2016•2017
SCHOOL FOR TRANSPORTATION SCIENCES
*Master of Transportation Sciences*

# Master's thesis

## Investigating the factors influencing the use of public bike sharing schemes for the last mile travel in Belgium

Supervisor :
Prof.dr.ir Tom BELLEMANS

Co-supervisor :
dr. Muhammad ADNAN

Shahbaz Altaf

*Thesis presented in fulfillment of the requirements for the degree of Master of Transportation Sciences*

Universiteit Hasselt | Campus Hasselt | Martelarenlaan 42 | BE-3500 Hasselt
Universiteit Hasselt | Campus Diepenbeek | Agoralaan Gebouw D | BE-3590 Diepenbeek

2016•2017
SCHOOL FOR TRANSPORTATION SCIENCES
*Master of Transportation Sciences*

# Master's thesis

## Investigating the factors influencing the use of public bike sharing schemes for the last mile travel in Belgium

Supervisor :
Prof.dr.ir Tom BELLEMANS

Co-supervisor :
dr. Muhammad ADNAN

Shahbaz Altaf
*Thesis presented in fulfillment of the requirements for the degree of Master of Transportation Sciences*

"Life is like riding a bicycle. To keep your balance, you must keep moving"

Albert Einstein

# Preface

This dissertation is submitted, to fulfill an integral requirement of Masters of Science program (Transportation Sciences) at the University of Hasselt. This endeavor is about the pro-rail public bike sharing program in Belgium including bits of auxiliary information surrounding that subject. I became interested in this topic owing to the couple of reasons, 1) climate change and the role of transport sector in exacerbating it, 2) Bicycling is an important ingredient of sustainable mobility that is a future of transportation. Overall, this study is unique because it is first time that a public bike sharing scheme is being studied and analyzed under the framework of discrete choice modeling.

This document is a result of approximately eight long months of effort. During that period, I faced many challenges like negligible understanding of local languages, scarcity of data, and time. However, I have gained a treasure trove of knowledge, not only regarding bike sharing schemes around the world but also an advanced data collection and modeling estimation techniques. I also want to acknowledge, the help of Ms. Nadine Smeyers and Mr. Marc Thoelen both officials at Hasselt university in translating my questionnaire into Dutch and French. Finally, special thanks to my co-supervisor Dr. Muhammad Adnan, who answered my every call and for his guidance every step of the way.

# Summary

Bicycling is a cheap and green form of transport and it is being touted as a solution to the many problems, transportation sector is facing today. Therefore, to promote cycling, a vastly popular method is the development of bike sharing schemes. These schemes are rental systems that allow potential users to hire bicycles from the designated bicycle stations and return them to any other or the same station. The idea behind the bike sharing is to provide an alternative form of public transport to cover the short and medium length journeys.

Bike sharing is one of world's fastest growing modes of public transportation. It is expanding at an average rate of 37% per annum since 2009. There are total of 1090 bike share systems in 60 countries worldwide. These schemes have a positive impact on the ridership of public transport, efforts to reduce car use and strengthening of cycling culture. However, a chunk of bike sharing schemes around the world are also failing owning to the, absence of a good marketing plan, lack of political will at all levels of government, poor placement and density of docking stations or a cumbersome registration process etc.

The principal element of any sustainable transportation system is a Public Transit (PT). Yet, the first and last mile access to and from PT stations remains either a nuisance or a struggle for the commuters. Research has shown that if cycling is used for the first and last mile of the trip, it will not only provide the benefits of walking but also help enlarge the catchment area of PT from 2km to 5km. In fact, there are three bike share and PT integration methods namely Bike-and-ride, Bike-ride with bike-bike and Ride-and-bike.

In Belgium, some progress has been made to ensure the integration of rail and bike. There are two programs, first, the provision 77,000 parking spots for the bicycles at the train stations till 2015 and second the permission to carry folding bikes on the commuter trains. However, the impact of these measures on the users and non-users of the bike sharing schemes is still not clearly known. Therefore, to analyze the impact of afore-mentioned and other strong factors, an experiment based on the principals of stated preference design was developed.

The selection of attributes and their levels was a long and comprehensive process. However, eventually ten variables/attributes were finalized, which were used in the stated preference design. Moreover, these attributes were divided into two sets, each containing six attributes (two common in each set). Later, full factorial design was employed to create choice tasks or alternatives. Each sub-set of attributes treated separately generating 432 alternatives. Further, it was decided not to present more than nine choices to any person. In consequence, 96 different questionnaires were developed and sent to people online through a single web link, which randomly distributed one survey from the complete set.

The survey remained active for three weeks, garnering 119 correct responses. This data was analyzed with the help of Microsoft Excel and SAS software in the next step. To elaborate, two kinds of analysis were conducted, descriptive and logistic regression based modelling. The former, showed the character of the data and relationship of one variable with another especially the interactions between bicycle ownership and socio-demographic variables. Regression analysis modelled the probability of bike share use with the ten attributes selected during the experimental design phase.

To make the regression results accurate and bias-less, the observations from the students, which were the largest segment among the respondents were copied into a new dataset. In result, models were developed based on two datasets. Further, it was decided to make three models for each dataset, comprising of stated choice, socio-demographic and attitude variables. Pithily, the results were slightly different for both the datasets but mainly showing 'tariff', trip distance', 'weather', 'car ownership', 'bicycle ownership', 'bike parking at the destination', 'attitude towards bicycle use' and 'employment status' does impact the decision of using bike sharing scheme for the last mile travel.

The upshot is, bike sharing can be popularized in Belgium. To do that transport authorities must work hand in glove with the urban planners to achieve the desirable urban form, where the distances to destinations are less. Moreover, also keeping close cooperation with the federal and local governments, encouraging them to invest in bike parking facilities and subsidizing bikeshare use tariffs. Finally, promotion programs must be launched either alone or with the non-government organizations to change the attitude of people regarding the bicycle use especially in the schools and colleges.

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF GRAPHS



# LIST OF FIGURES

# INTRODUCTION

Since, the advent of twenty first century, cycling is being touted as a solution to the many problems, transportation sector is facing today (Tang et al., 2011). In order to promote cycling, several kinds of approaches i.e. bicycling stimulation campaigns, provision of cycling related infrastructure and improving access for cyclist etc. (Pucher et al., 2010). However, a new and vastly popular method to promote and expand bicycling is the creation of bike sharing schemes. These schemes can be seen in the cities and towns all across the world, which is certainly a good starting point for the development of bicycling culture (Bachand-Marleau et al., 2012).

The benefits of cycling at both individual and societal level are significant and well known. At an individual level, cycling provide flexible and convenient way to complete short and medium length trips. Moreover, at the communal level, cycling assuage the problems like congestion, air pollution and global warming by cutting the trips made by cars. To elaborate, the car dependence is reduced automatically, when a bike sharing system starts to complete the first and last mile to the transit stations. Therefore, cycling advocates and municipalities especially in Europe are publicizing cycling as an antiseptic for the unsustainable transportation practices (Twaddle & Gerike, 2011).

## 1.1. PROBLEM STATEMENT

Sustainable development is a buzz word in the world today and transportation sector is important part of it. Therefore, it means, moving toward sustainable mobility is tantamount to achieving sustainable development. To be clear, sustainable mobility stresses, reduction in the use of cars and promotion of environment friendly modes of transport (Beroud et al., 2010). In fact, bicycle is both eco and cost friendly, mode of transport. These attributes of bicycling are at the center of bike sharing marketing campaigns. Moreover, this rising interest in cycling is coming at times, when environmental conservation and social health issues are stimulating the policy makers to reconsider their ways of managing transport (Porter and Kramer, 2011).

The principal of bike sharing is that an individual hires a bicycle from one of the several docking stations in the city and returns it at another or same location. The idea behind the bike sharing is to provide different and new form of public transport, to cover the short and medium length journeys (Hickman, 2010). There are few notable bike sharing schemes like Velo-Antwerp, Villo!: Brussels and Blue-Bike in Belgium which works under the same principals of bike sharing. Blue-Bike among them in fact it is a special kind of public bike sharing scheme, as it has strongly connected itself to the rail transit (Eltis, 2015).

In Belgium, research on the public bike sharing schemes including the pro-rail programs is non-existent. However, some scholarly work has been done on the multiple aspects of traditional cycling. Primarily, couple of studies (de Geus et al., 2014; Vandenbulcke et al., 2011) have tried to explore the determinants impacting the use of bicycles in Belgium. Moreover, the safety issue like risk to a cyclists, getting into an accident in Brussels, potential of E-bikes in realizing the idea of smart cities in the context of Belgium, can also be found in the accessible literature (Ioakimidis et al.,, 2016; Vandenbulcke, Thomas, & Panis, 2014).

Globally, little to no research has been carried out to examine the mode choice behavior of the non-users of the public bike share schemes. It is maintained that, stated choice experiments are a powerful tool for the examination and evaluation of bike share programs, especially when dealing with the non-users of these programs (Fishman et al., 2015). Therefore, a comprehensive study involving both users and non-users of a pro-transit public bike sharing scheme, is both necessary and pivotal. The results will optimistically provide the ways to increase the ridership of the existing bike sharing schemes and the associated public transit mode. Hence, this dissertation will try to answer the following questions:

**Primary Research question**

*"What are the factors; influencing the use of Public Bike sharing scheme for the Last mile travel in Belgium"*.

***Sub questions to the central research question***

a. How public bike sharing schemes exclusively associated with the railway stations differ from the traditional citywide bike sharing systems?
b. What is the level of willingness of Belgian people, to use pro-rail public bike sharing scheme to solve the Last mile problem?
c. How bike share users react to different tariff plans?
d. What is the purpose of using pro-rail bike share scheme by the existing and potential users?

## 1.2. SCOPE OF THE STUDY

The dissertation will cover previous research work on the bike sharing schemes and the factors that push or pull people from these schemes. Later, a pilot survey will be conducted to select the relevant attributes for the stated choice experiment including the selection of levels for these attributes. Further, an online survey, comprising both of a personal and the stated preference questions, will be developed and distributed. This survey will be distributed among the Belgian citizenry comprising both of users and non-users of the pro-rail public transit scheme. to the users of. In consequence, collected data will lead to model estimation and interpretation of their results. Finally, conclusions and recommendations for an improvement in the public sharing scheme will be presented.

## 1.3. SIGNIFICANCE OF THE STUDY

- It will provide a treasure trove of data regarding factors strongly influencing the behavior of individuals towards bike share use.
- A positive addition to the literature aiding policy makers in improving conditions for bicycling at the city or a country levels.
- It will set a foundation for the future in-depth studies on the bike share programs and their overall effectiveness.

## 1.4 ASSUMPTIONS FOR THE STUDY

- A small sample of population is a representative of an entire nation.
- People are aware of the rudimentary details pertaining public bike sharing programs
- Accuracy of an online survey is same as in person, pen and paper interviews/surveys
- Finding strong factors influencing bike share use, is the best way forward to improve/grow these programs

## 1.5 LIMITATIONS OF THE STUDY

- Scarcity of research based scientific information regarding public bike sharing schemes of Belgium.
- In-Person interviews are not possible with selected sample at each bike share station due to time and financial constraints.
- Operators or users of bike sharing programs may not cooperate in data collection.
- Only the most important variables impacting the use of bike share schemes will be part of this study owing to the limited resources

## 1.6 DELIMITATIONS OF THE STUDY

This study will not analyze the Public Bike’s impact on the:

- Ridership of associated public transit mode
- Road traffic congestion
- User’s personal physical health
- Energy and money savings

## 1.7 METHODOLOGICAL FRAMEWORK

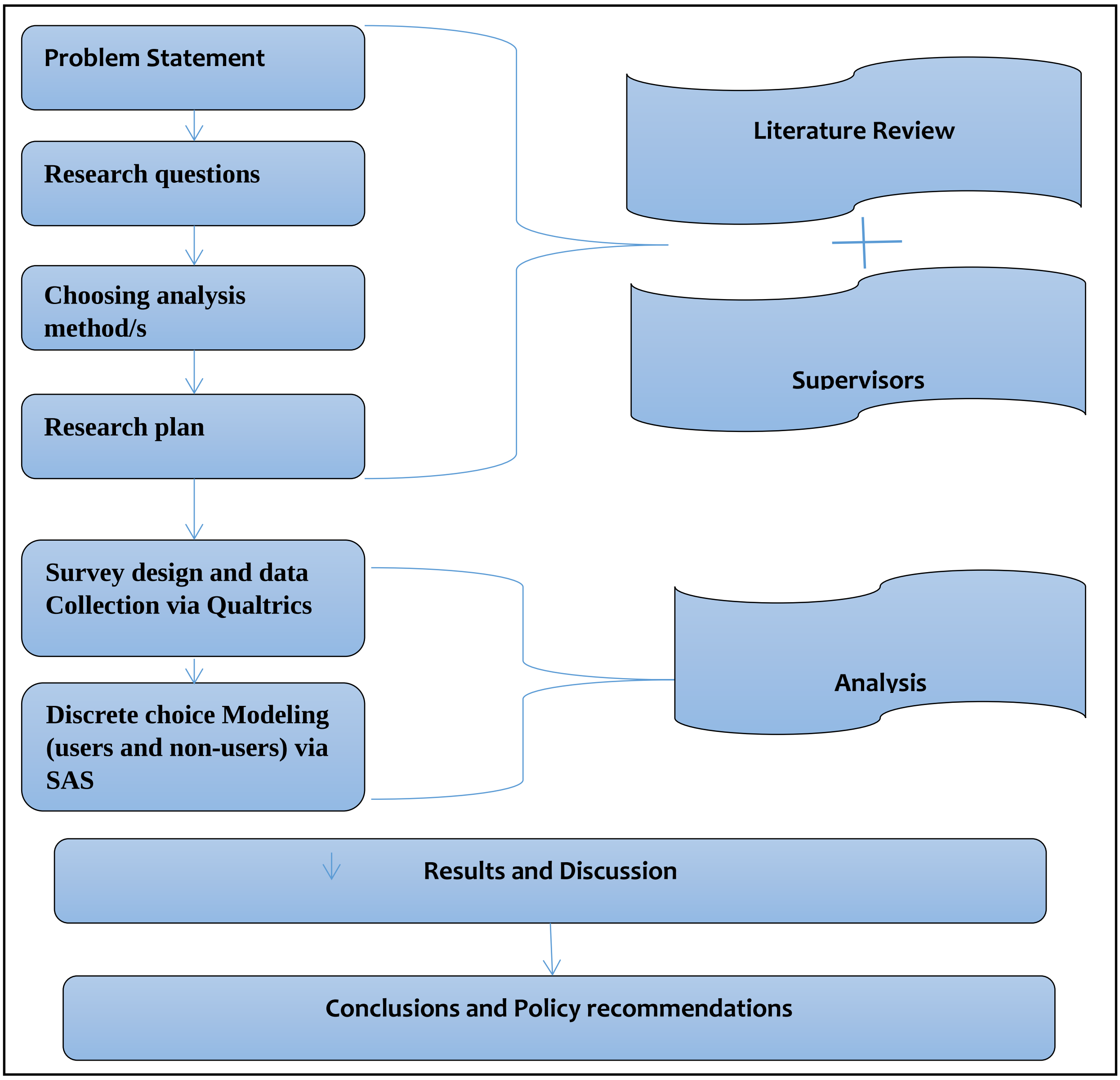



Figure 1: Methodological Framework of the study

# BACKGROUND STUDY

The purpose of this chapter is to lay out the story of bike sharing, starting from its inception to the current reality. In addition to that, the literature review provides the theoretical basis for the forthcoming research work (next chapters) including establishing significance and justification of it. For the sake of overview, the section two of the chapter deals with the concept of active mobility and different interventions adopted in different parts of the world to encourage it. Next section describes, the emergence of public bike sharing schemes and its roots in the active mobility. Further on, the significance of train-bike integration and the critical role of bike share schemes play in this marriage are studied in detail.

## 2.1. RISE IN POPULARITY AND ADOPTION OF ACTIVE MOBILITY

Human powered modes of transport, of all categories, including their infrastructure and environments are known as Active Transportation (Raine et al., 2012 and Transport Canada, 2011). However, (Litman, 2016) explained it more elaborately, stating, active transportation (a.k.a. non-motorized and human powered transport) refers to both functional and recreational travel activity performed through walking, cycling, and variations like wheelchair and handcart. Further, even static uses of pedestrian facilities for example standing on footpath and sitting at bus stop, are also part of active transport.

### 2.1.1. Evolution of Active Mobility

The issue of 'Active Mobility' took the centre stage at local and international levels after the Rio Conference on environment and development in 1992. Therefore, to push this sustianbility paradigm for transport, The Organization for Economic Co-operation and Development (OECD), organized a conference entitled "Towards sustainable Transportation" in 1996. It concluded that the transport systems of OECD and other countries are unsustainable and an effort towards non-motorized transport is imperative (OECD, 1997).

Meanwhile, health experts started to connect physical inactivity with the various health challenges in the 1970's and 1980's. They managed to found a strong link between health and transportation fields at the outset of 21$^{st}$ century. Moreover, they realized that, in order to popularize active transport among public, strong collaboration between health and transport professionals is necessary (Sallis et al., 2004).

There are different kinds of programs and policies, being prepared, launched and implemented; few among these are enlisted below:

a) PASTA (Physical Activity Through Sustainable Transport Approaches): an EU funded program, revealing, how promoting walking and cycling can lead to a healthier, more physically active population (PASTA 2016).

b) New Brunswick's Wellness Strategy (2014-2021): a Canadian province (New Brunswick) is striving hard to develop a "culture of wellness" in their communities. They want to achieve this goal by making changes in land use and urban form, which in turn, will promote active transportation and social cohesion (New Brunswick Department of Healthy and Inclusive Communities, 2014).
c) SWITCH: A major European Union Project, having an objective to reduce GHG-emissions and primary energy consumption by replacing car trips with walking and cycling for short length trips (EU, 2016).

### 2.1.2. Driving Factors for opting Active Mobility

*a) Uncontrolled Use of Motorized Transport*

The handiness and accessibility of motorized transport has minimized the use of active modes and increased the sedentary time spent (González-Gross and Meléndez, 2013). The statistics have shown that a huge number of adults (30%) either do not perform at all or in other case insufficient amount of physical activity (Hallal et al., 2012). Therefore, car-ownership, and a huge network of roads, to absorb the rising use of private vehicles are having an adverse effect on the public health and climate (Wu et al., 2016).

*b) Rampant use of fossil fuels*

Almost all (95%) of the energy demand, of the transport sector is met by petroleum based fuels. Private cars and aviation are the largest consumers of energy to date (Wu et al., 2016 ; Boden et al., 2015). The reduction in the consumption of fossil fuels, if reduced, will positively impact the climate change (Rissel, 2009). Institute for Transportation and development policy (ITDP) in 2015 developed a high use cycling scenario for the cities around the world and found that adopting bicycling even at the moderate scale could reduce energy use and $CO_2$ emissions tremendously (Mason et al., 2015).

### 2.1.3. Benefits of Active Mobility

The exact scale of benefits, to use active modes primarily depends upon the geography and location of the area. However, based on the existing evidence, planners, health officials, and Policy makers, are of the view that promoting cycling and other active modes is a task worth pursuing (Litman, 2016). Few of the most obvious and prominent benefits are discussed below:

*a) Amelioration of Transportation issues*

Walking and cycling have a direct relationship with public transport ridership. The place, where walking and cycling conditions including their usage is good, public transit ridership improves. There are significant potential savings in adopting active transportation like savings from reduced vehicle operations, vehicle ownerships and parking costs (Litman, 2016).

*b) Enhancing Transport Equity*

An active mode extends and boosts the mobility and accessibility of physically, socially and economically underprivileged people. In consequence, the social order, employment and welfare among paupers and their communities increases (Litman, 2013; ABW, 2014).

*c) Improvement in Health Conditions*

Consistent physical activity helps prevent various chronic diseases. Sometimes, it is also effective in halting the growth of existing diseases and related complications (EU, 2016). The major health benefits of Active transport are reported to be reduction in all-cause mortality, diabetes, obesity and hypertension (Saunders et al., 2013).

*d) Betterment of environment and climate*

Active modes have zero emissions, in terms of climate harming GHGs and breathable air pollution. It has also been observed that, emission reduction per mile for the vehicles is relatively large for the short urban trips owing to the high energy consumption during the cold starts and congestion. Therefore, a radical shift towards non-motorized modes is better for the environment and its inhabitants (Frank, et al. 2010).

*e) Positive impacts on Land use*

Policies favoring motorized transport lead cities towards road widening, provision of more parking lots and auxiliary facilities like street lights, utilities lines etc. In contrast, decisions supporting active mobility and public transit tend to stimulate denser and mixed use development (CTE 2008).

### 2.1.4. Bottlenecks and Challenges

*a) Land-Use Patterns*

In many developed countries, landform and built environment favor vehicular travel. Sprawling cities and towns makes it difficult for residents to access workplaces and commercial areas on foot or bike due to the larger distances and travel time (Garling et al, 2013).

*b) Perceptions and attitude*

Majority of the people in developed countries think that active transport modes are inferior vis-à-vis motor vehicles. There is a constant fear among the policy makers regarding the investments on active transport in these nations. Many car users reveal that a trip by cycle will be taxing and uncomfortable because there will be too much traffic on the roads for a bicyclist (Litman, 2016).

*c) Infrastructure*

It is clear from the last point that investments in active transport related real estate will depend upon the perceptions of the populace. The infrastructure like cycle paths and lanes are strongly associated with a higher number of bicycle trips. Thus, provision of active modes related facilities should be a foremost step of city Governments (Manaugh et al., 2016).

*d) Topography and Weather*

Terrain of the area does impact the usage of active modes. Cities with a hilly terrain and slopes have lower cycle participation rates than flatter cities (Taylor, 2009). Furthermore, seasonal and weather changes are deemed as barriers to active transport in many cities across the world (Pooley et al., 2011).

*e) Safety*

There is a wide spread belief that car is a much safer mode to travel than cycles. Many people are concerned about being exposed to the air pollution on the road. Though, the fact is driver and rider inhales the same kind of air on the road.  Nevertheless, safety concerns have been one of the principal concern of those who are not participating in active transport (Cheyne et al., 2015).

## 2.2. PUBLIC BIKE SHARING SCHEMES (PBSS)

Transport agencies, in major cities around world are striving to reduce the environmental impact of transportation emissions especially since the advent of 21st century. They are aiming to make their transportation systems, green or sustainable (Shaheen & Guzman, 2011). There are a number of ways available to achieve this goal such as promotion and employment of carpooling, public transit, eco-driving and active transportation etc. Currently, none of these solutions are more promising and saleable than the shared use of mobility like car sharing or bike sharing. Clearly, bike sharing is cheaper, user-friendly and sustainable than the car sharing. That is the reason, increasing number of people are adopting bike share for their short length trips (Nikitas, 2016). Hence, Public Bike Sharing Schemes (PBSS) are progressively being presented as a climate-smart and health benefiting mode of transport (Shaheen et al., 2011).

Today, the world is facing, severe environmental and physical health problems. The impact of these issues can be diminished through the less use of fossil fuels in vehicles and enhanced use of bicycles. Certainly, for the local governments, PBSS are not only a cost-effective substitute to the traditional public transport but also an indirect way to reduce the $CO_2$ emissions. Moreover, most people are willing to cycle within 1km to 5km range, another success factor for the bike sharing schemes (Quay Communications Inc., 2008). Lastly, bikes need very little space for the movement and parking than the automobiles, which in turn will save precious resources like Land from exploitation (Marie Claude, 2014; Shaheen et al., 2013).

### 2.2.1. What is PBSS?

PBSS are bicycle rental systems that allows potential users to hire bicycles from the designated bicycle stations and return them to any other or the same station for a short period of time *(or within the boundary of the bike share system)*. This property makes a bicycle sharing ideal for short distance urban trips (New York City Department of City Planning, 2009). The idea of bicycle-sharing is simple: use bicycle when needed with convenience, sans any responsibility and costs of owing a bike (Shaheen et al., 2010). This versatile short-term usage aims at fulfilling daily/routine mobility needs. In addition to the usage, system per se is flexible too, as it provides for self-service reservations, pick-up, and drop-off of bicycles (Shaheen et al., 2009).

Modern PBSSs are patently different vis-a-vis rental bicycle systems because they are mostly unattended, fully automated and can be accessed at any time. This allows for the management, monitoring and operation of the state of the system in real-time (Borgnat et al, 2009). Bike sharing dock stations are generally placed in an urban environment in the form a network to enable an on-demand mobility option. It is worth noting that, short journeys (e.g. less than 30 minutes) are usually free for annual subscribers, these journeys can be one-way or a return trip. Users can choose to join a bike sharing program on an annual, monthly, daily, or per trip basis. They can collect cycle from any dock station either by swiping their credit card, a membership card, mobile phones or by plain cash (Shaheen et al, 2013).

*a) Components of PBSS*

A typical bike sharing scheme is consists of various elements, whose design and scale is adjusted according to the local conditions in each city or country. These elements are; uniquely designed bicycles, docking stations, system access and user registration systems, maintenance programs, and bicycle rebalancing methods. Aforementioned components are developed by cities or companies independently, engendering a room for innovation and diversity in PBSS (Midgley, 2011; Transport Canada, 2009).

## 2.2.2. Evolution of PBSS

PBSSs have originated back in the 1960s albeit their growth was slow until better technology was developed, which could manage and operate the system efficiently. In fact, there were only five bicycle systems as of October 2000 (Shaheen et al., 2010; Shaheen and Guzman, 2011). Now, bike sharing is flourishing at an extraordinary rate, mainly owing to the small price tag on the development of these schemes, and convenience in implementing them compared to other transport schemes (Nikitas, 2016).

Bike Sharing schemes have undergone four distinct stages of change, since the launch of a first scheme in 1965. Some researchers have categorized this evolution into a so called ‘generations’ (Parkes et al., 2013). First two generations of bike share schemes have experienced problems like theft, which led to the invention of third-generation, known for its dedicated docking stations and automated payment system (Shaheen et al., 2013). Owing to the aforementioned developments and growing interest of public policy experts in cycling (Pucher & Buehler, 2012), PBSS are growing rapidly all over the world especially in Europe (Shaheen & Guzman, 2011).

*a) Bike Share Generations*

**First generation: ‘Free Bikes’**

These bikes were typically painted with one color; without locks and designated dock stations, placed randomly in the city for free use. In some free bike systems, bikes were kept locked; users had to get keys from a participating local business but by leaving a credit card deposit as security. Though, the actual bike use is free of cost. Almost all of the first-generation systems ceased working owing to the bicycle theft and vandalism, but some are still in operation (Shaheen et al., 2013).

The first PBSS was introduced in Amsterdam that was dubbed as ‘White Bikes’ also known as Free Bikes. Under this program, all the bikes were distributed around the city for the free public’s use. However, within a month, most of the bikes were either stolen or vandalized, the rest were found in nearby canals (EU, 2009)

**Second generation: 'Coin Deposit Systems'**

Coin Deposit schemes have proper docking stations, where bikes can be appropriately parked, borrowed and returned. Generally, a meager amount of not more than US$4 is demanded as a deposit from the users but the actual bike use is free. The coin-deposit systems did not help reduce theft and vandalism, partially because of user anonymity (Shaheen et al., 2013).

The first coin-deposit scheme of this generation was launched in 1995, labeled as Bycyklen *(In English: City Bikes)* in Copenhagen. To prevent vandalism, this system introduced bikes, which had the custom-made parts, so that they cannot be used in other bikes. Users pay a refundable deposit at one of the specified bike docks in the city for the unrestricted use of bike. To cover, all the costs of this system, a private company came forward; that was allowed to put its advertisements on the bikes for the sake of recovery of their investments (EU, 2009).

**Third generation: 'IT-Based Systems'**

IT-based schemes employ state of the art, electronic and internet based apparatus for the hiring, return, and tracking of bicyles. Dock stations are mostly unattended, as smart cards or smart keys allows for self-service. Moreover, the user registration through a credit or debit card has increased the user accountability many folds. These features are responsible for PBSSs recent expansion in both scale and locations (Shaheen et al., 2013).

The launch of Velo'v Bike share in Lyon, France turned out to be a seminal moment in the IT-Based schemes. Velo'v was the first one to introduce several innovations like electronic locks, smart cards, and telecommunication systems that were later copied by Velib Bike share in Paris (EU, 2009).

**Fourth generation: 'Demand Responsive systems'**

A fourth-generation bike sharing is an evolving concept that has yet to be fully deployed. Till now, the features of demand responsive systems are not quite clear but they are being developed upon the technology of IT-based systems. Moreover, schemes of this generation will have plenty of advanced features like multi-modal access, Payment system integration with public transit and car sharing, real-time transit integration and global positioning system (GPS) tracking. Lastly, some scholars have also floated the idea of dock-less bicycles, being touted as a solution for the rebalancing problems (Shaheen et al., 2013; Parkes et al., 2013; Shaheen et al., 2010).

### 2.2.3. Quantifying PBSS

Bike sharing is one of world's fastest growing modes of public transportation, it is expanding at an average rate of 37% per annum since 2009 (Meddin, 2015). However, this enthusiasm started only a decade ago, in the cities across Europe, America, Asia and Australia (Corcoran and Li, 2014). A total of 1090 PBSS have been implemented in 60 countries worldwide with 1, 530, 550 bicycles and Pedelecs until December 2016 (Meddin and DeMaio, 2016).

The biggest chunk of growth in bike sharing is happening in China, but Europe as a continent still leading with 400 schemes, largest majority of which can be found in Italy, Spain and France. 'Velib' in Paris, is the biggest scheme in Europe with 23,600 bikes. Since, its launch in 2007, it saw more than 100 million trips in its first 5 five years (EU, 2015). Earth Policy Institute in 2013 collected data on PBSS from around the world and compiled a list of top ten schemes, which is presented below:

Table 1: Cities with a largest public bike sharing Programs in the world

| *City* | *Country* | *Approximate Number of Bicycles** |
|---|---|---|
| Wuhan | China | 90,000 |
| Hangzhou | China | 69,750 |
| Paris | France | 23,600 |
| Zhuzhou | China | 20,000 |
| Shanghai (Minhang) | China | 19,170 |
| Taiyuan | China | 15,000 |
| Quingzhou | China | 10,000 |
| Taizhou (Jioajiang) | China | 10,000 |
| London | United Kingdom | 8,000 |
| Foshan (Chancheng) | China | 7,600 |
| Xuzhou | China | 7,500 |
| Zhongshan | China | 7,000 |
| Barcelona | Spain | 6,000 |
| Montreal | Canada | 5,120 |
| Foshan (Guicheng) | China | 5,000 |
| Guangzhou | China | 5,000 |
| Shenzheng (Yantian) | China | 5,000 |
| Zhuhai | China | 5,000 |
| Kunshan | China | 4,000 |
| Lyon | France | 4,000 |

*Source: Earth Policy Institute, 2013*

* The number of bicycles and programs changes rapidly and detailed year-to-year information is not always readily available.

### 2.2.4. Characteristics of PBSS

First, the most integral part of the bike sharing scheme is the docking Station, which usually accommodate 5-20 bikes. These stations are usually fully automated, self-service systems, located at major commercial and transportation centers, spaced about 300m apart to one another. The placement of docking stations, alongside transport hubs especially allows users to combine both cycling and transit. Owing to this property of PBSS, it is continuously being regarded as a best mode for the last mile or kilometer of the commute. Second, the cost of renting a bike is either a time-based or a pay-per ride fee and in most of the systems, the first half hour of use is free of charge (VTPI, 2016).

Third, the latest bike sharing systems are employing advanced IT based solutions which will add an extra layer of comfort in the bike hiring process e.g. a potential user can find out about the availability of bikes at the stations online. Furthermore, these smart systems enable bikes to fill the gap between the destinations and the transit stations more efficiently, for instance one can integrate all the modes of the journey better. Thereby, it lays down the structure for the new stronger form of cycling that supplement the existing public transportation system (Midgley, 2009).

Twenty public bike schemes are selected from around the world, for the in-depth analysis of their vital general, supply and demand characteristics. This examination is necessary to get the overview of the all kinds of properties pertaining to the chosen PBSS. Special standards are developed to pick these schemes from the crowd of more than thousand schemes. First rule is, as Blue-Bike is a Belgian scheme, therefore, all the bike sharing schemes of Belgium including Blue-Bike must be the part of this investigation. Blue-Bike is pro-transit scheme, hence, for the fair research; PBSS of its ilk are also made to the list. Moreover, other large European bike sharing schemes and the biggest schemes from each continent were made part of the study.

It is necessary to explain the reasons behind the formulation of above mentioned benchmarks, for the selection of schemes for the analysis. Thus, it is logical to start with the Pro-Transit schemes like ‘Call a Bike’ or ‘OV-Fiets’. These programs made to the list owing to their similarities with the Blue-Bike in terms of their set up, tariff plan and Marketing made to list. There are other giant schemes in Europe like ‘Velib’ and ‘Bicing’, which operate in almost similar environment, can reveal their secrets of success. Finally, outside of Europe, to incorporate the view of other parts of the world, the programs like ‘CitiBike’ in NewYork and ‘Wuhan Bike share’ in China were selected. These two PBSS are the world fastest growing schemes and the largest in their respective continents, a fact, which merits a through scrutiny of them. However, the bottom line is, all the twenty schemes are special in one way or another, the understanding of their characteristics and success factors, will enrich and strengthen this academic endeavor.

The comprehensive review and analysis of the selected schemes is compiled in the form of tables. The Table 2 is about general characteristics of the PBSS. The pivotal information like, number of docking stations in each bike share system can vary significantly; it can be 51 in one and whopping 1800 in another. Similarly, number of bikes in possession of these PBSS can be 23000 or just over 1000 in another scheme. The table 3 deals with the supply side of information, like tariff, which is zero for the first thirty minutes of bicycle use, in most of the schemes. In addition, for how long you can keep the bike once hired, it can 72 hours for pro-transit PBSS and 24 hours for the general PBSS.

The information regarding the demand characteristics is presented in the table 4. It reveals that, all the systems provide comfortable bikes with adjustable seats, luggage carriers and locks for the stress less rides. Moreover, self-service docking stations offer an extra layer of convenience for the bike share users. Lastly, system usage data (i.e. average trip length and average trip duration) is mostly unavailable, in open sources of information, which can truly predict health of any bike share scheme.

Table 2: General Characteristics of the PBSS

| **Sr.No** | ***System Name*** | ***Location*** | ***Terrain*** | ***Launched*** | ***#Bicycles*** | ***#Stations*** | ***Age limit*** |
|---|---|---|---|---|---|---|---|
| **1** | Blue-Bike | Belgium | Flat/Undulating/Hilly | 2011 | 1319 | 51 | 14 |
| **2** | OV-Fiest | Netherlands | Flat | 2001 | 8000 | 278 | DNA |
| **3** | Call a bike | Germany | Flat/Hilly | 2000 | DNA | 65 | DNA |
| **4** | Bike and Go | United Kingdom | Mostly Hilly/Flat | 2013 | DNA | 71 | DNA |
| **5** | Guangzhou Public Bike Share | Guangzhou, China | DNA | 2010 | 6433 | 119 | DNA |
| **6** | Velib | Paris, France | Flat | 2007 | 23600 | 1800 | DNA |
| **7** | Bicing | Barcelona, Spain | Mostly Flat | 2007 | 6000 | 420 | 16 |
| **8** | Velo-V | Lyon, France | Mostly Flat | 2005 | 4000 | 348 | 14 |
| **9** | Santander cycles | London, England | DNA | 2010 | 11500 | 748 | DNA |
| **10** | Villo! | Brussels, Belgium | DNA | 2009 | DNA | 180 | DNA |
| **11** | BikeMi | Milan, Italy | DNA | 2008 | 4650 | 334 | 16 |
| **12** | Velo | Antwerp, Belgium | DNA | 2011 | 1800 | 153 | 16 |
| **13** | Sevici | Seville, Spain | DNA | 2007 | 2500 | 250 | DNA |
| **14** | Valenbisi | Valencia, Spain | DNA | 2010 | 2750 | 275 | DNA |
| **15** | Veturilo | Warsaw, Poland | DNA | 2012 | 3039 | 204 | DNA |
| **16** | Velo-Toulouse | Toulouse, France | DNA | 2007 | DNA | 253 | 14 |
| **17** | Wuhan Public Bike share | Wuhan, China | DNA | DNA | 9000 | DNA | DNA |
| **18** | CitiBike | New York, USA | DNA | 2013 | 8936 | 589 | 16 |
| **19** | EcoBici | Buenos Aires, Argentina | DNA | 2010 | 3000 | 200 | 16 |
| **20** | CityCycle | Brisbane, Australia | DNA | DNA | 2000 | 150 | 17 |

*Source: Official websites of the PBSS*

Note: DNA stands for data not available

Table 3: Supply characteristics of the PBSS

| *System Identification* | | | *Working hours* | | | | *Subscription Type* | | *Tariffs* | | | | | | | *Surcharges* | | | | | | | *Renting options* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Sr.No*** | ***System Name*** | ***Location*** | ***Working days*** | ***Off season*** | ***24/7*** | ***Specific timing*** | ***Annual*** | ***Monthly*** | **First 30 min** | ***Daily*** | ***3-days*** | ***Weekly*** | ***Business*** | ***Special offers*** | **Other** | ***Bicycle Theft (With Key and police report)*** | **Bicycle Theft (Without Key and police report)** | ***Stolen or Lost Keys*** | ***Stolen or Lost Membership Card*** | ***Returning bike at another station*** | **Crossing bike keeping limit** | **Guarantee Deposit** | ***# bikes can be hired*** | ***Max time bike can be kept(h)*** |
| **1** | Blue-Bike | Belgium | DNA | - | Y | - | € 10.00 | - | DNA | € 3.00 | - | - | Business € 8.27.00 | (Membership fee) Student € 3.00 | | € 45.00 | € 350.00 | - | € 5.00 | € 10.00+ € 2.00/Km | € 8.00 /24h | - | 2 | 72 |
| **2** | OV-Fiest | Netherlands | DNA | - | Y | - | € 10.00 | - | DNA | € 3.35 | - | - | - | - | | € 50.00 | € 250.00 | € 20.00 | DNA | € 10.00 | € 5.00/24h | - | DNA | 72 |
| **3** | Call a bike | Germany | | - | Y | - | € 3.00 | € 9.00 | 0 | € 15.00 | - | - | - | Bahn Card € 39.00/yr | | € 75.00 | | | DNA | DNA | DNA | - | 2 | DNA |
| **4** | Bike and Go | United Kingdom | 365 | - | DNA | Varies w.r.t. location | £ 10.00 | - | DNA | £ 3.80 | - | - | Tailor made pricing | - | - | £ 50.00 | £ 400.00 | £ 20.00 | £ 10.00 | £ 15.00 | £ 7.50 | - | 2 | 72 |
| **5** | Guangzhou Public Bike Share | Guangzhou, China | DNA | - | DNA | 7 am to 10 pm | DNA | - | DNA | DNA | - | - | - | - | | DNA | DNA | - | DNA | DNA | DNA | - | DNA | DNA |
| **6** | Velib | Paris, France | 365 | - | Y | - | Velib Classic €29, Velib Passion €39 | - | 0 | € 1.70 | - | € 8.00 | - | Velib Youth € 29.00/yr Velib Solidarity € 19.00/yr | - | € 35.00 | DNA | - | DNA | 0 | € 35.00- €150.00 | € 150.00 | 1 | 24 |
| **7** | Bicing | Barcelona, Spain | DNA | - | DNA | Mon-Thur 05 am to 02 am, Fri 05 am to 03 am, Sat, Sun and Holidays 24 hours | € 47.16 | - | 0 | DNA | - | - | - | - | - | DNA | DNA | - | € 4.54 | DNA | € 150 | - | DNA | 24 |
| **8** | Velo-V | Lyon, France | 365 | - | Y | - | € 25.00 | | 0 | € 1.50 | € 3.00 | € 5.00 | € 49.00 | € 15.00 /yr | - | € 35.00 | DNA | - | € 5.00 | DNA | € 75.00 | - | DNA | 24 |
| **9** | Santander cycles | London, England | DNA | - | Y | - | £ 90.00 | - | 0 | £ 12.00 | - | = | £ 90.00 | - | - | DNA | £ 400.00 | £ 3.00 | DNA | - | DNA | - | - | 24 |
| **10** | Villo! | Brussels, Belgium | DNA | - | Y | - | € 33.60 | - | 0 | € 1.60 | - | € 7.90 | - | MOBIB card: € 32.6/yr | - | DNA | DNA | 10 E | DNA | DNA | € 150.00 | - | DNA | 24 |
| **11** | BikeMi | Milan, Italy | 365 | - | DNA | 7 am to 01 am | € 36.00 | - | 0 | € 4.50 | - | € 9.00 | - | - | - | DNA | € 620 | - | € 5.00 | DNA | € 150.00 | - | DNA | 2 |
| **12** | Velo | Antwerp, Belgium | 365 | - | Y | - | € 37.00 | - | 0 | € 3.80 | - | € 9.00 | - | - | - | $ 150.00 | DNA | - | € 5.00 | DNA | DNA | - | 1 | 4 |
| **13** | Sevici | Seville, Spain | DNA | - | Y | - | € 33.33 | - | 0 | DNA | | € 13.33 | - | - | - | | DNA | - | DNA | DNA | DNA | € 150.00 | DNA | DNA |
| **14** | Valenbisi | Valencia, Spain | 365 | - | Y | - | € 29.21 | - | 0 | DNA | - | € 13.30 | - | Moblis Card: € 29.21 /yr | - | DNA | DNA | - | DNA | DNA | DNA | - | DNA | DNA |
| **15** | Veturilo | Warsaw, Poland | 270 | 1/12 to 28/02 | Y | - | DNA | - | DNA | DNA | - | - | - | = | 0 | PLN 2000 | DNA | - | DNA | DNA | PLN 200 | - | DNA | 12 |
| **16** | Velo-Toulouse | Toulouse, France | DNA | - | Y | - | € 25.00 | € 10.00 | 0 | € 1.20 | - | € 5.00 | € 49.00 | PASTEL Card and Students card: € 20/yr | - | DNA | DNA | - | € 5.00 | DNA | DNA | € 150.00 | DNA | DNA |
| **17** | Wuhan Public Bike share | Wuhan, China | DNA | - | Y | - | DNA | - | DNA | DNA | - | - | - | - | - | DNA | DNA | - | DNA | DNA | DNA | - | DNA | DNA |
| **18** | CitiBike | New York, USA | DNA | - | Y | - | $155 | - | 0 | $12 | $24 | - | $ 140.00 | NYCHR $ 5.00 /Month | - | upto $ 1200 | DNA | $ 10.00 | DNA | DNA | DNA | - | 4 | DNA |

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **19** | EcoBici | Buenos Aires, Argentina | 365 | - | Y | - | DNA | - | DNA | DNA | - | - | - | - | - | DNA | DNA | - | DNA | DNA | DNA | - | DNA | 1 |
| **20** | citycyle | Brisbane, Australia | - | DNA | Y | - | DNA | AUD 5 | 0 | AUD 2 | - | - | - | - | - | DNA | DNA | - | DNA | DNA | AUD 330 | - | DNA | 24 |

Note: DNA stands for data not available and symbol (-) stands for not applicable *Source: Official websites of the PBSS*

Table 4: Supply/Demand Characteristics of the Schemes

| ***System Identification*** | | | ***Traditional Bicycle*** | | | | ***Dock Station*** | | ***Membership*** | | ***System Usage*** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Sr.No*** | ***System Name*** | ***Location*** | ***Locks*** | ***Adjustable Seat*** | ***#Gear*** | ***Luggage carrier*** | **Manned** | **Self-service** | ***Total*** | ***Other*** | ***Distance travelled*** | ***Avg trip length*** | ***Avg Trip duration*** | ***Daily Ridership*** |
| **1** | Blue-Bike | Belgium | 2 | Y | 3 | 1 | - | Y | DNA | - | DNA | DNA | DNA | DNA |
| **2** | OV-Fiest | Netherlands | DNA | Y | DNA | 1 | Y | Y | 1, 77,000 | - | DNA | DNA | DNA | DNA |
| **3** | Call a bike | Germany | DNA | DNA | DNA | DNA | - | - | DNA | - | DNA | DNA | DNA | DNA |
| **4** | Bike and Go | United Kingdom | 2 | Y | 7 | 2 | Y | - | 1000 | - | DNA | DNA | DNA | DNA |
| **5** | Guangzhou Public Bike Share | Guangzhou, China | DNA | DNA | DNA | DNA | - | - | DNA | - | DNA | DNA | DNA | 622,900 |
| **6** | Velib | Paris, France | 1 | Y | 3 | 1 | - | Y | 274000 | - | 382 million miles | DNA | DNA | 108090 |
| **7** | Bicing | Barcelona, Spain | DNA | Y | 3 | 1 | - | Y | 99772 | - | 1327460 miles/month | DNA | DNA | 44248 |
| **8** | Velo-V | Lyon, France | 1 | Y | 3 | 1 | - | Y | 52000 | - | DNA | 2.49/km | 14.7 min | 22000 |
| **9** | Santander cycles | London, England | DNA | DNA | DNA | DNA | - | Y | DNA | - | DNA | DNA | DNA | DNA |
| **10** | Villo! | Brussels, Belgium | 1 | Y | 7 | 1 | - | Y | DNA | - | DNA | DNA | DNA | DNA |
| **11** | BikeMi | Milan, Italy | DNA | Y | 3 | 1 | - | Y | DNA | - | DNA | DNA | DNA | 15890 |
| **12** | Velo | Antwerp, Belgium | DNA | Y | 3 | 1 | - | Y | DNA | - | DNA | DNA | DNA | DNA |
| **13** | Sevici | Seville, Spain | 1 | Y | DNA | 1 | - | Y | DNA | - | DNA | DNA | DNA | DNA |
| **14** | Valenbisi | Valencia, Spain | 1 | Y | DNA | 1 | - | Y | DNA | - | DNA | DNA | DNA | DNA |
| **15** | Veturilo | Warsaw, Poland | DNA | DNA | DNA | DNA | - | Y | DNA | - | DNA | DNA | DNA | DNA |
| **16** | Velo-Toulouse | Toulouse, France | DNA | Y | 3 | 1 | - | Y | DNA | - | DNA | DNA | DNA | DNA |
| **17** | Wuhan Public Bike share | Wuhan, China | 1 | Y | DNA | 1 | - | Y | DNA | - | DNA | DNA | DNA | DNA |
| **18** | CitiBike | New York, USA | DNA | Y | 3 | 1 | - | Y | 1, 18568 | 20,307* | 3715405 miles | 2.25 miles | 14.73 min | 54951/day |
| **19** | EcoBici | Buenos Aires, Argentina | DNA | DNA | DNA | DNA | - | Y | DNA | - | DNA | DNA | DNA | DNA |
| **20** | citycyle | Brisbane, Australia | 1 | Y | 3 | 1 | - | Y | 2767 | - | DNA | DNA | DNA | 822 |

*Source: Official websites of the PBSS*

Note: DNA stands for data not available, symbol (-) stands for not applicable and symbol (*) means only for the month on September 2016

### 2.2.5. Impacts of PBBS

It is maintained by (Shaheen et al., 2013) that bike share reduces travel time, improves public transport connectivity, enhance public health and lower air pollution. In addition, bike share helps in shedding lukewarm attitude of public towards cycling (Goodman et al., 2014). Probable effects of biking have been discussed in section 2.3 albeit within the ambit of active transport. Now, the major impacts specific to the bike sharing are discussed tersely below:

a) *Public Transport*

Bike share cuts the travel time for the short trips and in consequence, the catchment area of the public transit facilities expands. That's the reason, bike share has a tremendous potential, to not only make an existing transportation network more connected and efficient, but also persuade individuals to use different modes of transport with relative ease (Shaheen et al., 2010).

b) *Emissions and Car Use Reduction*

The results of survey conducted by the some PBSS of North America reveal reduction in $CO_2$ and car use reduction. The impact on the car ownership is negligible and mostly public transit and walking trips are shifted to bicycles rather than cars (Shaheen et al., 2013).

c) *Economic Benefits*

Most of the PBSS nowadays, provides economic benefits to the members, who complete their trips within 30 minutes, in addition to variety of saving packages for businesses, students and senior citizens. Bicycling is a low-cost mode of transport with a very small need for infrastructure vis-à-vis other modes. Thereby, relatively meager investments are required to create or expand cycling infrastructure. It is also, predicted that, shopping patterns of bike share users shift towards regions that are in proximity to bike sharing stations. This phenomenon will benefit the local shops of downtown and neighborhood regions of the city (Shaheen et al., 2010; EU, 2009). Actual economic benefits of cycling for all the countries of European Union are presented below:

Table 5: Internal and External economic benefits of cycling in EU countries with an average 7.4% mode share in 2010

| ***Sr.No*** | ***Type of benefit*** | ***Amount ( € )*** |
|---|---|---|
| **1** | Health benefits: reduced mortality | 114 – 121 bn |
| **2** | Congestion-easing | 24.2 bn |
| **3** | Fuel savings at US$ 100/ barrel | 2.7 – 5.8 bn |
| **4** | Reduced CO2 emission | 1.4 – 3.0 bn |
| **5** | Reduced air pollution | 0.9 bn |
| **6** | Reduced noise pollution | 0.3 bn |
| | **Total** | **143.2 – 155.2 bn** |

*Source: (ECF, 2015)*

Table 6: Annual economic impact of cycling on European countries businesses

| ***Sr.No*** | ***Type of industry*** | ***Amount ( € )*** |
|---|---|---|
| **1** | Tourism industry | 44 bn |
| **2** | Bicycle industry | 18 bn |
| | **Total** | **62 bn** |

*Source: (ECF, 2015)*

*d) Solidifying Bicycling culture*

Bike sharing schemes send strong visual statement to the city dwellers that cycles do belong on the streets and alleyways of their localities just by increasing bicycle mode share. (Nikitas et al., 2015) confirms this assertion by stating that commuters who use road transport, see PBSS as a powerful 'cycling promotion campaign'. Moreover, it will portray cycling as a safe and normal mode of transport in places, where it's not common yet (Nikitas, 2016). It has also been observed that, upon an implementation of a scheme, cities normally witness an increase in bicycle use including an uptick in private ownership of bicycles (Castillo-Manzano, et al., 2015).

## 2.2.6. Challenges and Opportunities

Although, the bike sharing schemes have been exploding throughout the world but recent years have witnessed a series of challenges confronting these systems. It is befuddling that 82 bike sharing systems have been closed since 2000, strangely 42 in Spain alone. In fact, the global bike-sharing industry is at the edge of either an enormous potential for growth or a conundrum. Hence, a closer look at challenges and opportunities for the global bike sharing schemes is necessary. Notwithstanding, no two systems face the same challenges owing several differences i.e. geography, business model, local culture etc. (Peter Midgley, 2013).
The most common challenges found in the literature are enlisted below:

- Insufficient number of bicycles to meet demand
- Absence of good communications and marketing plan
- Cycling infrastructure either not available or inadequate
- Lack of political will at all levels of government
- Poor placement and density of dock stations
- In convenient operating hours,
- Tough regulations on helmet use.
- Theft and vandalism of bicycles.
- Unfriendly topography and climate
- Inexperienced Cyclists
- Cumbersome registration or sign-up process
- Rebalancing: a process of moving bicycles across the bike share network, in order to maintain a reasonable number of bicycles at all the docking stations (Peter Midgley, 2013; Nikitas, 2016; Fishman, 2014; UN, 2011; Shaheen et al., 2010).

The good news, not everything is gloomy for Public bike-sharing Schemes. There are number of programs in both developed and developing countries, demonstrating innovation and best practices. Thus, there is a wealth of knowledge out there, which can assist struggling systems to effectively manage their operations (Peter Midgley, 2013). The following communication and technological advancements are said to be the solution, to the challenges, PBSS are facing today. Their brief explanation is presented below:

***Global Positioning System (GPS)*** has the ability to minimize the need for physical dock stations. It may also assist operators in enforcing rules and security measures by providing a 'geo-fence', which will alert administration whenever a user crosses a boundary of a program or in tracking stolen bikes (Parkes et al., 2013). Furthermore, real time bike tracking will generate information that can stimulate new wave of bicycle research and bring optimization in the system (Beecham &Wood, 2014).

***Electric-Bikes*** increase an attractiveness of bike share systems because it is an option for those, who have not previously considered cycling a suitable option or were not able to cycle owing many different reasons (i.e. old age). With e-bikes, it is would be possible to do longer trips, ride on a difficult terrain and in a warm weather (Heinen et al., 2010).

***Mapping and visualizations techniques*** in combination with GPS data can provide real time bike availability and system information to users anywhere in the world. Additionally, advance visualization methods, can also aid in putting PBSS in media spotlight incessantly and cost effectively. In turn new users will attract to the scheme and a bike-sharing culture in cities will start to flourish (Peter Midgley, 2013).

## 2.3. PRO-MASS TRANSIT PBSS

The principal element of any sustainable transportation system is, a Public Transit (PT). Yet, the first and last mile access to and from PT stations remains either a nuisance or a struggle for the commuters. They often need to switch their mode or a route to reach their final destinations. This phenomenon not only causes a barrier in the growth and popularity of PT but also wastage of rider's precious time. This constraint is especially harmful for those, who do not have other modes such as private vehicles available to them. Hence, on the whole, lack of smooth mobility is hindering or minimizing their access to jobs and services (Cervero et al., 2013; Cervero & Gorham, 1995; Richter et al., 2011).

Research has shown that if cycling is used for the first and last mile of the trip, it will not only provide the benefits of walking but also help enlarge the catchment area of PT from 2km to 5km (Krizek & Stonebraker, 2010). That is why; PBSS are emerging as a new mode of transport, not wholly for the short commuter or non-commuter trips but for establishing a connection with the PT stations as well. Therefore, bike sharing schemes in tandem with public transit, have a potential to fill this gap between transit stations and user's destinations. In consequence, people may benefit in terms of time saving, increase in level of comfort, and slashing in energy expenditure (Ma, Liu, & Erdoğan, 2015; Martin & Shaheen, 2014).

The evolving 'Demand Responsive' bike sharing systems are equipped with components, critical in making a better connection with the public transit. This means, placement of docking stations at or near PT stations, coordination with the transportation schedules and an integrated payment system etc. The aforementioned aspects of the demand responsive system will improve first and last mile access to the stations substantially. Ergo, cities and community groups are promoting PBSS as part of their intermodal transportation plans (EU, 2009). Moreover, some national railway companies like Nederlandse Spoorwegen (Dutch Railway) and Deutsche Bahn (German Railway) have also started operating their own PBSS (VTPI, 2016; Shaheen et al, 2011).

### 2.4.1. Bicycle sharing: Substitute or Complement to Transit?

a) *Substitute to PT*

The relationship between bike share and PT is not straightforward and sometimes outright convoluted. There are plenty of factors like trip distance, weather conditions and individual preferences which influence the nature of interaction between PT and PBSS. To elaborate, for the commuter trips, a bicyclist is limited by travel distance, usually up to 5km. Hence, if the distance is longer than that bike share won't be able to substitute for PT. In contrast, bicycle sharing can be a substitute for PT, if travel distance, weather conditions including other factors are feasible for cycling (Daddio, 2012 and Witte & Dorby, 2009).

b) *Complementary to PT*

Studies on the bicycle route choice conclude that people tend to prefer cycling over walking, patently (Schoner & Levinson, 2013). It is owing to the same preference that, bike sharing dock stations which fall within the 400-meter walking radius to PT stations attracts more commuters in comparison to the dock stations lying further away. In addition, a research conducted in Finland reveals that integrating bicycle sharing and public transportation could save approximately six minutes per trip. These results support the complementary nature of bike sharing, means a PBSS can make existing PT system efficient and more attractive for potential riders (Daddio, 2012; Jäppinen et al., 2013).

It is important to distinguish that only a handful scholars have suggested the role of bike share outside realm of integrated travel and multimodality. Almost all of them accept that, bike share and PT do align themselves against each other sometimes but they are invariably in competition with the private cars (Bachand-Marleau et al., 2011; Hegger, 2007). A statistical analysis from the PBSS (BIXI) in Canada has shown both, the substitute and complementary nature of bike sharing, as about third of respondents have replaced their transit trip with a bike sharing. On the other hand, more than 40% respondents have integrated PT with their bike share trip (Bachand-Marleau, 2011 and DeMaio, 2009).

### 2.3.2. Types of Integration

There are mainly three distinct bike share and PT integration opportunities, enlisted below:

a) *Bike-and-ride:* In this scenario, public transit user employs a bicycle to reach the PT station. The cyclist parks the bicycle at the designated parking facility provided by the transit station and resumes the journey on the PT.
b) *Bike-ride with bike-bike:* In this type of integration, PT rider uses his/her own bicycle for the first and last mile. The unique element in this case is that, the rider carries the bicycle onboard the transit vehicle.
c) *Ride-and-bike:* In this setting, a PT user, after completing the journey on the transit uses the bike share system for the last mile (Pucher & Buehler, 2009; Krizek & Stonebraker 2010 and Bachand-Marleau et al., 2011).

According to (Martens, 2004), the passengers of Dutch Railways mostly have their own bicycles. They use them more often at the home-end, for PT access/egress, thereby, fall in the 'Bike-and-ride' category. Furthermore, bike onboard is very popular in the United States, as bicycle racks on the buses have increased from 32% in 2001 to 74% in 2011 (APTA, 2013). Similarly, Dutch Railways allows bicycles onboard of designated cars of the trains, that lands both the cases in the 'Bike-ride with bike-bike' category (Villwock-Witte & van Grol, 2015). Lastly, the 'Ride-and-bike' has found its traction in Europe, for example BiTiBi (Bike-Train-Bike) is the new European Union project promoting the bicycle for the both first and last mile of train travel (BiTiBi, 2016).

### 2.3.3. Benefits of Integrating Bike Sharing and Public Transport

Numerous benefits of integrating PT and bike share have been presented in literature; some of the most significant are listed below:

- Expansion in the potential destinations for the bicycles riders
- Addition of comfort and flexibility in the PT use
- A robust and eco-friendly alternative to the motorized vehicles
- Enhanced mobility for the recreational and shopping trips
- Provides a better way to stay healthy (i.e. It reduces or eliminates the need for an additional exercise)
- Reduction in the demand for car park facilities at the transit stations
- Decrease in the congestion level around transit stations especially during peak times (Queensland Transport, 2006).

## 2.3.4. Case Studies

Further ahead, two examples of pro-Transit PBSS will be presented, in order to have a deeper but brief look into the workings of these special kinds of programs.

*a) Openbaar Vervoer-Fiets (OV-FIETS)*

The innovation team at the Dutch national railways known as Nederlandse Spoorwegen (NS) knew that 30% of their passengers use their own bicycles to reach the stations. Ergo, it was a logical conclusion on part of NS, to assume that the same number of passengers would be willing to use bicycles for their trip end journey. Hence, the team started to lay the ground work for a bicycle service owned and operated by the NS itself. In consequence, a bike sharing scheme was launched in 2001, named OV-Fiests short for Openbaar Vervoer-Fiets. The aim of this PBSS would be to provide access to the bicycles located at the station to reach the final destination. NS also believed that this facility would make trips more comfortable and attractive, in addition to increasing their ridership and catchment area (Villwock-Witte & van Grol, 2015).

PT users perceive the access and egress part of their journeys as time consuming and cumbersome vis-à-vis a transit. OV-fiets gave NS an opportunity to solve this problem by thinking more holistically, as it went from an organization merely providing a train service to a system that helps passengers move from their origins to the destinations. The results of various surveys are a testament to the success and popularity of this PBSS. One of the statistics shows that, satisfaction rate of OV-Fiests among 70% of its respondents; on a 10-point scale is 7 (or 8), highest in contrast with other aspects of the Dutch railways. Moreover, 10% of respondents switched their trip to a train–OV Fiets combination from a private vehicle and an increase in bike share–transit users from 30% to 50% (Villwock-Witte & van Grol, 2015).

*b) Guangzhou Bike sharing*

Number of Chinese cities had looked for ways to introduce PBSS as a new non-motorized mode. The idea came to fruition, when in 2010; Guangzhou city launched a bike sharing in combination with its BRT (Bus Rapid Transit) system. The Guagnzhou bike share consists of 6,433 bikes, placed at 119 docking stations around and close to the BRT system. In September 2010, BRT system opened the greenway as well, which was previously a garbage filled canal into a beautiful bike and walking path (Fjellstrom, 2010; “Sustainable Transport Award cities,” 2011). The system carries whopping 800,000 passengers a day, a proof a huge success of integrating transit-bike share. The results of the research by Transportation Development and Policy (ITDP) shows that in Guangzhou city, approximately two thirds of the PBSS trips have replaced motorized trips, in addition to saving the planet from 636 metric tons of $CO_2$ per year (van Ooijen and Li, 2013).

## 2.4. BLUE BIKE: A SOLE PRO-RAIL PBSS IN BELGIUM

Belgium is a small, highly urbanized country (i.e. population density is 30,528 $km^2$) in the Western Europe. It has been divided into three regions namely the 'Flemish region' in the north, 'Walloon region' in the south and 'Brussels-Capital region' in the central part of a country. All the regions are independent in exercising their powers within the domain of transport (except regarding the National Railways, the North Sea and the traffic code). That is why; most important transport agencies and authorities are working at the regional levels ("belgium.be, 2017"  and Witlox et al, 2013).

The travel patterns and behaviors are considerably different with regards to cycling in the Flemish region at the one hand and Walloon & Brussels regions on the other hand. To elaborate, 91% of all the commuter cyclists in Belgium live in Flemish area, whereas the rest (9%) live in Wallonia and Brussels regions (Vandenbulcke et al., 2011). It is owing to the fact that, pro-cycling actions such as traffic calming measures, provision of bicycle infrastructure and bicycle friendly road and city planning, are mostly applied in the Flemish region (Vandenbulcke et al., 2009). Lastly, nearly 21% of commuters live within the maximum cycling range (5km), but only 6% of them use bicycles as a primary mode of transport. This situation presents a tremendous opportunity to introduce cycling as new mode of public transport through PBSS (Verhetsel et al., 2007).

### 2.4.1. Blue-Bike Sharing Scheme

Train and bike is a successful combination, which can reduce motorized transport and increase number of bicycle trips especially for the last mile. In Belgium, some progress has been made to ensure the integration of rail and bike. There are two programs which are worth mentioning in this regard, first, the provision 77,000 parking spots for the bicycles at the train stations until 2015 and permission to carry folding bikes on the commuter trains. The second program is a nationwide public bike sharing scheme, launched in 2011 called Blue-Bike ("Eltis, 2015"). It is a facsimile of the successful 'OV-Fiets' bike sharing scheme in The Netherlands, explained well in the section 4.4.1. Therefore, in order to draw better results from this research, it is compulsory to study in detail the existing pro-transit public bike sharing scheme (Blue-Bike). This endeavor will be helpful in composing a well thought out survey for the public which will lead to impactful results ultimately.

## 2.4.2. Registration/Membership

In order to use Blue Bike, one needs to become a member first. To do that, a potential user can either browse for the scheme's official website or visit the nearest 'Fietspunt' during their hours of operation at 20 locations across Belgium. The process of registration for the membership through an online form is quite straightforward. The intended user will be asked about his/her basic personal details, type of membership and payment information ("Blue-bike, 2016"). The user friendly interface of the online registration form is presented below:

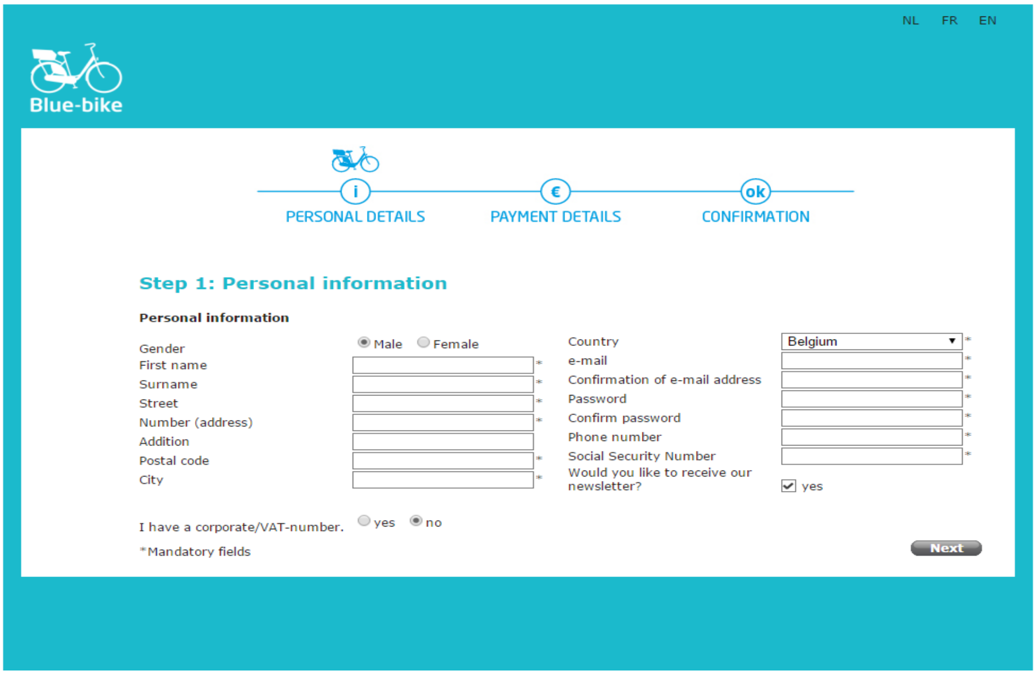



Figure 2: The screenshot of a registration page of Blue Bike

*Source: http://www.blue-bike.be/*

There are three kinds of memberships on the menu for the users and the qualification is mainly depended upon the level of education and type of profession ("Blue-bike, 2016"). The details of these types are succinctly explained below:

*a) General*

A potential user must pay 10€ once every year under this type of a membership. Later, he/she would be able to hire a bike with help of a membership card via an automatic machine placed at the dock stations. The bill will be sent once every month which is payable through Credit or Debit cards. In addition, member can view their completed journeys, bills, online through their online Blue Bike account ("Blue-bike, 2016").

*b) Student*

The membership fee for the students is 3€ for the first year and 10€ for the subsequent years. Moreover, they will get first two rides completely free, thanks to the financial assistance of Belgian National Lottery. Lastly, the benefits and services offered to the 'General membership' holders will also be part of a student package ("Blue-bike, 2016").

*c) Business*

This type of membership has more for the users than the previous two combined. To qualify for this type of membership, a business owner needs to present his VAT (Value Added Tax) identification number along with other requisites. The membership fee is 8.27€ per card every year and 2.48€ per journey rather than 3€. A member unlike other types can order multiple cards and use these as pool cards. It is also pertinent to mention here that, Blue-Bike is 100% tax deductible ("Blue-bike, 2016").

### 2.4.3. Guidelines to use Blue-Bike

Renting a bicycle is very simple but it is still important to shed some light on the process of, how to hire, return and pay for the rental. The details are briefly discussed below:

*a) Hiring*

To hire a bike, a member has to go to the nearest train station and follow the sign 'Fietspunt or 'Point-Velo'. Then, at the docking station, a user will place a membership card on an "Automatic Key distributor (AKD)". The machine will give the user a key or two keys as per the command. A number on the key would help identify and release the cycle from its parking spot ("Blue-bike, 2016").

*b) Returning*

A bike has to be returned to same station from where it was hired. The user will put the bike at the designated parking place and put the keys back in the AKD via his membership card ("Blue-bike, 2016").

*c) Payment*

There are three different kinds of rates namely 0€, 1€ and 3€ for the first 24 hours of bicycle hire. To explain, the cities which provide financial assistance to the Blue Bike have either low or no charge, for the first day of bike use ("Blue-bike, 2016"). The table delineating the rates at fifty locations all across the country is presented below:

Table 7: Tariff plan of Blue Bike for the fifty locations in the Belgium

| Sr. No | Cycle Point | Price (EUR) |
|---|---|---|
| 1 | Aalst | 3 |
| 2 | Aarschot | 3 |
| 3 | Antwerp Central Station | 3 |
| 4 | Antwerp-Berchem | 3 |
| 5 | Asse | 1 |
| 6 | Bruges | 1 |
| 7 | Brussels South | 3 |
| 8 | Brussels-Central | 3 |
| 9 | Brussels-Luxembourg | 3 |
| 10 | Brussels-North | 3 |
| 11 | Deinze | 0 |
| 12 | Deinze town hall | 0 |
| 13 | Dendermonde | 1 |
| 14 | Eeklo | 0 |

| | | |
|---|---|---|
| 15 | Geel | 1 |
| 16 | Genk | 1 |
| 17 | Gent-Dampoort, | 3 |
| 18 | Gent-Sint-Pieters | 3 |
| 19 | Geraardsbergen | 1 |
| 20 | Halle | 1 |
| 21 | Hasselt | 0 |
| 22 | Heist-op-den-Berg | 1 |
| 23 | Herentals | 1 |
| 24 | leper | 1 |
| 25 | Kortrijk | 1 |
| 26 | Leuven | 1 |
| 27 | Liège | 3 |
| 28 | Lier | 1 |
| 29 | Lier parking 'De Mol' | 1 |
| 30 | Lier Veemarkt | 1 |
| 31 | Lokeren | 1 |
| 32 | Mechelen | 1 |
| 33 | Mechelen-Nekkerspoel | 1 |
| 34 | Mol | 1 |
| 35 | Mons | 3 |
| 36 | Mortsel-Oude-God | 1 |
| 37 | Namur | 3 |
| 38 | Ninove | 0 |
| 39 | Oostende | 1 |
| 40 | Oudenaarde | 1 |
| 41 | Roeselare | 1 |
| 42 | Sint-Niklaas | 1 |
| 43 | Sint-Truiden | 3 |
| 44 | Tongeren | 1 |
| 45 | Torhout | 1 |
| 46 | Turnhout | 1 |
| 47 | Vilvoorde | 1 |
| 48 | Waregem | 1 |
| 49 | Aalter | 1 |
| 50 | Boechout P+R Capenberg | 1 |

*Source: http://www.blue-bike.be/*

### 2.4.5. Performance Evaluation of Blue Bike Scheme

Many studies have been conducted both by the Blue Bike and external organizations to find out about the overall health and functioning of the system. In this study, the results of the most recent surveys and raw unpublished data collected from the Blue Bike itself will be analyzed. The factors like awareness level of the users, usage of individual stations and many more will be studied in detail.

a) *Usage of Bike sharing scheme*

The use of Blue Bike has been increasing since the day it was launched. The statistics displayed below are the testament of scheme's growing popularity and usage over the years.

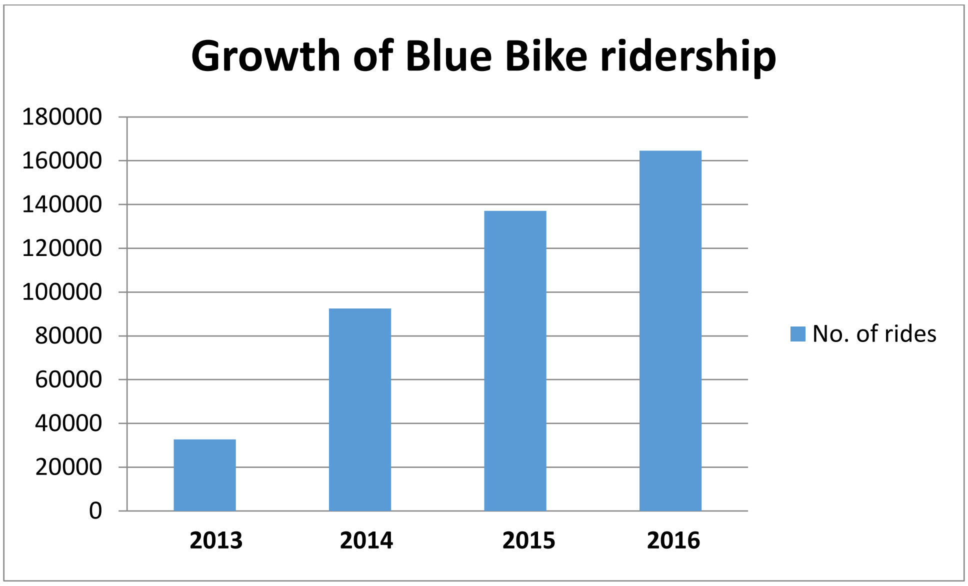



Figure 3: The growth of ridership level from 2013-2016 for the Blue Bike Scheme

*Source: (Blue Mobility, 2016a)*

a) *Awareness level*

The pen and paper survey was conducted at the three train stations Ghent Saint Peters, Ghent Dampoort and Liege Guillemans in 2016. The people were asked about various the train-bike integration services and facilities including Blue-Bike service. The main findings of these surveys are presented below:

| ***Factor*** | ***Ghent St.Peters*** | ***Liege Guillemans*** |
|---|---|---|
| 1. Awareness regarding bike parking, Fietspunt and other train-bike integration facilities available at the stations. | • 46% of respondents know about the train-bike facilities and interest in them has risen from 27% in 2014 to 30% in 2016.<br>• 51% heard about the train-bike combination at the train station and 20% have heard from friends. | • 52% of respondents know about the train-bike facilities and interest in them has risen from 15% in 2014 to 24% in 2016.<br>• 39% heard about the train-bike combination at the train station and 29% have heard from local media. |

| | | | |
|---|---|---|---|
| 2. | Awareness and knowledge about Blue Bike | • 44% of respondents have knowledge about Blue Bike.<br>• 56% heard about the Blue Bike at the train station and 20% have heard from friends. | • 24% of respondents have knowledge about Blue Bike<br>• 38% heard about the Blue Bike at the train station and 23% have heard from friends. |
| 3. | Usage of train-bike facilities and Blue Bike | • It is learned that 36% of respondents are using bike-train combination and 5% of respondents using Blue Bike specifically. It is also pertinent to state that 30% of train-bike users, use the facilities one a week and 67% of Blue Bike users use it once a week. | |

*Source: (Blue Mobility, 2016b)*

*b) Online survey*

The most valuable findings of this survey were that a huge chunk of Blue Bike users (29%) have a door to door trip distance of 40-80 kilometres. The scheme has been successful in avoiding 35% of tram and bus trips and 7% of car trips to the train station. Moreover, 20% of Blue Bike users are now combining their trip with train at least one a week. Finally, most of the trips (35%) are 15-30 minutes long (*Blue Mobility, 2016c).*

*c) Findings of Ipsos Survey*

Ipsos, a global market research and consulting firm conducted a survey in 2015, to find out about the socio-economic characteristics of Blue Bike users, their motivation to use the system and satisfaction level. The survey results revealed that mostly highly educated young people and workers use this bike share. They cited flexibility of the system including its swiftness to complete the last mile and health as main reasons for using the Blue Bike. Moreover, the system mostly received the positive feedback from the users regarding its performance. However, there is a small degree of dissatisfaction with regard to the small number of bikes at the docking stations and in adequate geographical spread of Blue Bike stations (Ipsos, 2015).

## 2.5. FACTORS IMPACTING THE USE OF PBSS

Many of the future plans and improvement projects designed by the management are based on the surveys conducted on the Blue Bike till date (see section 2.5.5). However, scientific studies must also be conducted on the factors influencing the use of bike sharing schemes. The results of these studies would help in drawing robust, rational and user oriented growth plans. Hence, a thorough analysis of the factors that influence the use of bike sharing schemes is necessary to devise future plans and projects for the Blue Bike. Moreover, previous research has identified several factors which affect the bicycle and bike share use. These studies with their title, methodologies employed and main findings are presented below:

Table 8: Existing research work on the factors influencing use of bike sharing schemes

| Sr.No | Title and Author of the study | Methodologies employed | Main Findings |
|---|---|---|---|
| 1 | Factors influencing the choice of shared bicycles and shared electric bikes in Beijing (Campbell et al, 2016). | *Data Type*: Stated preference *Modeling Type:* Multinomial logit model | Trip distance, air quality, weather and precipitation negatively affect bike sharing demand while User demographics do not have any impact on the mode choice. |
| 2 | Factors influencing bike share membership: An analysis of Melbourne and Brisbane(Fishman et al, 2015) | *Data Type*: Revealed Preference *Modeling Type:* Logistic regression model | People aged between 18-34, high income and work in the proximity (250m) to the bike share stations are most likely to become bike share members. |
| 3 | Effects of built environment and weather on bike sharing demand: a station level analysis of commercial bike sharing in Toronto (El-Assi et al., 2015) | *Data Type*: Revealed Preference *Modeling Type:* Distributed lag model and multilevel/ linear mixed effects model | Warmer weather, bicycle infrastructure and fewer crossings with main road positively affect bike share use. While, trip distance has inverse relationship with bike share usage. |
| 4 | Factors that Affect Bicycle Ridership: A Case Study of the B-Cycle Bike Share System in Austin, Texas (Casey-Marie Claude, 2014) | *Data Type*: Revealed Preference and GIS data *Modeling Type*: Ordinary least squares regression model | Proximity of a cycling station from a destination, in addition to en route bicycle facilities impacts the bike share system ridership. |
| 5 | Factors Influencing Travel Behaviors in Bike sharing(Kim et al, 2012) | *Data Type*: Revealed Preference Multiple *Modeling Type:* Multiple regression model | Bike share stations near commercial areas and parks attract more users than schools and subway stations. Rainfall also has a negative effect on the cycle use. |
| 6 | How land-use and urban form impact bicycle flows: evidence from the bicycle-sharing system (BIXI) in Montreal (Imani et al., 2014) | *Data Type*: Revealed preference data *Modeling Type:* Linear mixed models | Commercial areas and universities positively affect the bike share usage. Additionally, geographical spread of bike stations is more important than increasing the capacity of each station to increase the bike share use. |
| 7 | Factors influencing the propensity to cycle to work (Wardman et al., 2007) | *Data Type*: Stated Preference and Revealed Preference. *Modeling Type*: Hierarchical logit model | A combination of measures comprising, a segregated cycling path, trip end facilities and financial incentives is the most effective policy to encourage cycling to work. |
| 8 | Estimation of the Determinants of Bicycle Mode Share for the Journey to Work using Census Data (Parkin et al, 2008) | *Data Type*: Census data *Modeling Type*: logistic regression model | In flat areas, presence of bicycle infrastructure stimulates cycle use. However, in hilly to undulating areas, car ownership offsets affect the bicycle infrastructure. |

| | | | |
|---|---|---|---|
| 9 | How does our natural and built environment affect the use of bicycle sharing?(Mateo-Babiano et al, 2016) | *Data Type*: Revealed Preference. *Modeling Type*: source-sink theoretical model, correlation and regressions analysis | High dense neighborhoods and segregated bicycle pathways have positive affect on the system usage. |
| 10 | Facilitators and Barriers to public bike share adoption and success in a city with compulsory helmet legislation: A mixed-method approach (Zanotto, 2014) | *Data Type*: Telephone survey and Observational survey *Modeling Type*: Analysis of variance (ANOVA) | Bicycle infrastructure and weather mainly decide the frequency of bike sharing system use. |
| 11 | Determinants of bicycle commuting in the Washington, DC region: The role of bicycle parking, cyclist showers, and free car parking at work(Buehler, 2012) | *Data Type*: Regional Household Travel Survey *Modeling Type:* logistic regression model | Trip end facilities like showers and parking spots encourage while provision of free car decrease the chances of bicycle commuting up to 70%. |

*Source: (Authors own creation)*

Historically, revealed and stated preference surveys are used to collect choice data. Revealed preference data is usually of high quality and face validity but it is also very expensive and tedious to collect. In addition, there are several statistical limitations of revealed preference data. On the other hand, stated choice experiment enables, a researcher to select and isolate elements of interest and understand how different attributes are balanced against each other (Louviere et al., 2000; ChoiceMetrics, 2014). Stated choice experiments have also being used in the bike share mode choice studies as shown in Table 9. Therefore, keeping in view the requirements of this dissertation (i.e. the mode choice behavior of non-users of Blue Bike scheme is needed to study); it is sensible to choose stated choice experiment. Later, discrete choice modeling will be employed to analyze the collected data.

# EXPERIMENTAL DESIGN

This chapter primarily aims to lay out the procedures followed in the selection of attributes and their levels. Subsequently, how these attributes converted into choice tasks or alternatives and eventually into a tri-lingual online survey. The first step, in this regard is to define experimental design and present its importance in relation to other factors like, questionnaire preparation. Secondly, the whole process of attribute finalization including their levels and characteristics are copiously explained. Later, the management of these attributes and use of different statistical programs to produce realistic and feasible alternatives. Finally, organization of the survey comprising of several parts in addition to choose questions is described.

## 3.1. EXPERIMENTAL DESIGN: PROPERTIES AND MEANING

There are various types of investigation and research techniques available in both formal and informal settings. However, some sort of experiment design delineating an appropriate statistical analysis is common thread linking all of them (Lyles & Hummer, 2012). That is why, it is also an important component of all the stated preference experiments, which are often employed to improve the precision of the responses, to the choice task scenarios (Hess & Rose, 2009). It is albeit, in sharp contrast to the observational studies, which merely involves straightforward collecting and examining data. Lastly, to get some accurate results from these designed experiments, extreme care must be taken while constructing and executing them (Easton & McColl, 1997).

**Definition:**

It is a method of producing discrete combinations of attributes and their levels, that respondents evaluate in the choice questions (Bridges et al., 2011). These combinations or scenarios primarily notice the effect of independent variables (a variable that is changed or controlled) on the dependent variable (a variable being tested or measured) (Derek Fry, 2010).

### 3.1.1. Types of Experimental Research Designs

They generally divided into three distinct categories:

1. Pre-experimental designs
2. Quasi-experimental designs
3. True experimental designs

Briefly, true experimental design, which is also employed in this study, is characterized by two features, random selection of survey respondents and the random assignment of choice tasks. In consequence of this randomization, it can be determined with certainty that effect on the dependent variable is only owing to the independent variable(s). Hence, because of these properties, true experimental designs are considered the finest type of research designs (Jayesh Patidar, 2014).

There are many kinds of true experimental designs available. Ergo, it is dependent upon the nature and objectives of the study, to choose one of the following:

a) Post-Test Only
b) Pretest-Post-Test Only
c) Solomon Four Group Design
d) Randomized Block Design
e) Factorial Design:

This design has been used to for this research study. It allows for the testing of two or more hypotheses in a sole project. The researcher can manipulate two or more independent variables at the same time to examine their impact on the dependent variable (Jayesh Patidar, 2014).

## 3.2. ATTRIBUTES AND ATTRIBUTE LEVELS SELECTION

Discrete choice experiment (DCE) is an attribute-driven research methodology, designed specifically to prompt responses from stakeholders, regarding any current or upcoming phenomenon/project. Ergo, validity of a DCE, partly hinges upon the sensible specification of the attributes and the levels. Moreover, other components like choice questions format or analysis requirements also dependent on the type of attributes (see figure 4). Hence, a comprehensive step by step process for the identification and final selection of attributes along with their levels is crucial (Abiiro et al., 2014; F. R. Johnson et al., 2013)

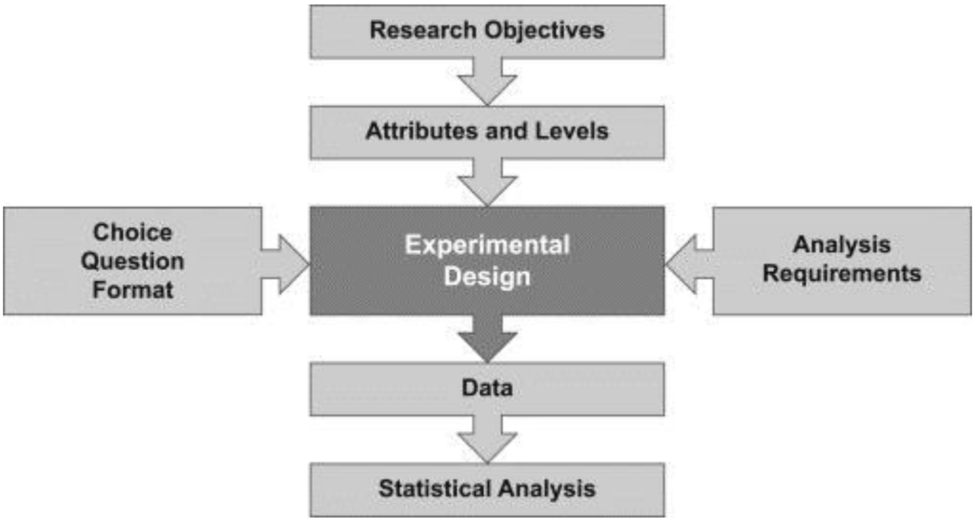



Figure 4: The role and position of attributes and other factors in the overall experiment design

*Source: Johnson et al., 2013*

### 3.2.1 Understanding Attributes and Levels

An attribute is a variable, also known as controlled or independent variable, whose values or levels are set by the researcher (Easton & McColl, 1997). It can be quantitative like 'trip distance' or qualitative like 'choice of colors' (Coast & Horrocks, 2007). In addition, number of levels, experimenter assigns to each attribute also hold importance because an increase in the number of levels might enhance the significance of that attribute (Ratcliffe & Longworth, 2002). Further, the selection of attribute levels also reflects the researcher belief regarding each levels contribution to overall utility (Juan de Dios Ortúzar & Willumsen, 2011).

### 3.2.2. Qualitative Research

DCE cannot include all the important attributes most of the times, but it must include the most pertinent, to the respondents (Lancsar & Louviere, 2006). Therefore, a qualitative literature research must be conducted to select all the attributes employed in the similar previous studies keeping in view the target population and the research objectives.

A list of sixteen attribute was prepared, after going through extensive literature search process. The studies mainly focus on finding the determinants impacting the bike share use in varied geographical, environmental and socio-cultural settings. These determinants can be divided into four groups:

a) *Bicycle Infrastructure and related Facilities*

Number of studies aiming to find out the factors that impact the use of public bicycles have concluded that bicycle paths, trip end facilities like shower and bicycle parking are strong enough reasons to persuade or dissuade public from using bike sharing schemes.

b) *Weather and Location*

It is observed, in the results of many studies that people tend to avoid using shared bikes during cold weather and rainfall. Moreover, some connection between terrain of the bike share catchment area and the distance of its docking stations from CBD (Central Business district) has also been found. In consequence, the factors like rain or snow, temperature, terrain and proximity between city center and bikeshare stations have been chosen for further analyses.

c) *Attitude and Socio-Demographic*

There are scholarly works though in a relatively short amount that deals with the attitudinal, cultural or tariff related issues. These studies found strong correlation between bike share ridership and variables like age, car ownership, sensitivity towards natural environment, affordability.

d) *Trip related Attributes*

Bike share researcher and scholars maintain that trip related factors play a critical role in one's decision making (either to choose public bike or not). They have enlisted attributes like travel distance, travel time, availability of other modes, waiting time and priority for the comfort level as the strong determinants (Fisman et al., 2015; El-Assi et al., 2015; Campbell et al., 2016; Ortúzar et al., 2000; Fishman, 2014; Kamargianni & Polydoropoulou, 2013; Yannis et al., 2015; Yin et al., 2016; Nikitas et al., 2015; Parkin et al.,2008; Kim et al., 2012; Faghih-Imani et al., 2014).

### 3.2.3. Survey for Attribute selection

A concise survey, comprising of 17 questions, all having three response options namely 'yes', 'maybe' and 'no' was created using Google Forms. To elaborate, 16 questions in this exercise, were based on the attributes selected during the qualitative research and last question was a blank, in case participants want to add a new attribute. This survey distributed was distributed among 32 students of Masters and Bachelors of Transportation sciences, online through a Facebook group in January 2017.

Author, received complete response from 22 students. The results of this excursion were later compiled and analyzed on Microsoft Excel. They revealed temperature, rain, distance to the destination, bicycle infrastructure as the strong attributes. Moreover, the factors like car ownership, availability of other modes and cost of bike share did not really come strong on the focus group analysis. However, very strong link between these attributes and bike share scheme use had been found during qualitative research. That is why, all these attributes were made part of the final choice experiment. Focus group survey is attached in the appendix-I.

### 3.2.4. Final Attributes and the Levels

Final attributes and their levels were selected keeping in view the results of focus group, recommendations from the Belgian bike share scheme and meetings with the research supervisors. It was agreed, to add three more in the list of seven already finalized (in the focus group) attributes. These three variables are 'bike parking at the destination', 'free car parking at the destination' and 'trip Purpose'. The studies ("Danish National Travel Survey, 2015; Buehler, 2012 and Kamargianni & Polydoropoulou, 2013) have also used these variables in their bike share research. Thence, ten attributes successfully pushed themselves to the final list. All of them were meticulously studied one by one, including the selection for their levels. The details are presented here below:

*a) Segregated Bike Lanes*

The presence of bike lanes especially the separate pathways encourage people to become members of the bike sharing schemes. Thus, in turn increases the demand for bicycles (El-Assi et al., 2015; Fishman et al., 2015). Evidence also suggests that if investments are made in the facilities for bicycle traffic, like segregated paths, the likelihood of people switching from motorized mode to cycling expands (Parkin et al.,2008).

Three levels (None, Half, All) were included in consonance with the work of (Campbell et al., 2016). These levels are easy understandable, as 'None' stands for no separate bike lanes, 'Half' means no bike lanes for part of the journey and 'All' denoting an availability of bike path for the whole journey.

*b) Trip Purpose*

Does the purpose of bike share use affect its ridership? Danish National Travel Survey, 2015 reveals that in Copenhagen, bike share trips made for work (48%) are slightly less than non-work (52%). In addition, the use of cycling for non-work trips also aids in increasing one's frequency to use bicycle for work trip (Stinson & Bhat, 2004). Thus, only two levels (Work, Non-Work) were created for this attribute. They are simple, easy to handle and fulfills the objectives of the study.

*c) Temperature*

There is a deluge of information available proving the significant impact of temperature on the bike share and usual bike use (Campbell et al., 2016; El-Assi et al., 2015; Parkin et al.,2008). However, author has not been able to find a single study stating the maximum temperature at which cycling is possible. Moreover, the levels for this variable was finalized, keeping in view the temperature variation trends of Brussels city for the whole year. It was assumed that whole Belgium follows the same temperature patterns. Pithily, these are levels 0°C, 10°C and 20°C ("www.eminf.com, 2013").

*d) Trip Distance*

There is a negative correlation between the use of bicycles and the trip distance. The further the destination, the greater the persuasion for people to choose another mode. In addition, literature also suggests that on average bicyclist ride 5km maximum. Therefore, to grasp in depth, how people react to difference trip lengths, three levels (0km, 3km, 5km) were developed for this attribute. Logically, 5km is the largest value in accordance with the established research findings (El-Assi et al., 2015; Campbell et al., 2016).

*e) Tariff*

Cost of travelling is a deciding factor in the mode choice, especially for adults (Kamargianni &Polydoropoulou, 2013). To add, the probability of using public bicycles instead of private vehicle or public transport is higher if the PBSS are cheaper than motorized modes (Yannis et al., 2015). Further, to finalize the levels, the rates of a large bike sharing scheme in Belgium were consulted. This scheme has four different kinds of rates but for this study six levels (0€, 1€, 2€, 3€, 4€, 5€) were generated. In these levels, the largest two would test if the people are willing to pay more than they presently are, for the better service or for any reason in future ("www.blue-bike.be, 2016").

*f) Rainfall*

It does not only decrease the usage of public bicycles but also negatively affect the proportion of the people who cycle to work (Kim et al., 2012). Thus, given the strong impact of rain, this attribute was assigned levels (Yes, No) rather than going into much detail i.e. defining levels as mild, drizzling or intense. Here, 'yes' means rainfall and 'no' means no rain. The results from these two levels would be enough to carry out the analysis efficiently.

*g) Bike Parking at the Destination*

It is stated that the use of bicycles becomes more frequent and desirable when bike parking is available. Therefore, one objective of this research work is to find out, how Belgian people react to availability and absence of parking spots at the end of their journeys. This demand, led to the creation of simple two levels (Yes, No) which are patently conveying the message of this attribute (Kamargianni & Polydoropoulou, 2013).

*h) Car Ownership*

Parkin et al.,2008 states that when more people owns private vehicles in any given area, than there is a strong possibility that less number of people would use bicycle or bike share. In addition, greater car ownership also offsets positive the influence of bicycle infrastructure on the bicycle use. Ergo, to study this important variable in this research, two levels were assigned to it (Yes, No).

*i) Free car parking at the destination*

Availability of free parking spots for the cars at the destinations can reduce bike commuting up to whopping 70% (Buehler, 2012). In order, to understand this phenomenon better in the Belgian context, the survey respondents would be provided this attribute with levels (Yes, No). The results will provide interesting statistics revealing mode choice habits of people in both situations, when free parking is present or not.

*j) Availability of other modes*

Past studies show that only walkers more willing to use bicycles more as compare users of other modes of transport (Ortuzar et al.,2000). Moreover, the author has not been able to find an extensive literature proving the strong connection between cycling and the availability of other modes. This situation, calls for a thorough analysis of this aspect/relationship. Thereby, three levels (Bus/Tram, Taxi/Uber, Walk) were created for this attribute. The results will hopefully rich enough to explain the decision-making habits of the society especially regarding this variable.

## 3.2.5. Organization of Attribute Tables

It has been observed that, if the number of attributes in an alternative or choice task gets more than six, respondents start to answer it randomly or in lexicographic fashion. Hence, can must be taken in organizing attributes including their levels in an alternative. Researcher might also want to consider the social, demographic and cultural milieu, in which choice tasks are presented. This exercise will help them better place, order and control the number attributes and their levels (Caussade et al., 2005).

There are ten attributes along with their varying number of levels, chosen for the experimental design in the last section of this chapter. However, as learned in the preceding paragraph, limited number of attributes in a choice task enable better results. That is why, blocking of attributes was performed. Two blocks were created, each block or sub-set comprises of six attributes because two factors 'tariff' and 'trip purpose' were common in both sets. These sets are presented here below:

Table 9: Block/Sub-set one of the Attributes

| Sr.No | Attributes | Attribute Levels |
|---|---|---|
| 1 | Tariff | €0 €1 €2 €3 €4 €5 |
| 2 | Trip Purpose | Work Non-work |
| 3 | Segregated Bike lanes/Paths | None Half All |
| 4 | Bike Parking at the Destination | Available Not-Available |
| 5 | Trip Distance | 1km 3km 5km |
| 6 | Rainfall | Yes No |

Table 10: Block/Sub-set two of the Attributes

| Sr.No | Attributes | Attribute Levels |
|---|---|---|
| 1 | Tariff | €0 €1 €2 €3 €4 €5 |
| 2 | Trip Purpose | Work Non-work |
| 3 | Free car parking at the destination | Available not-Available |
| 4 | Car ownership | Yes No |
| 5 | Availability of other modes | Bus/Tram Taxi/Uber Walk |
| 6 | Temperature | 0°C 10°C 20°C |

### 3.2.6. Development of Choices

In full factorial design, all the possible choice scenarios are considered, which makes it a most comprehensive experiment design method. With this design, it is statistically possible to evaluate both the main and interaction effects of the attributes (Louviere et al., 2000). It is owing to these properties; full factorial design was adopted for this research work. In addition, it is also necessary to make all the possible alternatives understandable and realistic. Therefore, each alternative/choice is presented as a 'package' of attributes like travel time, price with their levels intelligently (Ortuzar and Willumsen, 2011).

There are many software programs and tools available to generate choices keeping in view the principals of full factorial design. Few popular packages and a technique are delineated below:

- Statistical Analysis System (experimental-design macros)
- Ngene
- Statistical Analysis System (JMP)
- Statistical Package for Social Sciences (SPSS)
- Orthogonal designs that can be constructed without the assistance of special software

Statistical Analysis System (SAS) based Experimental-design macro was employed to create choice tasks (See macro in appendix-II). Each sub-set of attributes and levels was treated exclusively, generating 864 choice tasks in total, 432 for single sub-set. Although, it also feasible to provide twenty choice options to one respondent, without compromising the quality of results (R. M. Johnson & Orme, 1996) but it was decided to present only 9 choice tasks to each survey participant. In consequence, 96 questionnaires, containing 9 different choice options/alternatives in each of them, had to be produced to fulfill the full factorial design requirements.

## 3.3. SURVEY DEVELOPMENT

Discrete choice experiment (DCE) consists of developing, piloting and augmenting the experiment questionnaire. This survey is pivotal, not only for the success of the study but also for the validity of its results (Kløjgaard et al., 2012). Therefore, a questionnaire for this survey has been developed, comprising of six parts, one of which exclusively deals with the stated choice options. These are explained one by one briefly, stating their importance and the role they play in the achievement of overall objective of this experiment.

### 3.3.1. Socio-Demographic Questions

Collecting information on the social and demographic milieu of the target population is a great way to determine whether you are reaching out to your target audience or not. Similarly, whether you are gathering information you sought or not. Further, it also allows you to divide the respondents into different groups and later see hoe the answers vary among different groups. Lastly, it might help in explaining the factors that affect respondent's choice of answers ("Obsurvey, 2014"; "Checkmarket, 2016").

Therefore, in this research study, to check the prevalence and trend of using public bike sharing system in the target population, a set of seven questions were made part of this survey. They specifically gather socio-demographic information by asking about age, gender, employment status, education level and income from the respondents. The format, order and options within the questions can be viewed in the questionnaire attached as appendix-III (Q1 to Q7).

### 3.3.2. Transport and Travel related questions

It is critical to get a sense of the circumstances in which the travel habits are formed or maybe reformed. Moreover, it is also a belief that, travel behaviors tend to remain permanent in one's life and rarely change. That's the reason, it becomes extremely important for the transport researchers to understand the rationales behind the individual's travel/trip choices and related decisions in their studies. Lastly, travel habits are influenced by the complex set of factors, encompassing personal attitudes towards various transportation modes, capabilities related to their usage and mobility mode ownership (Flamm, 2004).

In the second section of the questionnaire, it is tried to include the questions which can fetch the basic information regarding the respondents current bicycle use habits and motivations behind it. Ergo, this part is comprising of five pithily laid out questions, asking respondents weather you own a bicycle, when and under which circumstances you use it. In addition, it asked if he/she has a driving license or not and membership with any public bike sharing scheme. These questions along with their choices are presented in the appendix-III (Q8 to Q12).

### 3.3.3. Public Bicycles Related Questions

Third section of the questionnaire is particularly designed for the PBSS user. The aim is to find out about the characteristics of both the PBSS trip and the user. To achieve this goal, targeted questions were asked namely, how often you use public bicycle and for what purpose? In addition, which mode(s) you have been using to reach PBSS station and the previous mode for the same journey you are making with the pubic bike now? Later, the characteristics of trip made by the previous mode like time, cost and comfort were asked. Ultimately, the section ended with the questions, how you rate public bike vis-a-vis other or previous travel mode(s) and suggestions to improve PBSS? These questions can be consulted or pondered upon by just going to appendix-III (Q13 to Q21).

### 3.3.4. Non-Users of PBSS

Fishman et al., 2015 argues that to increase the level of ridership of PBSS, researchers must start including non-users of the bike sharing schemes in their studies. In this way, they will be able to understand the underlying factors behind their current mode choice behavior. He further states that, such studies if conducted will also help underused bike share systems. Thereby, in this part of the survey, respondents were asked about the modes used for work and non-work related journeys including the modes selected for the last miles of the same trips. Moreover, they were asked about the membership in the other types of PBSS, different than the pro-train. This section of the survey can be looked at in appendix-III (Q22 to Q27) for additional understanding.

### 3.3.5. Stated Preference questions

The hypothetical scenarios which are constructed with aid of statistical package SAS and online Qualtrics (see section 3.2.6) were presented in this part of the survey. Total nine choice tasks were provided in each questionnaire, giving two ways to respondents to answer them. One, either to accept a single scenario by opting “Yes” or reject it by selecting “No”. One choice task is presented below for the greater understanding and clarity:

Table 11: Order and design of one choice scenario

| **VARIABELS** | **VALUES** |
|---|---|
| Tariff | 0 Euro |
| Segregated bike lanes/paths | None |
| Trip Distance | 3 KM |
| Bike Parking at the destination | Available |
| Trip Purpose | Non-Work |
| Rainfall | No |

It was assumed that participants to the survey might not able to understand the attributes mentioned in the scenarios. Therefore, brief explanation of some of the attributes was presented in the questionnaire. The same are delineated here:

*a) Occasional (non-work) trip*

The journey one makes for the purposes other than job or employment related activities, e.g. Shopping, recreation, casual meeting, random business meeting etc.

*b) Tariff*

The price/cost to use the Blue-Bike for 24-hour period.

*c) Segregated bike paths*

These are separate on-road or off-road bike ways. There are three options provided under this attribute, None, Half and All. "None" shall be selected when your bicycle journey does not have any separate bike ways but "Half" must be selected but at-least some part of journey has separate bike paths and "All" is selected when your complete journey is served by separate bike lanes.

*d) Trip distance*

The length of your journey on the Blue Bike Trip Purpose: The reason you are making this journey on Blue Bike.

*e) Availability of other modes*

Modes of transport which can be for the same trip in place of Blue Bike.

Lastly, the respondents were provided, a brief visual and textual situation, so that they can answer choice questions by putting themselves in the similar condition. The text and the figure are delineated here below:

Suppose, you are planning an occasional trip to another city within Belgium. You reached that city or town using train, bus etc. The transit station(s) in the city you are visiting has the facility of renting "Public Bicycle". You can make last part of your journey within the city on this rented bike.

*Example:* Imagine, you walked from your home to the train station to go to another city to meet some friends. You took the train and reached that city. Now for the last part of your journey, to reach the meeting place, you hired a Bike from the Blue Bike docking station present at the train station.

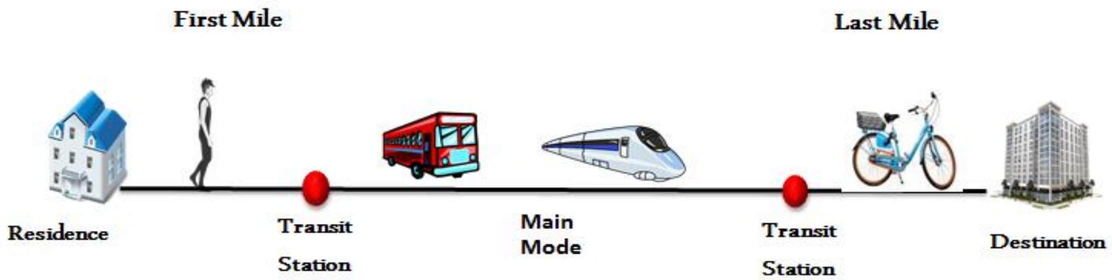



Figure 5: A figurative description of hypothetical situation explaining first and last mile travel

### 3.3.6. Attitude and perception related questions

Understanding social, cultural and psychological aspects of the area, city or a country, where one intend to launch or research a PBSS, is very useful. This gives an idea about the target population’s inclination towards adopting public bikes or not. In addition, ethical standing of a population acts as a mediatory between cultural values and the intention to adopt PBSS. That is why, policy makers and transport consultants must study all these behavioral parameters before launching or campaigning for a bike sharing scheme. Because, if the undergirding norms and values are in opposition to the goal of promoting PBSS, officials and transport practitioners must focus on changing the people’s values first (Yin et al., 2016).

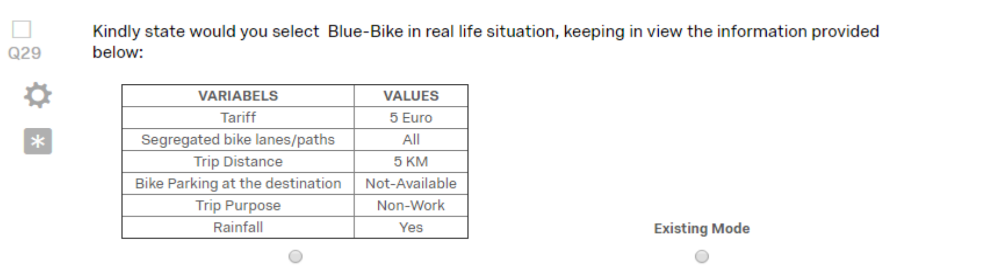
Given the importance of these entrenched values, which affects public’s attitude and perceptions at large. It was decided to include questions, in the form of statements. The reaction to those statements will allow researchers to assess whether public will be open towards any bike sharing system. These questions touched the issues like environment, materialism, collectivism and comfort i.e. Do you think PBSS are solution towards climate change? Happiness can be purchased with money. These questions along with the response options can be seen in appendix-III (Q37 to Q41).

## 3.4. Pilot survey

To expand the reach of the survey, it was pivotal to create an online version of it. Ergo, a web-based program 'Qualtrics' was used. It is a rapidly growing software-as-a-service company. Half of the Fortune 100 enterprises and top hundred business schools rely on Qualtrics technology ("Qualtrics, 2017"). Moreover, it helps you to evaluate and collect the responses on top of creating and distributing the survey.

This online survey was later translated into two languages, Dutch and French (main languages of Belgium) to receive, more and quality responses. Eventually, the tri-lingual version was launched in March 2017, as a pilot to get a reaction from people of all walks of life. Within a week, many positive ideas, comments and problems came the fore regarding the questionnaire. Hence, keeping in view these recommendations, this survey was modified and corrected in the following ways:

- In the stated preference part of the survey, scenario was presented in the format shown in the figure below. Many people were finding it difficult to understand or relate to the option "Existing Mode" with respect to the choice task. Therefore, it was later removed and format took its present form (see appendix-III).


Q29

Kindly state would you select Blue-Bike in real life situation, keeping in view the information provided below:

| VARIABELS | VALUES |
|---|---|
| Tariff | 5 Euro |
| Segregated bike lanes/paths | All |
| Trip Distance | 5 KM |
| Bike Parking at the destination | Not-Available |
| Trip Purpose | Non-Work |
| Rainfall | Yes |

Existing Mode

Figure 6: Presentation of choice task in the Pilot Survey

- In the socio-demographic part, education levels, initially contain an option "Three-year degree", which was inconsistent with local education system. This mistake was corrected.
- Many participants were leaving questions unanswered in the survey especially the parts which were critical to this research project. Therefore, necessary amendment was made, making it compulsory for participants to answer important questions.
- The section regarding the non-users of the PBSS needed two extra questions, specifically asking the individuals about the mode choices for their work and non-work trips.

## 3.5. Launching the Survey

Finalized, modified and tested version of the survey, now must carry 832 choice options, 9 options for one person. To achieve that, 96 copies of this survey were developed, each containing different choice tasks to fulfill the full factorial design requirement. Moreover, these surveys had to be distributed randomly. Hence, single web based 'Master Link' was created on the Qualtrics. It automatically but randomly distributes one link out of 96 to a user. Finally, in April 2017 this survey through the Master Link was made public/online. Many forums were used to spread the survey like official mailing portal of Hasselt university, Facebook groups related other universities, bicycling and transport.

# DATA ANALYSIS AND RESULTS

This chapter lays out the process followed to collect and prepare data for the analysis. Later, the utilization of that data in both the basic and complex descriptive analysis. Finally, methodology adopted for the model estimation is discussed. Moreover, this chapter, dives deep into the complicated and subtle changes needed to be made in the dataset for accurate outcomes. Ultimately, the final models are prepared and presented, a crux of this research study.

## 4.1. DATA COLLECTION AND PREPERATION

The first step before diving deep into the analysis phase is the collection of responses from all the surveys and putting them into one conveniently manageable file. Adoption of user-friendly software and techniques goes a long way in saving time and ensuring data quality. Moreover, the data collected directly from the questionnaires might not be useable directly for the analysis purposes. It may require to be formatted, cleaned or corrected first. This situation makes, data preparation very integral for the success of the project, which is nothing more than making sure your data is of high quality, desirable and in the format easily useable for analysis. Ergo, to do it right, might require a considerable amount of time and effort (Brown, 2016). Hence, lets discuss briefly about the data collection stage of this study.

### 4.1.1. Data Collection

The online survey link was active from April 1st, 2017 to 21st, 2017. In this period of three weeks, a total of 123 complete responses were collected. To elaborate, in the last chapter it was described that the survey link, randomly distributed surveys out of 96 questionnaires to the participants. Half of these questionnaires were based on the sub-set one of the discrete choice variables and other half were built upon the second sub-set. Furthermore, subset one got a total of 63 complete responses and sub-set two got 60. However, the pertinent fact here is that not all the questionnaires got the same number of responses. There were 72 questionnaires which received only a single response while 21 questionnaires got two responses each and 3 questionnaires got three responses each. Lastly, these answers were download from Qualtrics in the coded .csv format.

### 4.1.2. Data Preparation

Once all the data has been collected, the researcher must prepare the data to be analyzed. Organizing the data correctly can save a lot of time and prevent mistakes. That's the reason, .csv file prepared in the last step, was organized according their sub-sets and questionnaire numbers in a single file or database. Brown, 2016 has confirmed that, most researchers (78%) choose to use a database or basic statistical analysis program, Microsoft Excel. Now, it is high time to look for errors or other problems before starting any analysis with gravitas, to avoid confusion and difficulty with the statistical analysis later. Thenceforth, once the data has been entered, it is crucial to check the it for accuracy and arrangement. (Trochim, 2006). To achieve that goal for the study at hand, there is need to follow the steps delineated below:

a) *Data screening*

It must be done both using statistical analysis and manual observation. The aim is to identify four kinds of abnormalities namely lacking data, outliers, strange patterns and inconsistencies. Some of these issues can also be recognized by the experience or common sense (Van den Broeck et al., 2005). Therefore, data was imported into SAS software first to look for errors and understand it better. Three different commands 'Proc means', 'Proc freq' and 'Proc univariate' were employed to perform the task. This effort gave a complete picture of both the robustness and irregularities i.e. the missing values and outliers. Subsequently, the data was analyzed manually. It showed that Qualtrics has strangely coded the responses for the Questions eight and twenty-nine of the survey as *'23 for Yes & 24 for No'* and *'4 for Yes & 5 for No'* respectively. Similarly, all other questions with two response variables were coded as *1 & 2* including the stated preference questions.

*b) Data Treatment*

It is about the clarification and resolution of the troublesome data points and patterns. Honestly, the options to solve these issues are limited to correcting, deleting, or leaving the data unchanged. Hence, the decision regarding the choice of option depends upon the nature of data and the problem. Generally, the impossible values in the data must be corrected or deleted (Gardner and Altman, 1994). Moreover, all three options were employed to fix the present dataset. Firstly, the second row of the data was deleted. It contained the full names of the questions as presented in the survey. Instead, the questions numbers were used for further analysis.

Moving on, four responses were deleted owing to the skewed and impossible nature of the answers. It reduced the total number of responses to the survey to 119. The coding of the question twenty-nine was changed to *1 & 2,* which in sync with rest of the stated preference questions now. The coding for the Question eight was left unchanged because it won't affect the results in any way or form. Lastly, many columns which were automatically generated by the Qualtrics providing information like 'Response ID', 'Location', 'Start and end date of the survey' etc. were deleted.

*c) Coding*

Currently, there are only response variables present in the dataset already coded as *1 for Yes* and *2 for No*. However, for the model estimation, scenarios against which the survey participant has made its decisions/choices, must also be entered. Therefore, 90 new columns were created in the dataset. These columns were filled with the values as presented in the questionnaires. Now, to estimate the choice model and being able to accurately interpret the coefficients, creating a numeric values or coding, these scenarios is a good idea. The table 12 gives the complete picture of how the values of all the variables were coded. The variables with two values were dummy coded (1,0) and all other variables were assigned simple numeric values.

Table 12: Stated preference attributes and their levels with the assigned codes

| **Sr #** | **Stated Preference Variables** | **Levels with Numeric Codes** |
|---|---|---|
| 1 | Tariff | 0€=1, 1€=2, 2€=3, 3€=4, 4€=5, 5€=6 |
| 2 | Temperature | 0°C=1, 10°C=2, 20°C=2 |
| 3 | Trip Distance | 1 km= 1, 3km=2, 5 km=3 |
| 4 | Availability of other modes | Bus/Tram=1, Taxi/Uber=2, Walk=3 |
| 5 | Bike Parking at the destination | Available= 1, Not-Available=0 |
| 6 | Rainfall | Yes=1, No=0 |
| 7 | Car Ownership | Yes=1, No=0 |
| 8 | Trip Purpose | Work=1, Non-Work=0 |
| 9 | Free car parking at the destination | Available= 1, Not-Available=0 |
| 10 | Segregated bike lanes | None=1, Half=2, All=3 |

At this juncture, the portion of dataset particularly dealing with the stated preference questions was replete with the missing values. It is owning to the four missing variables in each sub-set of attribute, created during experimental design. According to (Willigers & Van Wee, 2011), the creation of these sub-sets and later joining them, does not create bias or error variance. Just to recall, each sub-set contains six variables, two common and four different. Thereby, to solve this issue of 'null values', one value was assumed from the given set of levels/values for each missing variable. The values chosen for the missing variables are presented in the table 13. The criteria to assume the value was to, imagine a situation where an individual will choose bike share over other modes of travel.

Table 13: Values assigned to the missing variables

| Sr # | Stated Preference Variables | Chosen Value |
|---|---|---|
| 1 | Temperature | 10°C |
| 2 | Trip Distance | 3km |
| 3 | Availability of other modes | Taxi/Uber |
| 4 | Bike Parking at the destination | Available |
| 5 | Rainfall | No |
| 6 | Car Ownership | No |
| 7 | Free car parking at the destination | Not-Available |
| 8 | Segregated bike lanes | All |

## 4.2. DESCRIPTIVE ANALYSIS

It is used to describe the elementary features of the study data. It helps to simplify the large amounts of data in a sensible way, usually in the form of summaries. These summaries can be quantitative (i.e. Tables) or visual (i.e. graphs). Moreover, descriptive analysis can either form the basis for more extensive statistical analysis or it may be sufficient for an investigation per se (Trochim, 2006). Therefore, the dataset of this research study was also analyzed using 'proc tabulate' and 'proc freq' commands in SAS program. The outcome of this examination provided some critical details regarding the socio-demographic, attitudinal and bikeshare related parameters.

### 4.2.1. Basic Statistics

The results of the basic descriptive analysis are provided here in the table 14. They show, only the details of twelve selected parameters. It is because of the large number of null values present in the dataset for other parameter/variables. Ergo, these twelve variables will be used for further examination and investigations. Now, the analysis at hand clearly signifies that mainly students of more than 18 years of age, having education Bachelors and above were the largest group among the respondents. It is perhaps, owing to the distribution of survey on the university of Hasselt platform and other Belgian education institutions webpages. Moreover, this dataset does not tell anything about the people under 18 and having education less than high school.

This analysis also reveals that there might be a potential to expand the membership of PBSS. This opening is because of the knowledge, large number of people (79%) have about the public bicycles but in contrast, only small number (12%) have its membership. Another fascinating result is about the belief that PBSS are one of the solution towards climate change. It states that a large chunk of respondents (46%) are not sure about the veracity of this statement. Therefore, there is a tremendous opportunity here, to push them towards using bikeshare. Finally, positive attitude of large number of respondents towards nature and collective goals bodes well for bikes sharing schemes. As, according to (Yin et al., 2016), the society which has these traits, is more willing to accept and adopt public bicycles provided there are right strategies to woo them.

Table 14: Basic statistical description of survey questions

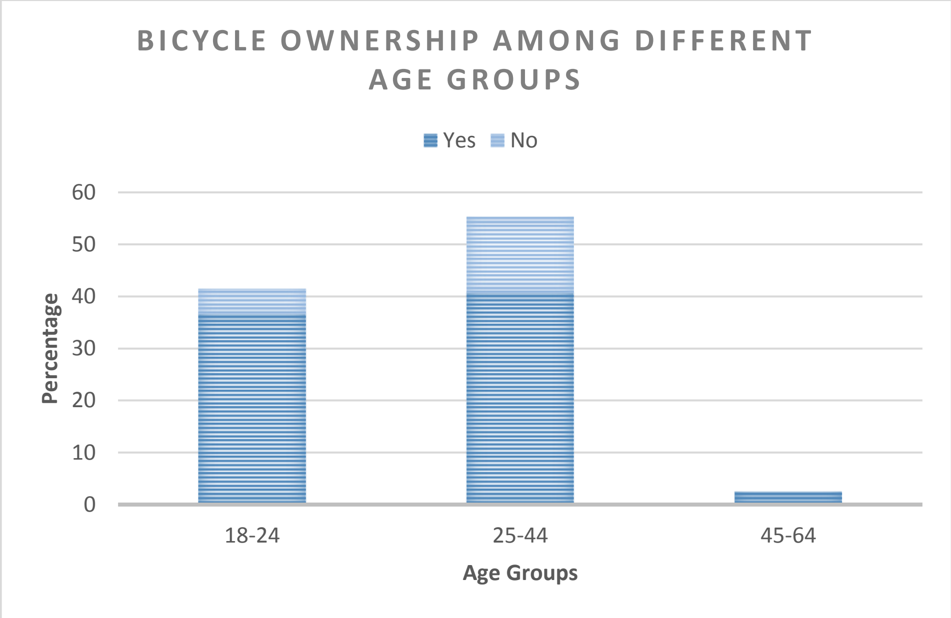
| Sr# | Question/Parameters | Basic description |
|---|---|---|
| 1 | Gender | The survey participants were 59% Male and 41% Females |
| 2 | Age | Majority of the people (97%) who attempted the survey were between 18-44 years of age. There were no responses from people <18 years of age and a minute 3% from the people greater 44 years old. |
| 3 | Education Level | The respondents mainly belonged to High School (24%), Bachelors (15%), Masters (48%) and Doctorate (11%) levels. The participation from other groups was negligible. |
| 4 | Employment Status | Students (69%) and full-Time employees (21%) patently dominated this category. In addition, Part-Time (3%) and Unemployed (4%) were also part of the mix, though not apparently significant. |
| 5 | Driving License | Most of the people (66%) had a driver license and substantial number (34%) did not have it either. |
| 6 | Bicycle Ownership | Surprisingly, whopping 80% of the respondents owns bicycle and only 20% in comparison did not have any cycle. |
| 7 | Knowledge of PBSS | It is perhaps greater education level of the respondents that majority (79%) knew about the public bike sharing schemes and minority (21%) did not have idea about their existence. |
| 8 | Membership of PBSS | In the dataset, 26 people did not answer to this question. However, among the respondents, 88% were not members of the bikeshare scheme. |
| 9 | PBSS as solution towards climate change | A slight majority (47%) believes public bicycles are a solution towards climate change. Though, roughly the same numbers (46%) are not sure about this claim. Further, only few (7%) deny this assertion. |
| 10 | Maintaining harmony with nature | Not a single participant disagrees with this statement. To elaborate, large number (81%) agreed that one should perform activities which are not harmful for the nature. |
| 11 | Working for common goals | The respondents were asked, is it better to work for the common goals? Most of them (67%) said yes, albeit the minority (29%) were not sure. |
| 12 | Buying happiness with money | The strangest results from the dataset were to this question, as majority (39%) were not sure if that's the true claim or not. Howsoever, 23% agreed and 38% disagreed with this statement. |

## 4.2.2. Analysis of Interactions between Variables

In this section, the relationship of 'bicycle ownership' and 'PBSS membership' with other variables will be tested and scrutinized. According to (Castillo-Manzano et al., 2015), private bike ownership and public cycle use have a complementary effect on each other. Therefore, it is pivotal for this research study to look at the influencing factors, impacting the use of bike share and possession of a bicycle. Hence to do this job, 'Proc freq' on SAS and Microsoft Excel are used.

*a) Age and bicycle ownership*

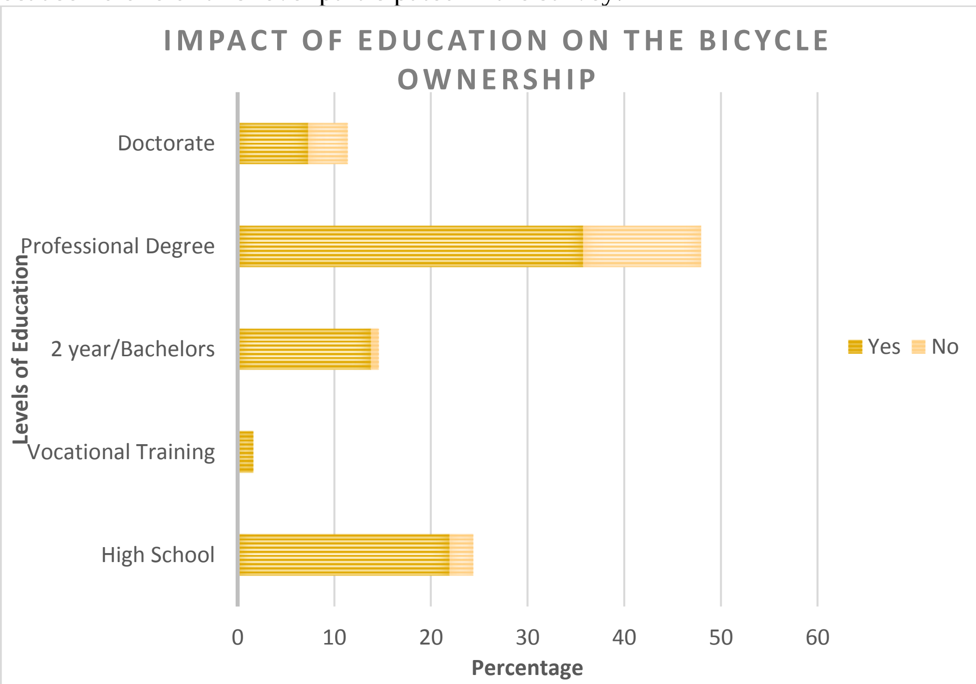
To analyze this interaction, the data regarding age was slightly modified. To elaborate, two categories of age, <18 and >65 were removed because 99% of respondents fall between 18 to 64. This action, in turn will provide easily interpretable and good quality outcome. This interaction between age and ownership is presented in the graph 1. The subject relationship, shows that the greater percentage of young people in the age bracket '18-24' owns bicycles vis-à-vis other groups. However, the largest group in numbers '25-44' is not far behind the group at the top. The interesting fact about the results was, all the participants in the age bracket '45-65' though in minute in numbers, owns a bicycle.




Graph 1: Relationship between bicycle ownership and age

*b) Education and bicycle ownership*

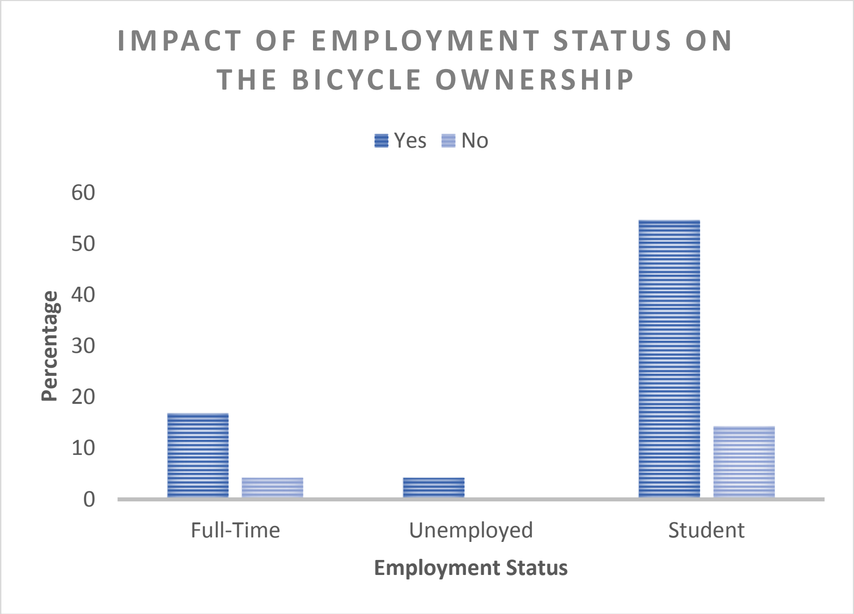
The subject association was also camp up significant (0.0730) in the chi-square test. Ergo, education will be analyzed further during model estimation phase. Nonetheless, the relationship presented in the graph 2 shows that the high school and bachelors level educated people have owns bicycles in greater number in comparison to graduate level educated people.  Lastly, a category less than high school is missing because no one of this level participated in the survey.




Graph 2: Relationship between bicycle ownership and education

*c) Employment status and bicycle ownership*

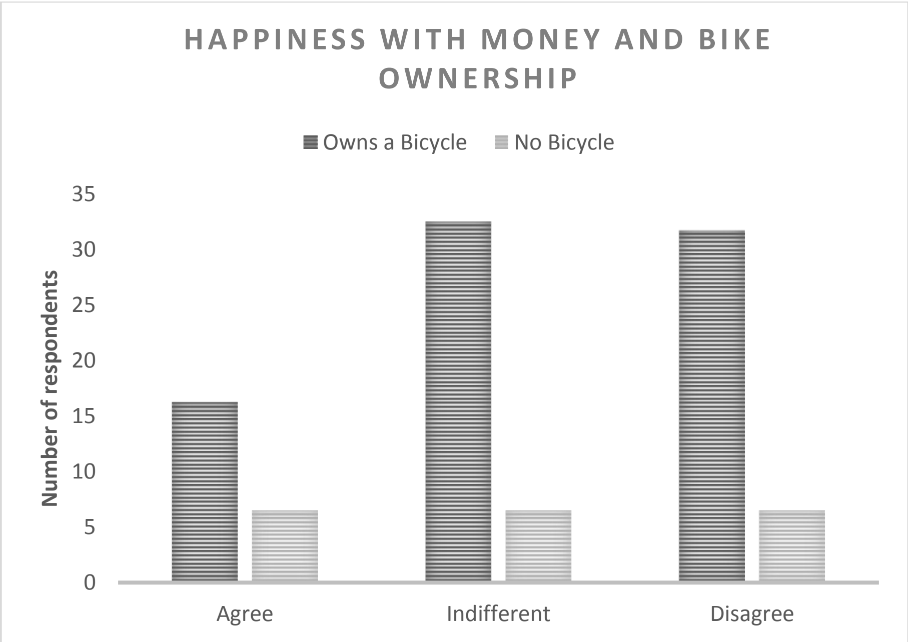
To study this relationship more efficiently, only three categories of employment status representing 95% of the participants, were taken into consideration. The results patently show students and full-time employees both own bicycles in the same percentage. However, the interesting fact seen, was all the unemployed people own a bicycle. These results are presented here in the graph 3.




Graph 3: Relationship between bicycle ownership and employment status

## d) *Bicycle ownership and buying happiness with money*

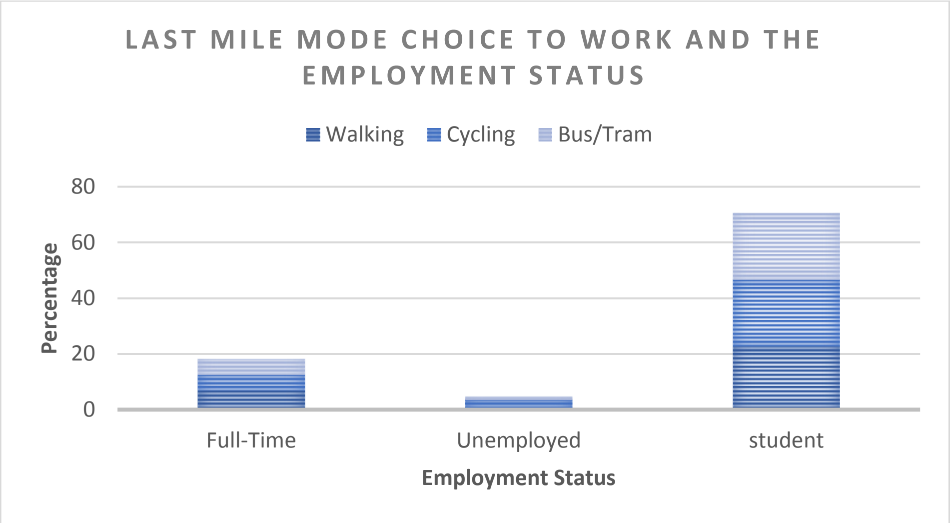
According to (Yin et al., 2016), people who are materialistic are less likely to own and use bicycle. Therefore, to test this hypothesis, a question '*do you think, happiness can be purchased with money?'* was included in the survey. The results of this analysis presented in the graph 4 approves this hypothesis. As, people who are indifferent and disagrees with the subject notion, owns more bicycles vis-à-vis people who hold opposite views.




Graph 4: Relationship between bike ownership and attitude on buying happiness with money

## e) *Employment status and last mile mode choice to work*

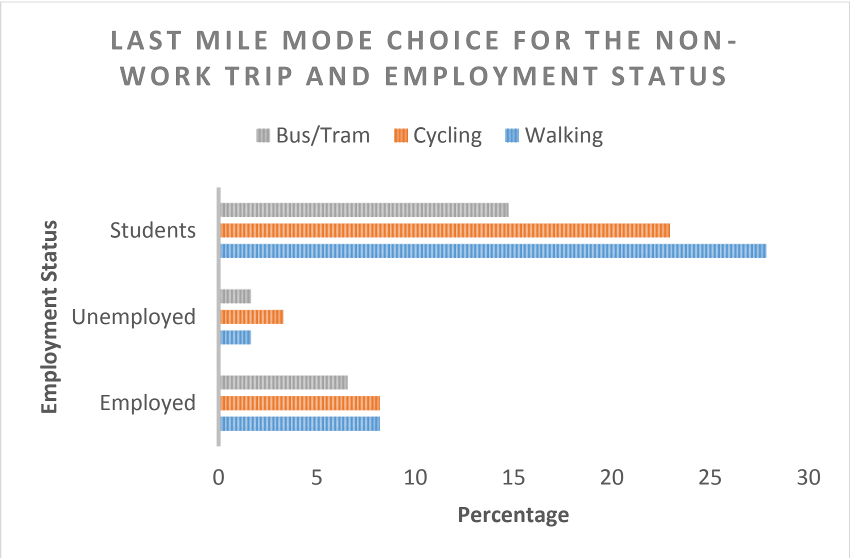
To conduct this analysis, the data regarding the last mile mode choice to work was modified a bit. Three categories were eliminated owing to either null or very small values. Similarly, for the employment, the data prepared in the graph 3 was utilized. The results of this analysis, presented in the graph 5 shows that there is no difference in the last mile mode choice to work for both students and the full-time workers. However, unemployed people use cycle more in comparison to other two categories, the result which is in sync with the earlier finding.




Graph 5: Last mile mode choice to work based on different employment status

*f) Employment status and last mile mode choice for non-work trip*

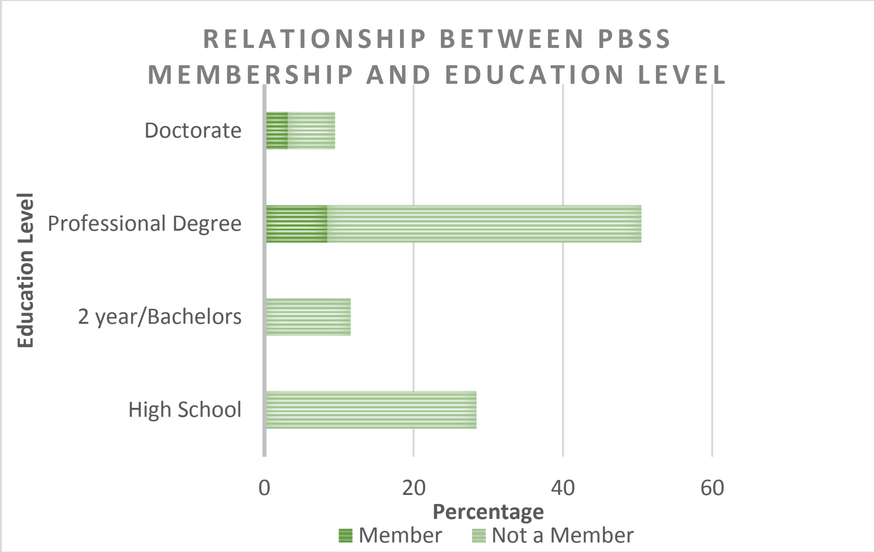
Mode choice behavior changes when people are not commuting to work. The results presented in the graph 6 attest to that fact. Nonetheless, in this analysis, employment status is examined with the last mile mode choice, for the non-work-related trips. This outcome is very different for students, as they tend to prefer walk and cycle more in comparison to work trips. The results for the employed and unemployed people are almost the same as for commuting to work.




Graph 6: Last mile mode choice to non-work trips based on employment status

g) *PBSS membership and education level*

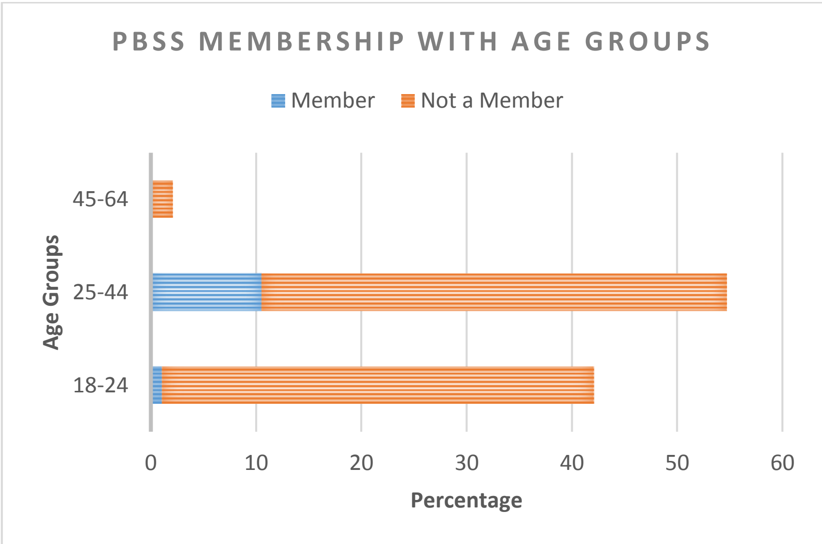
First, there is a strong association between the subject variables, as confirmed by the chi-square test (P value=0.0180). Moreover, the results of the interaction between education and PBSS membership are in utter contrast to the results of education with the bicycle ownership. Here, people with the graduate level education are members of PBSS but high school and bachelor students does have PBSS membership at all. These results can be seen in the graph 7.




Graph 7: PBSS membership w.r.t education level

*h) PBSS membership and age*

The graph 8 confirms the findings of the last graph. It shows that people in the age bracket ‘25-44’ are members of the PBSS in large number vis-à-vis other groups. It is owing to fact that; most graduate students fall under this bracket. Therefore, campaigns targeting high school and bachelor students, promoting bike share schemes, would go long way.




Graph 8: PBSS membership with respect to age

## 4.3. MODEL ESTIMATION

Statistical modeling helps in developing and testing theories by using causal explanation, prediction, and description. In addition, it is also employed to make sense of the behavior of the variable using certain mathematical expressions. Further, it is assumed that models with high explanatory power possess excellent power of prediction (Shmueli, 2010; Rawlings et al., 2006). In this research study, statistics will be used as a leverage to predict outcomes. Lastly, predictive modelling can successfully forecast, past, future or any other unknown event (Granville, 2015).

### 4.3.1. Model Selection

Selecting which regression model must be employed is both critical and daunting task. The most important aspect in this process, is an understanding of both the characteristics and type of research dataset. Howsoever, in this study, willingness of people to use bike share schemes is a function of socio-demographic, behavioral and bicycle related variables. Now, to model the effects of these variables, binary logistic regression seems quite suitable. It is mainly owing to the qualitative nature and binary distribution of response variable. Further, it will find out the relationship between discrete choices (binary, ordinal and nominal) and explanatory variables.

A person's willingness to use public cycle can be articulated by Y(Xi), here Xi represents the afore-mentioned variables. Moreover, if Y=0 represents unwillingness and Y=1 represents willingness to use public bicycle than following probability equation can be created:

$$P = 1/[1 + e^{(\alpha + \sum \beta_i X_i)}]$$

P here is the probability of people using bikeshare or public bicycle. α is the regression intercept, βi is the regression coefficient of the factor, Xi is the i-th factor (Yang & Long, 2016; "Statistics Solutions, 2017").

### 4.3.2 Model Building

A well thought out, sequential process had been followed to build a comprehensive model. Total twenty-six variables will be tested for the final model. Ten are related to stated choice, 6 to socio-demographic and 5 to attitudinal questions. These variables will be analyzed under various conditions using 'Proc logistic' in the SAS program. The step by step process is described here below:

*a) Development of two datasets*

It is clear from the descriptive analysis that most of the respondents to survey was students (69%). Therefore, to avoid any biasness in the results, the dataset would be divided into two sets. One set will contain responses only from the students and other will be a complete (original) dataset comprising both of students and other kind of respondents. This endeavor will help assess the mode choice behavior of students exclusively. In addition, a comparison between the results from both the dataset can be conducted for deeper understanding.

*b) Modelling two datasets*

In this part of modelling, all the variables concerned in each dataset were used at once for the regression analysis. Before, moving forward, it is also pertinent to mention that complete dataset based on original values comprises 1071 scenarios and students only data on 738 scenarios. The regression results showed that P-values of all the variables from the both the datasets, either significant or not, does not vary drastically. However, couple of variables like *'Free car parking at the destination'* and *'Car Ownership'* are the exception, which do vary significantly.

Further on, the variables *'Segregated bike lanes', 'Temperature', 'Availability of other modes', 'Trip Distance'* will be treated as categorical variables for in-depth examination of their levels and corresponding significance. One socio-demographic variable *'Employment status'* in complete data and *'Gender'* in students only data were significant. Similarly, *'PBSS as solution towards climate change'* is statistically significant in both. The strangest results were about the *'Trip Distance'* and *'Availability of other modes'* owing to the positive sign with their estimate values. Therefore, these variables will be looked at thoroughly later.

*c) Development of Three models*

In this section, it was decided to make three separate models for both the datasets, at 90% confidence interval. First model will contain only stated preference variables, second both stated preference and socio-demographic variables and third will include attitudinal variables in addition to other two groups. This exercise will clarify the relationship between different kinds of variables and their impact on the overall significance of the model.

At the outset, the three models with the *students only data* was created. Those three models showed a continuous improvement in the loglikelihood value from model one to model three. Moreover, '*trip purpose', 'free car parking at the destination', 'car ownership' and 'segregated bike lanes'* were found to be statistically insignificant in the model one. Continuing, in the model two along with the afore-mentioned insignificant stated preference variables, not a single socio-demographic variable turned out to be significant. Finally, in the model three *'PBSS as solution towards climate change'* was a sole significant attribute. Surprisingly, '*free car parking at the destination'* turned up significant and *'gender'* is turned insignificant.

Secondly, three models with the *complete dataset* was created. Here too, log likelihood value improved continuously from model one to model three. In the first model '*trip purpose', 'free car parking at the destination', and 'segregated bike lanes'* were statistically insignificant. Further, in the model two, along with three previously mentioned Stated preference variables, all the socio-demographic variables except employment status was significant. Similarly, in the model three, all the attitudinal variables except *'PBSS as solution towards climate change'* was significant. All other results were just confirming model one and two.

*d) Finalizing the models*

All the six models, three from each dataset were finalized individually by eliminating the insignificant variables (p-value> 0.1). The most popular method is the elimination of variables one by one, starting from least significant (Bursac et al., 2008). In the resultant models, there were few changes, which are worth mentioning. The model three and two based on students only data, has one statistically significant variable *'Bicycle Ownership'* from the socio-demographic *variables*. Moreover, *'free car parking at the destination'* no longer significant in the model three. The models based on complete data remained steady without any mentionable changes.

Trip distance (3km) is significant but has a positive sign on the estimate, which is counterintuitive. Moreover, the 'Availability of other modes' was negative and significant, defying common sense. In the same vein, data related to employment status must be converted into three categories as 95% of the responses fall under them. Nonetheless, to solve the problem with the trip distance, its two levels 3km and 5km were combined and the variable was dummy coded as 1=> 1km, 0 ≤ 1km. To fix availability, it was dummy coded as 1= Taxi/Uber, 0=Other modes.

## 4.3. FINAL MODELS

The updated datasets were utilized to develop the final models. All the models related to *complete dataset* are presented in the table 15 and entire output these models from SAS is attached in appendix IV. The results presented here gives all the attributes considered, the estimates and p-values of significant attributes. Lastly, for each model the number of observations, loglikelihood and McFadden's $R^2$ values are also provided.

Table 15: Logistic regression models based complete/original dataset

| **Variable Name** | **Model one** | | **Model Two** | | **Model Three** | |
|---|---|---|---|---|---|---|
| | **Estimate** | **P-Value (90% C.I)** | **Estimate** | **P-Value (90% C.I)** | **Estimate** | **P-Value (90% C.I)** |
| Intercept | 0.9239 | 0.0006 | 1.1846 | <.0001 | 0.9477 | 0.0013 |
| Tariff | -0.4333 | <.0001 | -0.4412 | <.0001 | -0.4477 | <.0001 |
| Car Ownership (Yes) | -0.4461 | 0.0115 | -0.4254 | 0.0166 | -0.4192 | 0.0193 |
| Free car parking at the destination | - | - | - | - | - | - |
| Trip Purpose | - | - | - | - | - | - |
| Temperature (0°C) | -0.3721 | 0.0039 | -0.3522 | 0.0066 | -0.3629 | 0.0057 |
| Temperature (20°C) | 0.274 | 0.0305 | 0.2711 | 0.0326 | 0.25 | 0.0506 |
| Availability of other modes (Taxi/Uber) | 0.4847 | 0.0058 | 0.4825 | 0.0064 | 0.5063 | 0.0046 |
| Bike Parking at the destination (Available) | 0.6432 | 0.0006 | 0.6937 | 0.0003 | 0.7091 | 0.0002 |
| Trip Distance (> 1 Km) | -0.9265 | <.0001 | -1.0152 | <.0001 | -1.0072 | <.0001 |
| Segregated bike lanes | - | - | - | - | - | - |
| Rainfall (Yes) | -1.262 | <.0001 | -1.2997 | <.0001 | -1.3296 | <.0001 |
| Gender | - | - | - | - | - | - |
| Age | - | - | - | - | - | - |
| Education Level | - | - | - | - | - | - |
| Employment Status (Unemployed) | | | 0.366 | 0.0594 | 0.3516 | 0.0724 |
| Employment Status (Students) | | | -0.4113 | 0.0006 | -0.3665 | 0.0026 |
| Bicycle Ownership | - | - | - | - | - | - |
| Driving License | - | - | - | - | - | - |
| PBSS as solution to climate change (Yes) | - | - | - | - | 0.4721 | <.0001 |
| PBSS as solution to climate change (No) | - | - | - | - | -0.5029 | 0.0057 |
| Working for common goals | - | - | - | - | - | - |
| Buying happiness with money | - | - | - | - | - | - |
| Maintaining harmony with nature | - | - | - | - | - | - |
| PBSS can cause inconveniences | - | - | - | - | - | - |
| *Number of Observations* | *1071* | | *1071* | | *1071* | |
| *Log Likelihood* | *-1262* | | *-1250* | | *-1232* | |
| *Pseudo R-Square (McFadden)* | *0.139* | | *0.148* | | *0.160* | |

The underlying table 16 is based on the *students only* observations. It is comprised of all three models taking into consideration twenty-one variables of concern. Moreover, parameter estimates and p-values of significant variables along with number of observations, loglikelihood and McFadden's $R^2$ are also delineated here. The comprehensive results in their entirety are presented on the appendix V.

Table 16: Logistic regression models based on the students only dataset

| **Variable Name** | **Model one** | | **Model Two** | | **Model Three** | |
|---|---|---|---|---|---|---|
| | **Estimate** | **P-Value (90% C.I)** | **Estimate** | **P-Value (90% C.I)** | **Estimate** | **P-Value (90% C.I)** |
| Intercept | 0.1493 | 0.5433 | 0.0239 | 0.925 | -0.0827 | 0.7549 |
| Tariff | -0.4721 | <.0001 | -0.4748 | <.0001 | -0.4824 | <.0001 |
| Trip Purpose | - | - | - | - | - | - |
| Temperature (0°C) | -0.4025 | 0.0062 | -0.4175 | 0.0049 | -0.4199 | 0.0048 |
| Temperature (20°C) | 0.2509 | 0.0849 | 0.2557 | 0.0803 | 0.2448 | 0.0953 |
| Free car parking at the destination | - | - | - | - | - | - |
| Trip Distance (> 1 Km) | -0.4617 | 0.0018 | -0.455 | 0.0021 | -0.4568 | 0.0021 |
| Availability of other modes (Taxi/Uber) | 0.3967 | <.0001 | 0.4008 | <.0001 | 0.4031 | <.0001 |
| Segregated bike lanes | - | - | - | - | - | - |
| Bike Parking at the destination (Available) | 0.3544 | 0.0041 | 0.3565 | 0.004 | 0.3604 | 0.0037 |
| Car Ownership | - | - | - | - | - | - |
| Rainfall (Yes) | -0.6542 | <.0001 | -0.6689 | <.0001 | -0.6714 | <.0001 |
| Gender | - | - | - | - | - | - |
| Age | - | - | - | - | - | - |
| Education Level | - | - | - | - | - | - |
| Employment Status | - | - | - | - | - | - |
| Bicycle Ownership (Yes) | - | - | 0.2128 | 0.0408 | 0.1985 | 0.0626 |
| Driving License | - | - | - | - | - | - |
| PBSS as solution to climate change (Yes) | - | - | - | - | 0.3236 | 0.0132 |
| PBSS as solution to climate change (No) | | | | | -0.3686 | 0.0551 |
| Working for common goals | - | - | - | - | - | - |
| Buying happiness with money | - | - | - | - | - | - |
| Maintaining harmony with nature | - | - | - | - | - | - |
| PBSS can cause inconveniences | - | - | - | - | - | - |
| *Number of Observations* | *738* | | *738* | | *738* | |
| *Log Likelihood* | *-901* | | *-844* | | *-838* | |
| *Pseudo R-Square (McFadden)* | *0.153* | | *0.157* | | *0.164* | |

# DISCUSSION AND CONCLUSIONS

This chapter explains the results of the descriptive and regression analysis already conducted. It goes deep in understanding surprising and interesting outcomes and how they relate to the bikeshare choice. Further, a set of recommendations are presented to the practitioners and scholars to improve both the bike share growth policies and research. Lastly, the concise set of most relevant conclusions are presented.

## 5.1 Discussion

The principal aim of this research was to find out the factors impacting the use of public bike sharing scheme, specifically the pro-rail. Moreover, exploring the willingness of Belgian people to use them and the uniqueness of pro-rail bike sharing itself. To realize this mission, a comprehensive survey was conducted whose results are presented the last chapter. Two different kinds of analysis were performed, descriptive and logistic regression.

### 5.1.1. Stated Preference Variables

Modelling results shows 'Tariff' statistically significant but negatively correlated with the bikeshare choice in all the models based on both 'complete' and 'students only' datasets. The negative sign with the tariff estimate establish that the probability to choose bikeshare decreases as tariff to rent them increases. This result is in sync with the previous studies (Buck et al., 2013; Wardman et al., 2007) stating the importance of lower prices to grow the PBSS membership.

The modelling results for 'Car Ownership' were different for both the datasets. It is significant and negatively related to the bikeshare choice in the model based on the 'complete' database but not significant at all in the model based on 'students only' data. This difference is perhaps owing to the less car ownership among the students as compare to general population. Nonetheless, the results for the complete dataset indicates that the probability of using bike share decreases as the car ownership among the population increases. This result corresponds to the research conducted by (Buehler, 2012), who states that car reduces bicycle commuting by 70%. Moreover, it contradicts with (Buck et al., 2013), who maintains that bike share members are more likely to own cars.

The attribute 'Trip Purpose' was exclusively added to the attribute list upon the request of a major transport company in the Belgium. Though, the result of model estimation were not significant for any model from either dataset. Moreover, there were large amount of missing responses for the questions related to bicycle and bikeshare use. Therefore, questions regarding the importance of trip purpose in the context of Belgium are still unanswered.

'Temperature' was statistically significant for both the datasets. However, there were categories of this variable namely 0°C & 20°C. Low temperature was negatively associated with bikeshare usage. In contrast, high temperature was positively associated. These results are identical to the findings of other studies (Campbell et al., 2016; El-Assi et al., 2015) stating warm weather is a boon for growth in bikeshare usage.

The modelling results for the attribute 'Free car parking at the destination' were not significant for students and general population. Again, it might be because of the fact that students do not own vehicles much, who are majority of the sample size. This conclusion, is opposite to (Buehler, 2012's) finding, maintaining free car parking spots leads to less use of bicycles.

'Trip Distance' turns out to be highly influential variable as it is significant and negatively correlated with the probability of bikeshare use in both the datasets. The results indicate that greater the distance, lesser the motivation to choose bikeshare. Previous studies (Campbell et al., 2016; Handy et al., 2010; El-Assi et al., 2015) came to the same conclusion that distance negatively affect the bikeshare demand. Therefore, bikeshare schemes would be more successful in high dense neighborhoods and cities.

The strangest, perhaps the surprising results were about the 'Availability of other modes'. There were two options available, Taxi/Uber and Public Transport. The results were statistically significant and positively correlated with the bikeshare choice in all the models from both the datasets. The best explanation for regression result is that students choose bikeshare in place of Taxi or Uber because it is cheaper. Ergo, bikeshare will thrive more in places and cities where there is less public transport like bus but more taxis.

The biggest shock of this research work was, the insignificance of the variable 'Segregated bike lanes' in all the models. The literature (Handy et al., 2010; Kamargianni & Polydoropoulou, 2013; Mateo-Babiano et al., 2016; Wardman et al., 2007; Yannis et al., 2015) on the bikeshare demand is replete with the findings, declaring the utmost importance of bicycle paths in increasing the bicycle use. These modelling results are may be due to the misunderstanding of the variable or people (participants of the survey) are happy to ride bicycle on the footpaths or on roads along with the motorized traffic. According to (de Geus et al., 2014) segregated bicycle paths are the strongest motivators for Belgians to use bicycles. Therefore, former explanation for these unusual results seems more plausible.

The more bike parking spots there are, the greater the usage of bicycles and bike shares by the public. The results of regression analysis for the variable 'Bike parking at the destination' confirms this claim. The subject attribute is statistically significant and positively related to the probability of bikeshare use in all the models. This finding is in agreement with the conclusions of the research work (Buehler, 2012; Wardman et al., 2007; Casey-Marie Claude, 2014) of the past. These studies states that trip end facilities like parking do help in encouraging people to use bicycles.

'Rainfall' was statistically significant and negatively related to the probability of bike share use. To elaborate, in the rainier climates and regions, the task of encouraging people to use bicycle is daunting. This outcome confirms the research work already conducted by (Kim et al., 2012; Zanotto, 2014). Moreover, transport authorities and researchers possibly cannot do much to alleviate that kind of situation.

### 5.1.2. Socio-demographic and Attitudinal Variables

The descriptive analysis is clear that bicycle ownerships and public bikeshare memberships both are higher among females. This conclusion is in sync with assertion made by (Buck et al., 2013). However, it contradicts the findings made by (Campbell et al., 2016; de Geus et al., 2014). The former states that user demographics does not impact the bike choice at all. Similarly, latter maintains that in Belgium its men who possess and use bicycles more than women. Therefore, to put this confusion to rest a larger sample size of population from all corners of Belgium is needed.

'Age' is not significant in any of the model developed from both the datasets. However, descriptive analysis does reveal some valuable information like people from 25-44 years of age are members of bikeshare in larger number than any other group. This conclusion is somewhat similar to the outcome, drawn by (Fishman et al., 2015) stating people between the age of 18-34 are more likely to use bikeshare. However, when it comes to the ownership of bicycles, people in the age bracket 18-24 leads all other age groups.

There was not any effect of education level on the probability of bikeshare choice as concluded by the regression models. Campbell et al., 2016 shares this results in sort by stating user demographics does not impact bikeshare use at all. However, descriptive analysis does shed some light on the relationship between PBSS membership and bicycle ownership with the education level. The upshot is more educated one individual is, greater is the chance of his/her becoming a bikeshare member and less chances of owning a bicycle.

Two categories of occupation namely unemployed and students found to be statistically significant but only for the models based on complete dataset. However, the bikeshare choice had an inverse relation with students and positive relation with unemployed. It is owing the fact that students mostly fall under the age bracket of 18-24 and have own their own bicycles. This assertion is confirmed during the descriptive statistics. Moreover, unemployed people use cycle in larger number, may be because of less tariffs involved. Lastly, another pattern was observed during the descriptive analysis that unemployed people use bikeshare more for the last mile regardless of trip purpose. In contrast, students tend to use walk more in non-work trips than the work trips (going to educational institution).

There is a strong correlation exist between bicycle ownership and PBSS ridership (Zou, 2014). The modelling result for this variable ‘Bicycle Ownership’ confirms this relationship as it is significant in the database comprising of ‘students only’ observations. Moreover, research shows that this relationship is complementary in nature (Buck et al., 2013; Castillo-Manzano et al., 2015) as increase in one will aid in the growth of other. Lastly, ‘Driving License’ does not have any effect on the probability of bikeshare choice. It turns out statistically insignificant in all other models across the board. Although, 66% of people do have a driver license but owing to less car ownership among students, it is statistically insignificant in the regression analysis.

The only variable ‘PBSS as a solution to climate change’ among all the attitude related questions turns up significant in the regression analysis. The subject variable was categorized into three levels namely ‘Yes’, ‘No’ & ‘Maybe’. First value (Yes) was positively correlated but second (No) associated with the probability of people choosing bikeshare in all the six models. To elaborate, if more people think bike sharing is a solution towards climate change than more people will use bikeshare. In contrast, if more people are against this notion that they are less likely to use bikeshare.

Furthermore, descriptive analysis shows that 81% of people believe that one should maintain harmony with nature. It is certainly a good harbinger for the bikeshare growth and usage. Because, Yang & Long, 2016 argues that people will participate in public bicycle related activities more if they have greater awareness of environment. Lastly, the previous research (Handy et al., 2010; Kamargianni & Polydoropoulou, 2013; Zou, 2014) is confident in its conclusion that positive attitude towards cycling do go a long way in increasing the bikeshare use.

In the logistic regression analysis, there are eleven socio-demographic and attitudinal variables. These variables are also discussed in detail in the descriptive analysis. Though, only three (Employment status, Bicycle ownership and PBSS as a solution towards climate change) out of them were found to be statistically significant in the models. Looking further into this connection, one can say that the modelling results approves the conclusions made by the descriptive analytics regarding the three afore-mentioned variables.

## 5.2. Conclusions

Several conclusions have been drawn after conducting a thorough literature review on the bike sharing schemes. Moreover, several deductions have also been made based on the descriptive and logistic regression analysis on the collected data. These inferences are presented below:

1. Factors that impact or influence the use of bike sharing schemes are numerous but each bike sharing scheme has its own set of roadblocks, mainly dependent on the local land use, weather conditions, bicycle infrastructure and public perception of cycling (see section 2.2.4 for more details).
2. Positive impacts of bike sharing for an individual and communities are obvious and tangible.
3. Bike sharing acts as a substitute and complement to public transit simultaneously.
4. Literature review has revealed that bike sharing schemes are a cheap, convenient and eco-friendly alternative for the first/last mile trips.
5. Modern bike sharing schemes are the products of decades of experimentation and innovation.
6. Although bike sharing schemes are exploding all over the world in total but a huge number of them are also being closed owing to many reasons (see section 2.3.6. for details)
7. There are primarily three ways to integrate bicycles and public transit (see section 2.4.2 for details)
8. Pro-transit/rail bike sharing systems have very different tariff, bike hiring and returning systems as compare to typical public bike sharing schemes.
9. The number of factors influencing population to use or not use bikeshare is different in both the students only and complete datasets i.e. eight and nine respectively.
10. The whopping bicycle ownership and good attitude towards bicycling, are the good indicators of public willingness to adopt bikeshare.
11. Cost is one of the important factor in the public bicycle use as regression analysis demonstrate that greater the tariff, lesser the motivation to choose bikeshare.
12. Trip purpose does not have any clout on the people’s decision making regarding the bikeshare use.
13. People tend to prefer bikeshare over Taxi or Uber for last mile travel.
14. Strangely, the presence or absence of segregated bike paths does not have any impact on the bikeshare usage.
15. Bad weather (rain and low temperature) negatively impacts bicycle use or bikeshare usage.
16. Bicycle ownership and bicycle membership are complementary in nature. Therefore, growth in one leads to growth in another.
17. People with higher level of education, are more inclined to use bikeshare than the Bachelors and high schoolers.
18. Females own bicycles in greater percentage than men as per descriptive statistics.

19. The larger the distance to destination from the bikeshare station lesser the impetus to use bicycle for the public.
20. More parking spots at the destinations means greater probability of choosing bikeshare.

## 5.3. Recommendations

This research study agrees with the approach suggested by Handy et al., 2010 that to increase the bicycle use, authorities should work on individual, social and physical environment levels. It is also maintained that, individual attitude toward bicycling is most essential factor in increasing regular use of bikes. The regression results of this study correspond to this conclusion. Therefore, to change the attitude of people towards bicycling, promotional and awareness programs must be launched by the state-run or private organizations. Moreover, schools and colleges must be the special target of these campaigns because the analysis of this study suggest they are not using bike share in the same amount as the students with higher level of education.

Transport authorities must involve urban planners and vice versa in decision making regarding the density, size and accessibility issues of city or region concerned. Smaller and compact towns are conducive for the bicycle use because it reduces the distance to the destinations. Ergo, these professionals must work hand in glove to achieve the desirable urban form. Lastly, federal and local governments must invest in providing bicycle parking facilities in addition to subsidizing bikeshare tariffs, to keep the cost of using these bicycles low as possible.

## 5.4. Limitations and Future Research Directions

Majority of the respondents, to the survey for this research, were students (69%). Therefore, to avoid the results to get little biased. Two datasets were created out of the collected survey responses. One was based on students only observations and other one was based on original values. Therefore, future researchers must involve all the segments of Belgian society in the data collection phase. Moreover, mostly people from Flanders (Limburg) participated in the survey, clearly not a representative sample for the whole Belgium. Hence, new studies on this topic must reach out to all the regions of the country for most robust conclusions.

Future research work on the bike sharing in Belgium must also involve bikeshare members in large numbers as they are not fairly represented in this study. Finally, two research areas can be extensively explored further, first, the impact of ‘segregated bike lanes’ on the bikeshare choice and second, the significance of ‘trip purpose’ for the same. These variables are already part of this study but their results are opposite to the deluge of already conducted research work. Therefore, to confirm the results of these factors in the Belgian setting, conducting a thorough study on them would be highly beneficial.

# REFERENCES


- Transport Canada. (2011). Active Transportation in Canada: A resource and planning guide. Ottawa, ON: Government of Canada.
- Raine, K., Muhajarine, N., Spence, J., Neary, N., & Nykiforuk, C. (2012). Coming to consensus on policy to create supportive built environments and community design. Canadian Journal of Public Health, 103, S5–S8.
- Sheyda Saneinejad. (2010). Modelling the Impact of Weather Conditions on Active Transportation Travel Behaviour.Department of Civil Engineering, University of Toronto.
- Held, M. Schindler, J. Litman, T. (2016). Cycling and Active Mobility-Establishing a third pillar of Transport Policy, Cycling Futures: From Research into Practice (Chapter 10). Routledge, London & New York.
- OECD. (1997). Towards sustainable Transportation, The Vancouver Conference: OECD Proceedings.
- PASTA (2016). Pasta-Physical Activity Through Sustainable Transport Approaches. Available at http://www.pastaproject.eu/home/ [accessed: 29 November 2016]
- Gehl,J. (2010). Cities for People. Island Press.
- New Brunswick Department of Healthy and Inclusive Communities.(2014). New Brunswick's Wellness Strategy 2014-2021. Government of New Brunswick. Avaialble at [www2.gnb.ca/.../Wellness.../NewBrunswickWellnessStrategy2014-2021.pdf 27 November, 2016]
- European Union. (2016). Switch Project. Vienna. Available at http://media.wix.com/ugd/241361_bb66e3af93e9434793efd9332a77084b.pdf [Accessed on 28 November, 2016]
- Trapp, G., Giles-Corti, B., Christian, H., Bulsara, M., Timperio, A., McCormack, G., & Villanueva, K. (2011). On your bike! A cross-sectional study of the individual, social and environmental correlates of cycling to school. International Journal of Behavioral Nutrition and Physical Activity. Retrieved from http://www.ijbnpa.org/content/8/1/123
- Wanner, M., Gotschi, T., Martin-Diener, E., Kahlmeier, S., & Martin, B. W. (2012). Active transport, physical activity, and body weight in adults: A systematic review. American Journal of Preventive Medicine, 42(5), 493–502. doi:10.1016/j.amepre.2012.01.030
- Heesch, K. C., Giles-Corti, B., & Turrell, G. (2014). Cycling for transport and recreation: Associations with socio-economic position, environmental perceptions, and psychological disposition. Preventive Medicine, 63, 29–35.
- Boden, T.A. Marland, G and Andres, R.J. (2015). National CO2 emissions from fossil-fuel buring, cement manufacture and gas flaring. Carbon Dioxide Information Analysis Centre, US Department of Energy.
- Hallal, P.C., Andersen, L.B., Bull, F.C., Guthold, R., Haskell, W., Ekelund, U.( 2012). Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet 380, 247–257.
- Physical Activity Guidelines Advisory Committee. (2008). Physical Activity Guidelines Advisory Committee Report [accessed: http://www.health.gov/paguidelines/ report/pdf/committeereport.pdf 23 November, 2016].
- González-Gross, M., Meléndez, A. (2013). Sedentarism, active lifestyle and sport: impact on health and obesity prevention.
- Rosenberg DE, Sallis JF, Conway TL, Cain KL, McKenzie TL. (2006). Active transportation to school over 2 years in relation to weight status and physical activity.
- Voss C, Sandercock G. (2010). Aerobic fitness and mode of travel to school in English school children.
- David H. Freedman. (2015). How to Fix the Obesity Crisis. Scientific American. DOI: 10.1038/scientificamericanfood0615-52
- Physical Activity Guidelines Advisory Committee. (2008). Physical activity guidelines advisory committee Report. Washington, DC: U.S. Department of Health and Human Services.
- Litman, T. (2016). Evaluating non-motorized transportation benefits and costs. Available at: http://www.vtpi.org/nmt-tdm.pdf [Accessed on 29 November 2016]
- ABW (2014), Bicycling and Walking in the U.S.: Benchmarking Reports, Alliance for Biking & Walking (www.peoplepoweredmovement.org); at www.peoplepoweredmovement.org/benchmarking.
- Saunders, L., Green, J., Petticrew, M., Steinbach, R., & Roberts, H. (2013). What are the health benefits of active travel? A systematic review of trials and cohort studies. PLoS One, 8(8), e69912.
- SQW. (2007). Valuing the Benefits of Cycling: A Report to Cycling England. Department for Transport, UK. Available at http://webarchive.nationalarchives.gov.uk/20121107103953/http://dft.gov.uk/cyclingengland/ [Accessed on 28 November, 2016].
- Lawrence Frank, Andrew Devlin, Shana Johnstone and Josh van Loon. (2010). Neighborhood Design, Travel, and Health in Metro Vancouver: Using a Walkability Index. Active Transportation Collaboratory, University of British Columbia.
- CTE. (2008). Improved Methods For Assessing Social, Cultural, And Economic Effects Of Transportation Projects. National Cooperative Highway Research Program (NCHRP) and American Association of State Highway and Transportation Officials (AASHTO).
- Charles Komanoff and Cora Roelofs. (1993). The Environmental Benefits of Bicycling and Walking: National Bicycling and Walking Study No. 15, USDOT. Available at http://atfiles.org/files/pdf/BikePedBen.pdf [Accessed on 27 November, 2016].

- Guide to Community Preventive Services. (2009). Physical Activity. Available at http://www.thecommunityguide.org/pa/default.htm [Accessed on 29 November, 2016]
- Anable J, Gatersleben B. (2005). All Work and No Play: The role of instrumental and affective factors in work and leisure journeys by different travel modes. Transportation Research Part A: Policy and Practice..
- Pooley, C. G., Horton, D., Scheldeman, G., Tight, M., Jones, T., Chisholm, A., Jopson, A. (2011). Household Decision-Making for Everyday Travel: A Case Study of Walking and Cycling in Lancaster (UK). Journal of Transport Geography, 19(6), 1601-1607.
- Taylor, K. (2009). Utilitarian Cycling: Investigating Latent Demand in Christchurch, New Zealand. University of Canterbury.
- National Travel Survey. (2013). Statistical Release. Department of Transport. Available at http://www.cycle-helmets.com/uk-travel-survey-2012.pdf [Accessed on 30 November, 2016]
- Hankey, S., Lindsey, G., Wang, X., Borah, J., Hoff, K., Utecht, B., et al. (2012). Estimating use of non-motorized infrastructure: Models of bicycle and pedestrian traffic in Minneapolis, MN. Landscape and Urban Planning, 107, 307–316.
- Heinen, E., Maat, K., & van Wee, B. (2011). The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances. Transportation Research Part D, 16, 102–109. Preventive Medicine: An International Journal Devoted to Practice and Theory.
- Abiiro, G. A., Leppert, G., Mbera, G. B., Robyn, P. J., & De Allegri, M. (2014). Developing attributes and attribute-levels for a discrete choice experiment on micro health insurance in rural Malawi. BMC Health Services Research, 14, 235. https://doi.org/10.1186/1472-6963-14-23
- Bachand-Marleau, J. (2011). Innovations in Utilitarian Cycling: Analyzing Characteristics of Users and Factors Influencing Their Travel Behavior. MS thesis. McGill University, Montreal, Quebec, Canada. Retrieved from http://tram.mcgill.ca/Teaching/srp/documents/Julie.pdf
- Bachand-Marleau, J., Larsen, J., & El-Geneidy, A. (2011). Much-Anticipated Marriage of Cycling and Transit: How Will It Work? Transportation Research Record: Journal of the Transportation Research Board, (2247), 109–117.
- Bachand-Marleau, J., Lee, B., & El-Geneidy, A. (2012). Better understanding of factors influencing likelihood of using shared bicycle systems and frequency of use. Transportation Research Record: Journal of the Transportation Research Board, (2314), 66–71.
- Blue-bike. (n.d.). Retrieved October 25, 2016, from http://www.blue-bike.be/en
- Borgnat, P., Fleury, E., Robardet, C., & Scherrer, A. (2009). Spatial analysis of dynamic movements of Vélo'v, Lyon's shared bicycle program. In ECCS'09. Complex Systems Society. Retrieved from https://hal.inria.fr/ensl-00408150/
- Buehler, R. (2012). Determinants of bicycle commuting in the Washington, DC region: The role of bicycle parking, cyclist showers, and free car parking at work. Transportation Research Part D: Transport and Environment, 17(7), 525–531.
- Campbell, A. A., Cherry, C. R., Ryerson, M. S., & Yang, X. (2016). Factors influencing the choice of shared bicycles and shared electric bikes in Beijing. Transportation Research Part C: Emerging Technologies, 67, 399–414.
- Castillo-Manzano, J. I., Castro-Nuño, M., & López-Valpuesta, L. (2015). Analyzing the transition from a public bicycle system to bicycle ownership: A complex relationship. Transportation Research Part D: Transport and Environment, 38, 15–26.
- Caussade, S., de Dios Ortúzar, J., Rizzi, L. I., & Hensher, D. A. (2005). Assessing the influence of design dimensions on stated choice experiment estimates. Transportation Research Part B: Methodological, 39(7), 621–640.
- Cervero, R., Caldwell, B., & Cuellar, J. (2013). Bike-and-ride: build it and they will come. Journal of Public Transportation, 16(4), 5.
- Cervero, R., & Gorham, R. (1995). Commuting in transit versus automobile neighborhoods. Journal of the American Planning Association, 61(2), 210–225.
- Cheyne, C. M., Muhammad, I., Scott, M., & Tien, C. (2015). Barriers to Active Transport in Palmerston North. Retrieved from http://mro.massey.ac.nz/xmlui/bitstream/handle/10179/7532/Cheyne%20et%20al_%20(2015)_%20Barriers%20to%20Active%20Transport%20in%20Palmerston%20North_%20(MU-PNCC%20Living%20Lab).pdf?sequence=1
- Coast, J., & Horrocks, S. (2007). Developing attributes and levels for discrete choice experiments using qualitative methods. Journal of Health Services Research & Policy, 12(1), 25–30.
- Daddio, D. W. (2012). Maximizing Bicycle Sharing: an empirical analysis of capital bikeshare usage. University of North Carolina at Chapel Hill. Retrieved from http://rethinkcollegepark.net/blog/wp-content/uploads/2006/07/DaddioMP_Final-Draft.pdf
- de Geus, B., Degraeuwe, B., Vandenbulcke, G., Panis, L. I., Thomas, I., Aertsens, J., … Meeusen, R. (2014). Utilitarian cycling in Belgium: a cross-sectional study in a sample of regular cyclists. Journal of Physical Activity and Health, 11(5), 884–894.
- Easton, V. J., & McColl, J. H. (1997). Statistics glossary (Vol. 1). Steps. Retrieved from http://www.ipl.org/IPL/Display?key=res:lii-9677&layout=blank
- El-Assi, W., Mahmoud, M. S., & Habib, K. N. (n.d.). Effects of built environment and weather on bike sharing demand: a station level analysis of commercial bike sharing in Toronto. Transportation, 1–25.
- Fishman, E. (2014). Bikeshare: Barriers, facilitators and impacts on car use. Queensland University of Technology. Retrieved from http://eprints.qut.edu.au/78009

- Fishman, E., Washington, S., Haworth, N., & Watson, A. (2015). Factors influencing bike share membership: An analysis of Melbourne and Brisbane. Transportation Research Part A: Policy and Practice, 71, 17–30.
- Fjellstrom, K. (2010). Bus rapid transit in China. Built Environment, 36(3), 363–374.
- Hegger, R. (2007). Public transport and cycling: living apart or together? Public Transport International, 56(2). Retrieved from https://trid.trb.org/view.aspx?id=808957
- Hess, S., & Rose, J. M. (2009). Some lessons in stated choice survey design. In European Transport Conference (Vol. 2009). Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.678.5504&rep=rep1&type=pdf
- Imani, A. F., Eluru, N., El-Geneidy, A. M., Rabbat, M., & Haq, U. (2014). How land-use and urban form impact bicycle flows: Evidence from the bicycle-sharing system (bixi) in montreal. Retrieved from http://tram.mcgill.ca/Research/Publications/Bixi_transport_geography.pdf
- Ioakimidis, C. S., Rycerski, P., Koutra, S., & Genikomsakis, K. N. (n.d.). A University E-Bike Sharing System used as a Real-Time Monitoring emissions tool under a smart city concept. Retrieved from http://resized.info/wp-content/uploads/2017/03/2016-15.pdf
- Jäppinen, S., Toivonen, T., & Salonen, M. (2013). Modelling the potential effect of shared bicycles on public transport travel times in Greater Helsinki: An open data approach. Applied Geography, 43, 13–24.
- Johnson, F. R., Lancsar, E., Marshall, D., Kilambi, V., Mühlbacher, A., Regier, D. A., … Bridges, J. F. P. (2013). Constructing Experimental Designs for Discrete-Choice Experiments: Report of the ISPOR Conjoint Analysis Experimental Design Good Research Practices Task Force. Value in Health, 16(1), 3–13. https://doi.org/10.1016/j.jval.2012.08.2223
- Johnson, R. M., & Orme, B. K. (1996). How many questions should you ask in choice-based conjoint studies. In Art Forum, Beaver Creek. Retrieved from https://pdfs.semanticscholar.org/a6b5/d4fe2cf43b47db3e46e4974c05616ca2b93a.pdf
- Kamargianni, M., & Polydoropoulou, A. (2013). Hybrid choice model to investigate effects of teenagers' attitudes toward walking and cycling on mode choice behavior. Transportation Research Record: Journal of the Transportation Research Board, (2382), 151–161.
- Kim, D., Shin, H., Im, H., & Park, J. (2012). Factors influencing travel behaviors in bikesharing. In Transportation Research Board 91st Annual Meeting, Washington DC. Retrieved from http://nacto.org/wp-content/uploads/2012/02/Factors-Influencing-Travel-Behaviors-in-Bikesharing-Kim-et-al-12-1310.pdf
- Kløjgaard, M. E., Bech, M., & Søgaard, R. (2012). Designing a stated choice experiment: the value of a qualitative process. Journal of Choice Modelling, 5(2), 1–18.
- Krizek, K., & Stonebraker, E. (2010). Bicycling and transit: A marriage unrealized. Transportation Research Record: Journal of the Transportation Research Board, (2144), 161–167.
- Lancsar, E., & Louviere, J. (2006). Deleting 'irrational'responses from discrete choice experiments: a case of investigating or imposing preferences? Health Economics, 15(8), 797–811.
- Litman, T. (2013). Evaluating active transport benefits and costs. Victoria Transport Policy Institute. Victoria, BC: Victoria Transport Policy Institute. Retrieved from Http://Www. Vtpi. Org/Nmt-Tdm. Pdf. Retrieved from http://vtpi.org/nmt-tdm.pdf
- Louviere, J. J., Hensher, D. A., & Swait, J. D. (2000). Stated choice methods: analysis and applications. Cambridge University Press. Retrieved from https://www.google.com/books?hl=en&lr=&id=nk8bpTjutPQC&oi=fnd&pg=PR9&dq=Louviere,+Hensher+%26+Swait+2000&ots=Wz_hblhmqa&sig=y84JsEuuQOWi59p-Wq-1XjdkDKc
- Lyles, R. W., & Hummer, J. E. (2012). Effective experiment design and data analysis in transportation research (Vol. 727). Transportation Research Board. Retrieved from https://www.google.com/books?hl=en&lr=&id=xxtnVaPJ82YC&oi=fnd&pg=PP1&dq=Effective+Experiment+Design+and+Data+Analysis+in+++Transportation+Research&ots=XyPmJKJdsN&sig=nCVPoeRNdJTw6WCbzC2AihjKGSE
- Ma, T., Liu, C., & Erdoğan, S. (2015). Bicycle Sharing and Transit: Does Capital Bikeshare Affect Metrorail Ridership in Washington, DC? In Transportation Research Board 94th Annual Meeting. Retrieved from http://smartgrowth.umd.edu/assets/bikeshare_transit_for_parisws_v1.pdf
- Manaugh, K., Boisjoly, G., & El-Geneidy, A. (n.d.). Overcoming barriers to cycling: understanding frequency of cycling in a University setting and the factors preventing commuters from cycling on a regular basis. Transportation, 1–14.
- Martin, E. W., & Shaheen, S. A. (2014). Evaluating public transit modal shift dynamics in response to bikesharing: a tale of two US cities. Journal of Transport Geography, 41, 315–324.
- Mason, J., Fulton, L., & McDonald, Z. (2015). A Global High Shift Cycling Scenario: The Potential for Dramatically Increasing Bicycle and E-bike Use in Cities around the World, with Estimated Energy, CO2, and Cost Impacts. Retrieved from https://trid.trb.org/view.aspx?id=1375683
- Mateo-Babiano, I., Bean, R., Corcoran, J., & Pojani, D. (2016). How does our natural and built environment affect the use of bicycle sharing? Transportation Research Part A: Policy and Practice, 94, 295–307.
- Midgley, P. (2009). The role of smart bike-sharing systems in urban mobility. Journeys, 2, 23–31.
- Nikitas, A., Wallgren, P., & Rexfelt, O. (2015). The paradox of public acceptance of bike sharing in Gothenburg. Proc. Inst. Civ. Eng. Eng. Sustain. Retrieved from http://www.polisnetwork.eu/uploads/Modules/PublicDocuments/2015_the-paradox-of-public-acceptance-of-bike-sharing-in-gothenburg_nikitas_wallgren_rexfelt.pdf

- Ortúzar, J. de D., Iacobelli, A., & Valeze, C. (2000). Estimating Demand for a Cycle-Way Network. Transportation Research A, 34(5), 353–373.
- Ortúzar, J. de D., & Willumsen, L. G. (2011). Discrete choice models. Modelling Transport, Fourth Edition, 227–268.
- Parkes, S. D., Marsden, G., Shaheen, S. A., & Cohen, A. P. (2013). Understanding the diffusion of public bikesharing systems: evidence from Europe and North America. Journal of Transport Geography, 31, 94–103.
- Parkin, J., Wardman, M., & Page, M. (2008). Estimation of the determinants of bicycle mode share for the journey to work using census data. Transportation, 35(1), 93–109.
- Pucher, J., & Buehler, R. (2009). Integrating bicycling and public transport in North America. Journal of Public Transportation, 12(3), 5.
- Pucher, J., Dill, J., & Handy, S. (2010). Infrastructure, programs, and policies to increase bicycling: an international review. Preventive Medicine, 50, S106–S125.
- Ratcliffe, J., & Longworth, L. (2002). Investigating the structural reliability of a discrete choice experiment within health technology assessment. International Journal of Technology Assessment in Health Care, 18(01), 139–144.
- Richter, J., Friman, M., & Gärling, T. (2011). Soft transport policy measures: Gaps in knowledge. International Journal of Sustainable Transportation, 5(4), 199–215.
- Rissel, C. E. (2009). Active travel: a climate change mitigation strategy with co-benefits for health. New South Wales Public Health Bulletin, 20(2), 10–13.
- Sallis, J. F., Frank, L. D., Saelens, B. E., & Kraft, M. K. (2004). ACTIVE TRANSPORTATION AND PHYSICAL ACTIVITY: OPPORTUNITIES FOR COLLABORATION ON TRANSPORTATION AND PUBLIC HEALTH RESEARCH. Transportation Research Part A: Policy and Practice, 38(4). Retrieved from /view.aspx?id=700495
- Schoner, J., & Levinson, D. M. (2013). Which Station? Access Trips and Bike Share Route Choice. Retrieved from http://conservancy.umn.edu/handle/11299/179838
- Shaheen, S., Cohen, A., & Chung, M. (2009). North American carsharing: 10-year retrospective. Transportation Research Record: Journal of the Transportation Research Board, (2110), 35–44.
- Shaheen, S., Cohen, A., & Martin, E. (2013). Public bikesharing in North America: early operator understanding and emerging trends. Transportation Research Record: Journal of the Transportation Research Board, (2387), 83–92.
- Shaheen, S., & Guzman, S. (2011). Worldwide bikesharing. Access Magazine, 1(39). Retrieved from https://escholarship.org/uc/item/6f16b7sv.pdf
- Shaheen, S., Guzman, S., & Zhang, H. (2010). Bikesharing in Europe, the Americas, and Asia: past, present, and future. Transportation Research Record: Journal of the Transportation Research Board, (2143), 159–167.
- Shaheen, S., Zhang, H., Martin, E., & Guzman, S. (2011). China's Hangzhou public bicycle: understanding early adoption and behavioral response to bikesharing. Transportation Research Record: Journal of the Transportation Research Board, (2247), 33–41.
- Shmueli, G. (2010). To Explain or to Predict? Statistical Science, 25(3), 289–310. https://doi.org/10.1214/10-STS330
- Stinson, M., & Bhat, C. (2004). Frequency of bicycle commuting: internet-based survey analysis. Transportation Research Record: Journal of the Transportation Research Board, (1878), 122–130.
- Sustainable Transport Award cities: Guangzhou. (2011, January 13). Retrieved January 7, 2017, from https://www.itdp.org/sustainable-transport-award-cities-guangzhou/
- Tang, Y., Pan, H., & Shen, Q. (2011). Bike-sharing systems in Beijing, Shanghai, and Hangzhou and their impact on travel behavior. In Transportation Research Board 90th Annual Meeting. Retrieved from https://trid.trb.org/view.aspx?id=1093278
- Twaddle, H. A., & Gerike, R. (2011). Stated preference survey design and pre-test for valuing influencing factors for bicycle use. Retrieved from http://mediatum.ub.tum.de/doc/1130707/file.pdf
- Van den Broeck, J., Argeseanu Cunningham, S., Eeckels, R., & Herbst, K. (2005). Data Cleaning: Detecting, Diagnosing, and Editing Data Abnormalities. PLoS Medicine, 2(10). https://doi.org/10.1371/journal.pmed.0020267
- Vandenbulcke, G., Dujardin, C., Thomas, I., de Geus, B., Degraeuwe, B., Meeusen, R., & Panis, L. I. (2011). Cycle commuting in Belgium: spatial determinants and 're-cycling'strategies. Transportation Research Part A: Policy and Practice, 45(2), 118–137.
- Vandenbulcke, G., Thomas, I., & Panis, L. I. (2014). Predicting cycling accident risk in Brussels: a spatial case–control approach. Accident Analysis & Prevention, 62, 341–357.
- Verhetsel, A., Thomas, I., Van Hecke, E., & Beelen, M. (2007). Pendel in België. Deel I: de woon-en werkverplaatsingen. Retrieved from https://lirias.kuleuven.be/handle/123456789/143654
- Villwock-Witte, N., & van Grol, L. (2015). Case Study of Transit–Bicycle Integration: Openbaar Vervoer-fiets (Public Transport–Bike)(OV-Fiets). Transportation Research Record: Journal of the Transportation Research Board, (2534), 10–15.
- Wardman, M., Tight, M., & Page, M. (2007). Factors influencing the propensity to cycle to work. Transportation Research Part A: Policy and Practice, 41(4), 339–350.
- Willigers, J., & Van Wee, B. (2011). High-speed rail and office location choices. A stated choice experiment for the Netherlands. Journal of Transport Geography, 19(4), 745–754.
- Witlox, F., Derudder, B., & Van Acker, V. (2013). Transport geography in Belgium. Journal of Transport Geography, 29, 108–110.

- Wu, N., Zhao, S., & Zhang, Q. (2016). A study on the determinants of private car ownership in China: Findings from the panel data. Transportation Research Part A: Policy and Practice, 85, 186–195. https://doi.org/10.1016/j.tra.2016.01.012
- Yang, R., & Long, R. (2016). Analysis of the Influencing Factors of the Public Willingness to Participate in Public Bicycle Projects and Intervention Strategies—A Case Study of Jiangsu Province, China. Sustainability, 8(4), 349.
- Yannis, G., Papantoniou, P., Papadimitriou, E., & Tsolaki, A. (2015). Analysis of preferences for the use of a bicycling sharing system in Athens. In International Cycling Safety Conference. Retrieved from http://www.nrso.ntua.gr/geyannis/wp-content/uploads/geyannis-pc213.pdf
- Yin, J., Qian, L., & Singhapakdi, A. (2016). Sharing Sustainability: How Values and Ethics Matter in Consumers' Adoption of Public Bicycle-Sharing Scheme. Journal of Business Ethics, 1–20. https://doi.org/10.1007/s10551-016-3043-8
- Zanotto, M. (2014). Facilitators and barriers to public bike share adoption and success in a city with compulsory helmet legislation: A mixed-methods approach. Health Sciences: Faculty of Health Sciences. Retrieved from http://summit.sfu.ca/item/14458

- Beecham, R., & Wood, J. (2014). Characterising group-cycling journeys using interactive graphics. Transportation Research Part C: Emerging Technologies. doi:10.1016/j.trc.2014.03.007
- United Nations. (2011). Bicycle- sharing schemes: enhancing sustainable mobility in urban areas. Commission on Sustainable Development, Department of Economic and Social Affairs.
- Heinen, E., van Wee, B., & Maat, K. (2010). Commuting by bicycle: An overview of the literature. Transport Reviews, 30(1), 59–96. doi:10.1080/01441640903187001
- Peter Midgley. (2013). The bike-share report: Hard times and hope for the future. The City Fix, World Resources institute. Avaialble at http://thecityfix.com/blog/bike-share-report-hard-times-hope-for-future-peter-midgley/ [Accessed on 05 December, 2016]
- Casey-Marie Claude. (2014). Factors that Affect Bicycle Ridership: A Case Study of the B-Cycle Bike Share System in Austin, Texas.
- European Cyclists' Federation. (2015). A European Roadmap for cycling –ECF proposal. Available at: http://ecf.com/files/wp-content/uploads/150429_An-EU-roadmap-for-cycling_ECF-proposal.pdf [Accessed on 02 December, 2016]
- New York City Department of City Planning. (2009). Bike-Share Opportunities in New York City, New York.
- Transport Canada. (2009). Bike-Sharing Guide, T22-180/2009E
- Midgley, P. (2011). Bicycle-sharing schemes: enhancing sustainable mobility in urban areas. Commission on Sustainable Development Nineteenth Session, New York.
- Institute of transportation and development policy. (2013).The Bike-share planning guide. Retrieved from https://www.itdp.org/the-bike-share-planning-guide-2/
- Quay Communications Inc . (2008). TransLink Public Bike System Feasibility Study. Vancouver, Canada
- Meddin,R. DeMaio, P. (2016). The Bike-sharing World Map. Available at www.bikesharingmap.com [Accessed on 06 December, 2016]
- Corcoran, J.J., Li, T., 2014. Spatial analytical approaches in public bicycle sharing programs. J. Transp. Geogr. 41, 268–271.
- Meddin, R. (2015). The Bike-Sharing World Map. Available at: http://www.bikesharingmap.com> [Accessed November 1, 2015]
- Earth Policy Institute. (2013). Largest Bike-Sharing Programs Worldwide, August 2013. Available at: www.earth-policy.org/datacenter/xls/highlights40_2.xlsx [Accessed on 25 November, 2016]
- Victoria Transport Policy Institute. (2016). Public Bike Systems: Automated Bike rentals for short utilitarian trips. Retrieved from http://www.vtpi.org/tdm/tdm126.htm
- Bührmann. 2008. Bicycles as public-individual transport – European developments. Available at: http://docplayer.net/22521099-Bicycles-as-public-individual-transport-european-developments.html [Accessed on 03 December, 2016]
- Alexandros Nikitas. (2016). There are now more than 1,000 public bike hire schemes. Why are they so popular?
- Goodman, A., Green, J., & Woodcock, J. (2014). The role of bicycle sharing systems in normalizing the image of cycling: An observational study of London cyclists. Journal of Transport & Health, 1(1), 5–8.
- Fishman, E. (2014). Bikeshare: Barriers, facilitators and impacts on car use (PhD thesis by publication). Queensland University of Technology, Brisbane.
- Witte, A. and Dorby, P. (2009). Characteristics of Successful Public Bike Systems. Montreal, Canada.
- American Public Transportation Association. (2013). 2013 Public Transportation Fact Book. Washington, D.C.
- Queensland Transport. (2006).Cycling and public transport. Queens land Government. [Available at: http://www.tmr.qld.gov.au/-/media/Travelandtransport/Cycling/Bike-user-guide/Technical-information/C6_Cycling_and_public_transport.pdf?la=en accessed on 22 December, 2016]
- BiTiBi. (2016). 10 good Practices. [Available at http://www.bitibi.eu/dox/BiTiBi_10_Good_Practices_2016.pdf accessed on 24 December, 2016]
- Van Ooijen, B. and Li, S. (2013). China shows leadership in bike share and greenways. Sustainable Transport, 24(1): 26-28.

- European Union. (2009). European Best Practices in Bike Sharing Systems. Intelligent Energy Europe
- Vandenbulcke G, Thomas I, de Geus B, et al. Mapping bicycle use and the risk of accidents for commuters who cycle to work in Belgium. Transp Policy. 2009; 16(2):77–87. doi:10.1016/j.tranpol.2009.03.004
- Vandenbulcke G, Dujardin C, Thomas I, de Geus B, Degraeuwe B, Meeusen R, et al. Cycle commuting in Belgium: Spatial determinants and‘re-cycling’ strategies. Transport Res a-Pol. 2011; 45(2):118-37.
- belgium.be. (2017). A statistical overview of the Belgian population. Available at [http://www.belgium.be/en/about_belgium/country/Population accessed on 11 January 2017]
- Eltis. (2015).Blue-bike: Belgium's national bicycle sharing system. [Available at: http://www.eltis.org/discover/case-studies/blue-bike-belgiums-national-bicycle-sharing-system accessed on 12 November, 2016]
- BiTiBi. (2015).Lessons Learned from the Project Meeting in Ghent & Liège (Belgium).
- Blue Mobility. (2016a). Analysis of the Blue Bike system usage. Unpublished raw data
- Blue Mobility. (2016b). Awareness survey in Flanders and Wallonia, Belgium – June, 2016. Unpublished raw data
- Blue Mobility. (2016c). Blue-Bike user survey in Flanders, Belgium – June, 2016. Unpublished raw data
- Ipsos. (2015). Report: Blue Bike research. Unpublished raw data.
- Beroud, B., R Clavel., S Le Vine., 2010. Perspectives on the growing market for public bicycles focus on France and the United Kingdom. European Transport Conference, Glasgow, Scotland, 11th October, 2010.
- Porter, M E., M R Kramer., 2011. Creating shared value: rethinking capitalism. Harvard Business Review, 89(1/2), 62-77
- Hickman, L., 2010. London and Paris: a tale of two bike-hire schemes. The Guardian, Tuesday 20 July 2010. [ Available at http://www.theguardian.com/environment/2010/jul/20/london-bike-hire-schemeparis-velib accessed:04/01/2017].
- Louviere, JJ, Hensher, DA & Swait, JD 2000, Stated Choice Methods: Analysis and Application, Cambridge University Press, Cambridge
- ChoiceMetrics. (2014). Ngene 1.1.2 User Manual & Reference Guide: The Cutting Edge in Experimental Design.
- Bridges JFP, Hauber AB, Marshall D, et al. Conjoint analysis applications in health—a checklist: a report of the ISPOR Good Research Practices for Conjoint Analysis Task Force. Value Health 2011;14:403–13.
- Jayesh Patidar. (2014). Experimental research design. [Available at: https://cirt.gcu.edu/research/developmentresources/research_ready/experimental/design_types accessed on 12/03/2017]
- Obsurvey. (2014). Using Demographic Questions for In-depth Data Analysis. [Available at: http://obsurvey.com/blog/using-demographic-questions-for-indepth-data-analysis/ accessed on 05/04/2017]
- Checkmarket. (2016). The importance of socio-demographics in online surveys. [Available at https://www.checkmarket.com/blog/socio-demographics-online-surveys/ accessed on 04/05/2017]
- Flamm, M. (2004) Comprendre le choix modal – Les déterminants des pratiques modales et des représentations individuelles des moyens de transport, Thèse de doctorat, Ecole Polytechnique Fédérale de Lausanne.
- The national travel survey. (2015). Fact sheet about cycling in Denmark. [Available at: https://stateofgreen.com/files/download/1256 accessed on 12/05/2017]
- Qualtrics. (2017). Qualtrics. [Available at: https://www.crunchbase.com/organization/qualtrics#/entity accessed on 24/05/2017]
- Derek Fry. (2010). The Importance of good experimental design. [ Available at: ec.europa.eu/enlargement/taiex/dyn/create_speech.jsp?speechID=16863&key accessed on 11/05/2017]
- Eric Brown. (2016). Data Analytics-the importance of data preparation. [Available at: http://ericbrown.com/data-analytics-data-preparation.htm accessed on 04/05/2017].
- William Trochim. (2006). Data Preparation- Research Methods Knowledge Base 2nd Edition. [Available at: http://www.socialresearchmethods.net/kb/statprep.php Accessed 14/05/2017].
- Gardner MJ, Altman DG. (1994). Statistics with confidence. London: BMJ. 140 p.
- *Trochim, William M. K. (2006).* "Descriptive statistics". *Research Methods Knowledge Base*. [Available at: *http://www.socialresearchmethods.net/kb/statdesc.php accessed on 11/05/2017.*
- Vincent Granville. (2015). 24 uses of statistical modelling (part I). Data Science Central. [Available at: http://www.datasciencecentral.com/profiles/blogs/top-20-uses-of-statistical-modeling accessed on 16/05.2017]
- Rawlings, J. O., Pantula, S. G., & Dickey, D. A. (2006). Applied Regression Analysis: A Research Tool. Springer Science & Business Media
- Statistics Solutions. (2017). What is logistic regression? [Available at: http://www.statisticssolutions.com/what-is-logistic-regression/ accessed on 22/04/2017]
- Bursac, Z., Gauss, C. H., Williams, D. K., & Hosmer, D. W. (2008). Purposeful selection of variables in logistic regression. Source Code for Biology and Medicine, 3, 17. http://doi.org/10.1186/17510473-3-17.

# Appendix

## Appendix-I: Attribute Selection Questionnaire

### What factors would influence you to use a Public Bike sharing scheme?

1. **Distance of a Bike share station or dock from your residence or place or work**
   *Mark only one oval.*
   - Yes
   - No
   - Maybe

2. **Terrain of the area**
   *Mark only one oval.*
   - Yes
   - No
   - Maybe

3. **Availability of other modes of transport**
   *Mark only one oval.*
   - Yes
   - No
   - Maybe

4. **Your level of comfort**
   *Mark only one oval.*
   - Yes
   - No
   - Maybe

5. **Car ownership (e.g. if you own a car you might not want to use bicycle** *Mark only one oval.*
   - Yes
   - No
   - Maybe

6. **No waiting time**
*Mark only one oval.*

- Yes
- No
- Maybe

7. **Temperature of the day**
*Mark only one oval.*

- Yes
- No
- Maybe

8. **Forecast of Rainy or snowy weather**
*Mark only one oval.*

- Yes
- No
- Maybe

9. **Affordability**
*Mark only one oval.*

- Yes
- No
- Maybe

10. **Your Age**
*Mark only one oval.*

- Yes
- No
- Maybe

11. **Distance to your destination**
*Mark only one oval.*

- Yes
- No
- Maybe

12. **Proximity of Bike-share dock from City Centre**
*Mark only one oval.*

- Yes
- No
- Maybe

13. **Sensitivity towards nature and environment**
*Mark only one oval.*

- Yes
- No
- Maybe

14. **Travel Time**
*Mark only one oval.*

- Yes
- No
- Maybe

15. **Trip end facilities like showers at office or parking spots**
*Mark only one oval.*

- Yes
- No
- Maybe

16. **Bicycle infrastructure like designated bike lanes, pathways, parking etc.**
*Mark only one oval.*

- Yes
- No
- Maybe

17. **Any other factor please specify**

Powered by
Google Forms

# Appendix-II: Experimental Design Macro

```
/* Analytical Skills: Experimental Designs with SAS */

%LET PATH = C:\Users\Shahbaz\Dropbox\Fourth Semester\Thesis\Work\Survey Design\SAS;
libname Test "&PATH";

/* Make a fractional factorial design with 4 attributes, each at 2 levels */
%MKTEX(6**1 3**2 2**3,n=432, seed=1000)

proc print;
run;

/* Format and label the attributes */
proc format;
  value forma  1 = "0 Euro"
               2 = "1 Euro"
                       3 = "2 Euro"
               4 = "3 Euro"
               5 = "4 Euro"
               6 = "5 Euro";
  value formb  1 = "None"
               2 = "Half"
                       3 = "All";
  value formc  1 = "1 KM"
               2 = "3 KM"
                       3 = "5 KM";
  value formd  1 = "Not-Available"
               2 = "Available";
  value forme  1 = "Non-Work"
               2 = "Work";
  value formf  1 = "No"
               2 = "Yes";
run;
data Test.ChoiceDesign;
  set randomized;
  format X1 forma. X2 formb. X3 formc. X4 formd. X5 forme. X6 formf.;
  label X1 = 'Tariff' X2 = 'Segregated bike lanes/paths'
        X3 = 'Trip Distance' X4 = 'Bike parking at the destination'
        X5 = 'Trip Purpose' X6 = 'Rainfall';
run;

OPTIONS ORIENTATION = PORTRAIT;
ODS RTF file = "&PATH\WZ6_design_mktex.rtf";
title "Final full factorial design with MKTEX";
proc print label;
  var X1 X2 X3 X4 X5 X6;
  id set;
  by set;
run;
title;
title;
ODS RTF CLOSE;

/* Export design to txt */
PROC EXPORT DATA= Test.ChoiceDesign
            OUTFILE= "&PATH\design_mktex.txt"
            DBMS=DLM REPLACE;
     DELIMITER='3B'x;
     PUTNAMES=YES;
RUN;
```

# Appendix-III: Questionnaire on Bikesharing

**Factors affecting the user's preferences to choose public bike sharing schemes for the last mile travel in Belgium**

Q1 Name of the respondent

Q2 Gender

- ❍ Male
- ❍ Female

Q3 Age

- ❍ Under 18
- ❍ 18 - 24
- ❍ 25 - 44
- ❍ 45 - 64
- ❍ 65 or older

Q4 Level of Education

- ❍ Less than high school
- ❍ High school graduate
- ❍ Vocational Training
- ❍ 2-year degree/Bachelors
- ❍ Professional degree/Masters
- ❍ Doctorate
- ❍ Other, please specify ____________________

Q5 Employment Status

- ❍ Employed full time
- ❍ Employed part time
- ❍ Self-employed
- ❍ Unemployed
- ❍ Retired
- ❍ Student
- ❍ Other, please specify ____________________

Q6 Average Monthly Income (in Euro)

______________________________________________________

Q7 City/Town of residence?

______________________________________________________________

Q8 Do you have a "Driving License"?

- ❍ Yes
- ❍ No

Q9 Do you own a bicycle?

- ❍ Yes
- ❍ No

Q10 How often you use your bicycle?

- ❍ Daily
- ❍ 2-3 times a week
- ❍ Few times a month
- ❍ Never
- ❍ If other, please specify ____________________

Q11 While considering a mode of transportation, which factors among the following you take into consideration? (Note: You can select max two options)

- ❑ Comfort
- ❑ Safety
- ❑ Environment
- ❑ Flexibility and Freedom
- ❑ Cost
- ❑ If other, please specify ____________________

Q12 Have you heard about the Public Bike sharing Scheme?

- ❍ Yes
- ❍ No

Q13 Are you a member of Public Bike sharing Scheme?

- ❍ Yes
- ❍ No

Q14 Which Transport mode you are using to reach the "Public-Bike" station(s)?

- ❑ Train
- ❑ Bus/Tram
- ❑ Taxi
- ❑ Uber/Carsharing
- ❑ Walk
- ❑ If other, Please specify ____________________

Q15 How often do you use Blue Bike?

- ❍ Daily
- ❍ 2-3 times a week
- ❍ Few times a month
- ❍ Never
- ❍ If other, please specify ____________________

Q16 Which factor(s) influenced you the most to become a member or use Public Bike Scheme? (Note: You can select max two options)

- ❑ Reduced Travel Time
- ❑ Personal health
- ❑ Money Savings
- ❑ Environment
- ❑ Any other, please specify ____________________

Q17 What is/are the purpose(s) of using Public Bike?

- ❑ Recreational trip
- ❑ Shopping journey
- ❑ Business/meeting trip
- ❑ Employment/work related trip
- ❑ Any other, please specify ____________________

Q18 Which Transport mode you were more frequently using before "Public Bike" for the same journey?

- ❍ Bus/Tram
- ❍ Taxi
- ❍ Uber/Carshare
- ❍ Walk
- ❍ If other, please specify ____________________

Q19 What are the characteristics of a trip made through the mode selected above?

| | Good | Neither good nor bad | Bad |
|---|---|---|---|
| Travel time (min) | ❍ | ❍ | ❍ |
| Travel Cost (Euro) | ❍ | ❍ | ❍ |
| Level of Comfort | ❍ | ❍ | ❍ |

Q20 How do you find Blue Bike in comparison to other modes?

- ❍ Much better
- ❍ Somewhat better
- ❍ About the same
- ❍ Somewhat worse
- ❍ Much worse

Q21 Please provide suggestion(s) to improve the Blue Bike scheme.

______________________________________________________________________________________________
____________________________________________________________

Q22 Are you a member of any other Bike sharing scheme in Belgium?

- ❍ Villo-Brussels
- ❍ Velo-Antwerp
- ❍ Other, please specify ____________________
- ❍ None

Q23 What is the purpose of using this Bike sharing scheme?

- ❍ Shopping trip
- ❍ Recreation trip
- ❍ Casual meeting trip
- ❍ Work related trip
- ❍ Other, please specify ____________________

Q24 Which transport mode you most often use for the daily commute to work?

- ❍ Private Car
- ❍ Carsharing
- ❍ Train
- ❍ Bus
- ❍ Bicycle
- ❍ Other, please specify ____________________

Q25 Which transport mode you are currently using to complete the last part of your work related journey?

- ❍ Walking
- ❍ Cycling
- ❍ Bus/Tram
- ❍ Uber/Carsharing
- ❍ Taxi
- ❍ Other, Please specify ____________________

Q26 Which transport mode you most like to use for the non-work-related journeys?

- Private Car
- Uber/Carsharing
- Train
- Bus/Tram
- Other, Please Specify ____________________

Q27 Which transport mode you are currently using to complete the last part of your non-work related journey?

- Walking
- Cycling
- Bus/Tram
- Uber/Carsharing
- Taxi
- Other, Please specify ____________________

Q28

Kindly state would you select Blue-Bike in real life situation, keeping in view the information provided below:

| VARIABLES | VALUES |
|---|---|
| Tariff/24 h | 0 Euro |
| Availability of other modes | Taxi/Uber |
| Temperature | 20°C |
| Free car parking at the destination | Not-Available |
| Trip Purpose | Work |
| Car Ownership | No |

- Yes
- No

Q29

Kindly state would you select Blue-Bike in real life situation, keeping in view the information provided below:

| VARIABLES | VALUES |
|---|---|
| Tariff/24 h | 3 Euro |
| Availability of other modes | Taxi/Uber |
| Temperature | 0°C |
| Free car parking at the destination | Available |
| Trip Purpose | Work |
| Car Ownership | Yes |

- Yes
- No

Q30

Kindly state would you select Blue-Bike in real life situation, keeping in view the information provided below:

| VARIABLES | VALUES |
|---|---|
| Tariff/24 h | 3 Euro |
| Availability of other modes | Bus/Tram |
| Temperature | 10°C |
| Free car parking at the destination | Available |
| Trip Purpose | Non-Work |
| Car Ownership | No |

- Yes
- No

Q31

Kindly state would you select Blue-Bike in real life situation, keeping in view the information provided below:

| VARIABLES | VALUES |
|---|---|
| Tariff/24 h | 4 Euro |
| Availability of other modes | Bus/Tram |
| Temperature | 10°C |
| Free car parking at the destination | Available |
| Trip Purpose | Non-Work |
| Car Ownership | No |

- Yes
- No

Q32

Kindly state would you select Blue-Bike in real life situation, keeping in view the information provided below:

| VARIABLES | VALUES |
|---|---|
| Tariff/24 h | 4 Euro |
| Availability of other modes | Walk |
| Temperature | 0°C |
| Free car parking at the destination | Available |
| Trip Purpose | Non-Work |
| Car Ownership | No |

- Yes
- No

Q33

Kindly state would you select Blue-Bike in real life situation, keeping in view the information provided below:

| VARIABLES | VALUES |
|---|---|
| Tariff/24 h | 0 Euro |
| Availability of other modes | Walk |
| Temperature | 10°C |
| Free car parking at the destination | Available |
| Trip Purpose | Non-Work |
| Car Ownership | No |

- Yes
- No

Q34

Kindly state would you select Blue-Bike in real life situation, keeping in view the information provided below:

| VARIABLES | VALUES |
|---|---|
| Tariff/24 h | 2 Euro |
| Availability of other modes | Walk |
| Temperature | 10°C |
| Free car parking at the destination | Available |
| Trip Purpose | Work |
| Car Ownership | No |

- Yes
- No

Q35

Kindly state would you select Blue-Bike in real life situation, keeping in view the information provided below:

| VARIABLES | VALUES |
|---|---|
| Tariff/24 h | 5 Euro |
| Availability of other modes | Walk |
| Temperature | 10°C |
| Free car parking at the destination | Available |
| Trip Purpose | Work |
| Car Ownership | No |

- Yes
- No

Q36

Kindly state would you select Blue-Bike in real life situation, keeping in view the information provided below:

| VARIABLES | VALUES |
|---|---|
| Tariff/24 h | 3 Euro |
| Availability of other modes | Bus/Tram |
| Temperature | 0°C |
| Free car parking at the destination | Available |
| Trip Purpose | Non-Work |
| Car Ownership | No |

- Yes
- No

Q37 Public Bicycles (i.e. Blue Bike) are one of the solutions towards Climate Change?

- Yes
- Maybe
- No

Q38 We should work hard for the goals of the group, even if it does not result in personal recognition

- Agree
- Indifferent
- Disagree

Q39 Happiness can be purchased with money

- Agree
- Indifferent
- Disagree

Q40 We should maintain harmony with nature

- Agree
- Indifferent
- Disagree

Q41 Using a public bicycle may cause certain personal inconveniences

- Yes
- Maybe
- No

# Appendix-IV: Modelling results (Complete dataset)

## Model One: Stated Preference variables

**The LOGISTIC Procedure**

| Model Information | |
|---|---|
| **Data Set** | SURVEY.BIKESHAREFINAL |
| **Response Variable** | Choice |
| **Number of Response Levels** | 2 |
| **Model** | binary logit |
| **Optimization Technique** | Fisher's scoring |

| | |
|---|---|
| **Number of Observations Read** | 1071 |
| **Number of Observations Used** | 1071 |

| Response Profile | | |
|---|---|---|
| **Ordered Value** | **Choice** | **Total Frequency** |
| 1 | 1 | 467 |
| 2 | 2 | 604 |

**Probability modeled is Choice=1.**

| Class Level Information | | | |
|---|---|---|---|
| **Class** | **Value** | **Design Variables** | |
| **Temperature** | 1 | 1 | 0 |
| | 2 | -1 | -1 |
| | 3 | 0 | 1 |
| **Car Ownership** | 0 | -1 | |
| | 1 | 1 | |
| **Trip_Distance** | 0 | -1 | |
| | 1 | 1 | |
| **Availability_of_other_modes** | 0 | -1 | |
| | 1 | 1 | |
| **Bike_parking_atthe_destination** | 0 | -1 | |
| | 1 | 1 | |
| **Rainfall** | 0 | -1 | |
| | 1 | 1 | |

| Model Convergence Status |
|---|
| Convergence criterion (GCONV=1E-8) satisfied. |

| Model Fit Statistics | | |
|---|---|---|
| Criterion | Intercept Only | Intercept and Covariates |
| AIC | 1469.148 | 1280.381 |
| SC | 1474.125 | 1325.168 |
| -2 Log L | 1467.148 | 1262.381 |

| Testing Global Null Hypothesis: BETA=0 | | | |
|---|---|---|---|
| Test | Chi-Square | DF | Pr > ChiSq |
| Likelihood Ratio | 204.7673 | 8 | <.0001 |
| Score | 185.8201 | 8 | <.0001 |
| Wald | 157.5918 | 8 | <.0001 |

| Type 3 Analysis of Effects | | | |
|---|---|---|---|
| Effect | DF | Wald Chi-Square | Pr > ChiSq |
| Tariff | 1 | 101.4328 | <.0001 |
| Car Ownership | 1 | 6.3882 | 0.0115 |
| Temperature | 2 | 8.7070 | 0.0129 |
| Trip_Distance | 1 | 18.5266 | <.0001 |
| Availability_of_other_m | 1 | 7.6016 | 0.0058 |
| Bike_parking_atthe_d | 1 | 11.6824 | 0.0006 |
| Rainfall | 1 | 43.6098 | <.0001 |

| Analysis of Maximum Likelihood Estimates | | | | | | |
|---|---|---|---|---|---|---|
| Parameter | | DF | Estimate | Standard Error | Wald Chi-Square | Pr > ChiSq |
| Intercept | | 1 | 0.1705 | 0.2022 | 0.7114 | 0.3990 |
| Tariff | | 1 | -0.4333 | 0.0430 | 101.4328 | <.0001 |
| Car Ownership | 1 | 1 | -0.2231 | 0.0883 | 6.3882 | 0.0115 |
| Temperature | 1 | 1 | -0.3721 | 0.1288 | 8.3403 | 0.0039 |
| Temperature | 3 | 1 | 0.2740 | 0.1266 | 4.6833 | 0.0305 |
| Trip_Distance | 1 | 1 | -0.4633 | 0.1076 | 18.5266 | <.0001 |
| Availability_of_other_m | 1 | 1 | 0.2423 | 0.0879 | 7.6016 | 0.0058 |
| Bike_parking_atthe_d | 1 | 1 | 0.3216 | 0.0941 | 11.6824 | 0.0006 |
| Rainfall | 1 | 1 | -0.6310 | 0.0956 | 43.6098 | <.0001 |

| Odds Ratio Estimates | | | |
|---|---|---|---|
| **Effect** | **Point Estimate** | **95% Wald Confidence Limits** | |
| **Tariff** | 0.648 | 0.596 | 0.705 |
| **Car Ownership 1 vs 0** | 0.640 | 0.453 | 0.905 |
| **Temperature 1 vs 2** | 0.625 | 0.413 | 0.946 |
| **Temperature 3 vs 2** | 1.192 | 0.794 | 1.790 |
| **Trip_Distance 1 vs 0** | 0.396 | 0.260 | 0.604 |
| **Availability_of_other_modes 1** | 1.624 | 1.150 | 2.292 |
| **Bike_parking_atthe_d 1 vs 0** | 1.903 | 1.316 | 2.751 |
| **Rainfall 1 vs 0** | 0.283 | 0.195 | 0.412 |

| Association of Predicted Probabilities and Observed Responses | | | |
|---|---|---|---|
| **Percent Concordant** | 74.4 | **Somers' D** | 0.495 |
| **Percent Discordant** | 24.8 | **Gamma** | 0.500 |
| **Percent Tied** | 0.8 | **Tau-a** | 0.244 |
| **Pairs** | 282068 | **c** | 0.748 |

## Model Two: Stated Preference and Socio-demographic variables

**The LOGISTIC Procedure**

| Model Information | |
|---|---|
| **Data Set** | SURVEY.BIKESHAREFINAL |
| **Response Variable** | Choice |
| **Number of Response Levels** | 2 |
| **Model** | binary logit |
| **Optimization Technique** | Fisher's scoring |

| | |
|---|---|
| **Number of Observations Read** | 1071 |
| **Number of Observations Used** | 1071 |

| Response Profile | | |
|---|---|---|
| **Ordered Value** | **Choice** | **Total Frequency** |
| **1** | 1 | 467 |
| **2** | 2 | 604 |

**Probability modeled is Choice=1.**

| Class Level Information | | | |
|---|---|---|---|
| **Class** | **Value** | **Design Variables** | |
| **Temperature** | 1 | 1 | 0 |
| | 2 | -1 | -1 |
| | 3 | 0 | 1 |
| **Car Ownership** | 0 | -1 | |
| | 1 | 1 | |
| **Trip_Distance** | 0 | -1 | |
| | 1 | 1 | |
| **Availability_of_other_modes** | 0 | -1 | |
| | 1 | 1 | |
| **Bike_parking_atthe_destination** | 0 | -1 | |
| | 1 | 1 | |
| **Rainfall** | 0 | -1 | |
| | 1 | 1 | |
| **Employment Status** | 1 | -1 | -1 |
| | 2 | 1 | 0 |
| | 3 | 0 | 1 |

| Model Convergence Status |
|---|
| Convergence criterion (GCONV=1E-8) satisfied. |

| Model Fit Statistics | | |
|---|---|---|
| Criterion | Intercept Only | Intercept and Covariates |
| AIC | 1469.148 | 1271.628 |
| SC | 1474.125 | 1326.368 |
| -2 Log L | 1467.148 | 1249.628 |

| Testing Global Null Hypothesis: BETA=0 | | | |
|---|---|---|---|
| Test | Chi-Square | DF | Pr > ChiSq |
| Likelihood Ratio | 217.5204 | 10 | <.0001 |
| Score | 195.5907 | 10 | <.0001 |
| Wald | 163.9006 | 10 | <.0001 |

| Type 3 Analysis of Effects | | | |
|---|---|---|---|
| Effect | DF | Wald Chi-Square | Pr > ChiSq |
| Tariff | 1 | 103.1121 | <.0001 |
| Car Ownership | 1 | 5.7387 | 0.0166 |
| Temperature | 2 | 7.8764 | 0.0195 |
| Trip_Distance | 1 | 21.3865 | <.0001 |
| Availability_of_othe | 1 | 7.4420 | 0.0064 |
| Bike_parking_atthe_d | 1 | 13.2382 | 0.0003 |
| Rainfall | 1 | 45.0679 | <.0001 |
| Employment Status | 2 | 12.6012 | 0.0018 |

| Analysis of Maximum Likelihood Estimates | | | | | | |
|---|---|---|---|---|---|---|
| Parameter | | DF | Estimate | Standard Error | Wald Chi-Square | Pr > ChiSq |
| Intercept | | 1 | 0.4025 | 0.2170 | 3.4390 | 0.0637 |
| Tariff | | 1 | -0.4412 | 0.0434 | 103.1121 | <.0001 |
| Car_Ownership | 1 | 1 | -0.2127 | 0.0888 | 5.7387 | 0.0166 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Temperature** | 1 | 1 | -0.3522 | 0.1295 | 7.3903 | 0.0066 |
| **Temperature** | 3 | 1 | 0.2711 | 0.1269 | 4.5644 | 0.0326 |
| **Trip_Distance** | 1 | 1 | -0.5076 | 0.1098 | 21.3865 | <.0001 |
| **Availability_of_other_m** | 1 | 1 | 0.2413 | 0.0884 | 7.4420 | 0.0064 |
| **Bike_parking_atthe_d** | 1 | 1 | 0.3468 | 0.0953 | 13.2382 | 0.0003 |
| **Rainfall** | 1 | 1 | -0.6498 | 0.0968 | 45.0679 | <.0001 |
| **Employment Status** | 2 | 1 | 0.3660 | 0.1941 | 3.5544 | 0.0594 |
| **Employment Status** | 3 | 1 | -0.4113 | 0.1203 | 11.6889 | 0.0006 |

**Odds Ratio Estimates**

| Effect | Point Estimate | 95% Wald Confidence Limits | |
|---|---|---|---|
| **Tariff** | 0.643 | 0.591 | 0.700 |
| **Car Ownership 1 vs 0** | 0.654 | 0.461 | 0.926 |
| **Temperature 1 vs 2** | 0.648 | 0.427 | 0.984 |
| **Temperature 3 vs 2** | 1.209 | 0.804 | 1.818 |
| **Trip_Distance 1 vs 0** | 0.362 | 0.236 | 0.557 |
| **Availability_of_other_modes 1** | 1.620 | 1.146 | 2.291 |
| **Bike_parking_atthe_d 1 vs 0** | 2.001 | 1.377 | 2.908 |
| **Rainfall 1 vs 0** | 0.273 | 0.187 | 0.398 |
| **Employment Status 2 vs 1** | 1.378 | 0.750 | 2.530 |
| **Employment Status 3 vs 1** | 0.633 | 0.460 | 0.871 |

**Association of Predicted Probabilities and Observed Responses**

| | | | |
|---|---|---|---|
| **Percent Concordant** | 75.3 | **Somers' D** | 0.511 |
| **Percent Discordant** | 24.2 | **Gamma** | 0.513 |
| **Percent Tied** | 0.4 | **Tau-a** | 0.252 |
| **Pairs** | 282068 | **c** | 0.756 |

## Model Three: Stated Preference, Socio-demographic and Attitude variables

**The LOGISTIC Procedure**

| Model Information | |
|---|---|
| **Data Set** | SURVEY.BIKESHAREFINAL |
| **Response Variable** | Choice |
| **Number of Response Levels** | 2 |
| **Model** | binary logit |
| **Optimization Technique** | Fisher's scoring |

| | |
|---|---|
| **Number of Observations Read** | 1071 |
| **Number of Observations Used** | 1071 |

| Response Profile | | |
|---|---|---|
| **Ordered Value** | **Choice** | **Total Frequency** |
| 1 | 1 | 467 |
| 2 | 2 | 604 |

**Probability modeled is Choice=1.**

| Class Level Information | | | |
|---|---|---|---|
| **Class** | **Value** | **Design Variables** | |
| **Temperature** | 1 | 1 | 0 |
| | 2 | -1 | -1 |
| | 3 | 0 | 1 |
| **Car_Ownership** | 0 | -1 | |
| | 1 | 1 | |
| **Trip_Distance** | 0 | -1 | |
| | 1 | 1 | |
| **Availability_of_other_modes** | 0 | -1 | |
| | 1 | 1 | |
| **Bike_parking_atthe_destination** | 0 | -1 | |
| | 1 | 1 | |
| **Rainfall** | 0 | -1 | |
| | 1 | 1 | |
| **Employment_Status** | 1 | -1 | -1 |
| | 2 | 1 | 0 |
| | 3 | 0 | 1 |
| **PBSS_for_Climatechange** | 1 | 1 | 0 |
| | 2 | -1 | -1 |
| | 3 | 0 | 1 |

| Model Convergence Status |
|---|
| Convergence criterion (GCONV=1E-8) satisfied. |

| Model Fit Statistics | | |
|---|---|---|
| Criterion | Intercept Only | Intercept and Covariates |
| AIC | 1469.148 | 1258.148 |
| SC | 1474.125 | 1322.840 |
| -2 Log L | 1467.148 | 1232.148 |

| Testing Global Null Hypothesis: BETA=0 | | | |
|---|---|---|---|
| Test | Chi-Square | DF | Pr > ChiSq |
| Likelihood Ratio | 235.0006 | 12 | <.0001 |
| Score | 210.4706 | 12 | <.0001 |
| Wald | 174.3397 | 12 | <.0001 |

| Type 3 Analysis of Effects | | | |
|---|---|---|---|
| Effect | DF | Wald Chi-Square | Pr > ChiSq |
| Tariff | 1 | 103.4956 | <.0001 |
| Car_Ownership | 1 | 5.4746 | 0.0193 |
| Temperature | 2 | 7.8554 | 0.0197 |
| Trip_Distance | 1 | 20.8032 | <.0001 |
| Availability_of_othe | 1 | 8.0488 | 0.0046 |
| Bike_parking_atthe_d | 1 | 13.6112 | 0.0002 |
| Rainfall | 1 | 46.1313 | <.0001 |
| Employment_Status | 2 | 9.4476 | 0.0089 |
| PBSS_for_Climatechan | 2 | 17.0415 | 0.0002 |

| Analysis of Maximum Likelihood Estimates | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |

| Parameter | | DF | Estimate | Standard Error | Wald Chi-Square | Pr > ChiSq |
|---|---|---|---|---|---|---|
| Intercept | | 1 | 0.1774 | 0.2303 | 0.5933 | 0.4412 |
| Tariff | | 1 | -0.4477 | 0.0440 | 103.4956 | <.0001 |
| Car_Ownership | 1 | 1 | -0.2096 | 0.0896 | 5.4746 | 0.0193 |
| Temperature | 1 | 1 | -0.3629 | 0.1312 | 7.6551 | 0.0057 |
| Temperature | 3 | 1 | 0.2500 | 0.1279 | 3.8203 | 0.0506 |
| Trip_Distance | 1 | 1 | -0.5036 | 0.1104 | 20.8032 | <.0001 |
| Availability_of_othe | 1 | 1 | 0.2532 | 0.0892 | 8.0488 | 0.0046 |
| Bike_parking_atthe_d | 1 | 1 | 0.3545 | 0.0961 | 13.6112 | 0.0002 |
| Rainfall | 1 | 1 | -0.6648 | 0.0979 | 46.1313 | <.0001 |
| Employment_Status | 2 | 1 | 0.3516 | 0.1957 | 3.2271 | 0.0724 |
| Employment_Status | 3 | 1 | -0.3665 | 0.1218 | 9.0543 | 0.0026 |
| PBSS_for_Climatechan | 1 | 1 | 0.4721 | 0.1160 | 16.5747 | <.0001 |
| PBSS_for_Climatechan | 3 | 1 | -0.5029 | 0.1819 | 7.6424 | 0.0057 |

| Odds Ratio Estimates | | | |
|---|---|---|---|
| Effect | Point Estimate | 95% Wald Confidence Limits | |
| Tariff | 0.639 | 0.586 | 0.697 |
| Car_Ownership 1 vs 0 | 0.658 | 0.463 | 0.934 |
| Temperature 1 vs 2 | 0.621 | 0.407 | 0.949 |
| Temperature 3 vs 2 | 1.147 | 0.760 | 1.731 |
| Trip_Distance 1 vs 0 | 0.365 | 0.237 | 0.563 |
| Availability_of_othe 1 vs 0 | 1.659 | 1.169 | 2.354 |
| Bike_parking_atthe_d 1 vs 0 | 2.032 | 1.394 | 2.962 |
| Rainfall 1 vs 0 | 0.265 | 0.180 | 0.388 |
| Employment_Status 2 vs 1 | 1.400 | 0.759 | 2.585 |
| Employment_Status 3 vs 1 | 0.683 | 0.494 | 0.944 |
| PBSS_for_Climatechan 1 vs 2 | 1.555 | 1.172 | 2.062 |
| PBSS_for_Climatechan 3 vs 2 | 0.586 | 0.337 | 1.020 |

| Association of Predicted Probabilities and Observed Responses | | | |
|---|---|---|---|
| Percent Concordant | 76.2 | Somers' D | 0.525 |
| Percent Discordant | 23.6 | Gamma | 0.526 |
| Percent Tied | 0.2 | Tau-a | 0.259 |
| Pairs | 282068 | c | 0.763 |

# Appendix-V: Questionnaire on (Students only dataset)

## Model One: Stated Preference variables

**The LOGISTIC Procedure**

| Model Information | |
|---|---|
| Data Set | SURVEY.BIKESHAREFINAL |
| Response Variable | Choice |
| Number of Response Levels | 2 |
| Model | binary logit |
| Optimization Technique | Fisher's scoring |

| | |
|---|---|
| Number of Observations Read | 738 |
| Number of Observations Used | 738 |

| Response Profile | | |
|---|---|---|
| Ordered Value | Choice | Total Frequency |
| 1 | 1 | 307 |
| 2 | 2 | 431 |

**Probability modeled is Choice=1.**

| Class Level Information | | | |
|---|---|---|---|
| Class | Value | Design Variables | |
| Temperature | 1 | 1 | 0 |
| | 2 | -1 | -1 |
| | 3 | 0 | 1 |
| Trip_Distance | 0 | -1 | |
| | 1 | 1 | |
| Availability_of_other_modes | 0 | -1 | |
| | 1 | 1 | |
| Bike_parking_atthe_destination | 0 | -1 | |
| | 1 | 1 | |
| Rainfall | 0 | -1 | |
| | 1 | 1 | |

| Model Convergence Status |
|---|
| Convergence criterion (GCONV=1E-8) satisfied. |

| Model Fit Statistics | | |
|---|---|---|
| Criterion | Intercept Only | Intercept and Covariates |
| AIC | 1004.151 | 864.513 |
| SC | 1008.755 | 901.345 |
| -2 Log L | 1002.151 | 848.513 |

| Testing Global Null Hypothesis: BETA=0 | | | |
|---|---|---|---|
| Test | Chi-Square | DF | Pr > ChiSq |
| Likelihood Ratio | 153.6382 | 7 | <.0001 |
| Score | 138.5896 | 7 | <.0001 |
| Wald | 115.9495 | 7 | <.0001 |

| Type 3 Analysis of Effects | | | |
|---|---|---|---|
| Effect | DF | Wald Chi-Square | Pr > ChiSq |
| Tariff | 1 | 80.8157 | <.0001 |
| Temperature | 2 | 7.5202 | 0.0233 |
| Trip_Distance | 1 | 9.7471 | 0.0018 |
| Availability_of_othe | 1 | 15.4437 | <.0001 |
| Bike_parking_atthe_d | 1 | 8.2349 | 0.0041 |
| Rainfall | 1 | 27.3097 | <.0001 |

| Analysis of Maximum Likelihood Estimates | | | | | | |
|---|---|---|---|---|---|---|
| Parameter | | DF | Estimate | Standard Error | Wald Chi-Square | Pr > ChiSq |
| Intercept | | 1 | 0.1493 | 0.2457 | 0.3694 | 0.5433 |
| Tariff | | 1 | -0.4721 | 0.0525 | 80.8157 | <.0001 |
| Temperature | 1 | 1 | -0.4025 | 0.1471 | 7.4927 | 0.0062 |
| Temperature | 3 | 1 | 0.2509 | 0.1456 | 2.9680 | 0.0849 |
| Trip_Distance | 1 | 1 | -0.4617 | 0.1479 | 9.7471 | 0.0018 |
| Availability_of_othe | 1 | 1 | 0.3967 | 0.1009 | 15.4437 | <.0001 |
| Bike_parking_atthe_d | 1 | 1 | 0.3544 | 0.1235 | 8.2349 | 0.0041 |
| Rainfall | 1 | 1 | -0.6542 | 0.1252 | 27.3097 | <.0001 |

| Odds Ratio Estimates | | | |
|---|---|---|---|
| | | 95% Wald | |
| Effect | Point Estimate | Confidence Limits | |
| Tariff | 0.624 | 0.563 | 0.691 |
| Temperature 1 vs 2 | 0.575 | 0.358 | 0.921 |
| Temperature 3 vs 2 | 1.104 | 0.692 | 1.762 |
| Trip_Distance 1 vs 0 | 0.397 | 0.222 | 0.709 |
| Availability_of_othe 1 vs 0 | 2.211 | 1.488 | 3.284 |
| Bike_parking_atthe_d 1 vs 0 | 2.031 | 1.252 | 3.296 |
| Rainfall 1 vs 0 | 0.270 | 0.165 | 0.441 |

| Association of Predicted Probabilities and Observed Responses | | | |
|---|---|---|---|
| Percent Concordant | 75.4 | Somers' D | 0.520 |
| Percent Discordant | 23.4 | Gamma | 0.526 |
| Percent Tied | 1.3 | Tau-a | 0.253 |
| Pairs | 132317 | c | 0.760 |

## Model Two: Stated Preference and Socio-demographic variables

**The LOGISTIC Procedure**

| Model Information | |
|---|---|
| **Data Set** | SURVEY.BIKESHAREFINAL |
| **Response Variable** | Choice |
| **Number of Response Levels** | 2 |
| **Model** | binary logit |
| **Optimization Technique** | Fisher's scoring |

| | |
|---|---|
| **Number of Observations Read** | 738 |
| **Number of Observations Used** | 738 |

| Response Profile | | |
|---|---|---|
| **Ordered Value** | **Choice** | **Total Frequency** |
| 1 | 1 | 307 |
| 2 | 2 | 431 |

**Probability modeled is Choice=1.**

| Class Level Information | | | |
|---|---|---|---|
| **Class** | **Value** | **Design Variables** | |
| **Temperature** | 1 | 1 | 0 |
| | 2 | -1 | -1 |
| | 3 | 0 | 1 |
| **Trip_Distance** | 0 | -1 | |
| | 1 | 1 | |
| **Availability_of_other_modes** | 0 | -1 | |
| | 1 | 1 | |
| **Bike_parking_atthe_destination** | 0 | -1 | |
| | 1 | 1 | |
| **Rainfall** | 0 | -1 | |
| | 1 | 1 | |
| **Bicycle Ownership** | 1 | -1 | |
| | 2 | 1 | |

| Model Convergence Status |
|---|
| Convergence criterion (GCONV=1E-8) satisfied. |

| Model Fit Statistics | | |
|---|---|---|
| Criterion | Intercept Only | Intercept and Covariates |
| AIC | 1004.151 | 862.250 |
| SC | 1008.755 | 903.686 |
| -2 Log L | 1002.151 | 844.250 |

| Testing Global Null Hypothesis: BETA=0 | | | |
|---|---|---|---|
| Test | Chi-Square | DF | Pr > ChiSq |
| Likelihood Ratio | 157.9013 | 8 | <.0001 |
| Score | 142.2635 | 8 | <.0001 |
| Wald | 118.5367 | 8 | <.0001 |

| Type 3 Analysis of Effects | | | |
|---|---|---|---|
| Effect | DF | Wald Chi-Square | Pr > ChiSq |
| Tariff | 1 | 81.0817 | <.0001 |
| Temperature | 2 | 7.9493 | 0.0188 |
| Trip_Distance | 1 | 9.4849 | 0.0021 |
| Availability_of_othe | 1 | 15.6134 | <.0001 |
| Bike_parking_atthe_d | 1 | 8.3034 | 0.0040 |
| Rainfall | 1 | 28.4145 | <.0001 |
| Bicycle_Ownership | 1 | 4.1845 | 0.0408 |

| Analysis of Maximum Likelihood Estimates | | | | | | |
|---|---|---|---|---|---|---|
| Parameter | | DF | Estimate | Standard Error | Wald Chi-Square | Pr > ChiSq |
| Intercept | | 1 | 0.0239 | 0.2541 | 0.0089 | 0.9250 |
| Tariff | | 1 | -0.4748 | 0.0527 | 81.0817 | <.0001 |
| Temperature | 1 | 1 | -0.4175 | 0.1482 | 7.9299 | 0.0049 |
| Temperature | 3 | 1 | 0.2557 | 0.1462 | 3.0582 | 0.0803 |
| Trip_Distance | 1 | 1 | -0.4550 | 0.1477 | 9.4849 | 0.0021 |
| Availability_of_othe | 1 | 1 | 0.4008 | 0.1014 | 15.6134 | <.0001 |
| Bike_parking_atthe_d | 1 | 1 | 0.3565 | 0.1237 | 8.3034 | 0.0040 |
| Rainfall | 1 | 1 | -0.6689 | 0.1255 | 28.4145 | <.0001 |
| Bicycle_Ownership | 2 | 1 | -0.2128 | 0.1040 | 4.1845 | 0.0408 |

| Odds Ratio Estimates | | | |
|---|---|---|---|
| Effect | Point Estimate | 95% Wald Confidence Limits | |
| Tariff | 0.622 | 0.561 | 0.690 |
| Temperature 1 vs 2 | 0.560 | 0.348 | 0.902 |
| Temperature 3 vs 2 | 1.098 | 0.688 | 1.755 |
| Trip_Distance 1 vs 0 | 0.403 | 0.226 | 0.718 |
| Availability_of_othe 1 vs 0 | 2.229 | 1.498 | 3.317 |
| Bike_parking_atthe_d 1 vs 0 | 2.040 | 1.256 | 3.313 |
| Rainfall 1 vs 0 | 0.262 | 0.160 | 0.429 |
| Bicycle_Ownership 2 vs 1 | 0.653 | 0.435 | 0.982 |

| Association of Predicted Probabilities and Observed Responses | | | |
|---|---|---|---|
| Percent Concordant | 76.0 | Somers' D | 0.528 |
| Percent Discordant | 23.2 | Gamma | 0.533 |
| Percent Tied | 0.8 | Tau-a | 0.257 |
| Pairs | 132317 | c | 0.764 |

## Model Three: Stated Preference, Socio-demographic and Attitude variables

**The LOGISTIC Procedure**

| Model Information | |
|---|---|
| Data Set | SURVEY.BIKESHAREFINAL |
| Response Variable | Choice |
| Number of Response Levels | 2 |
| Model | binary logit |
| Optimization Technique | Fisher's scoring |

| | |
|---|---|
| Number of Observations Read | 738 |
| Number of Observations Used | 738 |

| Response Profile | | |
|---|---|---|
| Ordered Value | Choice | Total Frequency |
| 1 | 1 | 307 |
| 2 | 2 | 431 |

**Probability modeled is Choice=1.**

| Class Level Information | | | |
|---|---|---|---|
| Class | Value | Design Variables | |
| Temperature | 1 | 1 | 0 |
| | 2 | -1 | -1 |
| | 3 | 0 | 1 |
| Trip_Distance | 0 | -1 | |
| | 1 | 1 | |
| Availability_of_other_modes | 0 | -1 | |
| | 1 | 1 | |
| Bike_parking_atthe_destination | 0 | -1 | |
| | 1 | 1 | |
| Rainfall | 0 | -1 | |
| | 1 | 1 | |
| Bicycle_Ownership | 1 | 1 | |
| | 2 | -1 | |
| PBSS_for_Climatechange | 1 | 1 | 0 |
| | 2 | -1 | -1 |
| | 3 | 0 | 1 |

| Model Convergence Status |
|---|
| Convergence criterion (GCONV=1E-8) satisfied. |

| Model Fit Statistics | | |
|---|---|---|
| Criterion | Intercept Only | Intercept and Covariates |
| AIC | 1004.151 | 859.972 |
| SC | 1008.755 | 910.616 |
| -2 Log L | 1002.151 | 837.972 |

| Testing Global Null Hypothesis: BETA=0 | | | |
|---|---|---|---|
| Test | Chi-Square | DF | Pr > ChiSq |
| Likelihood Ratio | 164.1790 | 10 | <.0001 |
| Score | 147.5255 | 10 | <.0001 |
| Wald | 122.2679 | 10 | <.0001 |

| Type 3 Analysis of Effects | | | |
|---|---|---|---|
| Effect | DF | Wald Chi-Square | Pr > ChiSq |
| Tariff | 1 | 82.2038 | <.0001 |
| Temperature | 2 | 7.9530 | 0.0188 |
| Trip_Distance | 1 | 9.4324 | 0.0021 |
| Availability_of_othe | 1 | 15.6440 | <.0001 |
| Bike_parking_atthe_d | 1 | 8.4024 | 0.0037 |
| Rainfall | 1 | 28.2756 | <.0001 |
| Bicycle_Ownership | 1 | 3.4677 | 0.0626 |
| PBSS_for_Climatechan | 2 | 6.1762 | 0.0456 |

| Analysis of Maximum Likelihood Estimates | | | | | | |
|---|---|---|---|---|---|---|
| Parameter | | DF | Estimate | Standard Error | Wald Chi-Square | Pr > ChiSq |
| Intercept | | 1 | -0.0827 | 0.2649 | 0.0974 | 0.7549 |
| Tariff | | 1 | -0.4824 | 0.0532 | 82.2038 | <.0001 |
| Temperature | 1 | 1 | -0.4199 | 0.1489 | 7.9512 | 0.0048 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Temperature | 3 | 1 | 0.2448 | 0.1467 | 2.7827 | 0.0953 |
| Trip_Distance | 1 | 1 | -0.4568 | 0.1487 | 9.4324 | 0.0021 |
| Availability_of_othe | 1 | 1 | 0.4031 | 0.1019 | 15.6440 | <.0001 |
| Bike_parking_atthe_d | 1 | 1 | 0.3604 | 0.1243 | 8.4024 | 0.0037 |
| Rainfall | 1 | 1 | -0.6714 | 0.1263 | 28.2756 | <.0001 |
| Bicycle_Ownership | 1 | 1 | 0.1985 | 0.1066 | 3.4677 | 0.0626 |
| PBSS_for_Climatechan | 1 | 1 | 0.3236 | 0.1305 | 6.1454 | 0.0132 |
| PBSS_for_Climatechan | 3 | 1 | -0.3686 | 0.1922 | 3.6791 | 0.0551 |

**Odds Ratio Estimates**

| Effect | Point Estimate | 95% Wald Confidence Limits | |
|---|---|---|---|
| Tariff | 0.617 | 0.556 | 0.685 |
| Temperature 1 vs 2 | 0.552 | 0.342 | 0.890 |
| Temperature 3 vs 2 | 1.072 | 0.670 | 1.716 |
| Trip_Distance 1 vs 0 | 0.401 | 0.224 | 0.719 |
| Availability_of_othe 1 vs 0 | 2.239 | 1.502 | 3.339 |
| Bike_parking_atthe_d 1 vs 0 | 2.056 | 1.263 | 3.348 |
| Rainfall 1 vs 0 | 0.261 | 0.159 | 0.428 |
| Bicycle_Ownership 1 vs 2 | 1.487 | 0.979 | 2.259 |
| PBSS_for_Climatechan 1 vs 2 | 1.321 | 0.929 | 1.879 |
| PBSS_for_Climatechan 3 vs 2 | 0.661 | 0.365 | 1.198 |

**Association of Predicted Probabilities and Observed Responses**

| | | | |
|---|---|---|---|
| Percent Concordant | 76.6 | Somers' D | 0.535 |
| Percent Discordant | 23.1 | Gamma | 0.536 |
| Percent Tied | 0.3 | Tau-a | 0.260 |
| Pairs | 132317 | c | 0.767 |

# Auteursrechtelijke overeenkomst

Ik/wij verlenen het wereldwijde auteursrecht voor de ingediende eindverhandeling:
**Investigating the factors influencing the use of public bike sharing schemes for the last mile travel in Belgium**

Richting: **Master of Transportation Sciences-Mobility Management**
Jaar: **2017**

in alle mogelijke mediaformaten, - bestaande en in de toekomst te ontwikkelen - , aan de Universiteit Hasselt.

Niet tegenstaand deze toekenning van het auteursrecht aan de Universiteit Hasselt behoud ik als auteur het recht om de eindverhandeling, - in zijn geheel of gedeeltelijk -, vrij te reproduceren, (her)publiceren of distribueren zonder de toelating te moeten verkrijgen van de Universiteit Hasselt.

Ik bevestig dat de eindverhandeling mijn origineel werk is, en dat ik het recht heb om de rechten te verlenen die in deze overeenkomst worden beschreven. Ik verklaar tevens dat de eindverhandeling, naar mijn weten, het auteursrecht van anderen niet overtreedt.

Ik verklaar tevens dat ik voor het materiaal in de eindverhandeling dat beschermd wordt door het auteursrecht, de nodige toelatingen heb verkregen zodat ik deze ook aan de Universiteit Hasselt kan overdragen en dat dit duidelijk in de tekst en inhoud van de eindverhandeling werd genotificeerd.

Universiteit Hasselt zal mij als auteur(s) van de eindverhandeling identificeren en zal geen wijzigingen aanbrengen aan de eindverhandeling, uitgezonderd deze toegelaten door deze overeenkomst.

Voor akkoord,

**Altaf, Shahbaz**

Datum: **2/06/2017**