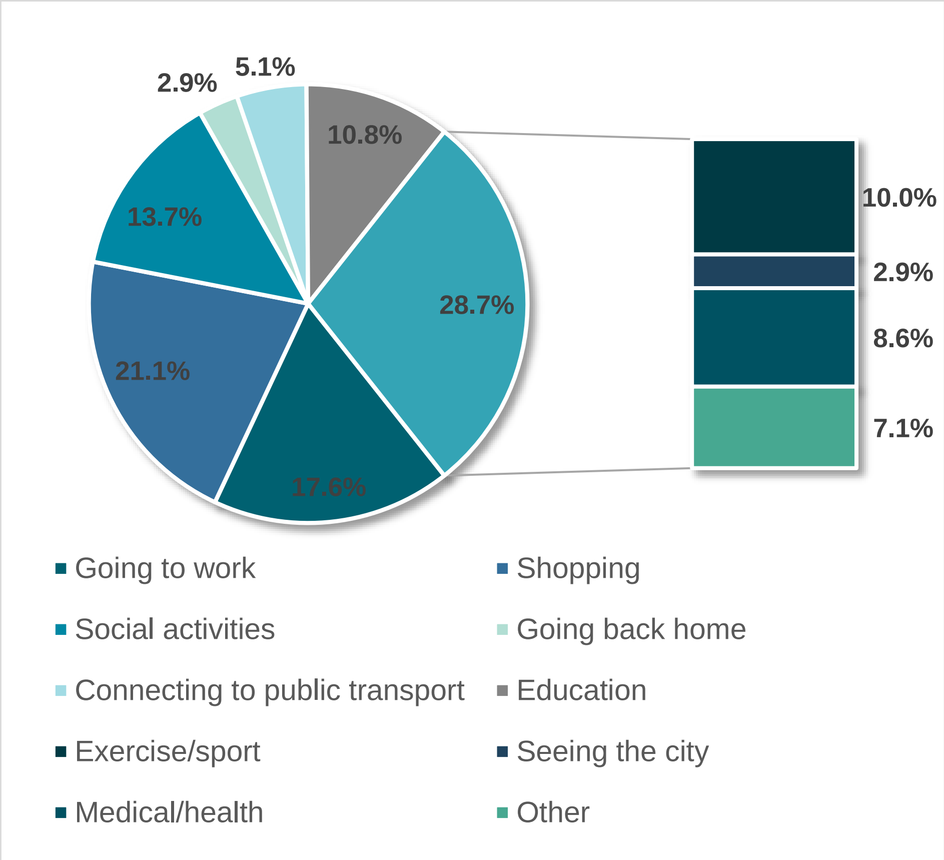


Figure 4- 12 Trip purpose of travellers

It is also apparent from the survey data that 75 percent of trips were home-based and originated from home included home in CBD (9.1 percent), and home but not in CBD (65.9 percent). This information does not include those home-based trips which ended at home.

The survey provides us with useful information on different characteristics of travel behaviour of trip-makers to central Adelaide. According to the graph below, most of the trips had at least 3km distance length and 30min time length.

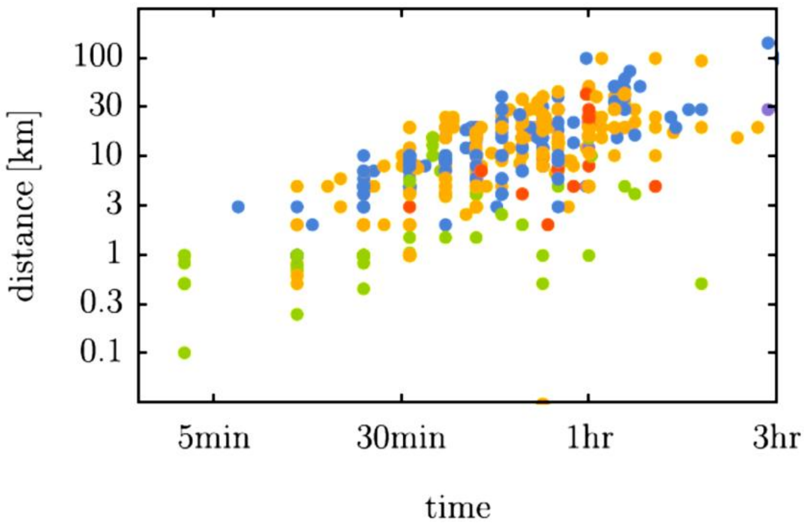


Figure 4- 13 Distribution of trips based on travel time, distance and mode of travel

The table below shows the modal choice of trips. This relates to the mode that chosen from the main origin (home or somewhere) to that destination. The appropriate provisioning of public transport system within the City of Adelaide area that included bus, train and trams, made public transit a popular mode for the majority of trip-makers. The second attractive option was car either as driving a car or as a passenger. The shared-mobility alternatives including shared bike or shared car, and shared-ride had very minor role in moving the trip makers.

Table 4- 6 Modal choice to the destination

Frequency		Percent
Private Car as driver	67	16.4
Private car as passenger	25	6.1
Taxi	3	.7
Bus/OBahn	87	21.3
Train	80	19.6
Tram	26	6.4
Private Bicycle	6	1.5
Shared Bicycle (OfO/O'Bike/CityBike)	1	.2
Motorcycle	2	.5
Walk	43	10.5
Combination of different types of transport INCLUDING A CAR	40	9.8
Combination of different types of transport NOT INCLUDING A CAR	20	4.9
UBER	4	1.0
GoGet Car or other hired car	1	.2
Other (Please specify)	3	.7
Total	**408**	**100.0**

Since the share of some modes were minor, the following five main categories were defined:

- Car (Private as Driver, Private as Passenger, Taxi, Motorcycle, Comb including Car)
- Public Transport (Bus, Train, Tram)
- Bike/Walk (Private Bicycle, Shared Bicycle, Walk, Eco Caddy)
- No Car (Comb not including a car)
- Car-Sharing (UBER, GoGet)

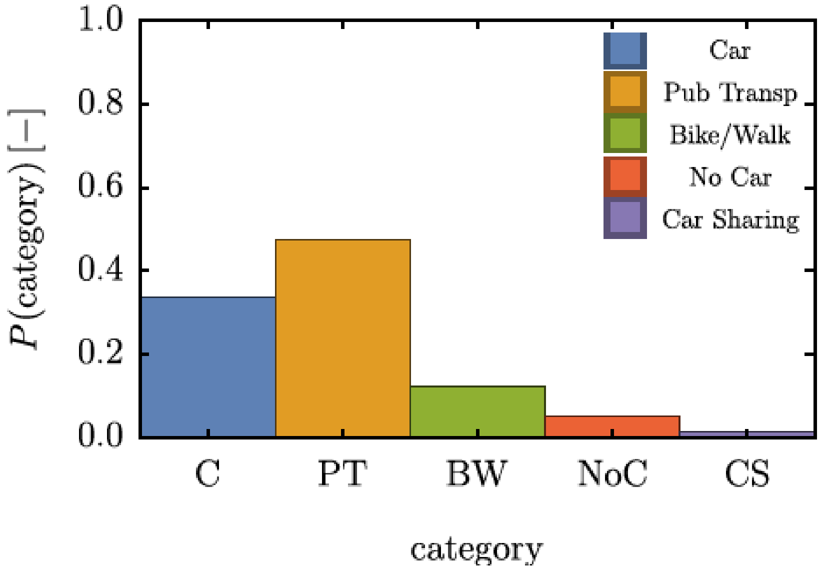


Figure 4- 14 Categorical histogram of users

Blue = Car (Private as Driver or Passenger, Taxi, Motorcycle, Comb. including Car), Orange = Public Transport (Bus, Train, Tram), Green = Bike/Walk (Private Bicycle, Shared Bicycle, Walk, Eco Caddy), Red = No Car, and Purple = Car/Ride-Sharing (UBER, GoGet Car)

However, the mode choice was significantly different among six destinations showing the impact of accessibility to the destination and the function of that destination. According to this graph, Adelaide oval and New RAH/SAHMRI had lowest share of non-motorised transport while Rundle Mall and Central Market as two shopping precincts had high share of walking and cycling. The new RAH/SAHMRI, Central Market and Adelaide Oval also had a high share of car usage.

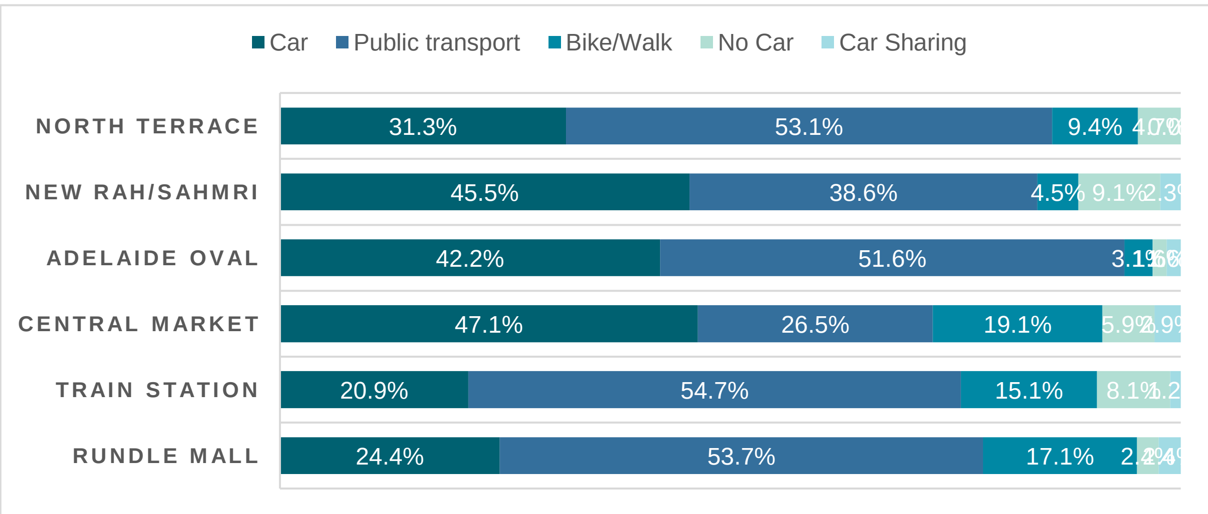


Figure 4- 15 Modal choice for each of six major destinations

Another interesting finding from the survey was the spatial distribution of trip makers based on the mode that they had chosen. The map below shows that car users mostly located in the outer suburbs, while public transport users live in middle rings and also along the major corridors which radially emanated from the CBD. In fact, this finding shows that the provision of public transport over medium distances (between 3 to 10km) from the CBD, and especially along the major corridors is effective in encouraging residents to catch public transport instead of opting for the car.

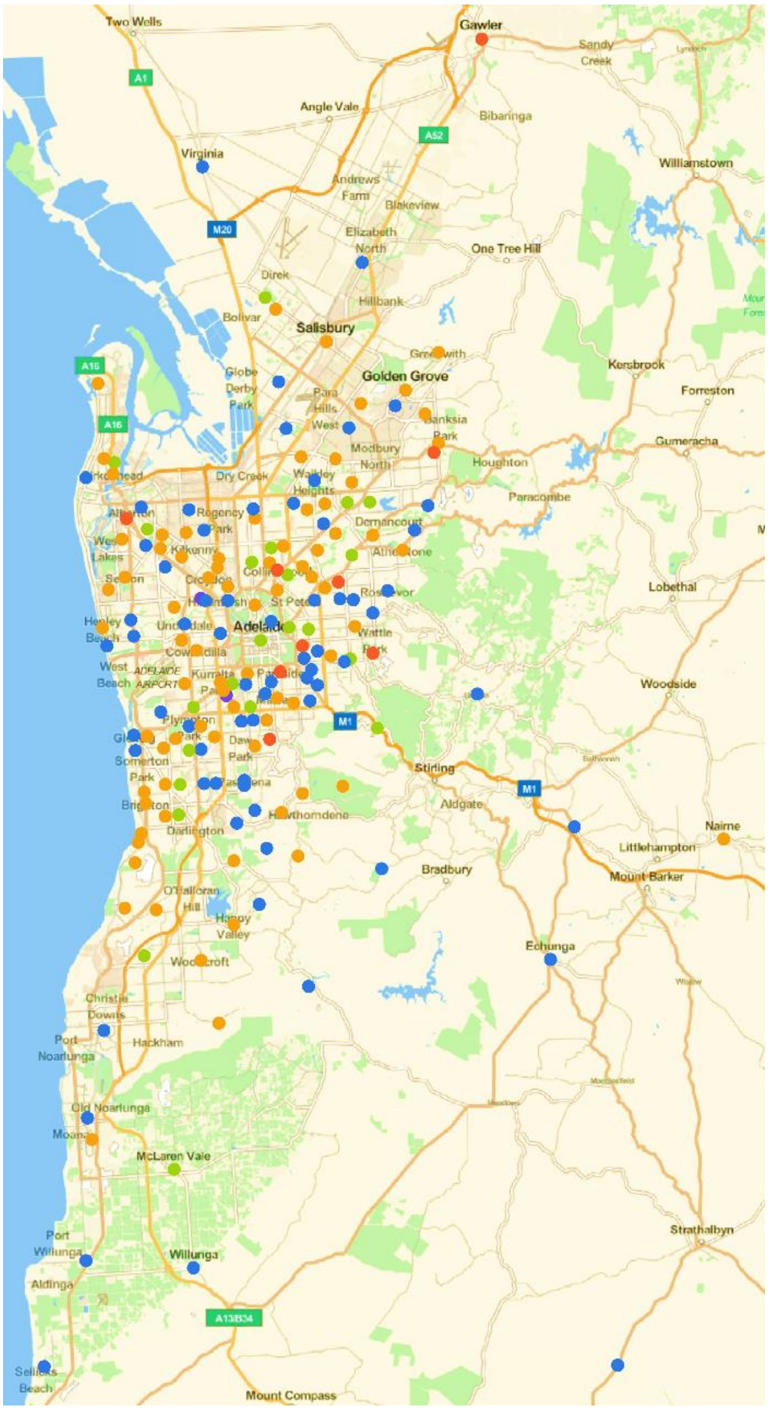


Figure 4- 16 User category on map

Blue = Car, Orange = Public Transport, Green = Bike/Walk, Red = No Car, and Purple = Car-Sharing

Car as the major mode of travel was mostly chosen for longer trips especially those longer than 10km. The graph below shows the distribution of car usage against the distance. The dark area represents the fraction of car users whose distance is 10 km which is 40 percent.

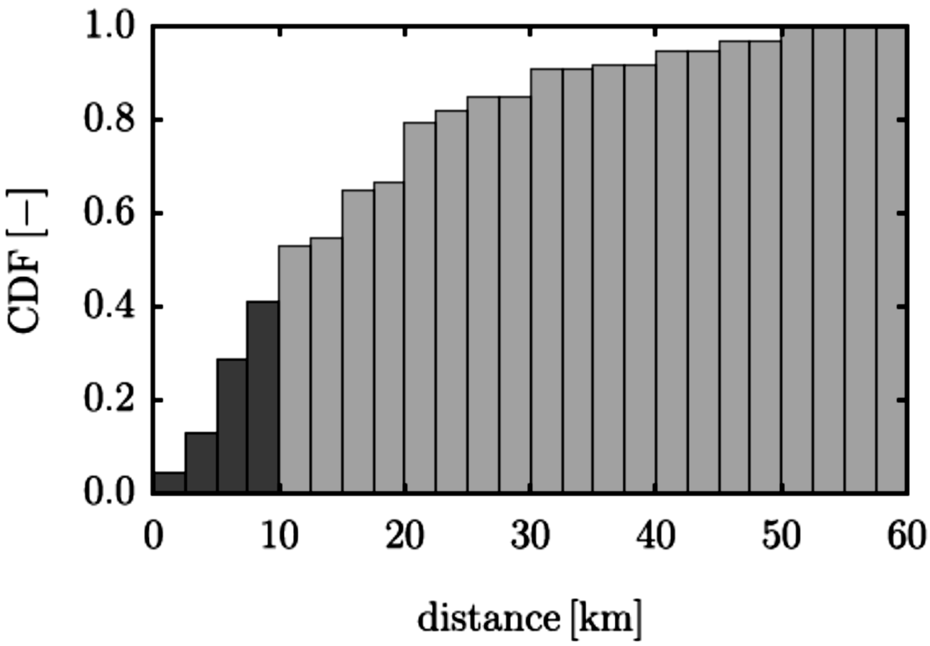


Figure 4- 17 Cumulative distribution of car users by distance

As noted before, the sharing mobility options indicated a very low contribution. The survey showed that sharing-bikes that included OfO, O'Bike and Adelaide Free Bike, all together had higher share in daily and weekly trips in comparison with ride-sharing of UBER and car-sharing of GoGet. While only 7.8 of respondents had an experience of using shared-bikes, about one-third of respondents (29.9 percent) expressed their interest in using shared-bikes. For the ride-sharing option of UBER, the situation was better as 29.8 percent of respondents had experienced using UBER. The majority of them would take UBER a few times a year. GoGet as the car-sharing alternative was used by only 2.4 percent of respondents. However, one-third (33.1 percent) expressed their tendency to consider it in the future.

Table 4- 7 Frequency of shared-mobility services usage

	Sharing-bike (OfO, O'Bike, Free-bike)		**UBER**		**GoGet**	
	Value	Percent	Value	Percent	Value	Percent
Daily	4.0	1.0	1.0	0.2	0.0	0.0
A few times a week	7.0	1.7	2.0	0.5	0.0	0.0
once a week	2.0	0.5	15.0	3.7	1.0	0.2
Once a month	3.0	0.7	30.0	7.4	4.0	1.0
A few times a year	16.0	3.9	70.0	17.2	5.0	1.2
Never used but would be interested	122.0	29.9	122.0	29.9	135.0	33.1
Never used and will never used	254.0	62.3	168.0	41.2	263.0	64.5

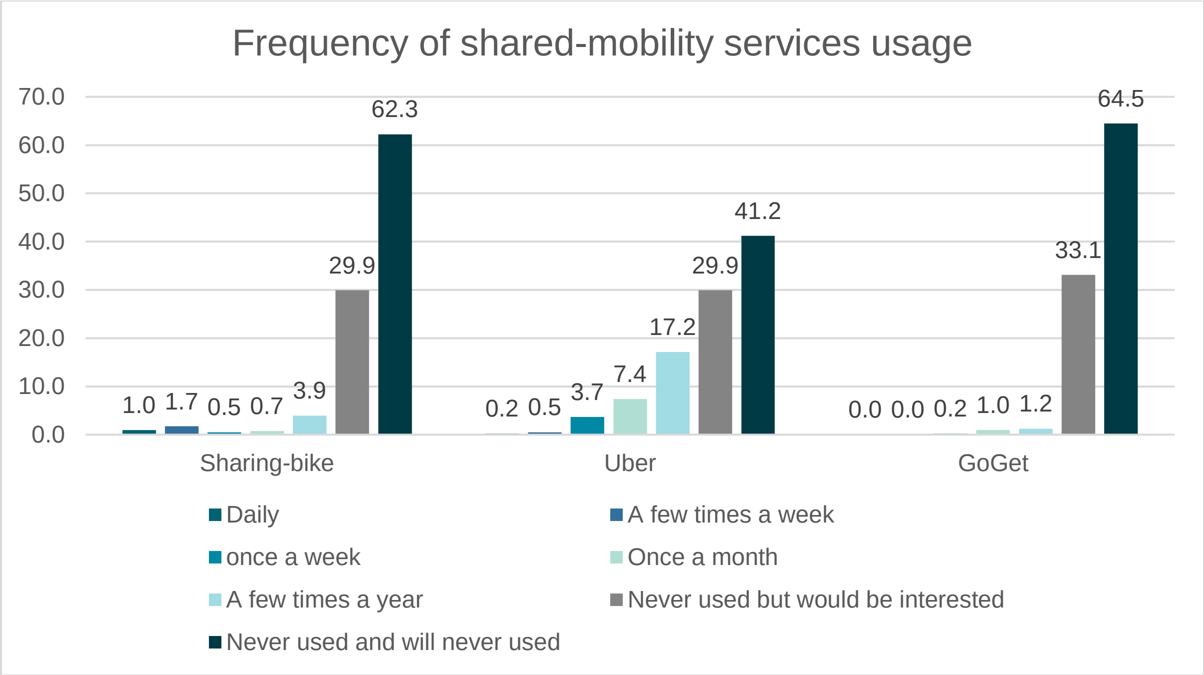
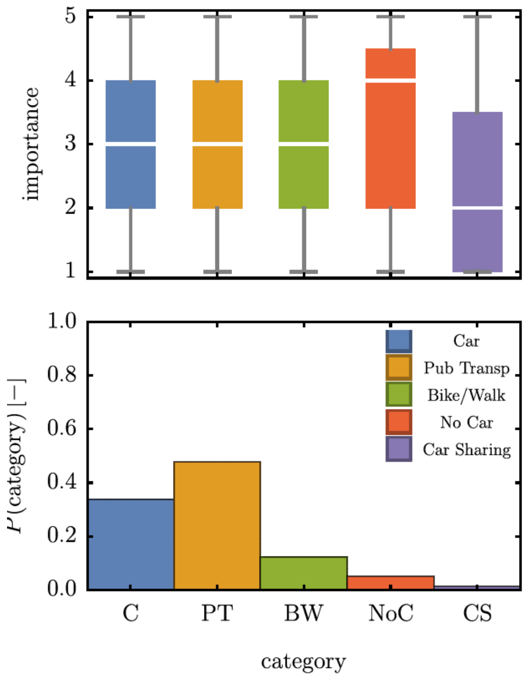


Figure 4- 18 Frequency of shared-mobility services usage

One of the important questions of the survey was asking about the role of different criteria when choosing a mode. The criteria included: environmental issues and other issues such as comfort and costs. The results of the question of environment against the modal choice are depicted below. The result shows that non-car users (combined mode without including a car) were more sensitive about the environmental issue and considered it when choosing a mode. The attitude to the environment for the users of other modes included car, walk/cycle and public transport were moderate with similar pattern.



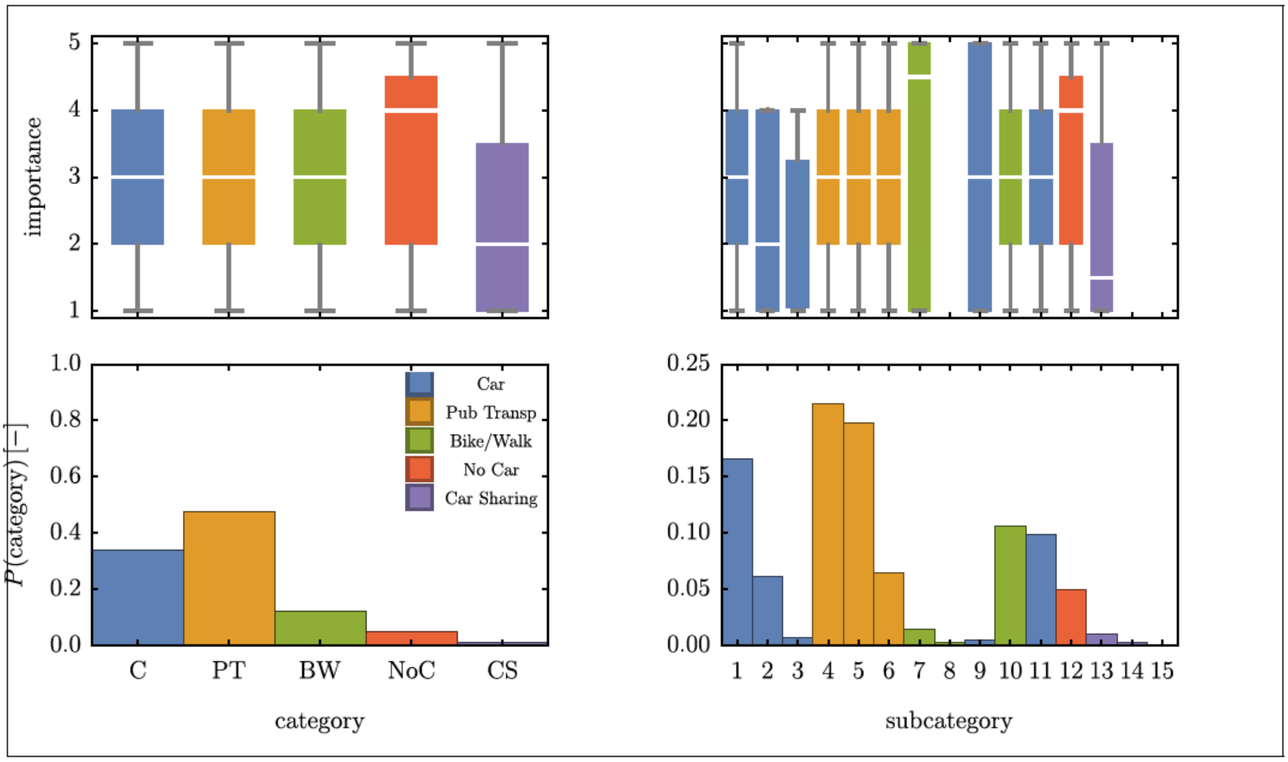


Figure 4- 19 Environmental issue importance (top row) for categories of modal choice.

Blue = Car, Orange = Public Transport, Green = Bike/Walk, Red = No Car, and Purple = Car/Ride-Sharing

The importance of 11 criteria when choosing a mode for travel is depicted below. Convenience and safety were regarded as the most important criteria whereas exercise and status showed the lowest priority. The importance of comfort, speed, health and independence were similar and moderate to somewhat.

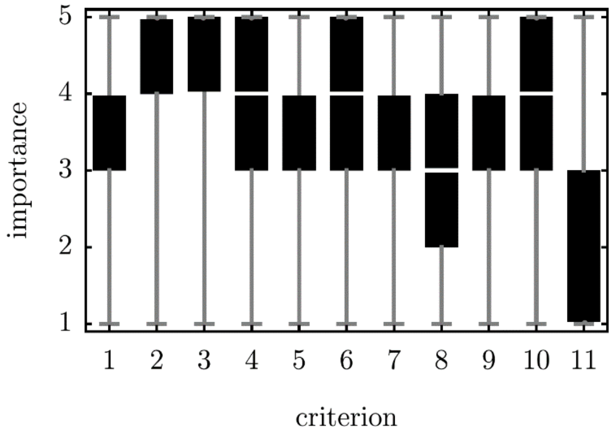


Figure 4- 20 Importance for the criterion in using a transport mode

(1) Comfort, (2) Convenience, (3) Safety, (4) Cost, (5) Speed, (6) Time, (7) Health, (8) Exercise, (9) Distance, (10) Independence,(11) Status.

Furthermore, the preference of trip-makers against gender type is examined. This comparison showed significant differences among males and females in choosing a mode. As shown below, males and females criteria have similar attitudes towards the aspects of comfort, convenience, time, health, exercise, distance and status. On the other hand, safety, cost and independence were more important for females than males. By contrast, males considered speed of higher importance.

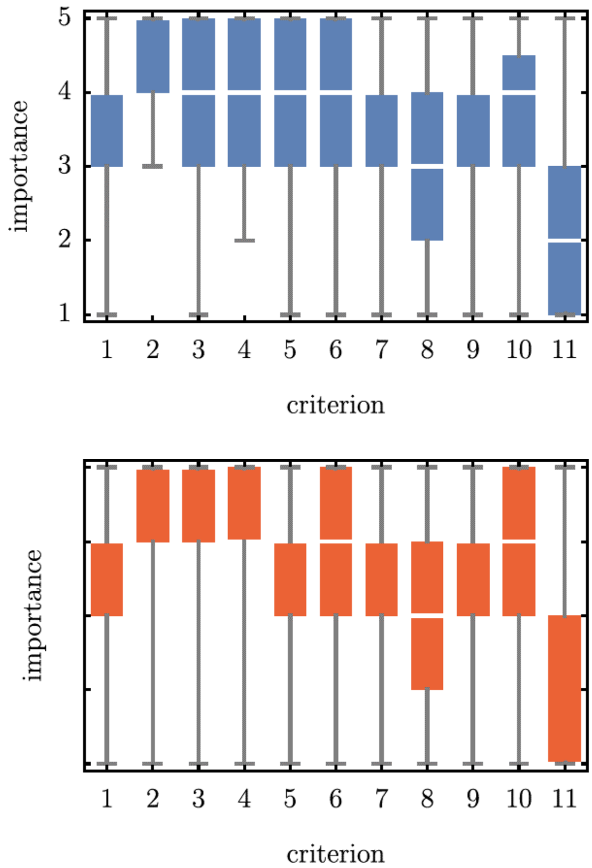


Figure 4- 21 Importance of those 11 criteria for gender groups
(top) male (37%) and (bottom) female (62%)

The importance of those 11 criteria were also examined for three age groups included those aged under 25 years (16 percent), those between 25 and 65 (42 percent) and those aged over 65 (42 percent). This fragmentation shows that different age groups have similar and dissimilar preferences in choosing a mode. For example, the older cohort considered safety and health with higher priority while the younger-age group considered speed. Both young and middle-aged groups considered travel time and distance as two more important criteria while choosing a mode.

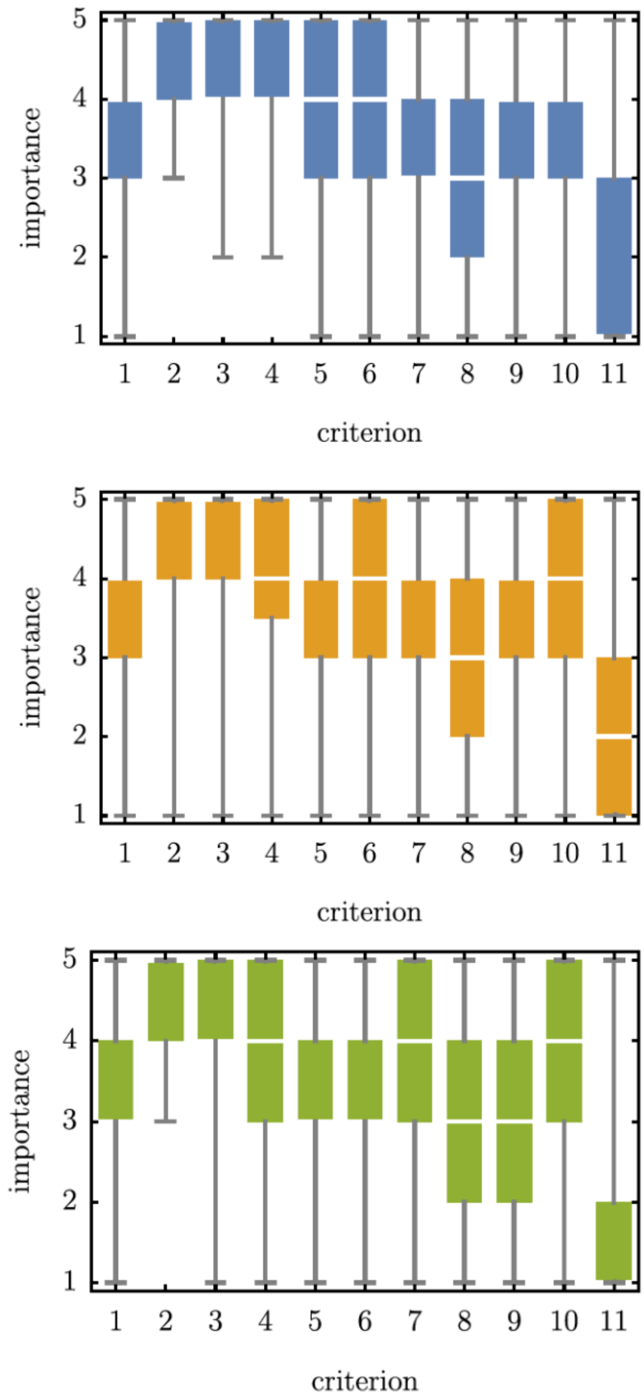


Figure 4- 22 Importance of those 11 criteria for age groups

(top) age < 25 yr (16 %), (centre) 25 age < 65 (42 %) and (bottom) 65 _ age (42 %)

The main modes for last-mile were walk (60 percent) and public transport, mostly tram (27 percent).

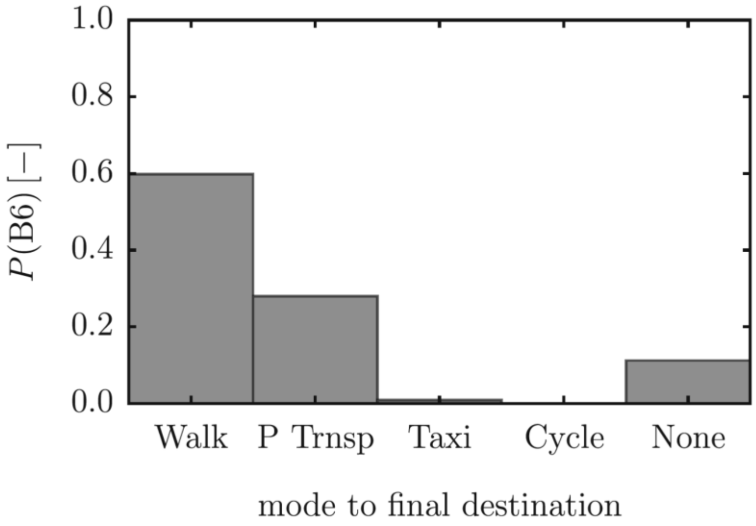


Figure 4- 23 From car park to final destination

(1) Walked, (2) PT, (3) Taxi, (4) Cycle, and (5) None.

The respondents who used a car for the last segment of their trip to the destination (last-mile), rated three factors as the main reasons: convenience; saving time and flexibility/reliability. The lowest importance was for independence and status.

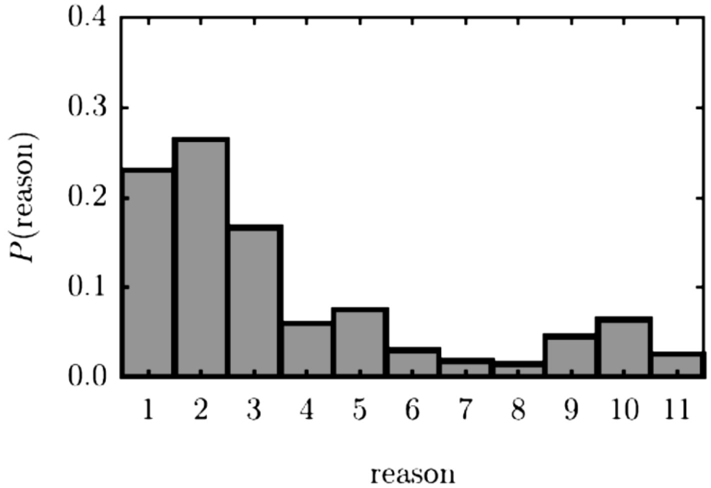


Figure 4- 24 Reason to use a car in the last trip (last-mile)

(1) Saving time, (2) Convenience, (3) Flex/Reliability, (4) Safety, (5) Park, (6) Habit, (7) Health, (8) Indep/Status, (9) Children/Family, (10) Lack of alternative, (11) don't like other.

This group (n=107) then was asked to report their preference in substituting the car for the last-mile with other alternatives included taking a bike/shared-bike; taxi/shared-car and public transport. According to the graph below, public transport was the most preferred option followed by taxi or shared car.

Furthermore, if the population is divided into three age groups, the preference for each segment would be different. While the younger group (aged less than 25) preferred bike and taxi/shared-car; the middle-aged showed higher tendency to use taxi/shared-car and public transport. The older segment (aged over 65) was interested to replace car for last-mile with public transport.

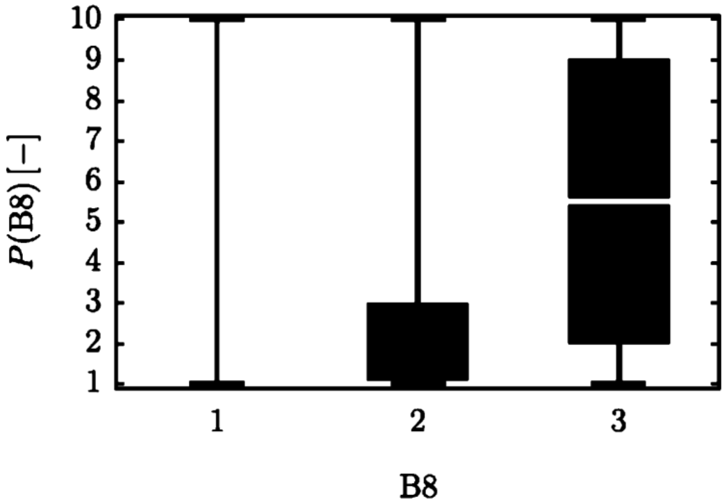


Figure 4- 25 Likeliness in taking (1) bike, (2) taxi/shared-car, and (3) PT rather than using a car
(107 Respondents)

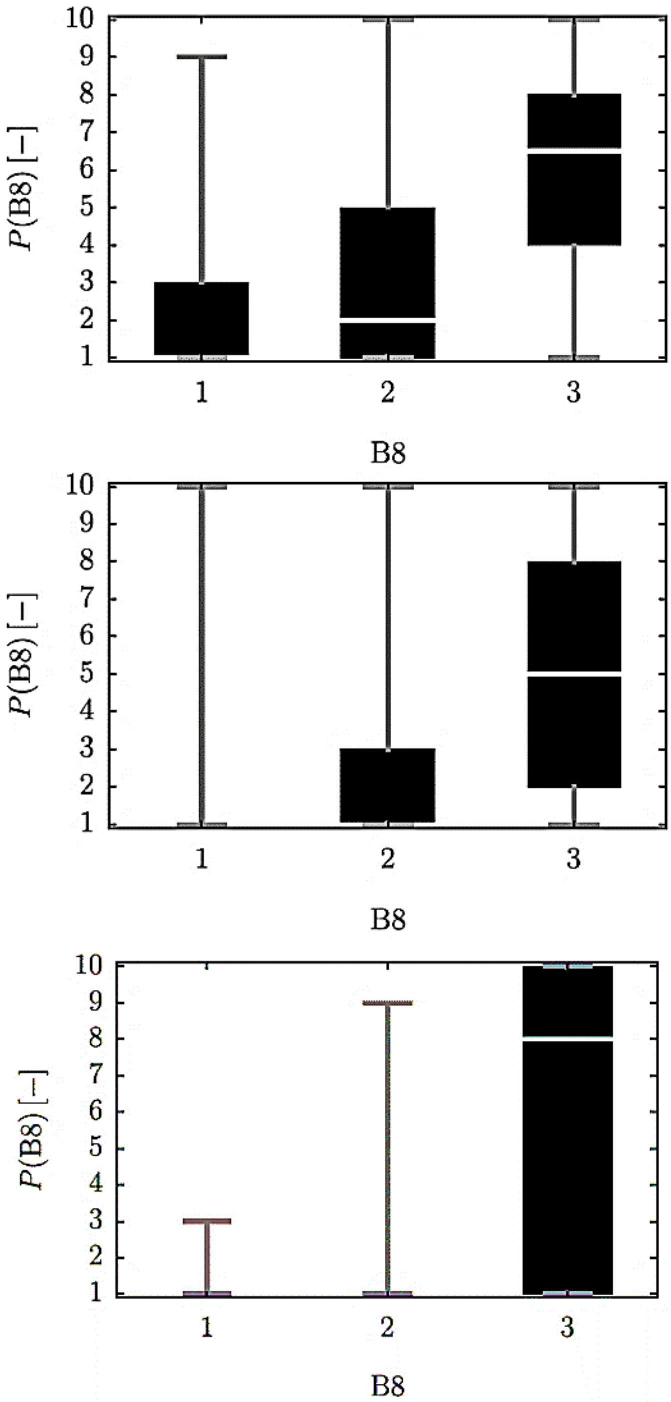


Figure 4- 26 Likeliness in taking (1) bike, (2) taxi/shared-car, and (3) PT rather than a car among (top) age < 25 yr, (centre) 25 ≤ age < 65 and (bottom) 65 ≤ age.

As discussed earlier the current level of using shared-mobility was very low among the respondents. However, a considerable proportion of the respondents (approximately one third) expressed their willingness to explore more and consider it as an alternative for the future. In this regard, they were asked to mention factors which are affective in the likelihood of using shared-bikes. The two most important aspects included: closer destination (if bikes provided close to origin/destination of my trips) and establishing safe lanes/paths.

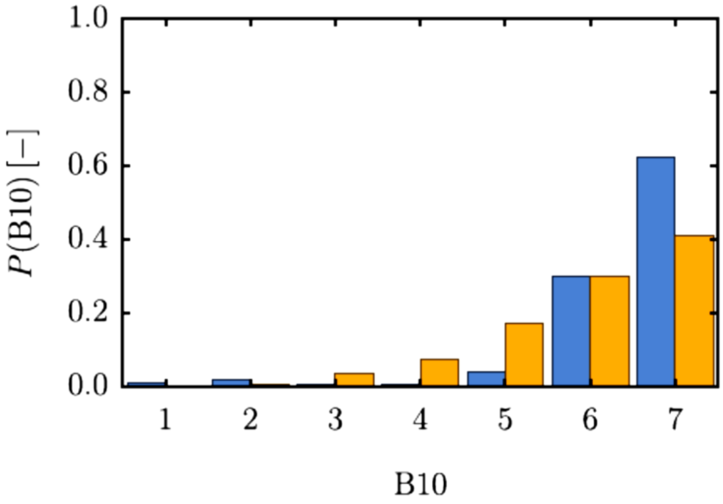


Figure 4- 27 Current level of usage of shared transport

(1= daily; 7= never used and will never use): (blue) bike sharing, (orange) car sharing

Similarly, the respondents were asked to mention the factors which encourage them to take ride-sharing service like UBER and car-sharing service such as GoGet. Three most important factors in considering UBER was cost, value and personal security. For using GoGet, the value of the service was regarded as the most important determinant.

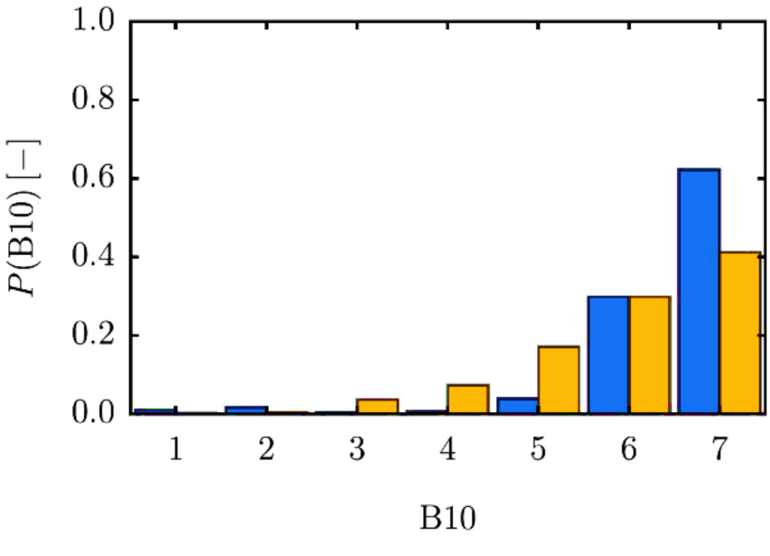


Figure 4- 28 Current usage of shared transport

Blue = bike sharing, Orange = car sharing. The options are (1) daily; (2) a few times a week; (3) once a week; (4) once a month; (5) a few times per year; (6) never used but would be interested; (7) never used and will never use).

Notice that respectively 60 percent (bike-sharing) and 40 percent (car-sharing) of people assert that they have never used the system and they will never use it.

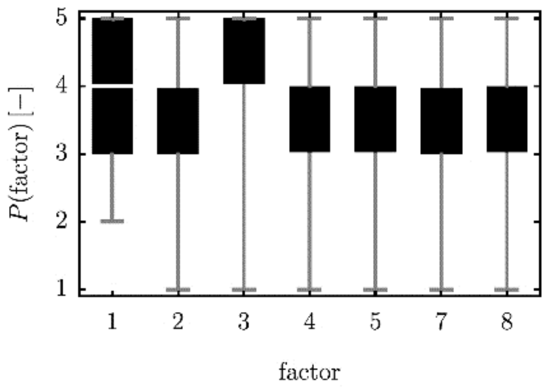


Figure 4- 29 Factors affecting the likeliness of using bike sharing

(1) closer destination, (2) increasing facilities, (3) safe lanes/paths, (4) compulsory helmet is waived, (5) car speed 30 km/h within CBD, (7) more incentives, (8) cyclists prioritized at intersections.

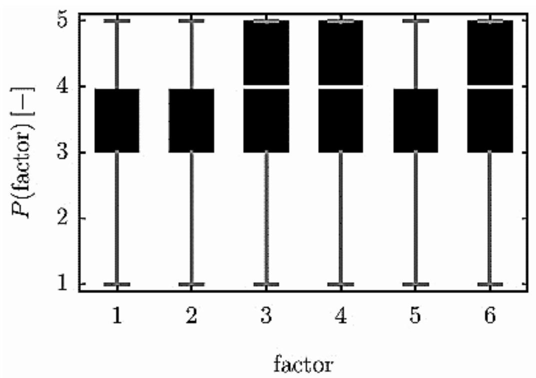


Figure 4- 30 Factors affecting the likeliness of using UBER

(1) close proximity of cars, (2) vehicles availability, (3) cost, (4) value, (5) vehicle cleanliness, (6) personal security.

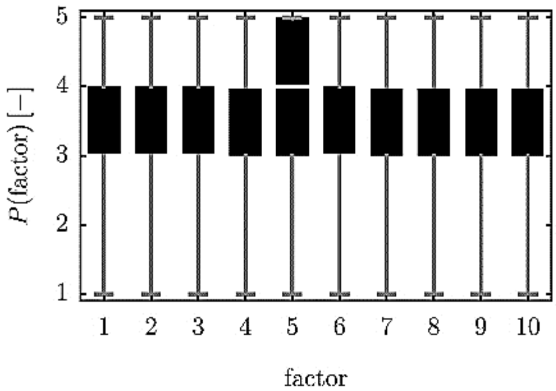


Figure 4- 31 Factors affecting the likeliness of using GoGet

(1) closer destination, (2) vehicle selection,(3) vehicle availability, (4) cost, (5) value, (6) cleanliness, (7) good access parking in CBD, (8) better than traditional car-renting service, (9) quick rental process, (10) liability/insurance.

Finally, the respondents were asked to express the most discouraging dimensions of shared transport. According to the graph below, owning a personal car and using public transport/walk/personal bike were the two most discouraging factors for using shared-mobility schemes.

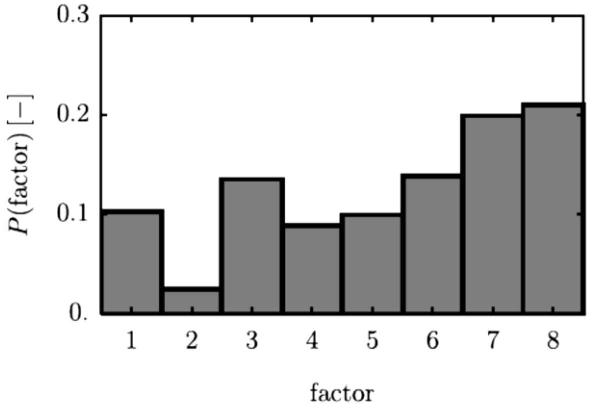


Figure 4- 32 Factors discouraging the use of sharing-transport

(1) difficulty in finding rideshare in a convenient location, (2) difficulty in using smartphone app, (3) not happy to provide CC details, (4) personal safety, (5) it would not benefit me, (6) not aware of a scheme in my area, (7) I have my own car, (8) use public transport/walk/bicycle.

Bivariate preliminary graphs can tell us more the correlation between variables. From the graph below it is clear that car has a uniform distribution across age, while public transport is more appealing among younger people (17-24 years old) and young older (55-69 years old). Looking at question B10 instead (current usage of shared transport options available in Adelaide), the biggest share of respondents answered that they never used the system and will never use it (blue rectangles in the graphs). UBER seems to have clearer pattern (look at B10_2 graphs), being used/or being interesting predominantly among younger people (less than 30 years old). Again, nothing clear as far as concerns income. Both bicycle sharing (B10_1) and GoGet car (B10_3) do not have many users among the respondents of the survey.

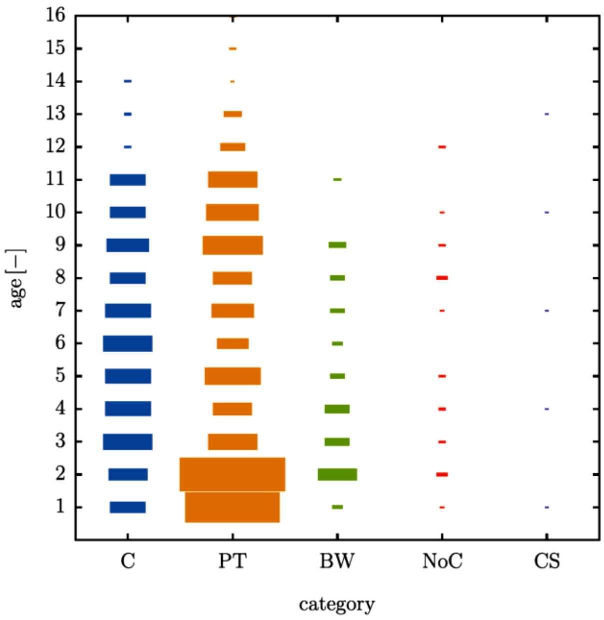


Figure 4- 33 Modal choice against age of the trip-maker

4.5. Data collection on actual users

A web-based online survey was designed with the participation of the actual users of car-sharing (GoGet and UBER) and bike-sharing schemes (OfO and O'Bike). The main objective of these two surveys was to explore the usage frequency and satisfaction level of Adelaide's current CSS and BSS from the viewpoint of real users. The participants were randomly approached on the street among those using CSS and BSS. They were introduced the online link to do the survey if reluctant, therefore, the recruitment leaded to a voluntary sample as a non-probability sampling method. This type of sample is almost made up of people who self-select into the survey due to having a strong interest in the survey topic.

The respondents reported their experience of their CSS and/or BSS trip if they have at least one. The data collection took two weeks due to limitation of finding and tracking an actual CSS and/or BSS user. This approach of sampling has its own limitations sine the sample size was relatively small, and the selection of cases were not fully arbitrary. No exclusion criteria were applied unless for incomplete or non-honest responses (if detected). The response rate of those introduced the survey outline was 80 percent showing high reluctance of CSS/BSS users to participate in relevant research surveys. The data then analysed by descriptive and inferential methods.

The survey questionnaire included three main parts. Part 1 asked for information on users' attitudes towards the current CSS/BSS in City of Adelaide (within the City of Adelaide). More specifically, close-ended questions using a Likert five-point scale were designed to rank potential factors affecting travellers' modal choice with the inclusion of car share. Moreover, the performance of Adelaide's current CSS/BSS was examined by asking sampled participants to evaluate physical and perceived characteristics of the system. The physical features included the location and accessibility to CSS/BSS; basic components such as the availability of mobile apps, the possibility of off-street parking for a shared car (GoGet), the sign up process, and advertising. In addition, other attributes such as payments which related to cost of usage, deposit fee, payment method, and incentives for users were also categorised in addition to the physical characteristics of the system. Users' perceived attributes of the CSS/BSS included the maintenance and cleanness, safety and security, and waiting times.

Part 2 of the survey questionnaire asked the participants to report their experience of car/bike sharing usage. Their frequency of using a shared car/bike, the distance and time duration while using a shared car/bike, were investigated. The questionnaire also included several in-depth questions to explore the main reasons for using shared car/bike from the view point of users, in addition to the shortfalls of CSS/BSS, and their general satisfaction with CSS/BSS in Adelaide. Part 3 includes the socio-demographic characteristics of sampled participants such as the gender, age, education level, type of employment, residency status, household information, and car ownership.

4.6. Data analysis on actual users: BSS users

4.6.1. Demographics of bikeshare users

The demographics of users of three bikeshare schemes in Adelaide are presented by four main indicators included gender; age; employment type and level of education. Approximately 53.3 percent of the surveyed users are males, while 46.7 percent are females. In terms of age group, the majority of users are young people. As such, over a fifth of responses (21.7 percent) are those aged between 30 and 34, followed by the age groups from 35 to 39 (16.7 percent). Interestingly, three age groups have similar percentages of responses, including those aged 20-24 (13.3 percent), 25-29 (15 percent), and 40-44 (11.7 percent), and those aged between 45 and 49, and 17-19 accounted for the same proportion, at 8.3 percent, while the data for surveyed users at their ages over 49 occupied the smallest percentage (5 percent).

With respect to users' employment status, over a third of responses (33.3 percent) is working full time with over 35 working hours per week. Students are the second highest group of bikeshare users (28.3 percent), followed by those with full time jobs less than 35 working hour per week (15.0 percent). The remaining groups are casual worker (13.3 percent), working from home (6.7 percent), and others (3.4 percent). The level of education of respondents is dominated by Undergraduate Degree (40 percent), while roughly 20 percent of responses are those having Postgraduate Degree. The rest of sampled users are people with High school certificate (18.3 percent) and no degree (21.7 percent).

4.6.2. Impacts of demographic characteristics on bike usage

The use of two independent sample t-test analysis in SPSS indicated a statistically significant differences ($p<0.05$) in the means of frequency of using bikeshare between male and female users in Adelaide. More specifically, males (Mean = 2.67; SD = 1.354) were recorded to have a higher frequent usage of bikeshare than female counterparts (Mean = 1.5; SD = 1.019). This is consistent with Goodyear's study (2013), which clarified that males were reported to have a better cycling record as compared to female users in countries with low level of cycling trips like Australia, thereby leading to the fact that women have a lower level of bike sharing participation than men counterparts (Fishman, 2016).

Moreover, using one-way ANOVA test in SPSS it was found that the young users are likely to have higher satisfaction than the old counterparts. To date, there have been statistically significant differences in the means of general satisfaction with BSS in Adelaide between users aged 17-29 and those aged over 45 ($p<0.10$). In this regard, the former group (Mean = 3.55; SD = 0.826) was recorded having higher satisfaction than the latter one (Mean = 2.60; SD = 0.85). Likewise, statistically significant differences were also existed in the means of users' satisfaction with Adelaide's bikeshare schemes between users aged 30 to 40 and those aged over 45. The results of one-way ANOVA analysis showed that over-45-year-old users (Mean = 2.60; SD = 0.894) had lower satisfaction associated with the quality of Adelaide's bikeshare programs than that of the younger users between 30 and 40 years old (Mean = 3.60; SD = 0.699).

These findings could be reasonably explained by the fact that young generations are more likely to have participation in bikeshare programs than that of the old ones (Fishman et al., 2013; D. Fuller et al., 2011). This situation is also determined in the case of bikeshare in Adelaide through the survey results of this study which shows the dominance in the presence of people at their young ages. Therefore, it could lead to the likelihood that they have better experiences and satisfaction with bikeshare programs than the group of older users. No statistically significant correlation was found by examining the usage frequency and two other demographic characteristics included the level of education and employment type.

4.6.3. Frequency of usage

The users' frequency of using BSS is one important indicator to evaluate the performances of the bike sharing system (Buck et al., 2013b; Fishman & Schepers, 2016). In the case of Adelaide, the survey results recorded a low frequency of bikeshare utilisation among users. Over half of respondents (51.7 percent) stated that they used bikeshare a few times per year, while the data for those that utilised BSS daily was negligible, at only 5.0 percent. A similar trend occurred to users that used bikeshare a few times a week (10.0 percent). It means that despite the existence of three different bikeshare schemes in Adelaide, statistics for the frequent use of people was still low (Figure 4- 34). Notably, this finding is similar to the research results of Fishman et al. (2015), and Fishman (2016), which identified low bikeshare usage in Australian cities.

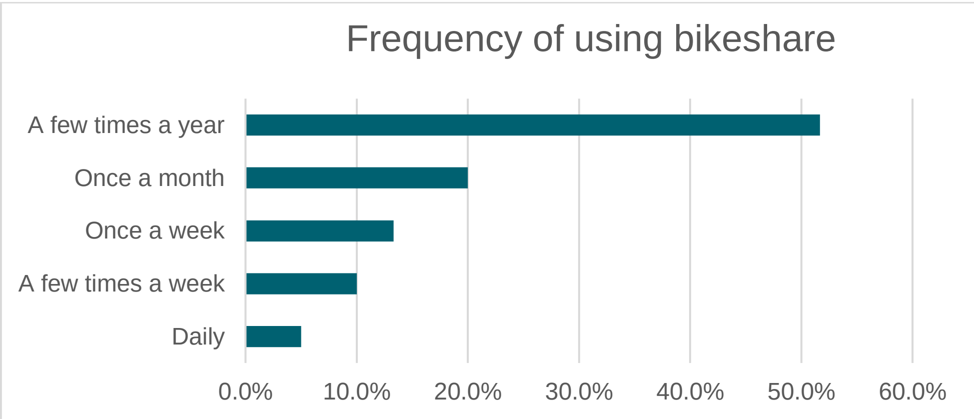


Figure 4- 34 The frequency of using bikeshare

The low utilisation of bikeshare in Adelaide could be explained by a number of plausible reasons. In terms of urban planning perspectives, Fishman and Wyss (2017) believed that a low-density city like Adelaide is not an ideal environment for the development of bike sharing programs. Indeed, although the 30-Year Plan for Greater Adelaide has an emphasis on building a compact city based on infill development to increase high population density in the city centre (Government of South Australia, 2017). However, as 2018 estimated, the population density of Adelaide city is still low with 15.92 persons per hectare (City of Adelaide, 2018). By contrast, cities with better performances on bikeshare like Paris and London have a much higher in population density than Adelaide, at 113 and 80 people per hectare respectively (Loader, 2015). Indeed, travel distances would be increased in a city with a low density (Heinen, Maat, & Van Wee, 2011). Accordingly, it discourages people's participation in bike sharing programs because of its low competitiveness as opposed to other travel options such as private cars (Elliot Fishman & Martin von Wyss, 2017). This helps to explains why Adelaide is one of the most car-dominated capital cities in Australia (Mees, Sorupia, & Stone, 2007; Nguyen et al., 2018), while cycling contributes a negligible percentage to the market share of transportation modes in (Fishman et al., 2012; Mees et al., 2008).

4.6.4. Purpose of usage

It was evident that three of the most popular purposes that led to the use of bikeshare programs in Adelaide in relation to users' participation in social activities, shopping, and commuting to work or back home (respondents were allowed to choose two options) (Figure 4- 35). To explain, attending social activities was the user's most important purpose for using Adelaide's BSS, at 61.7 percent, followed by shopping and going back home (which accounted for 25 percent and 23.3 percent of responses respectively). Going to work came third, with 20 percent of responses. Notably, these findings are supported by research results of Yang et al. (2011), LDA-Consulting (2012) and Shaheen et al. (2012) associated with bikeshare programs in Beijing, Washington DC, and four different bikeshare schemes in North America. Indeed, these studies confirmed that social activities and commuting travel to work/back home were two of the most popular reasons that created bikeshare trips among users. Furthermore, Transport for london (2014), and Fishman (2016) also share the consensus expressed in these studies regarding the trip purposes of bikeshare users as mentioned.

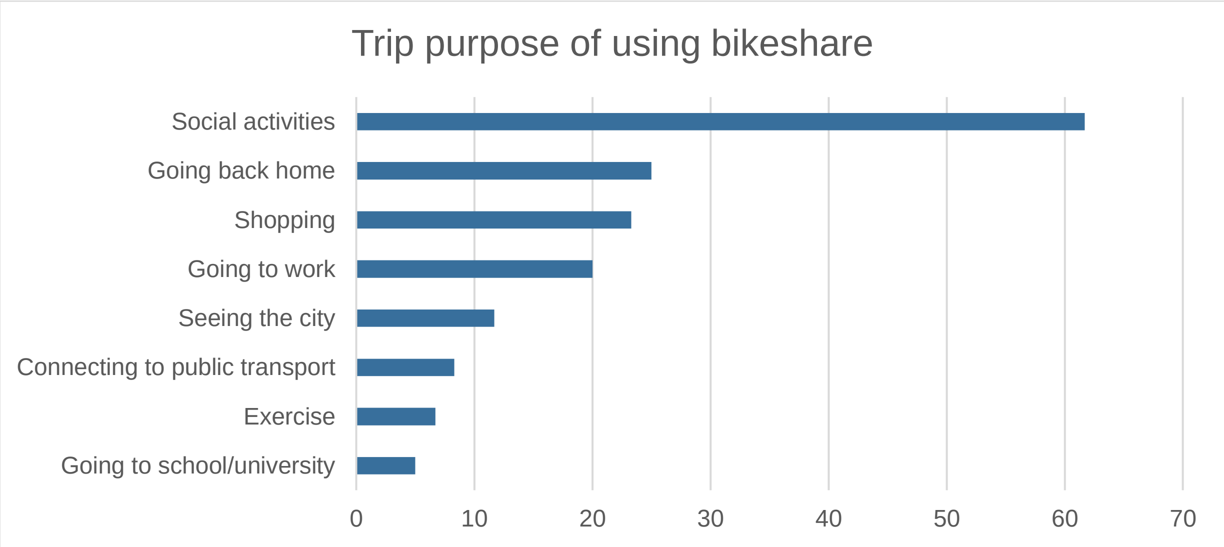


Figure 4- 35 Trip purpose of using shared bike

Other trip purposes that have been found in the survey of bikeshare programs in Adelaide, including seeing the city (11.7 percent), and connecting to public transport (8.3 percent). The former had been indicated in Brisbane's bike sharing program, CityCycle. In particular, 'leisure or sightseeing' is one common reason that leads to the use of bikeshare among 65 percent of casual users of CityCycle program(Fishman, 2016). Interestingly, trips associated with users' travel to school/university are only a small proportion (5 percent) in using bikeshare among Adelaide's users. Surprisingly, it contradicts to findings of Shaheen et al. (2012), who concluded that travel to/from school is also one of the main purposes of bikeshare usage. However, as noted by LDA Consulting (2012), trip purposes of bikeshare users may vary from case to case because of the differences of users' socio-demographics, therefore, distinct reasons are justified for a case of bike sharing program.

4.6.5. Users' general satisfaction with bike sharing

It is worth to consider that the satisfaction of users with BSS in Adelaide is created by an evaluation of quality attributes. As noted, two main quality attributes were included in the survey for users' evaluation, which are physical and perceived attributes. Surveyed participants were asked to assess different indices within attributes, using 5-point Likert rankings from 'very dissatisfied' to 'very satisfied'. Considering Likert rankings as the weight of responses, ranging from 1 to 5, details of attributes and results of users' evaluation are presented in Table 4-8.

To summarize (Figure 4- 36), cyclists were satisfied with vehicle conditions/facilities provided by the relevant companies (avg score= 3.60) and comfort/easiness (avg score=3.07). within these two categories, some factors included quality condition of the bike (lighting, braking, gearing, tires and helmet) were scored high showing a high level of satisfaction.

Furthermore, the users rated comfort highly whilst riding, parking and adjusting the bike for user requirements (such as with regard to seating height). On the other hand, bikes were criticized by users as being less suited for family/group travel, transport a bag/luggage and difficulties with locking/unlocking bikes. Users were less satisfied with accessibility to a bike (in terms of distribution) and the cost of usage and incentives for frequent users. The arbitrary distribution of dockless OfO and O'Bike vehicles made trip planning complicated for those who wish to connect to public transit or have a fixed appointment time at a particular destination. In addition, often users often had to contend with long walking distances to find a bike. Furthermore, the service was mainly established within the boundary of the City of Adelaide and limited or non-existent for those living in more distant suburbs. Users were also dissatisfied with paying an upfront deposit and the cost of usage. No specific incentive was available for frequent users apart from a point penalty scheme for inappropriate or thoughtless usage.

Table 4- 8 User's evaluation of quality attributes of BSS

Attribute	Index	Users'	Rating
Location and accessibility to bike	Service coverage areas (suburbs)	2.15	L
	Distribution and location of bikeshare system	2.48	L
	Possibility of finding unused share bikes' location	3.23	M
	Availability at pick up and drop off (walking distance to access a bike)	2.17	L
	Average 1	2.51	M
Registration	Mobile apps facilities	2.21	L
	Sign up process & registration	2.18	L
	Personal information confidentiality	3.32	M
	Status & image and the reliability of the brand	2.90	M
	Average 2	2.65	M
Cost & incentives	Incentives for frequent use	3.05	M
	Cost of usage	2.90	M
	Using credit cards to pay upfront deposit & payment process	1.97	L
	Membership fee deposit	2.21	L
	Average 3	2.53	M
Comfort & easiness	Comfort of bicycle ride	3.06	M
	Easiness of carrying bag	1.77	L
	Comfort with bike height/size and seat can be adjusted	3.02	M
	Bike stands easily when parking	3.72	H
	Easy locking/unlocking system	2.92	M
	Easy warning bell	3.74	H
	Comfort when using pedals	3.62	H
	Comfort when parking at off-street parking	2.92	M
	Comfort for family/group riding	2.08	L
	Average 4	2.98	M
Conditions and facilities	Adequate lighting systems	3.82	H
	Adequate braking system	4.01	H

	Adequate gearing	3.07	M
	Tires with adequate pressure	4.02	H
	Helmet availability (attached to bike) & cleanness	3.07	M
	Maintenance and cleanness of the bike	3.81	H
	Average 5	3.63	H
Perceived enjoyment	Enjoyable when riding OfO	2.96	M
	Enjoyable when riding O'Bike	3.14	M
	Enjoyable when riding AFB	2.48	M
	Average 6	2.86	M

H= high>3.5; M= 2.5<moderate<3.5; L=Low<2.5

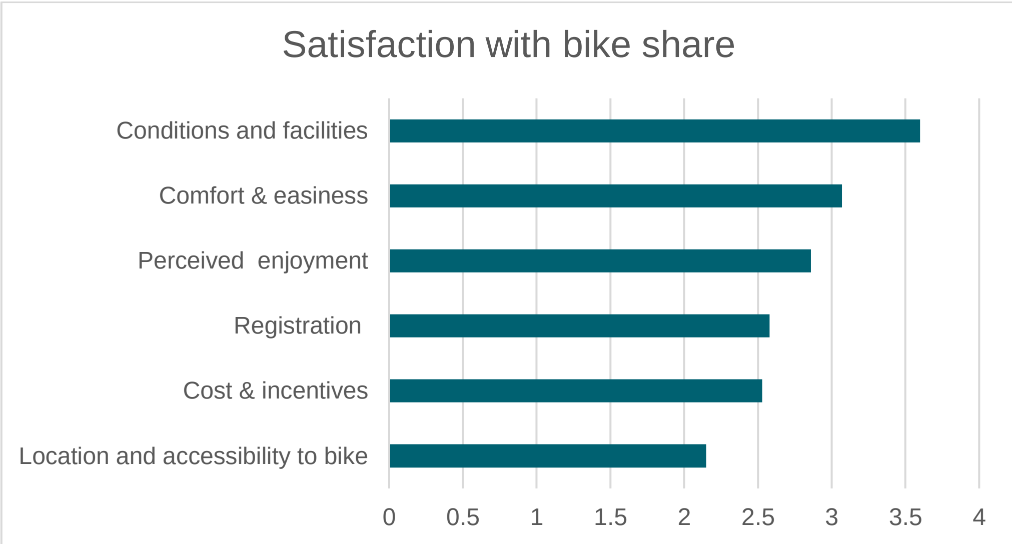


Figure 4- 36 Satisfaction with different attributes of BSS

4.6.6. Influential factors of bikeshare usage

The sampled bikeshare users were asked to report the importance of various factors for choosing bikeshare as their travel option. In this regard, we divided factors into two main groups, which are internal and external factors. Users' perceptions were considered as internal factors such as comfort/convenience, status and image, and health and exercise. Meanwhile, external factors related to the physical conditions of the current bikeshare system in Adelaide, including cost savings, travel distance, speed/time saving, and safety and security.

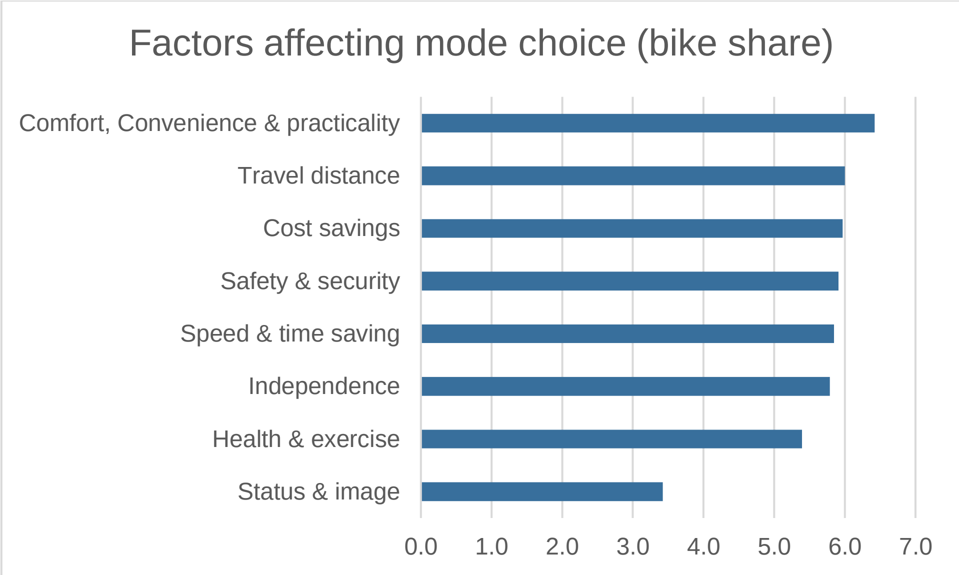


Figure 4- 37 Factors affecting modal choice (bike share)

With regard to the internal factors, comfort/convenience was the first reason that attracted the choice of users' to bikeshare in Adelaide. To date, 20.5 percent of respondents indicated that this factor is 'very important' for them to choose bikeshare. Interestingly, literature also confirms that convenience is the major factor that results in people's choice of bikeshare in several case studies of BSS worldwide such as North American cities (S. A. Shaheen, 2012), Washington DC, London (LDA-Consulting, 2012), Melbourne and Brisbane (Fishman et al., 2014). Health and exercise is another important factor that impacts bikeshare choices of Adelaide's users. To date, 25.6 percent of users rated this factor 8 out of 10 in their ranking points for choosing bikeshare. Results of surveys conducted by the Traffix Group (2012) for Melbourne Bike share also emphasized that health and exercise as were motivating factors, accounting for 35 percent of users' responses. Similar findings were presented in study about Capital Bikeshare in Washington DC

One noticeable result of the data analysis is that status and image did not act as a strong motivation for users' choice of bikeshare in Adelaide. In fact, nearly a third of responses (28.2 percent) marked this factor the lowest point (1 out of 10) regarding its importance to motivate their decisions for choosing to use bike sharing. Indeed, none of previous studies considered this factor as a strong motivation for bikeshare riders.

With respect to external factors or the physical attributes of bikeshare in Adelaide, cost savings came first in the list of influential factors of bikeshare choices among users. This is consistent with several studies in the literature. Ogilvie and Goodman (2012), and Fishman (2016) concluded cost savings is a motivating factor for people's choice of bikeshare. Sharing the same research findings, LDA Consulting (2012) also pointed out the pivotal role of saving money when choosing Capital Bikeshare program in Washington DC among low income groups. However, it is interesting to note that results of Chi-square tests indicated there is no statistical associated between the choice of bikeshare programs and low-income users in Adelaide. This is consistent with outcomes of a study implemented by Fishman et al. (2015), who claimed that bikeshare users in Australia normally have higher income than the general population.

Limited studies have been done to justify barriers that prevent people from using bikeshare (Fishman, 2016). Accordingly, it is necessary to investigate users' concerns while using bikeshare before having an appropriate policy implication for increasing the situation and quality of the current bike sharing systems in Adelaide, thereby helping to attract a higher participation of people in using bikeshare programs. The main safety concerns of the users when riding a bike were illustrated Figure 4- 38 . This is consistent with previous studies of different bike sharing systems worldwide. Indeed, safety concerns have been widely discussed among researchers as one of major barriers to cycling generally and bikeshare riders in particular (Gardner, 2002; Garrard, Crawford, & Hakman, 2006; Horton, Rosen, & Cox, 2007).

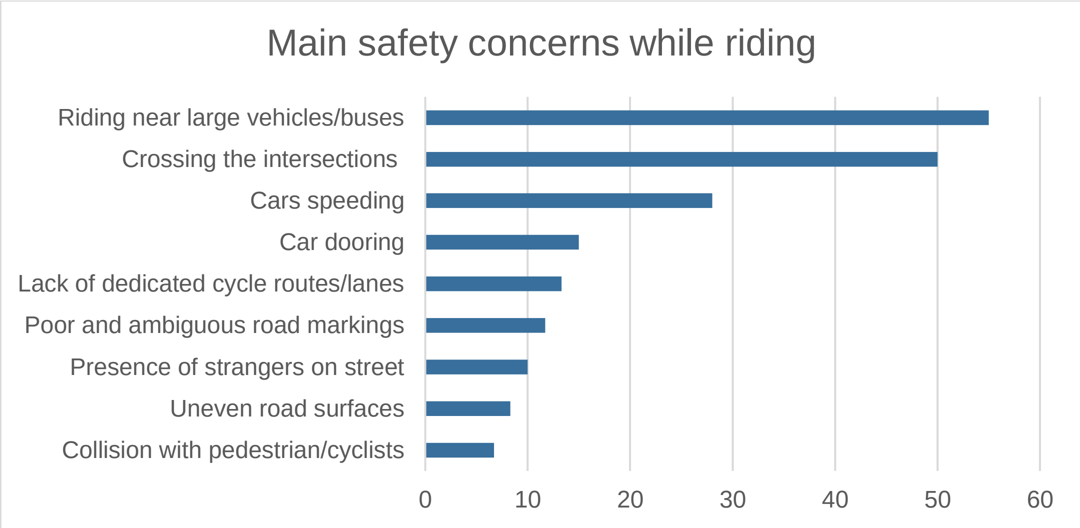


Figure 4- 38 Users' main safety concerns

In the case of Adelaide, two major barriers of safety concerns are the intervention of private vehicles on the road, and the poor quality of infrastructure conditions for travel of bikeshare users. In terms of the intervention of other vehicles on the road, over a half of responses (55 percent) pointed out that riding near large vehicles or buses created the fear while riding bikeshare, followed by crossing the intersections (turn left or right) (50 percent); car speeding (28 percent) and car dooring/on-street car parking (15 percent). Previous studies in the literature showed that there is an increasing concern about awareness and behaviour of motorised transport drivers towards the cyclists (Fishman et al., 2014; Garrard et al., 2006). As a result, it raises safety concerns among bikeshare users while riding near large vehicles on the road. Similarly, vehicle speed especially car speed is also another barrier to users of bikeshare (Fishman et al. 2014) noting that in the study of CityCycle in Brisbane riders felt unsafe due to the excessive speed of motor vehicles.

In addition to the intervention of other vehicles on the road, users' concerns about the lack of dedicated bicycle infrastructure are also highlighted. In particular, 13.9 percent of responses reported that the shortage of dedicated bicycle routes and lanes is a major hindrance that prevents them from using bikeshare. Other attributes of infrastructure such as poor and ambiguous markings and uneven road surfaces were also noted by surveyed participants. Consistent with these findings, Fishman and Schepers (2016) strongly believed that the deficiency of bicycle infrastructure could be a drawback that limits bikeshare users. Indeed, study of Fishman et al. (2014) about Brisbane's bikeshare provided strong justification of the need to provide sufficient quality infrastructure for cycling, as essential to avoid negative perceptions in the community about bike sharing programs.

4.7. Data analysis of actual users: Car Sharing Services (CSS) users

The collected data from the actual users of CSS was coded using IBM SPSS ver 22. Two levels of analysis undertaken included: a) descriptive analysis on the characteristics of CSS and the users' attitudes toward it; and b) inferential analysis including median test, one-way analysis of variance (ANOVA) test and Factor Analysis, in order to examine the association between influential factors and their effects on the usage of the system.

4.7.1. Demographics of CSS users

The demographics of CSS users in City of Adelaide are presented by four main indicators as noted in the data collection process. Details of gender and the age group of the respondents are provided below.

Approximately 56 percent the participants were males, while 44 percent were females. In terms of the dominant age group, most respondents were young people. As such, a considerable share of surveyed users (14.1 percent) were aged between 17 and 19, 24.6 percent were aged between 20 and 24 followed by the age group from 25 to 29 (19.5 percent) and the age group between 30 and 34 (14.9 percent). The three remaining age cohorts included the age groups of 35-39; 40-44 and 45 and over had similar shares (9.2; 7.3; and 10.6 respectively). The education level of the sampled respondents was dominated by those with an undergraduate degree (39.0 percent), while roughly 17.1 percent of respondents had a postgraduate degree. The rest of sampled users are people with High School Certificate (36.6 percent) and no degree (7.3 percent). With respect to the weekly income level of users, about one fifth of respondents (19.4 percent) reported their income between $1 and $199 followed by the income category of $200 to $299 (17.1 percent). The share of individuals with income between $300 to $599 (13.4 percent) was close to the category of $600 to $799 (14.6 percent). The relatively high-income groups included $800-$999; $1000-$1250 and $1250 or more had shares of 9.9; 11.2 and 9.5 percent respectively. 4.9 percent of the survey sample reported having no income.

4.7.2. Frequency of using CSS

Two key variables in investigating CSS are membership and frequency of use (Becker et al., 2017). In the case of Adelaide, all participants were either members of one or two schemes and the survey results recorded a low frequency of shared-car utilization among users. In relation to the issue of usage, over a one-fourth of respondents (27.3 percent) stated that they used CSS a few times per year, while the data for those that utilised CSS daily was negligible, at only 4.8 percent (Figure 4-39). A similar trend was found for users with car-share usage a few times a week (7.2 percent). This means that despite the existence of two different car schemes in Adelaide including GoGet and UBER, these statistics on the usage rates in the frequent category for these services have been marginal. This finding is similar to research results of Fishman et al. (2015), and Fishman (2016), which concluded that there was low usage of shared vehicles (sharing bikes and sharing cars) in Australian cities when compared to Europe and east Asia.

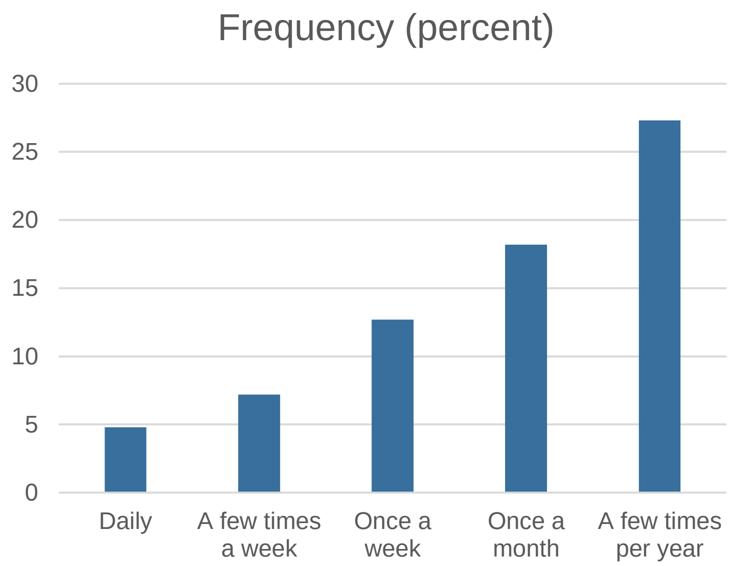


Figure 4- 39 The frequency of using shared-car of surveyed users in City of Adelaide

4.7.3. Impacts of demographic characteristics on CSS

In order to determine whether there is statistical evidence that the associated population means are significantly different, parametric Independent Samples t-test was applied and the results showed that with the level of confidence at 95 percent, there are statistically significant differences in the means of frequency of using shared-car between men and women in Adelaide ($t = 2.035$; p-value < 0.011). The result of Levene's Test for Equality of Variances was $F=3.091$; Sig. = 0.015 confirming that this has violated the assumption of homogeneity of variances in the population as the basic requirements of doing t-test. This is consistent with finding in a large-scale international study within four major metropolitan areas: London, Madrid, Paris, and Tokyo (Prieto et al., 2017), which found that gender matters with regard to CSS adoption intention. This result can be attributed to the fact that generally males have less safety concerns than do females when using shared cars.

The result of one-way ANOVA test found no significant relationship existed between the age category and frequency of CSS ($F= 0.818$; $p< 0.563$). One reason for this was probably that our survey does not have a high variance of age groups as shown in Figure 4- 39. In fact, this is contradictory with some former studies that determined that age was an important factor in CSS usage (C. Celsor & A. Millard-Ball, 2007). Some previous studies (D. Kim, J. Ko, & Y. Park, 2015; Prieto et al., 2017; Rotaris & Danielis, 2018) argued that older people are less likely to use CSS.

This is probably since older adults have the habit of using their own cars for many years and it is difficult to change their commuting habits. On the other hand, younger adults due to having lower level of vehicle ownership and being more familiar with smart technologies such as mobile phone applications, are more likely to make use of CSS. Younger commuters appear to be less car-oriented and to hold positive attitudes towards substitutes to car ownership (Kuhnimhof et al., 2012), especially for the age group of 25 to 49, who were found to be more likely to take CSS instead of private vehicles when compared with other age groups (R. Cervero, 2003; Martin et al., 2010).

Another interesting outcome from this survey was that education level has a significant impact on the frequency of CSS usage as demonstrated by the one-way ANOVA test result (F=4.261; p<0.022). The education level was categorized into four groups that included postgraduate; undergraduate; secondary school; primary school or no certificate. This is consistent with findings of some American studies which found that having at least one academic degree is strongly associated with CSS usage (R. Cervero, 2003; Martin et al., 2010).Similarly, Christine Celsor and Adam Millard-Ball (2007) found that car-sharing neighbourhoods are more likely to have higher shares of residents with bachelor's degrees than in non-car-sharing neighbourhoods. The results from a study in Tokyo showed that educated people are more welcoming of shared-cars and eco-cars due to having a higher level of environmental understanding and concern (Ohta, Fujii, Nishimura, & Kozuka, 2013). In fact, the positive attitudes towards shared-mobility is partly due to environmental and climate change concerns, therefore, attitudes towards the environment as a non-observable variable strongly influence respondents' acceptance of car-sharing (Zheng et al., 2009). For this reason, the degree of knowledge of CSS and environmental awareness are regarded as the main factor in using CSS (Nobis, 2006; Rotaris & Danielis, 2018).

As Australia is a multicultural country, the residency status (country of birth) in five categories included: Australian-born; overseas-born but with Australian citizen/resident status; visiting (temporary visa); student visa; and other visa types. These residency categories were analysed against frequency of CSS usage. The ANOVA result showed no statistically significant difference among these four groups in terms of CSS usage (F= 0.260; p<0.854). This finding is contradictory to the international comparative study by Prieto et al. (2017) which found that British, Spanish and Japanese adults are all less likely to use CSS services when compared to the French, whereas most of background studies have had little consideration of nationality impact on CSS. However, in our case study area, the mobility issue appears to be similar for all groups of residency status and visa type.

In examining the association between personal income level and the frequency of usage of CSS, we categorised both variables and applied the Chi-square test based measure of association: the Gamma coefficient. The association was shown to be significant as shown by the Chi-Square score= 74.411; p< 0.0.31, where the Gamma symmetric coefficient= 0.34; p< .045). This result confirms that increasing the income level would increase the frequency of car-sharing options. Our results are only partially consistent with those generally reported in the literature. From our analysis, in fact, it emerges that low-income groups such as the students would be less likely users of CSS, while employers or employees are the most probable users. In Australian cities, as in most developed countries, a considerable discount on fares are guaranteed to students thus making them less likely to catch relatively costly car sharing options. Indeed, in the City of Adelaide, tram services and certain bus services are free to all travellers. Robert Cervero (2003) found that those who were self-employed or worked were more likely to use CSS. In Daejin Kim, Joonho Ko, and Yujin Park (2015) found that while having higher income level was correlated positively with participation in an electric vehicle sharing program, participants with higher household incomes were found to be less likely to change their existing driving behaviour, which was habitual.

Another interesting result of our survey was the positive correlation between the number of cars available by corresponding household and the frequency of CSS usage although this result was not shown to be statistically significant at 95 percent (Rho= 0.231; p<0.08). This is contradictory with the literature stating that not-owning a private car leads to higher likelihood of CSS usage (C. Celsor & A. Millard-Ball, 2007; Zhou & Kockelman, 2011) and the average number of cars per household is negatively correlated with CSS usage (Becker et al., 2017) The residents of non-car households are more likely to be CSS users, which is supported by research in the US (E. Martin & S. Shaheen, 2011). The connection between income level; car ownership and CSS usage frequency is uncertain and requires further investigation using advanced statistical analysis.

However, CSS in the Australian context is not regarded as an alternative mobility for low-income and non-car owners as advocated in the literature. An US study explains that car-sharing would be rather well-accepted by those who do not need to own a vehicle (Zhou & Kockelman, 2011). On the other hand, (Ohta et al., 2013) found that the number of cars per household negatively affects the acceptance of car-sharing and electric-cars. The author then argued that the association between car ownership and CSS usage would be moderated in cases where gender was considered. While males show a higher intention for car-sharing than owning a car than females do, females responded with a higher intention towards car-sharing as an alternative to owning an additional car than males do (Ohta et al., 2013). While car ownership affects CSS usage, an important related question is whether the model (and type) of owned car matters or not. Having a relatively recent car is directly correlated with CSS as new vehicle owners might wish to maintain their cars in excellent condition and keep their kilometres low (Prieto et al., 2017). According to Korean research, car owners were less likely to give up their cars, but had a high likelihood of buying electrical vehicles (EVs), thus, this electric car-sharing program appears ineffective in decreasing car ownership (D. Kim et al., 2015). Ferrero et al. (2018) argues that regardless of income level, the perception of today's people is shifting over time with the diffusion of car-sharing services, therefore, many city dwellers are moving from a car ownership vision towards a car-as-a-service vision of urban mobility or what also is known as 'Mobility as a Service' (MaaS).

The size of household was positively associated with the frequency of CSS usage although not determined statistically significant when using bi-variate Spearman correlation test (Rho= 0.017, p> 0.155). The comparative study between Canadian and American users on a sampled population (with average 2.2 persons per household) found a different result, where household size directly affects car sharing (Millard-Ball, Murray, Ter Schure, Fox, & Burkhardt, 2019). The positive correlation between frequency of CSS usage and household size is justified because large families have higher mobility needs, thus requiring more vehicles. Some argue that household composition is influential in choosing shared modes instead of household size (Rotaris & Danielis, 2018). In this regard, especially where there is the presence of children and a family mobility pattern with a substantial dependence on private cars are correlated with a higher tendency to use CSS. According to Daejin Kim et al. (2015) single families showed a greater likelihood of relinquishing a car and enduring participation in the sharing-car scheme. Both station-based car-sharing, and free-floating car-sharing schemes attract mostly young adults living in small households (Schmöller, Weikl, Müller, & Bogenberger, 2015). Householders as younger and highly educated adults living in households with few private cars are more likely to take CSS (Burkhardt & Millard-Ball, 2006; Jörg Firnkorn & Müller, 2011). In similar research, (Christine Celsor & Adam Millard-Ball, 2007) found that car-sharing neighborhoods in the US are more likely to have greater shares of one-person households. Some argue that having a person employed or not-employed in a household affects the likelihood of CSS usage by the household. However, the arguments are arbitrary. The presence of unemployed people in a family increase the likelihood of CSS usage (Rotaris & Danielis, 2018; Zheng et al., 2009). On the other hand, the presence of employed people in a household is an indication of affordability thus increasing the chances of taking a CSS service.

The last connection examined was the relationship between travel purpose and frequency of usage (Figure 4- 40). Carsharing trips are more likely to be used for shopping, personal business, and recreation trips versus commute trips as found by (Cervero, 2003; Millard-Ball et al., 2019) in the US. However, in our data, we only classified them into two categories: work trips; non-work trips (included shopping, education, social activity, linking to public transit and airport, getting kids to/from school, going back home). The results of Two Independent Samples t-test showed that there is significant difference between these two groups (t=2.680, p<0.05), while Levene's Test for Equality of Variances was also significant (F= 3.081, p<0.007).

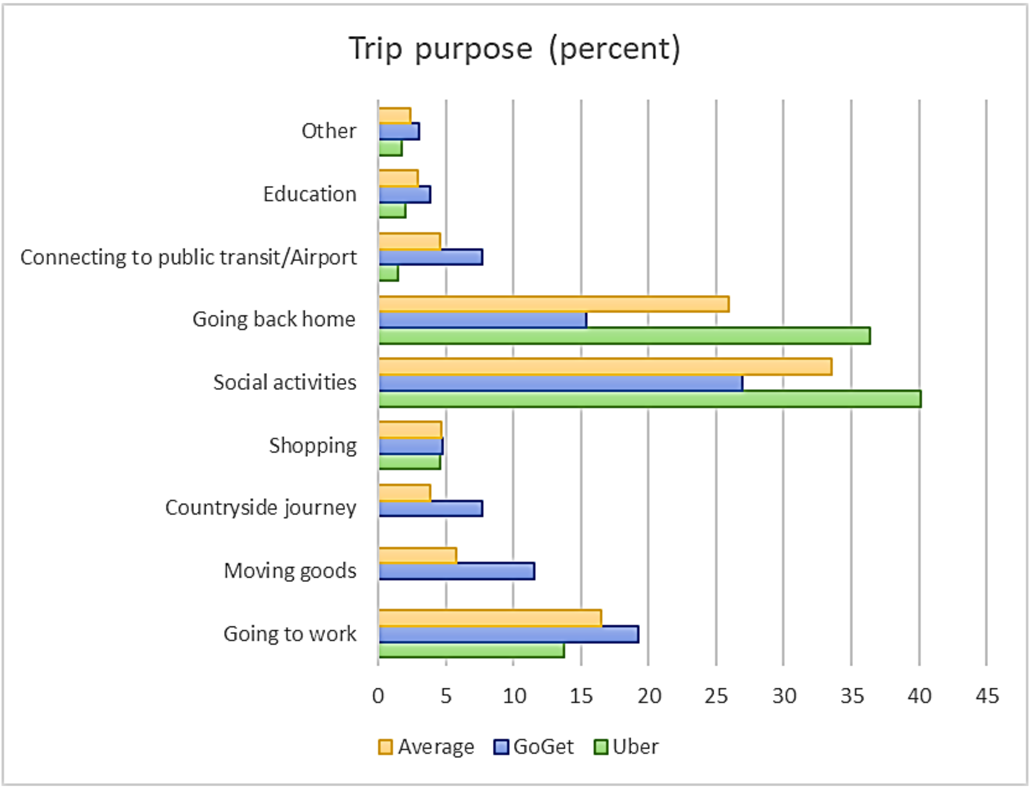


Figure 4- 40 The trip purpose of using shared-car of surveyed users in City of Adelaide

This is consistent with the literature suggesting that car-sharing is mostly welcomed as an appropriate mode of travel for educational trips (Zheng et al., 2009); shopping and socio-recreational trips (Schmöller et al., 2015) rather than work-related trips.

A similar survey in Turin, Italy showed that car-sharing users use it just when no other modes of travel are accessible and not to go to work places (Lerro, 2015).

4.8. Analysis of satisfaction with the services

The questionnaire asked about the respondents' opinions on car sharing service. The answers were collected as to whether they agreed or disagreed with different statements about car sharing service attributes. 23 attributes were rated.

All ratings applied the following scale: (1) strongly disagree; (2) disagree; (3) neutral; (4) agree; and (5) strongly agree. They also answered some questions regarding the desirable policies to improve the quality of shared mobility systems.

Figure 4- 41 Satisfaction with using shared-mobility options: (a) UBER quality; (b) GoGet quality

From Figure 4- 41 (a), it can be witnessed that maintenance and cleanliness, sign up methods, reliability and availability are by far three most satisfied components of users with UBER's "quality". In this context, the three least satisfied factors are identified as promotions and incentives, cost (fare) and waiting time. The surge pricing model of UBER, and the variability and uncertainty in pricing that this causes may be the reason that the cost of fares attracted user dissatisfaction. As presented in Figure 4- 41 (b), three most satisfied components of users with GoGet service are vehicle quality (maintenance and cleanness), availability at pick up and customer service quality. In contrast, the three least satisfied factors are indicated as flexibility in fuel type, cost (fare), promotions and incentives.

Amongst people with the opinion that car-sharing services are too expensive, they may not be taking into account the high fixed costs related to operating and maintaining a private car. These results suggest that users could have distorted perceptions of the actual costs of car when compared to car-sharing costs (Lerro, 2015). However, this finding can be argued because car sharing models, itself is not cheap unless car usage is very low. In fact, the judgment depends on the annual distance travelled, and the choice of car too, because with making the wrong choices, costs for private car ownership can be double than that what an individual expects, if for example reliability and economy are poor.

4.9. Potential shift from car to sharing-mobility

4.9.1. General trend of commuting

As discussed earlier, Adelaide is relatively mono-centric city where over a third of jobs (34 percent) are located a maximum of 4km from the Adelaide's CBD. Furthermore, comparing the share of outer jobs (66 percent) with 2011 (65 percent) shows that a minor decentralisation of employment occurred between 2011 and 2016 (ABS, 2011, 2016). This pattern is similar to other capital cities of Australia. As the graphs show below, the share of non-motorised modes are small at the metropolitan level, while it is significant at the city level (i.e. within the CBD area).

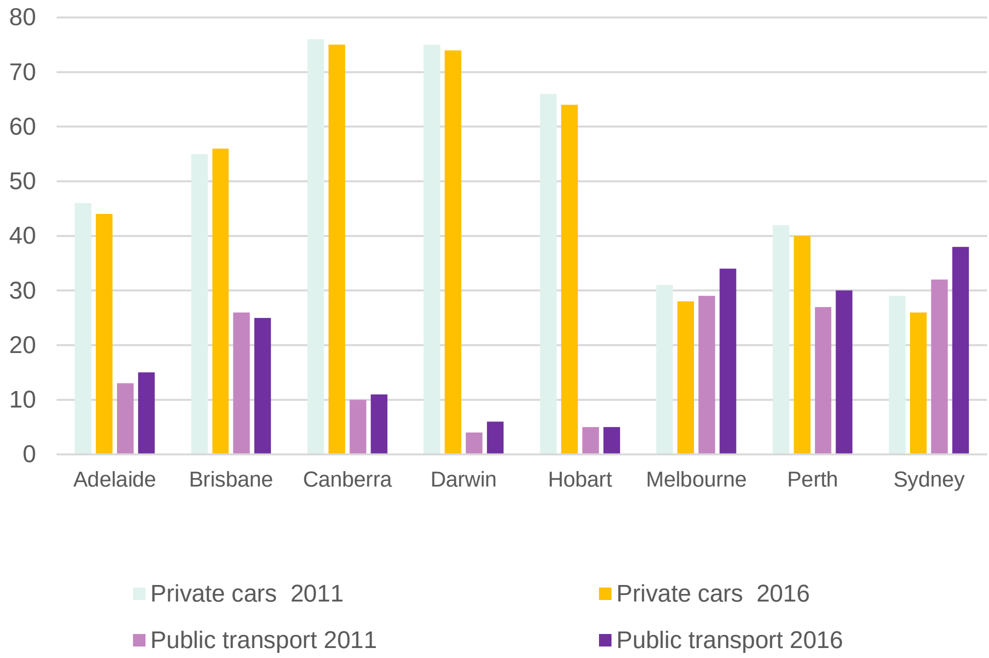


Figure 4- 42 Car and public transport at City level

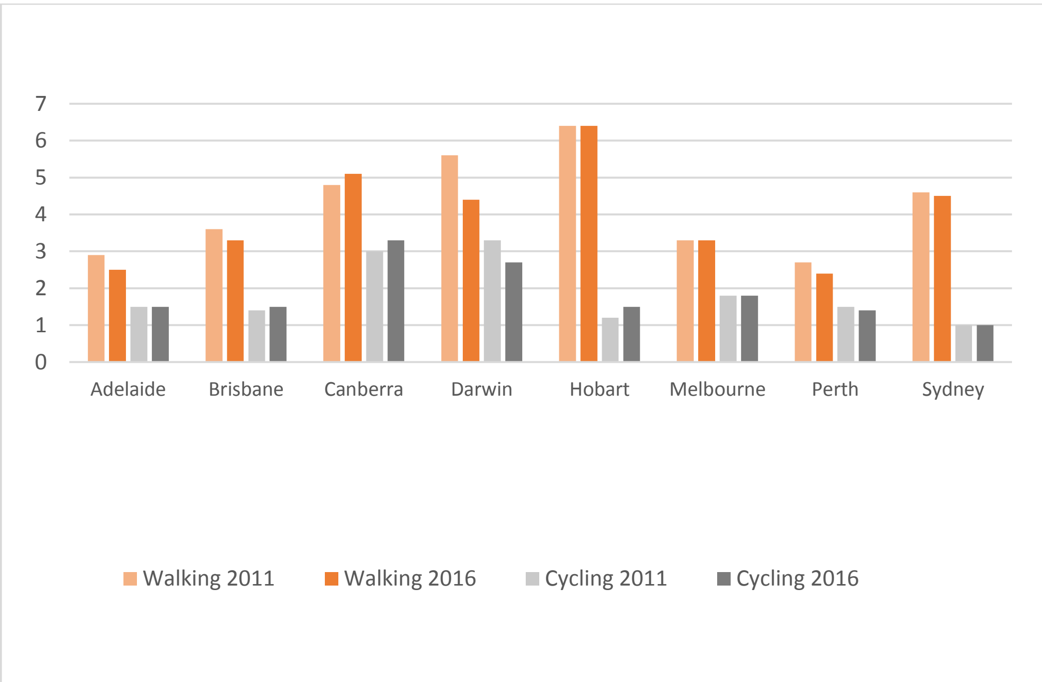


Figure 4- 43 Walking and cycling at metropolitan level

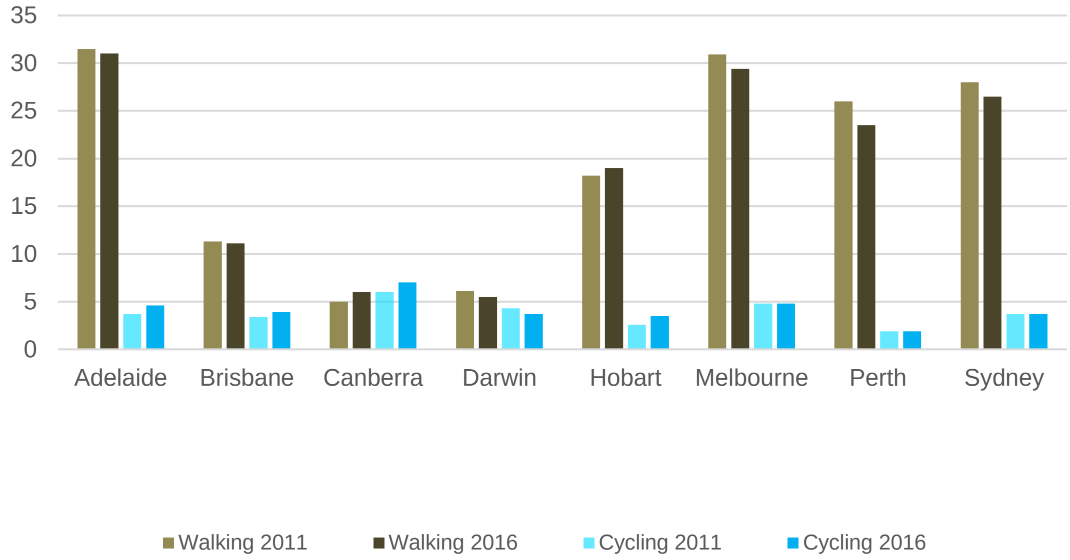


Figure 4- 44 Walking and cycling at City level

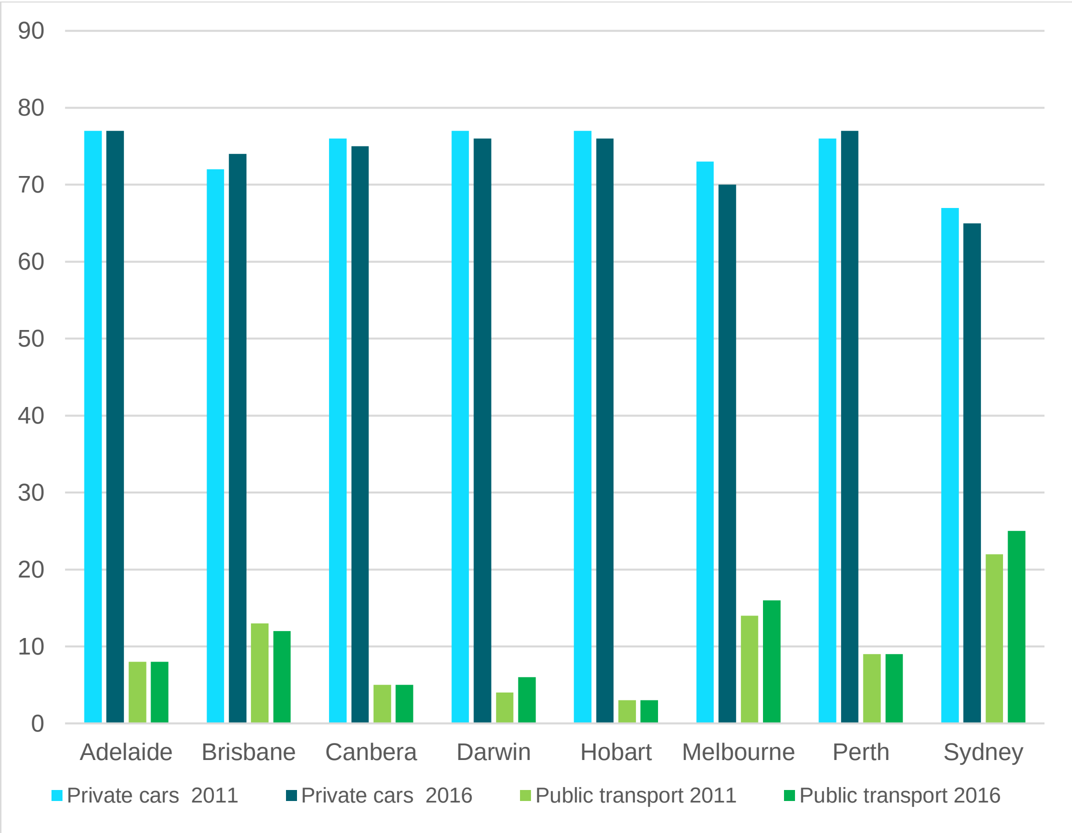
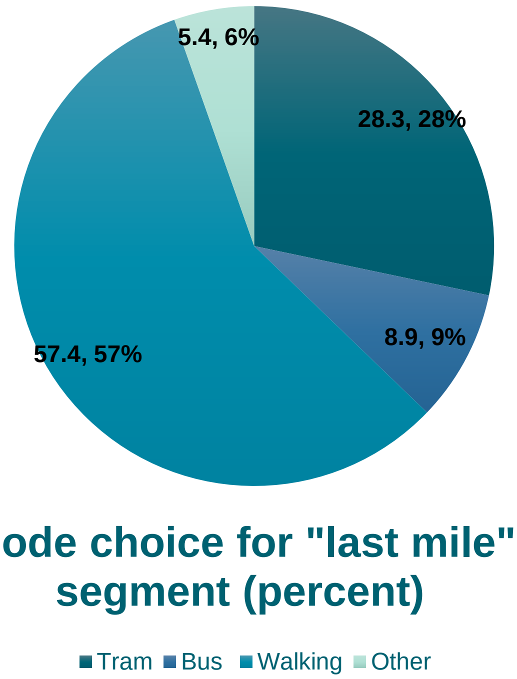


Figure 4- 45 Car and public transport at Metro level

However, the survey showed a low reluctance of respondents to choose sharing-mobility for last mile.



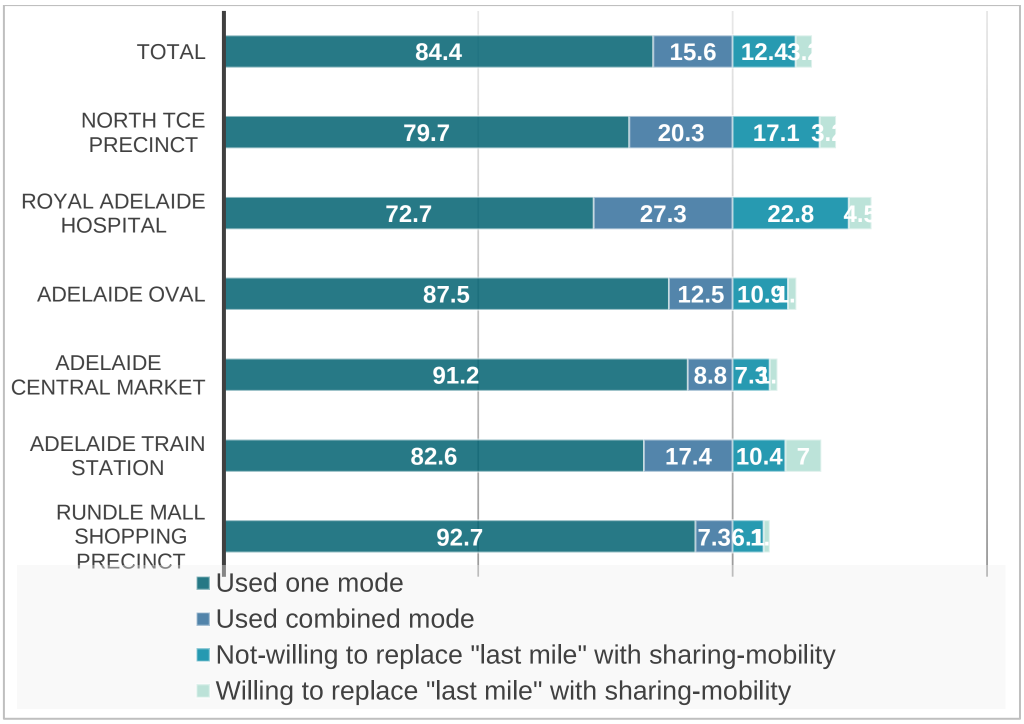


Figure 4- 46 The mode of “last mile” segment (above) and the reluctance to using shared-mobility alternatives for “last mile” segment (below)

4.9.2. Model of modal shift

Based on the findings from the literature in this field, a discrete choice model based on the micro-economic theory of utility maximisation philosophy was developed in this research to examine the complex impacts of socio-demographic, physical characteristics and the personal habit/psychological factors likely to change commuting behaviour and the likelihood of modal shift.

Discrete choice theory was developed only in the 1970s by Nobel economist Daniel McFadden based on the traditional microeconomic theory of consumer behaviour (Train, 2009). However, while in theory the goods per se generate utility, in discrete choice modelling the properties of the goods generate the utility. The logit function is regarded as the main essence of discrete choice models. Logit models are inherently able to represent complex characteristics of travel decisions of individuals by including important socio-demographic and policy-sensitive explanatory factors (Anwar & Yang, 2017). The outputs of discrete choice models are frequently utilised as an input for cost benefit analyses (CBA) of transportation projects. The other advantage of logit to conventional regression is that it does not assume that independent and dependent variables are correlated linear, therefore it does not entail that the variables to be normally distributed. Rather, the logistic regression function estimates the likelihood that a certain event would happen based on the independent variables. A discrete choice model is a mathematical function which forecasts an individual's personal choice based on the utility or comparative benefit (Ben-Akiva, Lerman, & Lerman, 1985). According to the purpose of this chapter, the binary logit model is used as an analytically convenient modelling method.

Mathematically, for the nth individual, let i and j be the two alternatives in the choice set of each individual:

$U_{in} = V_{in} + \varepsilon_{in}$ (1)

$U_{jn} = V_{jn} + \varepsilon_{jn}$ (2)

Where: Uin - the true utility of the alternative i to the nth individual; Vin- the deterministic or observable portion of the utility estimated by the analyst; ε_{in} – the error of the portion of the utility unknown to the analyst.

$V_{in} = f(X_i, S_n)$ (3)

Where: Xi - the portion of utility associated with the attributes of alternative i; Sn – the portion of utility associated with characteristics of the nth individual.

The deterministic component of utility can be written as below for model:

$$V_{Mode\ shifted\ (MS)} = \beta_0 + \beta_{1\_MS} * retired + \beta_{2_{MS}} * age + \beta_{3_{MS}} * house\ strucure + \beta_{4_{MS}} * level\ of\ education + \beta_{5_{MS}} * perceived\ safety + \beta_{6_{MS}} * cost\ savings + \beta_{7_{MS}} * house\ relocation + \beta_8 * job\ change + \beta_9 * having\ driver\ license \quad (4)$$

Where β_0 is the constant, $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8, \beta_9$ are the coefficients of variables.

The probability that the nth individual choose alternative (Pin) as proposed by Ben-Akiva and Lerman is presented as follows:

$$P_{in} = \frac{1}{1+e^{-v_n}} = \frac{e^{v_{in}}}{e^{v_{in}}+e^{v_{jn}}} \quad (5)$$

The probability that an individual will choose mode shifted can be written as:

$$P_{MS} = \frac{e^{v_{in}}}{e^{v_{in}}+e^{v_{jn}}} = \frac{e^{v_{MS}}}{e^{v_{MS}}+e^{v_{MNS}}} \quad (6)$$

The binary logit model employed in model estimation has the following form:

Modal shift = *f(x):*

$$f(x) = \frac{1}{1+e^{-\beta X}} \quad (7)$$

$$ln\frac{f(x)}{1-f(x)} = \beta X = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \beta_9 x_9 \quad (8)$$

$$\frac{f(x)}{1-f(x)} = e^{\beta X} \quad (9)$$

Where: x is a vector of selected explanatory variables, β0 is the constant and β is a vector of estimated coefficients. PMS is the probability that the n-th individual makes a switch to the other modes. A binary logit model for commuting was developed for two choices, namely, mode shifted (MS) and mode not shifted (MNS), in order to compare the utility of these two alternatives and identify those factors which would affect an individual to move from traveling by one mode to choosing another mode. In this model, the dependent variable was "1" if the commuter made a change in his/her mode within a certain period (last three years) and "0" for not changing the mode.

The coefficients are estimated by fitting the data to the model. The maximum likelihood (MLL) estimation method is a frequently used fitting method. This technique comprises choosing values for the coefficients to maximise the probability (or likelihood) that the model predicts the same choices made by the observed individuals. The method yields highly accurate estimates.

The Omnibus Tests of Model Coefficients is used to check that the new model (with explanatory variables included) is an improvement over the baseline model. It uses chi-square tests to see if there is a significant difference between the Log-likelihoods (specifically the -2LLs) of the baseline model and the new model. If the new model has a significantly reduced -2LL compared to the baseline then it suggests that the new model is explaining more of the variance in the outcome and is an improvement. Here the chi-square is highly significant (chi-square = 91.271, df = 10, p < .000) so our new model is significantly better. The pseudo R squared (Nagelkerke R Square) value of 0.30 (compared to the model with no coefficients) for individual's modal change model show an appropriate fit for the model developed for entire metropolitan area (-2 Log likelihood=360.885) (Table 4-9). In fact, the explanatory power of this model is modest, even though not oddly low for modal choice models. The t-statistics of the constant and the coefficients of variables in the model are all above the threshold values of ±1.96 (95 percent level of confidence) showing the coefficient estimates of attributes are all significant. The result showed that in overall 84.2 percent of prediction by the model was true. The classification table gives the overall percent of cases that are correctly predicted by the model (in this case, the full model that we specified). This percentage has increased from 79.2 for the null model to 88.6 for the full model.

The model coefficients show the importance and strengths of urban factors and their ability to improve the explanatory power of behavioural models. All analysis was done by SPSS ver. 22.0, produced by IBM. The model, and the values of attribute coefficients, their significance and the Wald values and Exp (B) as the measure of elasticity are detailed in Table below.

Table 4- 9 Variables in the Equation

	B	S.E.	Wald	df	Sig.	Exp(B)
C6=Retired/lost job	4.267	1.342	10.111	1	.001	71.310
C6=Age_16_29	3.875	1.369	8.018	1	.005	48.195
C6=Flat, apartment or unit	4.433	1.390	10.176	1	.001	84.218
C10= postgraduate_study	-1.585	.371	18.294	1	.000	.205
B2_3. [Safety/personal security] Using the scale below, how do you rate the following criteria when choosing a transport mode?	.349	.149	5.460	1	.019	1.418
B2_4. [Cost savings] Using the scale below, how do you rate the following criteria when choosing a transport mode?	.601	.172	12.219	1	.000	.548
CarUsers_Movedhouse	.969	.490	3.915	1	.048	.379
CarUsers_Changedjob	1.912	.475	16.225	1	.000	.148
Possessing_DrivingLicense	2.417	.655	13.638	1	.000	.089
Non_Motorised	-2.925	.733	15.939	1	.000	.054
Constant	1.935	1.494	1.677	1	.195	6.927

4.9.3. Discussion on modelling outcome

This model shows that two reasons were highly significant in making a shift in modal choice. One was the change in home location (wald=3.915, $p<0.048$) and the other one was job change (wald=16.225, $p<0.000$). This important finding is in line with previous research. A brief study of modal shift for journey to work in Australian cities found that between 2011 and 2016, journey to work public transport mode shares went up significantly in Melbourne and Sydney but dropped significantly in Perth, Brisbane and Adelaide. Private transport mode shifts did the opposite. The main drivers of change included the changing distribution of jobs within cities; changes in transport costs; increases in workplace density; (negative) growth in the cost of "private motoring" (including vehicles, fuel and maintenance); changes in car parking costs and changes in population distribution (Loader, 2018).

Similarly, Song et al. (2017) found that change in employment status could affect modal change from private car to non-motorised choices if the distance to job was reduced. Changes in home location could affect the car use habit as found by Bamberg (2006). Santos et al. (2010) noted that people who experience a substantial life change are increasingly expected to respond to the changes in the relative utility of different travel modes. When people change their work or residence places, in fact, they change their travel behaviour to adapt to the new conditions (Song et al., 2017).Changes in commuting mode are a function of changes in life, changes in cost and marketing (Clark, Chatterjee, & Melia, 2016; Kroesen, 2014)

Not all socio-demographic variables are associated with the probability of making a transition in modal choice for commuting. Gender, income, household size, ethnical background, home-ownership and type of job as main socio-economic characteristics in our study, did not appear to be associated with increased or decreased probability of making a modal shift. Kroesen (2014) in a similar German study found that gender is not an important factor affecting modal shift. He argued that males and females have become more equal regarding employment conditions thus making their travel activity patterns similar. However, the findings here are partially contradictory with similar studies in rest of the world.

The Oakil et al. (2011) study of cause and effect analysis on 200 respondents in Utrecht, Holland showed that the shift from commuting by car were correlated significantly with changes in work conditions, job changes, and changes in family composition. Switches to commuting by car were significantly associated with a new baby or separation from a partner in explaining changes in commuting mode, while residence displacement was not significant (Clark et al., 2016).Young adults lean towards car commuting in their early stages in the labour force. This finding is contradictory to some studies which found older adults (aged 50 to 59) have higher tendency to change the mode of commuting (Chatterjee et al., 2016). However, our finding is in line with Clark et al. (2016) confirming that the younger generation is more likely than other age groups to switch towards car commuting. In a European study (in Netherlands), it was found that younger people are also more likely to switch from car usage to the bicycle or public transport (Kroesen, 2014).

The holders of driving licence were more likely to change their mode of travel to cars. This can be explained by the fact that those being certified as driving licence holders are more likely to get access to a motor vehicle and change the commuting mode to vehicular option.

The residents of apartments/flats/units tended to switch from one particular mode to another compared to those who live in other dwelling types. This can be explained by parking space limitations associated normally with apartment living especially in inner suburbs or central Adelaide area.

Those retired or lost their jobs within last three years are more likely to move to non-car and cheaper modes (perhaps explained by these individuals wanting the flexibility in choosing public transit or walk/cycling to fulfil lesser activity and lifestyle needs). Interestingly, Clark et al. (2016) discussed that these groups have less obligation to commute at certain times, instead, they are more flexible to choose other modes included non-car choices.

Those had higher education (postgraduate degree) were less likely than other educational groups to switch to other modes for commuting, which can be explained by the fact that a highly educated group normally have more fixed jobs and residential locations that do not require them to change the mode of commuting. One reason is that people with high-education people are likely to have higher incomes and thus travel more by private vehicles. (Brand, Anable, & Tran, 2013; Thornton et al., 2011) In contrast, some argue that having higher academic qualifications may change the personal attitudes towards the environment and lead to reducing car usage (Van Dender & Clever, 2013). Interestingly, some former studies have found that highly-educated adults inclined to have more pro-environmental attitudes but choose less sustainable transport options (Anable, Lane, & Kelay, 2006).

Two travel-related personal factors were found to impact the modal change: one is attitudes to safety and another one is attitudes towards the cost. The former has positive effect on modal shift showing that higher expectation from car use leads to higher likelihood of modal change. On the other hand, a greater attention to the cost is associated with lower probability of modal shift. This finding confirmed the role of perceived factors in affecting behaviour. According to Prochaska's models (1986; 1994), the change of behaviour is a deliberate procedure which needs constant consideration.

A positive attitude to safety and a negative attitude to the cost when choosing a mode appeared across respondents and is at least an important starting point for behaviour change if more reliable, safer and cheaper options provided. Relocation of home or job is the main determinant of commuting modal shift as discussed in several studies (Chatterjee et al., 2016; Santos et al., 2010; Song et al., 2017; Transport for london, 2014). Our study found this significant only for those who currently use car and experienced a modal shift (from non-car to car commuting). Clark et al. (2016) suggested that presenting travel information packs explaining accessible transport options within the neighbourhood area would be an appropriate strategy for those who have recently moved to an area. One interesting finding of the model is that the value of Exp (B) parameter as the index of elasticity for home relocation (0.379) is 2.6 times larger than the elasticity for job relocation (0.148) confirming the stronger impact of home location on the mode of commuting. In this study, the correlation between positive attitudes to the environment and job changes was also examined but there was no statistically significant association.

Chapter 5: Discussion and Conclusion

5.1. Introduction

This study has investigated the actual and potential use of sharing mobility alternatives (bikesharing, E-scooter sharing and carsharing) in the City of Adelaide, South Australia over a one-year period during which dockless bikes and then e-scooters were operating in Adelaide. This study has explored behaviours and perceptions relating to sharing mobility alternatives and how they can be considered as affordable, eco-friendly and sustainable modes of transport.

The findings of this research illustrate several relationships between participant gender, age groups, existing employment characteristics, education level, current travel characteristics, and preferences relating to sharing transportation approach. These findings relate to the case study of the City of Adelaide and present useful data for the future development of sharing mobility services, in terms of targeting market interest amongst end-users, and in examining prospects for sharing mobility to reduce car dependency and reducing mobility carbon emissions, ideally through zero emissions active transport solutions, and where motorised mobility is unavoidable, opting for shared mobility to ultimately displace private vehicle ownership, and preferably in zero carbon emissions vehicles.

5.2. Findings

5.2.2. Bike sharing and e-scooters

The low frequency of bikeshare utilisation is reported in Adelaide as only 5 percent of users reported using the bikeshare as their daily travel option. Interestingly, literature in relation to Australian BSS also pointed out low frequency of bikeshare usage in the case of CityCycle (Brisbane) as well as Melbourne Bike share (Fishman et al., 2015). More importantly, in the condition of a low-density city like Adelaide, it could be a barrier for bikeshare development (Elliot Fishman & Martin von Wyss, 2017). Furthermore, due to high car dependency (Somenahalli, Sleep, Primerano, Wadduwage, & Mayer, 2013) as well the availability of an abundance of car parking spaces, and relatively affordable parking costs (Council, 2016; Nguyen et al., 2018), bikeshare programs struggled to make inroads as popular and dominant local mobility solutions in Adelaide.

A lack of ubiquitous dedicated cycling infrastructure in the form of on-road cycle lanes, dedicated cycle rights of way, limited parking, hostile traffic mix and a high urban speed limit of 50km/h, have not helped the uptake of cycling. Added to this, for local trips within Adelaide's CBD, walking may offer the best door to door journey times. A perception that the city was being junked with abandoned bikeshare bicycles, also conspired to create challenges to public acceptance of bikeshare. Furthermore, Adelaide City Council in a bid to avoid repeating the spectre of abandoned bikeshare bicycles cluttering and impeding public spaces, placed limits on the number of dockless bicycles to the extent that they could never provide the level of availability necessary to be functional as a transport choice. The portability of bikeshare bicycles and the inability to geofence their operation adequately also worked against bikeshare.

However, the key weakness in the business model for bikeshare is that they do not work well in a low density urban setting where bicycles can be dispersed to far-flung destinations where the cost of retrieval outweighs any income from the hire by several orders of magnitude and return to a location where a new hiring is likely to occur. The dispersal problem of share bikes does also paradoxically make a mockery of its zero carbon emissions claim if a 2 tonne motor vehicle has to be dispatched to retrieve and redistribute share bikes to preferred locations in the Adelaide CBD. Interestingly, Christian Haag, CEO of Bike SA in a personal discussion in 2018 after OfO withdrew from Adelaide, highlighted that the other problem in securing a commercially viable service was the issue of vandalism. OfO during its short time in Adelaide had to contend with more than 60 share bikes being cut in half (representing approximately 15 percent of its operational fleet).

Adelaide City Council's second take on shared mobility suggests that e-scooters with their much more sophisticated geofencing capability might have solved the dispersal problem that occurs post-hire, however, often there is still the re-distribution issue which requires operational intervention to relocate e-scooters to where new demand will occur. The operator gets around this to some extent however by providing incentives to users that will yield discounts on future hiring. The first trial of e-scooters with Lime from February to April 2019 resulted in around 140,000 trips being recorded (which was similar to the rates achieved with share bikes), and based on the doubling of e-scooter capacity provided in the second trial which runs through to October 2019 with Beam and Ride, potentially 980,000 rides will have been completed over the period from February to October 2019.

In theory, based on current usage, this could yield a maximum reduction of 355 tonnes of carbon emission annually for local trips within the City of Adelaide using shared mobility. This is however, a potentially heroic assumption because it assumes that users would have used a passenger car as a sole occupant (which on average generates around 242 grams of carbon dioxide per km) (ABS, 2018) and that they are not switching from electric trams to e-scooters (or shared bikes), or switching from walking/private cycling to shared mobility or making trips that they would not have otherwise made, and that recharging is from zero carbon emission sources and that retrieval of e-scooters for recharging and maintenance is done in a carbon neutral manner.

Within the context of Adelaide City Council's carbon emissions profile, shared mobility would have a negligible impact unless the City of Adelaide can encourage out of City Council commuters to forsake private car ownership and switch to low carbon mobility in the form of active transport or public transport. The current configuration of shared mobility for Adelaide will not allow trips to originate or terminate outside the City of Adelaide's 'square' mile, which greatly reduces the potential for shared mobility to make any meaningful inroads into reducing the 40 percent share of Adelaide commuters who use a car to travel into Adelaide's CBD. Given that the average commuting distance for Adelaide is around 12km, and approximately 33,000 commuters drive to work in the Adelaide CBD, around 161 000 tonnes of carbon emissions could be saved from substituting zero carbon emissions mobility for car trips, since Australia's car fleet is largely petrol or diesel powered (ABS, 2018; City of Adelaide, 2017; i.d.community, 2018).

At best, shared mobility in the City of Adelaide has useful marketing value in improving local mobility options and signalling the importance of having carbon free, local environmental impact mobility in a meaningful and visible manner. Shared mobility should be seen in the context of being a local mobility solution that aims to support Adelaide City Council's larger strategy of increasing the number of city centre residents who not need to own their own car, and instead rely on shared mobility for short trips and accessing public transit, and using carshare for those trips that require a motor vehicle (such as shopping expeditions or recreational outings that can't be easily accessed by bicycle, shared mobility or public transit).

This study suggests that the demographic distribution of those using bike share is broadly similar to that of those who cycle in Metropolitan Adelaide. A bike share user is more likely to be male and in a younger age group. In fact, whilst a diversity of people use bike share, it was younger adults and males and who were most likely to have used BSS. Not surprisingly, this is consistent with previous studies (Fishman & Schepers, 2016; Goodyear, 2013), who both concluded that there was a higher participation rate of males in using bike sharing. Furthermore, this reflects the dominant demographic profile of conventional commuter cyclists, raising questions about the potential of BSS to reach out to other socio-economic groups. In fact, the reliance of BSS on smartphones and online payments, can also be a discriminating factor across different age and ethnic groups, gender and income levels. This has implications if bike share is to bring the health benefits of cycling to a wider audience.

It is evident that users are relatively satisfied with Adelaide's current conditions and the quality of BSS. Apparently, this diversity of bikeshare services brings significant advantages for the development of BSS in Adelaide. However, in order to increase bikeshare usage, bikeshare operators need to formulate a standard for their services which is represented by a list of quality attributes as mentioned in the paper. In fact, Adelaide requires a Local Government framework for regulating future bike sharing schemes; to cater for public demand, by facilitating take-up, while minimizing risk and inconvenience to the public. This regulatory framework can be developed through a participatory process with various stakeholders.

The study also showed that conditions/facilities and comfort/convenience were two positive sides of sharing bike story. By contrast, the cost and geographical distribution were regarded as two dissatisfying factors. This is consistent with studies of other scholars, who presented the decisive role of these two factors in attracting bikeshare users (Chan & Shaheen, 2012; Fishman et al., 2014); LDA Consulting, 2013; Transport for London, 2014). In fact, a comprehensive bikeshare system with appropriate and supportive infrastructure and physical conditions can play a vital role in the decision of individuals to use BSS.

Finally, as a barrier for using BSS in Adelaide, the safety concerns associated with the intervention of cars on the road and inadequate provision of dedicated infrastructure for bikeshare were considered as discouraging factors to use BSS. Despite the Government of South Australia and Adelaide City Council having already invested considerable effort to increase people's level of cycling participation, the exploration of barriers presented in this study on bike sharing systems provides a foundation to develop a future successful BSS in Adelaide. Interestingly, many bikeshare operators around the world quietly shifting their focus to e-scooters and e-bikes as the next phase of shared mobility systems (possibly because of increased management control over their operation), which suggests that either the BSS systems will need to be changed to address their deficiencies or that sharing mobility is set to become more complex and diverse in its service offerings in future. At the current point in time, sharing mobility systems now seem to have transitioned towards personal e-mobility, dominated by e-scooters.

At the time of the survey, both types of docked (Adelaide free bike) and dockless (O'Bike and OfO) were available. One disadvantage of dockless bikes as expressed by the users was the unavailability of bikes at high demand locations such as Adelaide's Central Train Station or close to the Rundle Mall precinct when required. This issue was important because these points are considered as starting points of many trips. On the other hand, respondents expressed their satisfaction with the option of leaving a dockless bike in any location at the conclusion of their journey. Potential new bike share schemes should carefully consider the physical access of potential users especially for the purpose of ensuring the integration of share bikes with public transport.

The other advantage of dockless bikes of OfO and OBike was their capability to be accessed via smart phones. The apps developed by both service providers had a range of facilities to hire, pay, lock and unlock the bikes. However, for those who did not own a smart phone or were not familiar with the functions of the apps, this issue can be regarded a disadvantage and raises the risk of social exclusion which was dependent on the age, gender, education and level of income.

Sharing similar findings with the literature, this study confirms that the fundamental purposes of bikeshare usage, are the user's participation in social activities and returning home. In most cases, bike share has replaced walking trips as either "first-mile" or "last-mile" segments. Besides the existence of other trip purposes such as using it in conjunction with public transit connecting to public transport, and seeing the city, the results of this study indicate a contradiction to study of by (S. A. Shaheen, 2012) who believes that the trip to school is considered as one of important reasons that leads to the use of bikeshare among people. Consequently, it creates the fact that purposes of utilising bikeshare may vary from case to case, therefore an in-depth investigation about the performances of current BSS is required. It is clear from the survey that the City of Adelaide cycling context remains one of the most significant reasons why people see bike share as unviable for them. The perceived fear and vulnerability against motorised traffic are well perceived as barriers to the uptake of cycling as an alternative. These reasons are similar to the common barriers for general cyclists.

Bike share in Adelaide city should be understood within the general context of cycling in the area and specifically in relation to the operational context of the OfO and O'Bike schemes, which was short-lived and, arguably, poorly managed. These two companies clearly experienced difficulties in aligning their offering to the area especially O'Bike which failed in having its permit renewed and was ordered by the Adelaide City Council to cease operating in Adelaide (I. A. s. I. News, 2018). As the first such scheme in Adelaide, they were both advised by Adelaide City Council that it was a provisional trial. Despite the apparent 'failure' of this scheme, implied by the companies withdrawing the bikes within one year, it has provided a basis on which to draw implications for how to approach, communicate, roll out and operate any future schemes.

The grid pattern of Adelaide's road network allows for many routes to be selected by cyclists. On the other hand, the utilised routes reflect an aspiration for safety because most routes include the West Terrace Bikeway and almost all routes are enclosed to roads with bike lanes. According to the data extracted from annual Super-Tuesday bike counts, which included 42 intersections, the establishment of the Frome Bikeway has had a considerable impact on the number of cyclists, which increased approximately 19.5 percent in 2015 comparing to 2014. The survey also showed that while the overall number of cyclists increased from 2016 to 2017, the share of female cyclists (30.5 percent) decreased by 3 percent although, compared to 2011, the share of female cyclist actually increased. The extension of bike routes is an important step forward in developing cycling infrastructure, especially with the establishment of a separated east/west route through the city that will connect to cycling routes in the adjacent suburbs in a safer way ((AILA), 2017).

Cycling in Adelaide needs to become a safer mode of transport to increase its modal share. It is necessary to investigate how cyclists interact with the existing provided infrastructure to allow for future improvement. According to the BicycleNetwork (2018a) when cyclists use sidewalks to avoid traffic lights and vehicular traffic it reflects poor planning outcomes. It should be mentioned that some aspects of current and recent cycling infrastructure are supportive of cycling including the establishment of bike lanes, turning refuges, dedicated green signal for cyclists at intersections and dedicated off-road cycling routes. Based on the findings of this study, safety is the main consideration for cyclists and thus safety requires the highest priority through implementing new infrastructure that supports this. Hence a focus is required on the allocation of road space for cyclists and assisting in reducing the safety fears associated with being an "outsider" as described by Fishman (Fishman et al., 2012).

According to BicycleNetwork (2018a) the key routes cyclists take through the Adelaide CBD are not limited to roads, instead, depending on the cyclist's ability, they tend to use both paved roads and sidewalks. On the other hand, almost all riders would use bikeways and roads with bike lanes. The most usual routes include Morphett Road when approaching from the north, West Terrace when approaching from the west and Pirie Street from the east. These three corridors contain heavy amounts of bike traffic during peak morning and evening hours. Since the majority of main trip generators are placed in the northern half of the CBD, cyclists also frequently use Grenfell Street, King William Street and Waymouth Street. This arrangement of route selection shows the importance of safety whilst travel time is considered a lesser priority.

The implication of this finding is to increase the number and length of bike lanes and provide a further allocation of road space for cyclists. This objective could be met with the introduction of buffer zones between bike lanes and parked cars and stopping spaces at lights for bicycles.

The quality and design of the sharing bikes themselves had been discouraging factors to some users. Some respondents found the vehicles to be slow and heavy and some users found the bikes uncomfortable to ride due to the single gear and low saddle height. Some found it hard to cycle at the speed they wish. It was also reported the lack of helmet availability for some dockless bikes frustrated access to them for prospective users.

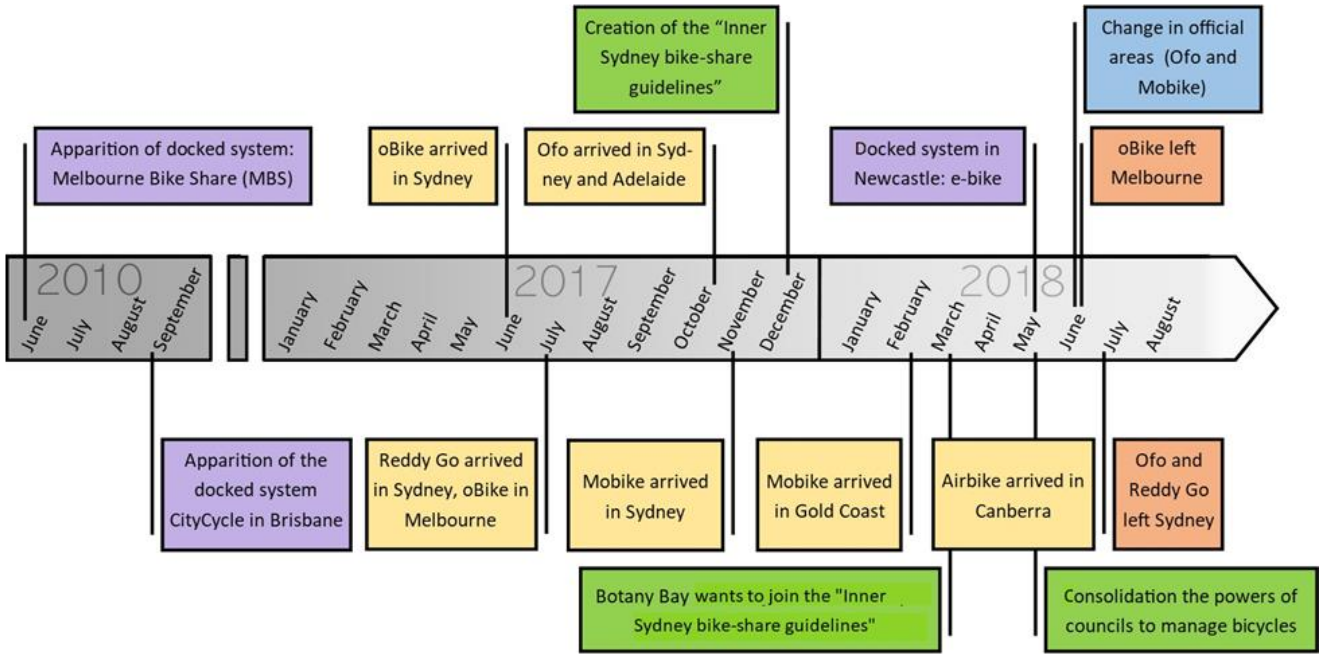


Figure 5-1.The rise and fall of Bikeshare in Australia (2010-2018). (Heymes, 2019)

5.2.3. Car sharing

This research also evaluated two car-sharing schemes (GoGet and UBER) operating in the City of Adelaide using empirical data. The scope of the project was to realise the socio-demographic characteristics of current users of the system; travel purpose and the primary motivations behind the choice of using car-sharing and identifying the features of the service that affect the satisfaction of CSS in order to determine how CSS could be improved to better meet users' needs.

While confirming several aspects already discussed in the literature, this research revealed that, due to their different characteristics, the market for shared-cars is not sufficiently well developed in the Adelaide context, and that its current level of activity is highly dependent on socio-demographic characteristics. This study recommends a revision in the car sharing business model to make it a much flexible and economic option for car owners to consider substituting car ownership with carsharing to meet their daily commuting needs, given that the economic savings are ensured when traveling for these short distances.

The cost was shown as one of main determinants of satisfaction/dissatisfaction, with shared-car users expecting lower costs and more promotions and financial incentives. One advantage of car-sharing schemes is that the cost system is transparent, so it is expected that the users of shared-cars can make a judgement when comparing the cost of shared systems with the continuous cost of private car which could reduce the distance travelled by one's own car in the longer term (Katzev, 2003; Litman, 2000; S. A. Shaheen & Cohen, 2007).

However, deeper economic analysis with comparing the actual costs of using a shared vehicle (either GoGet or UBER) for a set car trip distance is required to achieve a more precise result. If the business case stacked up for shared car usage, private motorists would switch very quickly. The business case for individual consumers is less convincing the higher one's annual travel is, and at 12,000km per car annually, the typical annual car mileage in Australia, private car ownership is likely to come out significantly lower than using shared vehicles for the same distance. Note however, that in an inner city location, annual car mileages will be much lower than the 12,000km per year mileage for the national vehicle fleet. It seems that the trade-off point when the costs of a share car exceed that of using one's own car are probably at around the 4000-5000km/year threshold, depending on parking costs and vehicle preferences. Shared car ownership doesn't present a convincing case for high mileage households using cars. However, it would be affordable for low car mileage households or where households use alternative modes (such as public transport and active transport for the bulk of their travel). Interestingly, where shared car use (GoGet for example), has succeeded, is where private parking is difficult or unavailable (such as in Sydney). UBER succeeds for the same reasons that there is demand for taxis, out of convenience or to enjoy a social outing without the stress of driving safely or it is the only quick way to reach a destination (such as when travelling to an airport).

Furthermore, the analysis showed that most respondents had used a sharing vehicle for non-work destinations such as education, shopping and especially leisure/social activities (and returning home after) but with lower frequencies. This means that despite owning a private vehicle, shared-services were used due to private car costs (i.e. such as parking fees) or other kinds of restrictions (e.g. time pressures and traffic congestion), which suggests that a shared mobility service can fulfil a need for non-regular commuting in urban core areas. In fact, the usage of shared-cars is almost always occasional and at least in the Adelaide context, not yet embedded in commuters' daily travel patterns. However, in cases where private car usage costs are high and impractical, they substitute private vehicles with sharing cars.

The satisfaction with current UBER and GoGet services is moderately high and the maintenance and cleanliness, sign up methods, reliability and availability and the quality of the mobile app (with its ability to securely pre-order, pre-pay, review services and track vehicle location) are the main reasons why people use these services. By contrast, an absence of promotions and incentives, the high cost (i.e. fares, particularly the uncertainty with UBER's "surge" demand pricing model) and long waiting times are the primary weaknesses for these services. A key concern of users was that the service is not reliable (i.e. in terms of availability or waiting times). Given the fact that this system was only introduced within the past two years, there is considerable market potential for a much greater take-up of CSS, particularly for those who live or work in City of Adelaide where parking spaces are limited and can be costly for households that do not have their own dedicated off-street parking space. The significant (albeit different in quantity) impacts of moving house and changing jobs on shifting travel modes from private car to other alternatives included public transport and sharing mobility showed that these actions are crucial in defining the patterns of activity, therefore, any policy in jobs and housing distribution as exogenous factors would have travel patterns significantly affected.

5.3. Policy Implications

Although the shared mobility may be a minor modal alternative in the overall spectrum of transportation activities, they can offer a significant efficiency in providing supply to job-related, social and recreational short trips. BSS and CSS can be attractive options not only for those individuals residing in a certain city but also for regular commuters and tourists.

Their importance is also crucial when dealing with the connections to/from major trip generators (i.e. public transport hubs), which in turn can reduce the demand for motorised transport with its attendant adverse traffic and environmental consequences. However, changing circumstances and challenging economics have resulted in "market failure" of these systems (especially BSS), due to a variety of reasons that can change according to the studied context (inappropriate vehicle maintenance, insufficient availability in certain locations or at certain times, the personal concern of users about sharing their credit card details, and so on). Indeed, whilst UBER is on paper heavily capitalised with venture capitalists funds, it is not profitable and it remains unclear when, if ever it will become economically viable. UBER's losses were $US 1.8 billion in 2018 worldwide, however, this is in a climate of rapid company expansion, with revenue of $11.3 billion (up 43 percent over the previous year and a capital valuation of $120 billion in 2018 (Zaveri & Bosa, 2019). The usage of the related open-source data for research purposes could be a feasible strategy to gain a deeper understanding of the functioning of the current BSS and CSS in Adelaide (the research team was not provided with big data by service-providers).

This research project can help policy makers having insights into the performances as well as influential factors of the bike sharing system. Due to the low density of population within the metropolitan area, planning policy needs to prioritise integration between land use and transport. This requires planning and development documents to be revised as these provide objectives and targets that drive change. As described before, the current planning documents lack guidance or targets for the future of sharing mobility. Specific sharing mobility targets and objectives from the State level could help to enhance the approach of local government in implementing infrastructure within the Adelaide CBD for shared-mobility.

As mentioned in the 30-year Plan for Greater Adelaide, strong emphasis on infill development would be critical to transform Adelaide into a denser city (Government of South Australia, 2017), thereby creating an appropriate environment for the future development of bikeshare. In addition, due to users' safety concerns about the lack of dedicated bike lanes and routes, a dedicated transport plan should be proposed to facilitate better investments in bicycle infrastructure with the aim of providing safe and functional environmental conditions for bikeshare riders. Priorities should be given to build more dedicated bike lanes and routes within Adelaide's CBD where bikeshare are frequently used. As noted in Adelaide Smart Move 2012 – 2022, a variety of relevant work will be conducted to create better infrastructure for cycling (City of Adelaide, 2012). Within the context of an improved bike network and infrastructure, sharing-bikes can reduce the barriers included fixed costs of ownership and storage spaces and making the cycling as an accessible alternative for everyone.

Bicycle safety is perceptually one of the most important subjects that concern people in making a safe modal choice. The high death rate for road accidents in urban areas involving vulnerable road users such as cyclists makes it seem that only cars are a priority for taking action (Pucher & Buehler, 2008). According to the Australian Automobile Association (2018), cyclist deaths jumped from 25 to 45 which indicated an increase of 80 percent between 2016 and 2017.

To increase the safety for cycling, several strategies could be adopted. Firstly, speed limits (such as mandating 30 kph) for both cars and bikes in cities would reduce the risk of road accidents. This is consistent with the request of bicycle lobby groups such Bicycle Network (BN) to reduce the speed limit of cars and allow cyclists to ride on footpaths (in Victoria's case) (BicycleNetwork, 2018b; A. News, 2017). Furthermore, a decrease in the use of motor vehicles and the encouragement of cycling in urban areas could decrease the frequency and severity of accidents'. Moreover, policies, laws, and regulations for road traffic need to be revised in order to give the government a chance to make an integrated holistic system to protect cyclists who share the road spaces with motorised traffic. Currently, the law defines bicycles as vehicles for use on the road and road-related areas, and regulates bicycle riders, as it does for drivers of motor vehicles and all road users, without fully considering the fact that cyclists are extremely vulnerable road users in traffic crashes. Placing the onus on the driver to prove that they were not at fault in an accident with a cyclist would encourage greater care on the part of motorists, a system that is effective in the Netherlands.

Considering the fact that substituting motorised modes with bikeshare (especially for first-mile and last-mile segments) could have substantial health, economic, environmental and social benefits. Notwithstanding this, the evidence showed that such benefits depend not only on the type of sharing bike, its quality, the consistency of system operation and the geographical area covered by the system but also on the environment in which biking occurs. This study confirmed that policy-makers are required to be diligent in catering to diversity across different age groups, gender, income levels and cycling experience to ensure that those consequential benefits can be enjoyed by all of society's members.

There are some strategies suggested to improve the conditions for cyclists: first road space allocation for cyclists is a key priority. Cyclists now suffer from a lacking suitable spaces for parking on commercial streets. Furthermore, ensuring that cyclists are safer and to decrease the rate of accidents, separated routes are required for cars, pedestrians and cyclists. The successful experiences of European countries (e.g. London) in building traffic-free bicycle highways and Cycle Super Highway can be applied to Australian cities such as Adelaide.

In conjunction with improved road space allocation, the traffic rules and regulations should be revised to giver higher priority for cyclists. This is more crucial where the road space is shared between cyclists and motorists and pedestrian. As safety is now a critical issue for cyclists in Adelaide, the design of intersections, traffic lights, speed zones and bike lanes should be revisited to provide safer circumstances for cyclists.

It is also required to develop basic infrastructure for cyclists such as an increase the bicycle parking spaces inside commercial, retail centres, education institutions and residential buildings within the central city area. The separation of riding spaces into independent car and bike lanes for the purpose of improving safety for cyclists which is experienced along the Frome Road with the Frome Road Bikeway in Adelaide has been a successful design initiative which can be replicated in other major streets.

Figure 5-2 Adelaide's Frome Road Bikeway Success Story

Bikeshare in Adelaide has a potential to be fitted into travel routines, as some respondents combined it with either walking or public transport as an evidence of taking bikeshare for "first mile" and/or "last mile" journeys. It is therefore, required to promote more linkages with public transport network in order to make cycling usage more feasible for longer distances. Providing sufficient and safe parking spaces within public transport stations such as Adelaide Railway Station and permitting the carriage of bikes on the public transport vehicles would improve the connections of cycling to public transport. Currently, cyclists are not allowed to carry their bikes on buses and Adelaide trams which is regarded as a barrier to long-distance trips by these modes. The idea of bike sharing provision at the locations of transit stops would help to provide mixed modes of bikes and public transit. The experiences of European and Asian cities in this regard show that mixing bikes and public transit can be a reliable alternative to private vehicle usage, while the bikes have their own parking spaces, and an exclusive dedicated road space.

The above findings confirm that future bike share schemes should purposefully take into account the design and maintenance of the vehicles in order to encourage potential users to cycling again because poorly managed bike sharing system could deter people from using these system for cycling.

It is recommended that car-free zones be developed such as Rundle Mall for enhancing the safety of cyclists. Developing car-free or low-speed zones is not only required within the city of Adelaide but also should be considered at the neighbourhood level. Furthermore, providing direct and safe cycling links to public transport stations and interchanges should be developed as set out in Adelaide's 30-year Planning Strategy.

The Frome Street Bikeway was provided with an exclusive bike lane since 2015 to make cyclists feel safer and more comfortable when riding a bike. However, the majority of Adelaide roads lack separated and protected path for cyclists.

Another recommended strategy is in developing e-bikes since this market has not developed significantly in Australia. It is estimated that currently there are a total of over 40 million e-bikes operating around the world, and this market has significantly expanded from 33 million in 2011 to 40 million in 2015. China has the largest share, with over 26 million e-bikes in use in 2015. The adoption and public acceptance of e-bikes are strongly dependent on governmental incentives and supporting infrastructure.

The Bike sharing schemes in the City of Adelaide encountered two types of barriers: a) external barriers referring to the natural environment included topography and weather conditions (sunlight, wind, humidity, rain, etc.); and the built environment which included a lack of dedicated space for cycling, poor road markings, exposure to high volumes of motorised traffic and high speeds, lack of priority at intersections; and b) internal barriers such as the operation of system including the design and quality of bikes, operation quality and maintenance, the credit card payment, the reliance on smartphones and the geographical distribution of bikes.

The survey showed that only 9.8 percent of shared-car users don't have a car. There is considerable scope for car-owners to substitute their car trips with car ride share trips, which would result in a considerable saving given that the average Australian household pays $7,554 per annum per private vehicle (Australian Automobile Association, 2016).

The volume and congestion of vehicular traffic in the metropolitan Adelaide are increasing due to a gradual growth of population that is increasingly choosing to live closer to the city. Despite the fact that urban road network and infrastructure have been improved within the last two decades, traffic congestion has not been significantly reduced in Australia's large cities. Furthermore, due to inconvenience and low reliability of public transport, it has been less attractive for people to substitute public transport with personal car usage.

While the number of registered cars in Greater Adelaide increased from 774,936 to 824,311 from 2012 to 2016, in the case of the City of Adelaide it decreased from 23,965 to 22578, reflecting the partial success of transport policies in overcoming car-dependency. This is consistent with the international experience of push-and-pull policies in European countries such as Germany, Denmark, UK and Holland (Pucher & Buehler, 2008).These countries experienced the parallel policies of reducing car parking spaces and making it more expensive for car users at local level in particular cities.

The evidence shows that public transport usage for commuting to work is less popular than four decades ago. Moreover, a large proportion of public transport vehicles still use diesel fuel which is regarded as a source of air pollution and significant carbon emissions. For inner suburbs and CBD area, sharing mobility services provides an advantage over other modes of transport especially private cars and public transport. Sharing mobility is regarded as a cost-effective, affordable and fast-growing industry which will be sustainable in the longer-term. According to Pucher and Dijkstra (2003), decreasing the speed of vehicular traffic is the most important policy for improving the safety for cyclists. The Action Plan for Carbon Neutral Adelaide (2016-2021) has the target of doubling the number of cycling trips within the boundary of Adelaide City by 2020.

According to the socio-economic profile of the respondents, the majority of users were from low and middle-income groups, expecting cheaper modes of transport. Sharing mobility is a significant alternative to many people due to its relative advantages including flexibility, affordability, ease of access, connectivity to public transport and a capability to save the environment. Sharing mobility has additional benefits of lower travel costs and the potential for increasing physical activity as well as removing the cost of bike ownership and parking spaces at home. Therefore, targeted information campaigns on the potential benefits and economic savings related to car-sharing, in combination with a better distribution (ensuring reliable access to CSS) and wider availability of vehicles could initiate growth in CSS adoption rates. Users also expect that regulators provide regulations to protect passengers' personal safety and help ensure safe driving behaviour by UBER drivers.

The research outcomes of the project have reflected some important aspects of BSS and CSS in the City of Adelaide and the characteristics of the actual users based on an intercept survey. The findings of this study lead to the need to reconsider transport policy to have a better accommodation of sharing mobility systems to mitigate the high use of motorised transport. Notably, the research has provided reliable evidence to support the necessity of incentive policies and actions in order to reduce private car usage as mentioned in the Integrated Transport and Land Use Plan regulated by the Government of South

Australia and the Strategic Plan of Adelaide City Council. The study on the sharing-mobility schemes in the City of Adelaide would help to formulate the foundation for further investigations with regard to other sharing-mobility systems in Metropolitan Adelaide.

This study also presented some new visions which may be beneficial when trying to encourage more people to take shared mobility options (more often). Most notably, it was shown that neither all car users nor all non-car users are the same which may have significant implications for sustainable mobility policies. The positive association between being in a young category (17-29 years old) with the likelihood of modal shift, opens up an opportunity to consider this group as a proper target. As many of young generation including students cannot afford buying or using a car and while being less willing to use infrequent bus services, for many of them sharing mobility services can be a reliable and flexible option.

Our survey found that about 28.8 percent choose a multimodal option rather than a single mode to reach their destination. A trip-maker who takes multiple modes can be viewed as a thoughtful journey choice maker, while an individual who solely chooses a single mode is more likely to be a habitual travel maker (Kroesen, 2014). By contrast, single-modal persons are more likely to be stable commuters and less likely to response to behavioural change measures/actions.

A varied set of transport policies and strategies addressing different socio-economic groups, is required to be adopted for increasing the share of sustainable modes in the short and the long term.

Short term strategies include identifying and supporting those who have already used non-motorised or public transport infrequently. In the longer term, bringing jobs closer to homes and encouraging job concentration in centres and physical improvements such as increasing the coverage of safe cycling routes within the central Adelaide area are suggested. Increasing public knowledge of the carbon footprint of their travel through general campaigns and media are essential.

Former studies advocating smarter planning through Transit-Oriented Development (TOD) or Traditional Neighbourhood Development (TND) approaches claim that the local built environment has a significant facilitating role to play in encouraging commuting by non-motorised modes when people relocate their job or home. This is apparent from our study, since central Adelaide comprises 20 percent of jobs and this local government jurisdiction in Adelaide has the highest rate of walking and cycling (37 percent). In addition to ensuring reasonable accessibility to workplaces, the quality of the built environment, especially with regard to the presence of non-residential land uses and having safer footpaths and cycling routes, qualifies the Adelaide CBD as having amongst the best areas to walk/cycle for employees (comparing with the rest of metropolitan area).

Although in the short term, it is nearly impossible for Adelaide and its suburbs to reach zero carbon emissions with its current modes of transport (excluding the use of carbon offsets), the State Government's has endeavoured to increase the patronage of Adelaide's public transport systems in an attempt to reduce carbon emissions from private vehicles. If public transit and other alternatives such as active travel and shared mobility can cater for a large amount of people within a close distance to the city, then there will be less private vehicle usage and therefore less carbon emissions (J. Yang, Shen, Shen, & He, 2012).To be able to increase the use of public transport, more compact and transit-oriented developments such as the Bowden redevelopment need to occur (Rafat, Mirhadi, Sharifi, & Soltani, 2018). Compact developments would result in more people living in a smaller area, and also generally closer to the city. Many of these developments could also limit the availability of car parking for each dwelling.

For the major trip generators, as major sources of public transit and shared mobility patronage, it would seem that they have a critical role to play in supporting appropriate low emissions transit solutions. This could partly involve the provisioning of infrastructure that accommodates shared micro-mobility in making it highly visible with on-site micro-mobility vehicle parking and in providing the pathway corridors to allow easy direct ingress and egress. It would also involve ensuring that shared micro-mobility vehicles are always available to meet anticipated demand, which may require a redistribution of micro-mobility vehicles when an imbalance begins to result in these vehicles being widely dispersed away from the demand points in the urban setting.

Furthermore, more reliable and efficient public transport, where the journey time to workplaces can be reduced, would be an appropriate alternative for those commuters who wish to change their mode of travel. In fact, having the right mix of urban planning and transport strategies which target a mixed-development, that is well-serviced by public transport, can be effective in achieving a modal shift from cars to more environmentally sustainable travel options.

In light of the upheaval of the shared micro- mobility sector in Australia, there is uncertainty about whether the private sector can be relied upon to deliver a sustainable business model. Service providers of shared micro-mobility have demonstrated that the technology is workable and conceptually sound, however, the economics are challenging. A hybrid public-private partnership model may be the best way forward in much the same way that public transit services are often delivered in Australia, which may be the only way that a continuity of service experience is provided. The alternative is that shared micro-mobility is managed and provided by the public sector, with public sector branding as another form of public transport. The management of shared micro-mobility as part of a city's greater public transport operations, would ensure that there is genuine and effective integration of shared micro-mobility with public transport services to support the first mile-last mile conundrum of public transit.

5.4. Further Research

This project is the first step along this research endeavour investigating options to reduce mobilty related carbon emissions. The stories of sharing mobility schemes narrated by the data that we have collected and interpreted can provide planners and practitioners with more knowledge, which would be useful to prevent failures and replicate successes in other cities over the world, where the BSSs are now at a developing stage. Further research aimed at discovering additional factors (i.e. related to the built environment and the bike-friendliness of a city) can affect and improve the success of shared systems.

Further studies could be carried out to include the participation of different stakeholders to present their perceptions towards BSS in Adelaide. More specifically, policy makers, urban planners, transportation experts could be invited to take part in the study. This will provide a basis to have local authorities, local employers, transit service providers and share-bike providers to collaborate with each other to establish a connected and reliable service which covers key strategic locations included employers and transport interchanges, whilst also giving people the flexibility to make longer journeys by cycling.

Research around travel speeds particularly the variances between confidence/ability groups will assist in improving the requirements between groups. Understanding the difference will allow for the adaption of cycling infrastructure or road rules restricting vehicular travel. By using speed monitoring devices it is possible to identify routes that would serve as potential bicycle corridors or where congestion for cycling needs to be alleviated. Also, questions pertaining to the reason for their cycling journey will help to identify whether journeys through the CBD are recreational or as part of a commute. Due to the broad range of cyclists throughout Adelaide these areas of further research will help to develop a stronger understanding of the phenomenon associated with route selection through the Adelaide CBD.

It is recommended investigating the multimodality capability of sharing systems and the issue of "first mile" and "last mile" of urban commuter trips which relates to the movement of people from a transportation hub to a destination such as home or work-place (Schaefers, 2013). As the literature has shown, CSS work more efficiently where a reliable public transit system exists (Huwer, 2004; E. Martin & S. Shaheen, 2011). Furthermore, one of the primary goals of car-share schemes is to improve environmental sustainability through reducing vehicle related carbon emissions, however, more research is required into discovering the exact role that CSS has on the environment. Shared-car services not only require designated parking spots (particularly for GoGet where a car must be parked until a user collects it), but also have access to a public space, which normally requires local governmental intervention. It is expected that governmental support is increased if car-sharing complements travel demand management and environmental goals, while the reason for CarSharing is simply to exploit demand for this type of service as a business opportunity. CSS still has a considerable way to go before it becomes commonplace in cities such as Adelaide. However, this research has shown that there is positive support for CSS that can be built upon and expanded to allow car sharing to play a dominant role in meeting the travel needs of inner city residents.

In addition, further research is required to investigate about the real potential for increased market share of CSS and BSS, for example, key statistics about what share of mileage travelled these CSS are meeting the needs of. If the proportion of residents using CSS and their pattern of usage is accurately modelled, then improved mobility services could be developed. Although Bikeshare appears to have failed as a transport mode both in Adelaide and internationally, it does seem that e-scooters may offer a workable model going forward for micro-mobility transport solutions, whilst car-share, particularly with regard to UBER, continue on a rapid expansionary phase that appears likely to completely disrupt existing taxi services, and possibly challenge the community mindset that only a car can provide independent mobility. However, unless UBER switches to zero emissions vehicles, the carbon emissions saving may be modest. A longer term strategy would be to change Adelaide's urban form to a higher urban densities supported by TOD based network, where shared mobility (such as Bike-Share, E-bike-Share and e-scooters) provide the first mile-last mile trips and car share meets the occasional need for a larger, multi-person motor vehicle, either through Self-Drive (as offered by GoGet) or as a taxi service (as provided by UBER). The rise of e-mobility and autonomous vehicles over the next decade appear set to create the basis for a promising future for an emissions free, safe and highly purposeful mobility future.

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