Electrical shared bikes in Curitiba: infrastructural measures that lead to more users

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1 Preface

You are now reading a Bachelor Thesis about shared bicycles in Curitiba, Brazil. In April 2017, I traveled to Brazil to be there for 10 weeks, working on this thesis. I experienced how the previous knowledge from the Civil Engineering bachelor of the University of Twente can be adjusted with another culture, language and different ways of working on the university.

During the research, I realized how complex it is to introduce bicycles as a transport mode in a city. I learnt that the number of trigger factors that play a role to let people cycle is higher than I could imagine, and that they depend on the culture. Additionally, I learnt to work with different research methods and combined them to answer the research question.

I want to thank all partners of the Memorandum of Understanding between Dutch and Brazilian organizations, to make it possible to experience this amazing assignment. These institutes helped me very much, for example because it was possible to spread my survey thanks to the connections of those people. I also want to thank K. Geurs, A. Grigolon and T. Gadda for supervise me and M. van den Berg for the help to make it possible to go to Brazil.

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3 Abstract

In this bachelor thesis, the new shared bike system in Curitiba is investigated, and advice for infrastructural measures that can lead to more users is given. First, a GIS analysis is done to see which of the shared bicycle docking stations have the most potential. Second, a survey is conducted to see what triggers and barriers people experience to use the system. Third, these survey results are used to determine statistics between the respondent's characteristics and to see the differences in barriers experienced on the three research locations. Finally, these results are combined to give advice for infrastructural changes for the three research locations.

GIS analysis to find potential docking stations
43 docking stations will be implemented this year in Curitiba. First, a calculation is made to determine which of these 43 docking stations are next to a BRT stop. 14 of the 43 docking stations will be next to a BRT bus stop. From these 14, for each docking station a calculation is made to see which other docking stations are easily reachable by bike, using information from shared bicycle systems in other cities. To calculate this, the bikeability index from Motta (2017) is used. The bikeability index is an 1-9 index with for each road of Curitiba, including the cycle infrastructure, safety, topography, mixed land use and residential density. It is not known how important these factors are on the probability of the bicycle use. Therefore, two scenarios are created: a scenario where the bikeability has not many impact, and a scenario where a worse index has more influence on the probability of the cycle route. From this GIS analysis, two docking stations in the center (Rui Barbosa square and Rua João Negrão) are selected for research. They seemed to have the most potentially reachable destinations. Also, a terminal (Terminal Cabral) is chosen, because this terminal has the most transfer possibilities. Therefore, on this location, the shared bicycles can be a feeder mode for the BRT lines.

Investigating barriers and triggers that people experience to use the shared bicycle system
The aim of this research is to find what infrastructural measures can lead to more users of the shared bike system. The GIS study helped to determine which bus stops have potential, but the location based factors should be found. Therefore, the next step of this research is to find what barriers people experience to use the shared bike system, and what motivates people to use shared bikes. A survey is conducted on the three bus stops that seemed to have the most potential. People were asked to say how important five barriers or triggers are for them: the price of the system, increasing or decreasing of travel time, traffic insecurity, cycle facilities and cycle paths. The cycle paths were rated as the most important trigger. The most important conclusions: Men, young people and higher educated people have the most potential to use the shared bike system. The non-electrical bike is more popular for all groups. Younger people relatively prefer the electrical bike the most, compared to the probability to the non-electrical bike.

Infrastructural changes that can lead to a higher potentiality of the system
Because the cycle paths seemed to be the most important trigger, for the Rui Barbosa square a design change recommendation is given, with additions in the cycle network. A suggestion for a simple addition is given, but also some ideas for more difficult additions are shown. For Rua João Negrão (Estação Tubo Central) a design change recommendation for adding this docking station to the cycle network of the city is given too. Bicycle lanes seems to fit the most. For Terminal Cabral, the general advice is that more docking stations are needed before the system can be used as a feeder mode for the BRT line from Terminal Cabral to the city center.

4 Introduction

4.1 Context

A modern bus system is developed in Curitiba (Brazil) in 1974, with bus lanes and tube stations. This bus system is a good alternative for a metro system (Demery, 2004). Downtown, the car use is high, which results in traffic jams and environmental consequences (Lindau et al., 2010). This bus system works well, and is efficient. But, the municipality of Curitiba wants to add cycling as a transport mode. One of the advantages of cycling is to make bus stops more reachable, because people can cycle to bus stops with high frequency lines. Curitiba stimulated cycling by creating bicycle paths and cycle facilities. To make it more comfortable and safer, they now try to create a contiguous bicycle network through a big part of the city (Motta, 2017).

To get the bicycle accessible for more people, plans with shared bicycles are being developed. In Curitiba, the City Hall works together with the institutions IPPUC (Research and urban planning of Curitiba) and URBS (Institute for Public Transport in Curitiba) to implement a shared bicycle system. The main idea is to make the BRT bus stops more accessible, to reduce the amount of small bus lines which are expensive to maintain (URBS, 2017a). The start date of the shared bike system is not known. At this moment, the investors are being searched.

In many other cities, shared bicycle plans are popular (Sagaris, 2015). But, cycling in Curitiba is not always safe. Parts of the city cannot be reached by bike safely. Cycling on the pavements or between the cars is necessary often. There are more reasons why people do not use the bike often. Social safety and prestige of the bike as a transport type are examples of barriers people experience while cycling in Curitiba (Duarte, 2014). It is important to know how which measures can motivate people to use the shared electrical bike system.

4.2 Objective

The aim of this bachelor thesis is to find out how effective infrastructural measures can be on BRT bus stops with the most potential users for the shared bike system. To find out what measures could be effective, it is needed to find out why people would not use shared bikes, and what motivates people to use shared bikes.

4.3 Research question

Main question:
Which infrastructural measures can have a positive effect on the number of users of the new electrical shared bicycle system to cycle from a Bus Rapid Transit bus stop to their destination and back?
Sub questions:

1. Which bus tube stations have the most potential for the shared bikes in combination with the BRT busses?
2. Which barriers do people experience to combine the bus with a shared bike as a part of their trip, and what motivates people to switch to a shared bike?
3. Which infrastructural measures can have a positive effect to reduce these barriers and how can people be motivated for the shared bikes?

4.4 Terminology

Bus Rapid Transit (BRT)
Curitiba has a Bus Rapid Transit system, high frequent bus lines. The capacity is much higher than normal busses and it is a good alternative for a metro system (Duarte & Rojas, 2012). In this document, the Bus Rapid Transit system will be abbreviated to BRT. BRT busses have their own bus lanes.

Shared bicycles
System where people can pick up a bicycle, and bring it back or to another place within 45 minutes. Subscription is needed. This system is also known with the terms bicycle sharing, bike-share, cycle hire or public bike. The place where you can get a shared cycle (and where you can bring it back) is called a **docking station**.

Bikeability index (BI)
Recently, Motta (2017) created a bikeability map for Curitiba. For all roads, a score between 1 and 9 is given. The score '1' means that it is impossible to cycle, and '9' means that the cycle conditions are perfect. This bikeability index includes the cycle infrastructure, safety, topography, mixed land use and residential density.

5 Literature review

This literature review will make clear how to determine the factors that play a role in how effective shared electrical bikes can be. The first paragraph of this literature review will explain what works and what does not work in existing shared bicycle plans in other countries. There is described which information from other cities can be used in Curitiba. These information is used to determine the potential of the system, and to give suggestions for more users of the system.

5.1 Shared bicycle plans in other cities

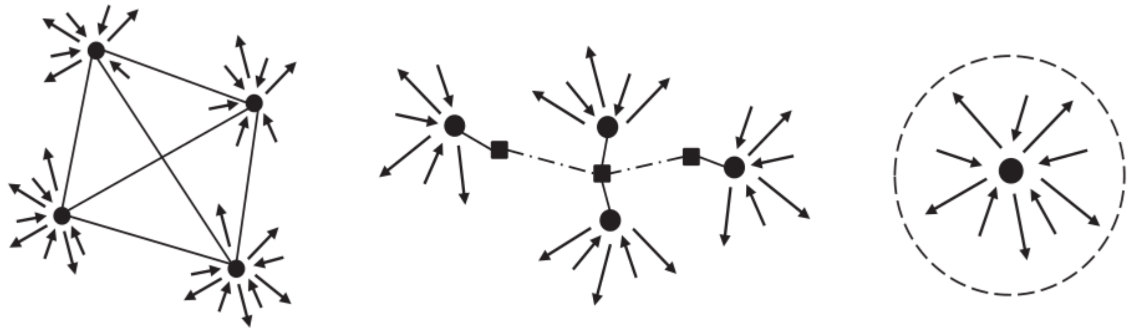
Cycling plans are very popular in many countries. It is an effective way to reduce the number of cars driving in the city. Bike share systems can be an efficient way to reach climate goals and air quality aims. In Washington D.C, the bike-share plan reduced the number of miles driven per year by almost 7 million kilometers (LDA, 2012).

The successfulness of these systems varies a lot in different cities. Therefore, it is important to investigate the effectiveness, and to fully understand the factors that influence people's choice to use a shared bike.

Effectiveness of a shared bike system on the public transport
How the public transport users can be increase, is different for every city. A research from the University of Carolina investigated different cities with surveys, and asked people to investigate the transport mode switches. They saw an increase of the public transport use of 7% in Washington, 11% in Montreal, and 9% in Toronto (Martin & Shaheen, 2014) after implementing shared bikes. In these cities, the people that shifted to public transport in combination with the shared bikes, are more likely to be male, and in most cities, there is a relation between the age and the number of users of the system. Younger people use the system more than older people, and their income is slightly higher than average. Lower incomes experience the price as a more important barrier than higher incomes. A clear relation between education level and the use of shared bikes is not found for these cities. (Martin & Shaheen, 2014)

The areas where the travel time can be decreased the most, are the most successful for the use of shared bikes as a part of people's trip (Jäppinen et al., 2013). They investigated where the shared bikes can have the most advantages. The travel time can be decreased the most in the city center, on trips where the shared bike trip length is about 1,5 km. For shorter trips, walking is faster in most cases. For longer trips, other public transport modes, like busses, are faster. But, this depends on the quality of the other public transport modes. For example, on the transfer time.

The types of users of the shared bicycles can be divided in three groups, as showed in Figure 5-1. A group A user is a person that uses the shared cycle to cycle from one to another dock, for example from home to a dock next to work. Group B are people that have not a direct public transport connection, and use the shared system to reach the public transport network. In this case, the shared cycle system is a feeder mode for the existing public transport facilities. In this research, there will be investigated if people are willing to use the shared cycle in this way. Group C shows a situation where the person gets a bike, and brings it back to the same docking station. For example, to make a cycle trip for fun.(Lv et al., 2011)



Note: ● Sites for public bicycle ── Public bicycle routes ; – • – • – Traditional public transport routes; Other Legend same as in Figure 1.

Figure 5-1: Types of shared bicycle use (Lv et al., 2011)

Non-electrical bikes versus electrical bikes

The shared bicycles in Curitiba will have an electrical engine. When paying half the price, this engine will not work. So, there is choice between a non-electrical bike and an electrical bike. Campbell et al. (2016) investigated what the differences are between electrical and non-electrical bikes in a case study of Beijing. This paper investigated that the average speed is 9.1 km/h for non-electrical bikes and 12.1 km/h for an electrical bike. Mainly young/middle age males with low income and education levels seem to use the electrical bike relatively more than the non-electrical bike. This paper also investigated that the advantages of an electrical bikes are mainly experienced in low density areas outside the city center. For high density and diversity of attractions, non-electrical bikes seem more popular.

Triggers and barriers

A successful shared bike system could serve as a feeder mode for high density public transport lines (Jäppinen et al., 2013). In Curitiba, these high density public transport lines are the BRT bus lines. According to ITDP (2013), the most important factors for a successful shared bike system, are the number of destinations that can be reached in a safe and fast way. Spatial factors seems to have a huge role in the successfulness of the system. Daddio (2012) investigated that the bicycle infrastructure seems to be important, the attractors (shops, museums, etc.), universities, cafes, and hotels. In these researches, there is no relation found between the successfulness of the shared cycle systems and different income groups.

Campbell et al. (2016) investigated the weather conditions where the use of the bike is not comfortable. They investigated that the shared bike system is used very little on days that exceed 30°C, or days below 0°C. Also, a day with more than 1,3 cm rain is a day with almost no users of the system. They also investigated that environmental conditions and individual travel habits are the primary groups of factors, much more than the socio-demographic factors. They investigated that shared bikes are the most successful in areas with a high population density, and diversity of attractions.

In Latin America, a research in Santiago (Chile) concluded that the following triggers have a positive influence of the bicycle use: Car-free centers, restrictive car-parking policies, intersection modifications, separate cycling facilities, coordination with public transport and car-free zones. In their research, these urban measures seemed the most important, but also the behavioral change (e.g. cycling education, awareness) and cycling economy (e.g. cycle services, tax exemptions) seemed important. (Sagaris, 2015)

Figure 5-2: Three main groups of triggers for people to use the bicycle (Sagaris, 2015).

The difference between Latin America and North America, Asia and Europe is mainly public safety. People (mainly women) do not feel safe on a bike in all neighborhoods, and they do not feel safe on the bike, because of violence (Mosquera et al., 2012).

Decreasing infrastructural barriers will not always lead to more cyclists (Chatterjee et al., 2013). Other factors, like the social environment, is huge. And, when people make the same trip every day, it is hard to change people's habit. Most people will only change a part of the trip to a (shared) cycle, when they for example get a new job (Chatterjee et al., 2013).

Cycle trip length for non-electrical and electrical bikes
A case study about the city Zhongshan, in China, (Zhang et al., 2017) describes that for non-electrical bikes, the average cycle trip is 2.7km, and 94.8% of the trips are less than 30 minutes. This will be useful to determine how reachable the shared bicycle terminals will be. Daddio (2012) concluded that for all cities, the shared bicycles can be a prevalent transport mode for trips up to 4 kilometers, when the cycle environment is good. Martens (2007) also based the accessibility of the shared bicycle docking station on an area of 3-4 kilometers. Campbell et al. (2016) investigated that the average speed for non-electrical bikes is 9,1 km/h, and 12,1 km/h for electrical bikes in Beijing. So, in average, with an electrical bike can be reached 1,3 times more in the same time. But, the shared bikes will have a limited speed in Curitiba. Therefore, there is not known yet how long the average trip will be in Curitiba

5.2 Cycling in Curitiba

In 1977, the first bicycle paths were carried out in Curitiba (Duarte, 2014). The public support of cycle facilities comes from a small group, and is not appreciated by everyone. Despite that, Curitiba succeeded to implement a cycle network that covers a big part of the city. Because of the success of shared bicycle plans in other countries, Curitiba will start with implementing a shared electrical bike system this year. The bikes can be a feeder mode for the BRT system of Curitiba.

Quality of the cycle network
The current cycle network is shown in Appendix A: Cycle network. The quality of the current cycle network is investigated in 2016 by Schilte (2016). Not all neighborhoods are reachable, and not all high-density business areas in the city center are reachable. 33% percent of the inhabitants of Curitiba have access to the cycle network within 200 meters from their home (Schilte, 2016).

Barriers and bikeability in Curitiba
Motta (2017) determined the barriers that people experience to cycle in Curitiba. The conclusions are, that the most experienced barrier is the behavior between car users and cyclists, and the lack of cycling infrastructure. The traffic unsafety is also a very important barrier. Public unsafety seems less important. But, still more than 60% of the respondents experiences it as an important or very important barrier. These factors could all have a huge impact in the numbers of users of the shared bicycle system. He also investigated, that the accessibility to cycle infrastructure is the most important motivator to cycle.

Also, the bikeability map of Motta (2017) is useful, to calculate for each docking station how reachable they are. With this information, there can be determined which docking stations have the most potential. There are 5 factors used for this bikeability index: residential density, mixed land-use, safety, topography and type of infrastructure. The influence of each factor is based on a survey, were respondents gave their opinion about the influence of the factors on their choice to cycle.

There are different kinds of cycle infrastructure implemented in Curitiba. Motta (2017) investigated the probability to cycle on these kind of cycle infrastructures. For 50% of the respondents, it is unlikely or very unlikely that they will cycle on exclusive bus lanes or general roads. The respondents experience the bicycle lanes and bicycle paths as the most likely to cycle on. For 85% of the respondents, it is likely or very likely that they will use these bicycle paths and bicycle lanes. The calm lanes, bicycle routes and shared sidewalks are experienced as worse than the bicycle paths and bicycle lanes.

The different kinds of cycle infrastructures are showed in Figure 5-3.

Bicycle path (Ciclovia)

Bicycle lane (Ciclofaixa)

Calm lane (Via calma)

Shared sidewalk (Passeio compartilhado)

Bicycle route (Ciclorrota)

General roads (Vias de tráfego geral)

Exclusive bus lanes (Via exclusiva de ônibus)

Figure 5-3: Different kinds of infrastructure designs in Curitiba

Competition with other transport modes

To conclude how much users the shared bikes can have per day, it is important to investigate which transport mode switches are possible. Motta (2017) investigated the dominating transport modes in Curitiba. The car, bicycle and bus determine more than 90% of the respondent's main transport modes. Therefore, this paragraph analyzes those three transport modes. Most times, to take a BRT bus, another transport mode is needed to reach the BRT bus stop. These transport modes are called “feeder modes”. To determine which changes can have a positive effect on the shared bikes in combination with the bus, it is important to know which feeder modes people use. In Figure 5-4, the most common feeder modes for the BRT are viewed in the upper row. Switching from the car to a shared bike is also possible, but this is not investigated in this thesis. This thesis analyzes current BRT users. People who cycle already, are not directly a competition for the shared bikes. People who make the whole trip by bike, and have their own bike, have no reason to switch to a shared bike. But, people who use the bike as a feeder mode can replace their own bike for a shared bike. This has the advantage that it is not necessary to park the bike at a bus stop.

The following transport mode combinations are possible, with the main transport mode: bus, car or bicycle (own bike):

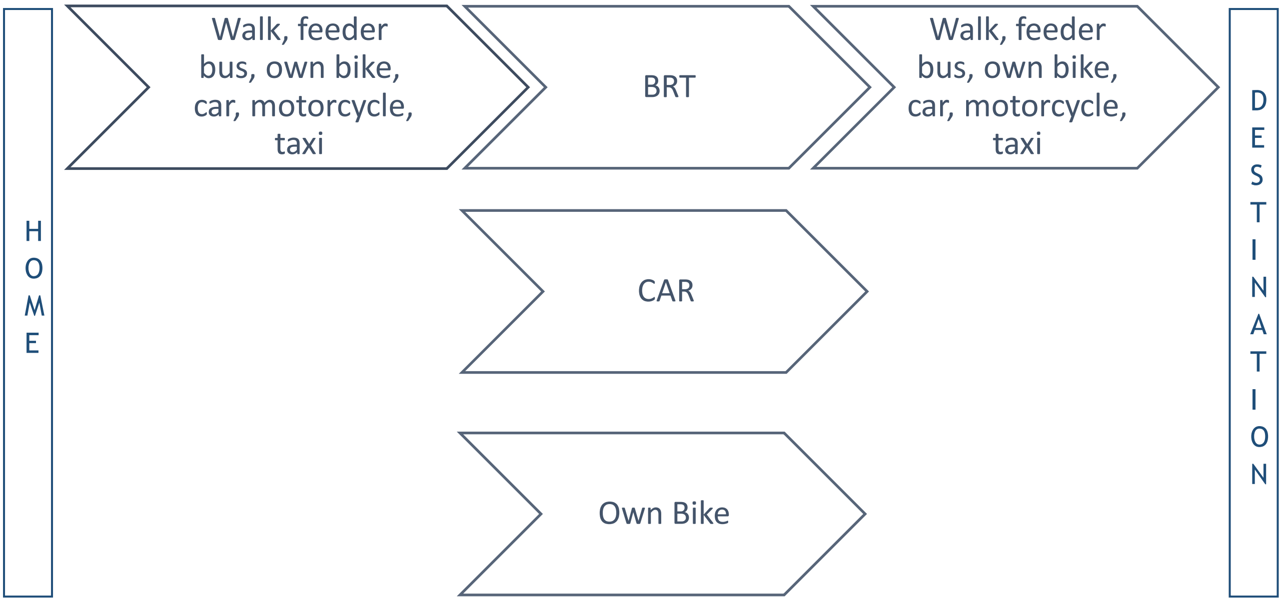


Figure 5-4: Transport mode possibilities

6 Methods

The three sub questions are divided in three sub chapters in the method part of this thesis. The first subchapter (6.1) is about the GIS study to find the bus stops with the potential for the shared bicycles. The second subchapter (6.2) describes the surveys and the methods to find triggers and barriers for the shared bikes. In the last subchapter (6.3), the way of finding measures are given.

6.1 GIS study to find BRT stations with potential for the shared bikes

The goal of this GIS analysis is to find the docking stations with the most potential for the shared bike system. This research focusses on the shared bikes in combination with the BRT busses. ArcGIS is used to make the calculations. The information about shared bikes in the literature study, are combined to analyze the docking stations in Curitiba. There is created a cyclable area for each docking stations in 2 ways: with 2 scenarios. To find the potential of the bus stops, these steps are carried out:

1. Where are the shared bicycle docking stations, which part of the city do they cover and how is the system compared to other cities?
2. What factors are necessary to know which docking stations are potential for shared bicycle use? (for example: income, bikeability, bike facilities, safety properties, user characteristics).
3. Combining the factors with the information about the shared bicycle system: which bus stations are the have the most potential for shared bicycles in combination with the BRT busses?

Step 1: The shared bicycle docking stations

The locations of the docking stations for the shared bicycle systems are gained from URBS (2017a). They are shown in Appendix B: Locations of shared bike docking stations. 35 of the 43 docking stations are in the downtown division 'Matriz'. The properties of the system are as following:

Name	Bike Facil CWB
Number of docking stations	43 *First step will be 25 docking stations, and after 140 days the 18 other docking stations will be implemented*
Number of bikes	480
Price for non-electrical bike *The prices for the electrical version of the bike are not determined yet, but will be about twice the price of a classic bike. The bikes are the same, but the battery will not work when a non-electrical version is rented.*	• Day fare: R$5 (€ 1,50) • Month fare: R$12 (€ 3,50) • Semiannual fare: R$54 (€15,50) (wisselkoers.nl, 2017) • For this price, you can use the bike 45 minutes. After these 45 minutes, you pay R$2,50 for every 15 minutes.
Extra services	• Free Wi-Fi at all docking stations • Front and back led lights on all bikes • GPS on all bikes • For theft safety, the bikes can be blocked

Table 6-1: Properties of the shared bicycle system in Curitiba. (URBS, 2017a)

Step 2: Factors
The literature is used to see which factors have influence on the use of shared bikes. They are based on shared bike systems in other cities. To find docking stations with the most potential, the following data is used:

Category	Data name		Source
BRT system	BRT lines		(URBS, 2017b)
	Bus stops		
	Bus schedule		
Bikeability	Topography	9.6%	(Motta, 2017)
	Safety	33.0%	
	Cycling infrastructure	37.9%	
	Mixed land use	12.3%	
	Residential density	7.2%	
Business licenses	Business licenses per neighborhood		(CityHall, 2016)
Shared bicycle system	Docking stations		(IPPUC, 2017)

Table 6-2: Used data and sources

The other data that is used are the roads, general shape files from Curitiba and the neighborhood shapes.

Bikeability data
The bikeability score of Curitiba is based on 5 components: Topography, Safety, Cycling infrastructure, Mixed land use and Residential density. These 5 components are the 5 main factors that determine how bikeable a road is. With this data, there can be determined if people use a road to cycle or not. Motta (2017) created different distributions for people that do not cycle already, and for people who do. These percentages are determined by a survey. In this thesis, the distribution for non-cyclists are used, because people who do not cycle already have the most potential to use the shared bicycles in combination with the bus. People who cycle already, have their own bike. Another, more advanced method, could be to use the five separate components. This can be useful in further research. For example, to see differences in electrical and non-electrical bikes. The topography may have less influence on the use of electrical bikes.

300 meters buffer zone
A docking station has a reachable 300-meter buffer zone, according to ITDP (2013). That means that 300 meters is the maximum walkable distance. People with a destination further away than 300 meters from a docking station, have no potential to use the shared bike system. Also Zhang et al. (2017) calculates 300 meters as buffer zones to calculate the potential of a docking station.

Business license data
To determine where people are traveling to, business license data is used. Business data includes offices, shops, hospitals, churches etc. So, this data is a good estimation of the destinations of people’s trip. The data is only available as business licenses per neighborhood. The first intention was to use the public transport card data. But these data cannot not be used, because people can prosecute their trip with another transport mode after exiting the bus.

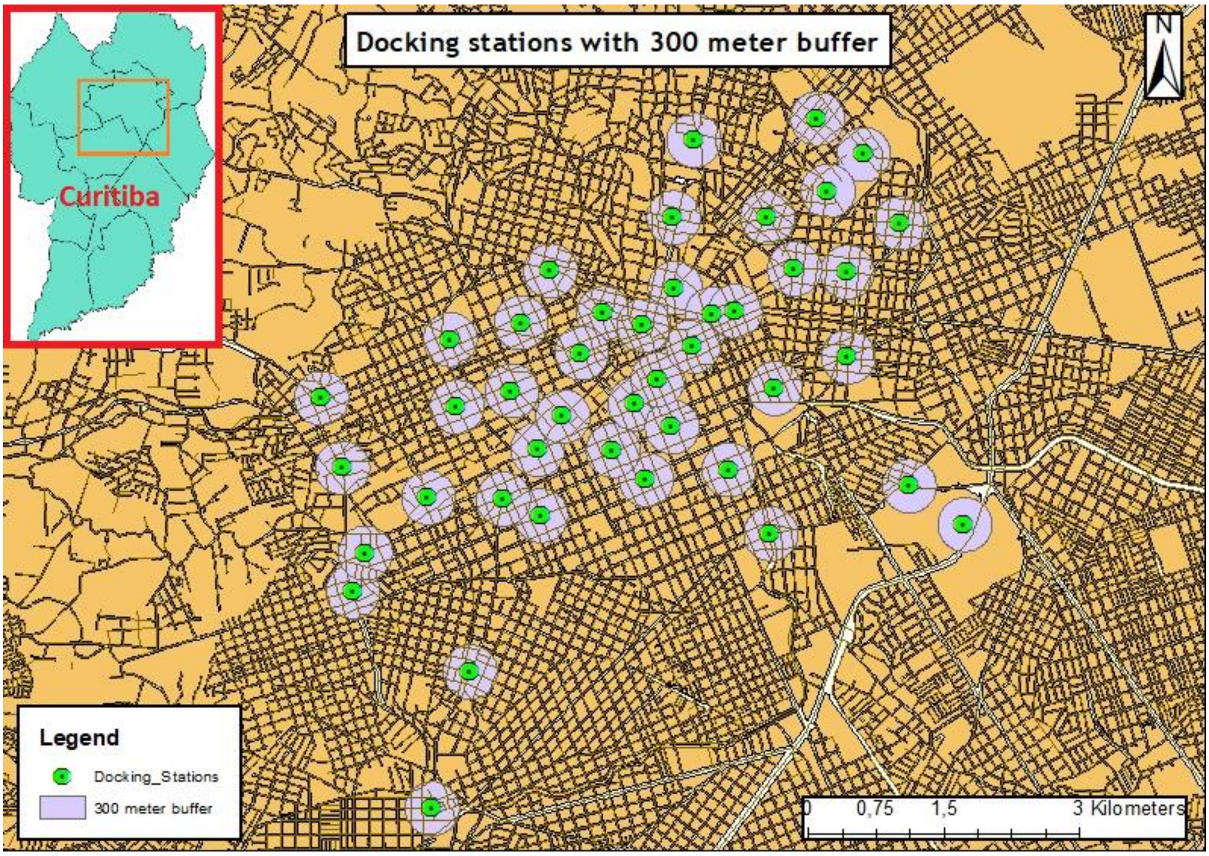


Figure 6-1: Location of the 43 docking stations with 300-meter buffer zone

Step 3: Choosing the potential research locations

The goal is to find the docking stations that may be have the most potential for the shared bicycle system in combination with the bus. To accomplish this, for every docking station of step 1, the factors of step 2 are used to determine the probability of the number of users with the following steps:

1. In step 1, the docking stations that are directly accessible from a BRT bus stop are selected. Only the bus stops where a bike can be taken immediately after leaving the bus, have potential for the combination of the shared bikes with the BRT bus. To make sure that all BRT bus stations are included in this selection, there is chosen to take the size of the big terminals as the maximum walking distance from the bus stop to the docking station. This is ±200 meters on Terminal Cabral and Terminal Portão.
2. Step 2 combines the factors, to create an area that is reachable by bike for each docking station. This is done with 2 scenarios (see: scenarios).
3. For each of these 14 docking stations: determine which of the other 43 docking stations are within this area. For the 14 docking stations, there is created a map. These maps are shown in the chapter 'results' (7.1).
4. In step 4, there will be determined how many services and business there are in that those areas, for all the 43 docking stations, using the business license data. After that, for the BRT bus stations that are next to a docking station, these destinations will be summed. Also, the number of buses that passes the bus stop are calculated. These information is shown in Appendix C: Information about the docking stations.
5. In step 5, these destinations and number of busses are used to select the docking stations that seem to have the most potential for the shared bikes in combination with the BRT bus.

Scenarios

As reviewed in the literature study, Daddio (2012) investigated that the shared bicycles can be a prevalent transport mode for trips up to 4 kilometers. This only happens on roads with good bicycle circumstances. Therefore, in a perfect situation, with the highest bikeability index (9) on the whole road, there is assumed that people will cycle this 4 km. But, how much the distance will decrease for lower scores, is unknown. Therefore, in the research the bus stops are chosen in 2 scenarios: one scenario with low impact for bad cycle circumstances, and one scenario where bad cycle circumstances have much influence. Also, the influence of the number of transfer possibilities is unknown. Therefore, the number of transfer possibilities are calculated in the third measurement strategy. The measurement strategies are calculated with the properties below:

	Name of measurement strategy	**Properties**	
1	Scenario 1: bikeability index has little influence	Formula for distance barrier:	$Scaled\ Barrier = 9 \cdot \frac{1}{bikeability}$
2	Scenario 2: bikeability index has much influence	Formula for distance barrier:	$Scaled\ Barrier = \left(9 \cdot \frac{1}{bikeability}\right) \cdot 5 - 4$
3	Transfer possibilities	Number of passing busses during the working days (Mon-Fri)	

Table 6-3: Scenarios which are used to determine the potential of the docking stations

In scenario 1, a low bikeability score has not much influence on the shared bike use on this road. The inverse of the bikeability score of this road is token. This number is multiplied by 9, because the scaled barrier must be 1 when the bikeability is 9 (because there is no barrier when the bikeability is 9). This results in a 'scaled barrier' number, which ArcGIS multiplies with the traveled distance. When the bikeability index is 9 on the whole road, the scaled barrier is $\frac{1}{9} \cdot 9 = 1$. This means that the distance of 4 km is multiplied by 1, so in this case 4 km can be reached. When the bikeability is 1, the scaled barrier is $\frac{1}{1} \cdot 9 = 9$. This means that the distance traveled on this road will be multiplied by 9 in the ArcGIS calculations. The reachable distance of the docking station to this point will be 9 times less in this case. In the real formula, a low score will have more influence. Because, for example, on highways it is not possible to cycle. Therefore, in the second scenario, there is chosen to multiply the scaled barrier factor by 5 times. 5 is chosen, to see the difference in the impact, but still let it be realistic. The '-4' is necessary to let the scaled barrier be 1 by a bikeability score of 9, Value 1 means 'no barrier' in ArcGIS. There is assumed that there is no barrier when the bikeability index is 9. Another reason to make a huge difference between those two scenarios, is to make sure that also the reachable destinations from the electrical bikes are included in the research. The reachable distance with an electrical bike is higher, because less physical effort is needed. As described in the literature study, Campbell et al. (2016) investigated the difference in speed for users of the electrical bikes and users of the non-electrical bikes in Beijing. It seemed that users of a non-electrical bike travel with an average of 9.1 km per hour, and users of an electrical bike travel with an average of 12.1 km per hour. This means that the probable reachable area of an electrical bike is probably $\frac{12,1}{9,1} = 1,3$ times higher, when the maximum travel time is assumed to be the same. However, for safety, the electrical bikes will have a limited maximum speed in Curitiba, so the exact difference cannot be known yet. In chapter 7.1, the results from the ArcGIS calculations are showed. In that chapter, there is also described which bus stops will be investigated.

When these steps are followed, the potential for the 14 docking stations close to a bus stop are determined. These are bus stops that have potential following literature, and previous research in Curitiba. But, this does not directly mean that these docking stations will have the most shared bike users in the future. Therefore, the bus stops that seem to have the most potential, must be investigated. What barriers do people experience to use the shared bikes? And what measures can motivate people to use a shared bike? It is not possible to determine this in the GIS study, because this location specific data cannot be calculated with existing data. Therefore, a different method is used to investigate the next sub question, described in the next sub chapter.

6.2 Barriers that people experience to use the (electrical) shared bikes

To find barriers and triggers for the shared bike system, surveys and interviews are performed. With these survey, there can be determined which measures can motivate people to use the shared bikes on the bus stops with the most potential.

Questions

In Appendix D: Survey in Portuguese, the original survey is shown. The survey is divided in 4 parts:

1. The trip: Where do you come from, what bus stops did you use, and what transport mode did you use to reach your destination? And, how often, and for what reason do you make this trip?
2. Personal information: age, gender, income and education level.
3. Factors for shared bicycle use (based on literature study): price, time increase or decrease, safety, cycle facilities, cycle paths (1-5 scale) and other barriers or triggers (open question, free to answer). These 5 factors are chosen based on literature, to people's choice to use a shared bike. The barriers and motivators that can be changed by the municipality, are asked. For example, the climate cannot be changed, so is not asked in the survey.
4. How likely it is for the person to use a classic or electrical bike (1-5 scale). These questions are used as the threshold variables in the statistic tests.

The information about the questions is explained below:

	Category	Question	Description/Source
1	The trip	At what bus stop did you start your trip?	Open question. Home address not asked, because of privacy
2		Which of the following bus stop did you use to transfer, departure or leave?	14 answer possibilities: the 14 bus stops where a docking station will be implemented
3		What other transport modes do you use to reach your destination?	Car, Motorcycle, Bicycle, Taxi/Uber, Another bus, Walking
4		What is your destination?	Zip code, address, POI
5		How often do you make this trip?	Times per week/months/year
6		What is the reason of this trip?	Work, School, University, other
7	Personal information	What is your age?	Classes of 15 years, <25, 25-40, etc.
8		What is your gender?	Male/Female
9		What is your family income?	The minimum income until 10x the minimum income (IBGE, 2017)
10		What is your highest attended education level?	Following the same classes as the governmental questionnaire (IBGE, 2017)
11	Trigger/Barrier factors	Price	To conclude what kind of bus users will use the system in case of changes and which changes can lead to more users. Likert scale with 5 possibilities: from not important until very important.
12		In/decreasing of time	
13		Traffic insecurity	
14		Cycle facilities	
15		Presence of cycle paths	
16		Other	Open question to mention other barriers and triggers
17	Probability of bike use	Non-electrical bike	Likert scale with 5 possibilities from very unlikely until very likely
18		Electrical bike	

Table 6-4: Survey questions in English with extra information

Triggers and barriers
To determine what changes can lead to more users, it is important to understand which factors people experience as important. According to the literature study, cycle paths, traffic insecurity and cycle facilities seemed to be the most important barriers. The travel time also seemed to determine people's switch to shared bikes in other cities. The price can be a barrier for lower incomes. Therefore, the price is included in the survey as well. This survey also includes trip information questions to see where respondents experience barriers and see where triggers can have influence. There are questions about the respondent's characteristics to see differences between groups. In the results, this information is used to see on which locations changes can have influence, and if different groups of users differ. Also, there is a free open question to mention barriers and triggers.

Strategies
The target group of this survey is small, due to 2 big limitations. First, only bus users are the target group of this research. And second, only users from a bus stops where a docking station will be implemented are the target group. Therefore, the first strategy was to ask people on the potential bus stations, oral. After a while, it became clear that this strategy did not lead to many respondents. In 4 hours, only 6 people answered the questions. To reach more people, small flyers were hand out with an URL and QR-code, so that people could fill in the survey online. This strategy did not work too, from the 400 flyers that were spread only 19 URL/QR-code hits were registered. 8 people completed the survey this way. The described two strategies would never lead to enough respondents, so the strategy was changed. Instead of asking people at the bus stops, there was tried to reach as many as possible different kinds of final destinations in the city. All universities and different work places were asked to spread the survey. The persons were asked to fill in which of the potential bus stops they use, to make sure that they are potential users. The disadvantage of this is that not all type of bus users can be asked. The uncertainties of this will be described in the discussion (chapter 8). There was sent a letter to the potential survey respondents. In this e-mail, information about the target group and the URL and QR-code to the web page of the survey were included. The following authorities were asked to spread the survey:

Name	**Type**	**Location**
UTFPR	University	Rebouças and Campo Comprido
UFPR	University	15 locations in the whole city
PUCPR*	University	Prado Velho
UniCuritiba*	University	Rebouças
Oscar Niemeyer museum*	Workplace	Centro Cívico
SETRAN	Workplace	Centro
Municipality: department of health	Workplace	Rebouças
Municipality: City Hall	Workplace	Centro
URBS	Workplace	Jardim Botânico
IPPUC	Workplace	Juvevê

Table 6-5: Locations where survey is spread. The star (*) means that probable the survey is not spread, because there are no respondents found with these locations as their destination or start point.

This strategy lead to 237 useful respondents. Excluded the respondents that filled in the survey wrong. The survey was spread by the contact persons through various creative ways. Therefore, there are people with other destinations than showed in Table 6-5. To clarify, for example, some surveys were shared on Facebook, which results in respondent's destinations spread over the whole city. Most respondents were students from the UTFPR campuses. The UFPR campuses had many respondents as well. Students dominate the results, so this can affect this research. This is discussed in chapter 8.

6.3 Find changes that can have a positive effect

To determine the main barriers of the three research locations, the following steps are taken:

- First, the start locations and the destinations of the respondents are georeferenced in ArcMap. There is determined to choose the point that is the closest to the bus stop that is investigated, because that is the most useful one to investigate.
- Second, there is investigated if there are differences in the probability to use a shared bike and the user characteristics, trip properties and the experience of barriers. There are used statistic t-tests, and an ordinal linear regression. The open barriers and triggers people mentioned in the survey makes it possible to analyze if there are special factors that can have impact on people's decision to choose the shared bike as a transport mode on their trip.
- Third, this information is combined, and suggestions for measures can be given. The methods to find these changes depend on the barriers. The suggestions are divided in 4 categories. These categories are:
    1. Add services
    2. Design changes
    3. Social changes
    4. Other changes

1. **Add services**: for example, simple services could be: adding bicycle racks, services for disabled people, or change the docking station locations. Literature helps to find what services they use in other cities to motivate people to use the shared bikes.
2. **Design changes**: If the cycle environment is the most important barrier, the infrastructure should be changes. Literature can help to determine which cycle infrastructure is experienced as the best.
3. **Social changes**: Social changes cannot be done directly by the municipality. However, advice can be given to the municipality for long term changes. With propaganda or commercials, barrier like the prestige of the cycle can be changes.
4. **Other changes**: Maybe there are other obstacles, that cannot be put into a category described above.

7 Results

The three sub-questions will be answered in this chapter. The first sub-chapter demonstrates the results of the GIS study, where the goal is to find the docking stations with the most potential for the shared bikes in combination with the BRT-busses. This GIS study uses the literature study, to successful shared bicycle docking stations in other cities. The second sub-chapter gives the results of the survey and the statistic differences, where the goal is to find barriers and triggers people experience to use the shared bicycle in combination with the bus. The third subchapter gives the location based results, which lead to the answers on the main research question: the measures that can have a positive effect on the number of users of the shared bicycle use in combination with the bus.

7.1 Docking stations with the most potential

In this paragraph, the results from the GIS calculations are shown. There is described which bus stops have the most potential to investigate, concluded from the three scenarios from the GIS analysis. In this research, the docking stations with the most potential are the docking stations where the shared bicycle can have the most advantages for the current bus travelers. To find these docking stations, the bus stops with the highest number of possible destinations reachable by bike are selected. Therefore, the reachability maps of the 14 docking stations that are next to a BRT bus stop are created and shown below. With these maps, there can be calculated which other docking stations are reachable. Then, the number of business licenses close to these docking stations are calculated, using the business license per neighborhood data. This data gives a good impression of the proportion of the bus traveler's destinations. These calculation results are shown in Table 7-1. Also, the number of busses passing per week are calculated, to find the bus stop with the most transfer possibilities.

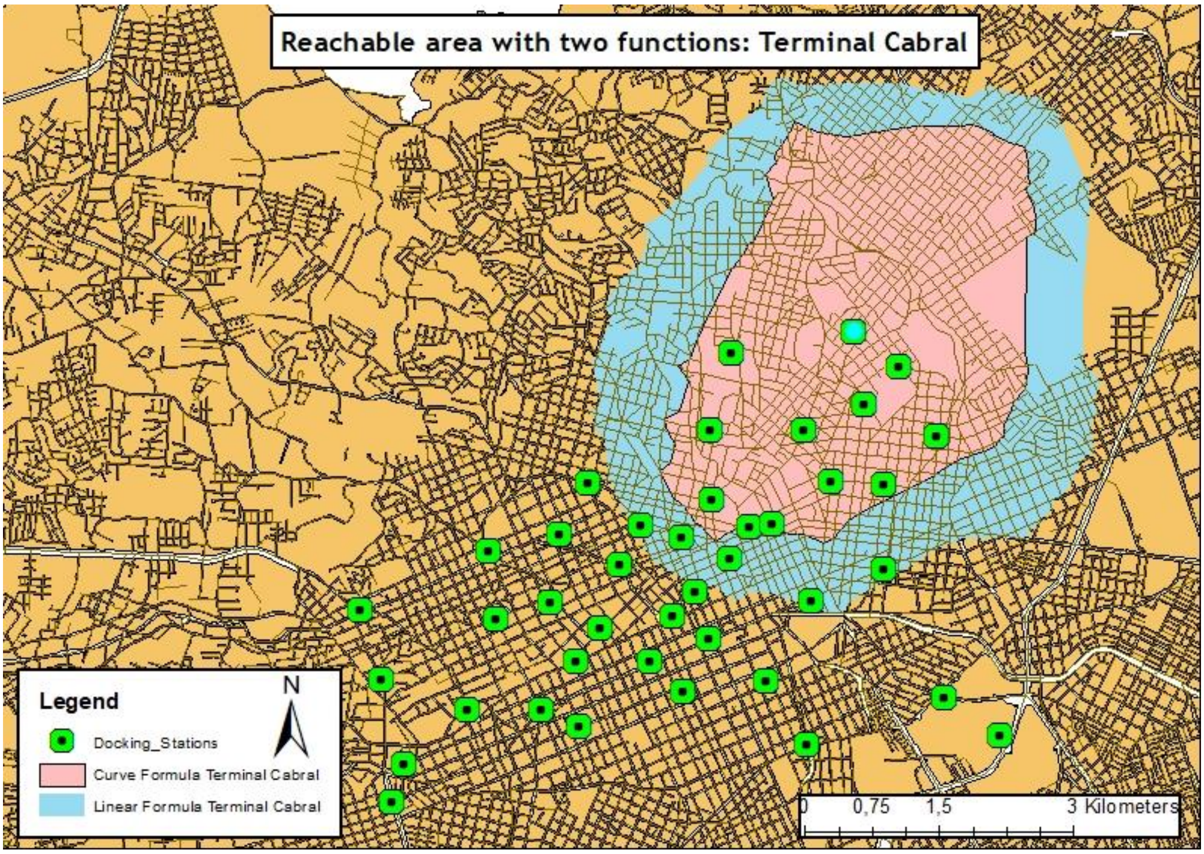


Figure 7-1: Reachable areas with two functions: Terminal Cabral

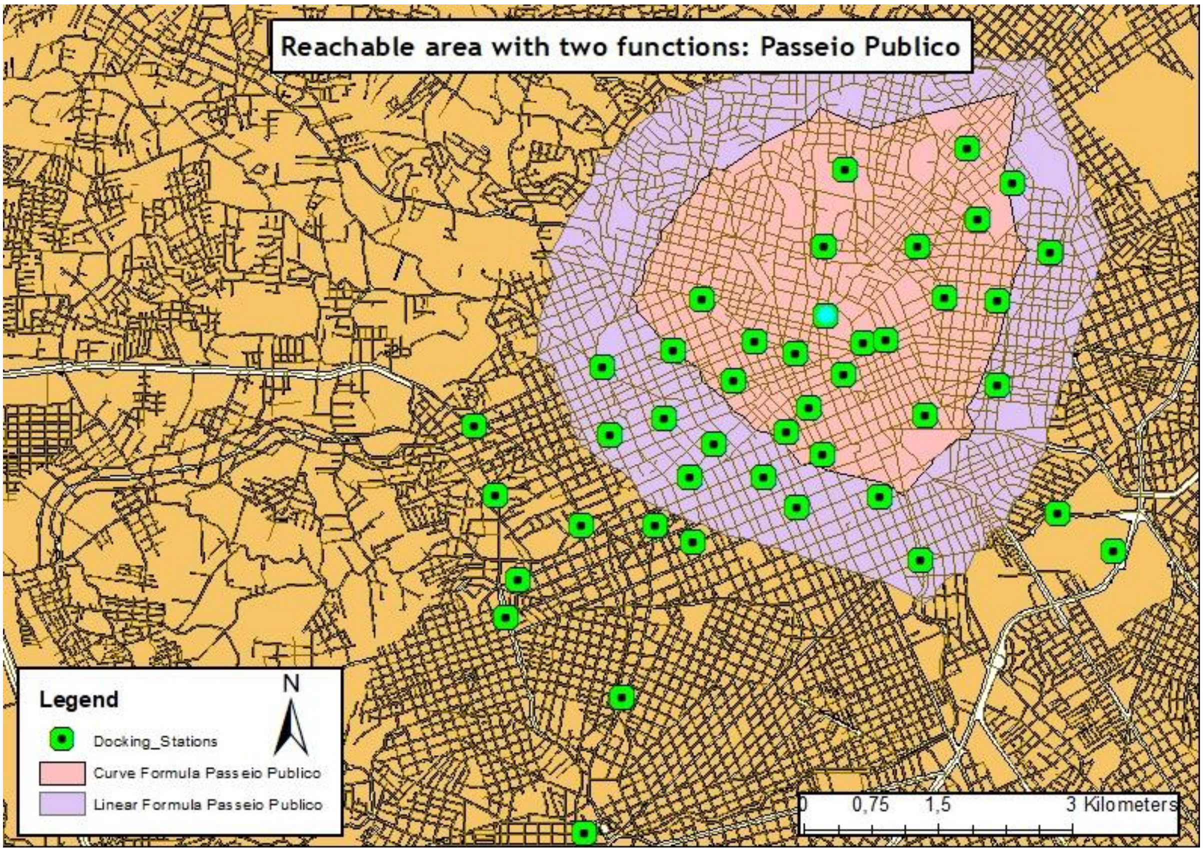


Figure 7-2: Reachable areas with two functions: Passeio Publico

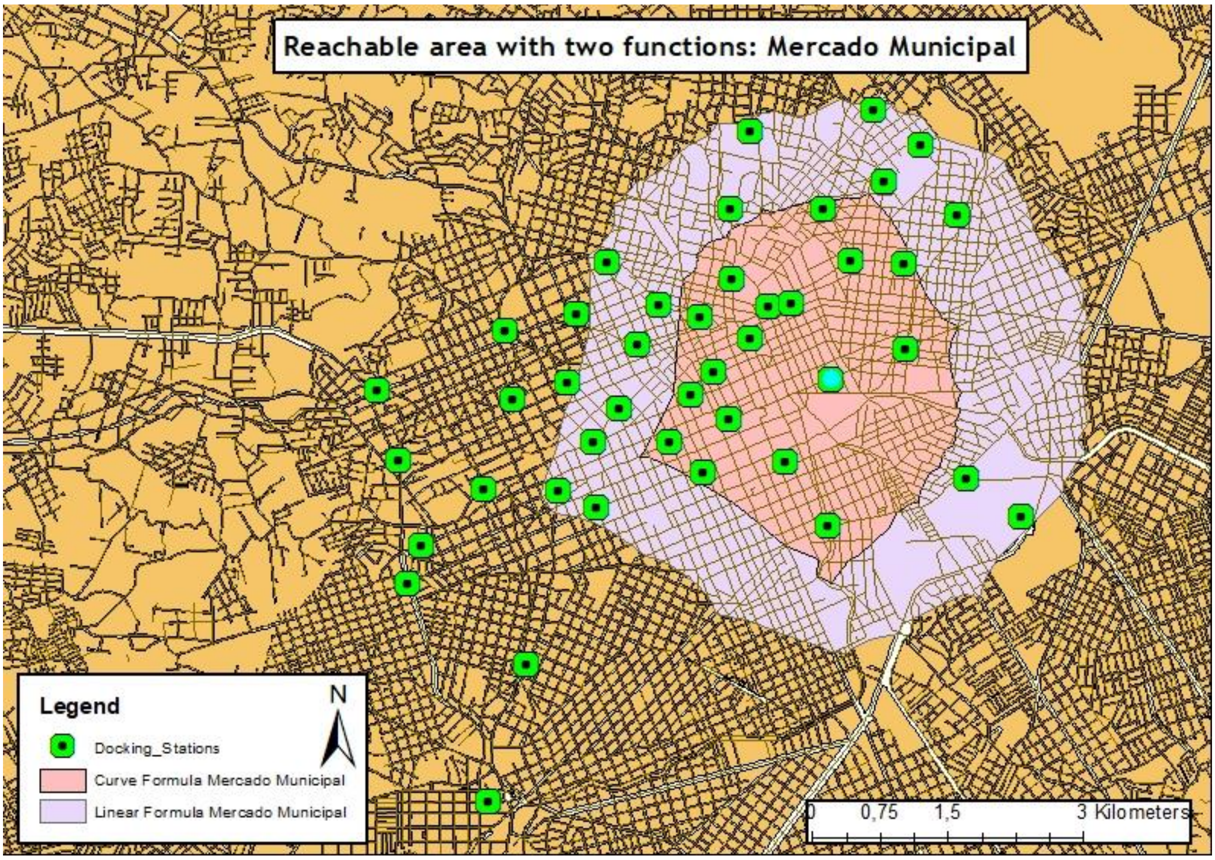


Figure 7-3: Reachable areas with two functions: Mercado Municipal

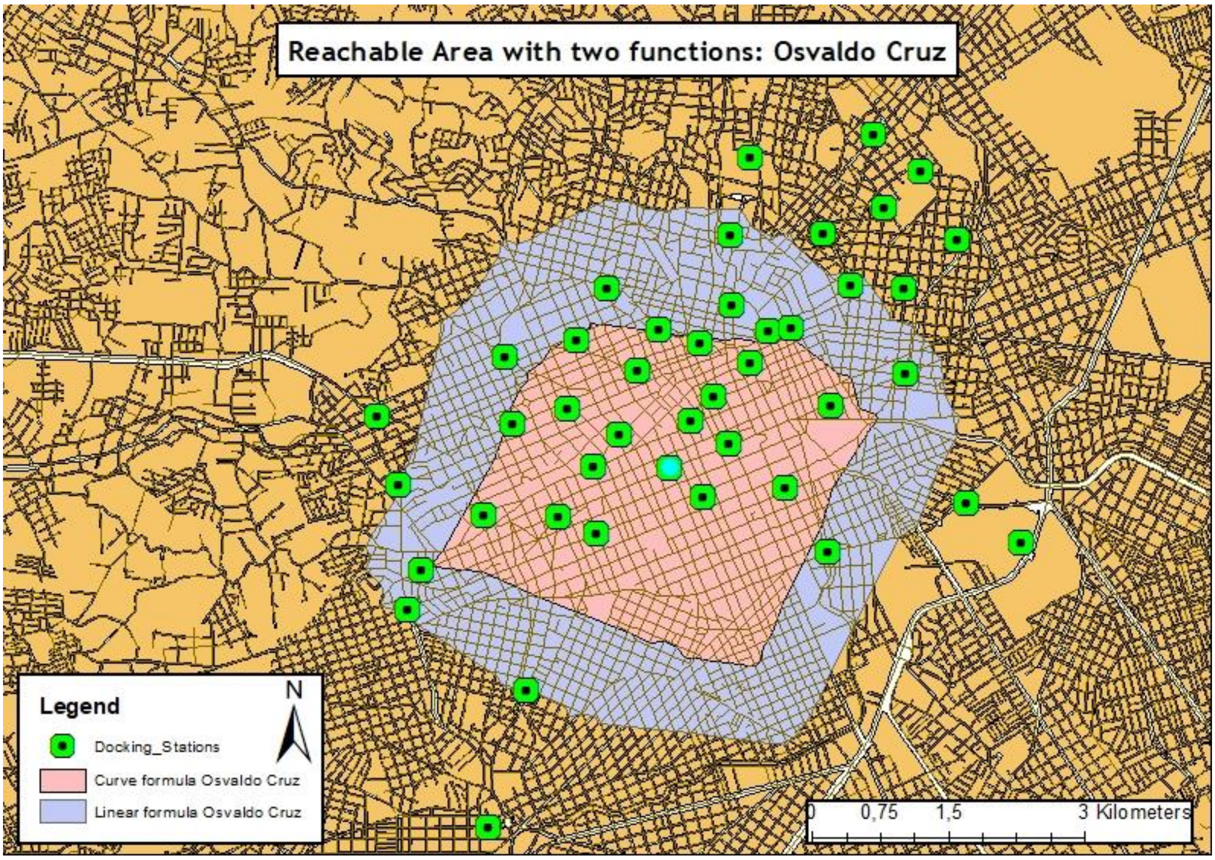


Figure 7-4: Reachable areas with two functions: Osvaldo Cruz

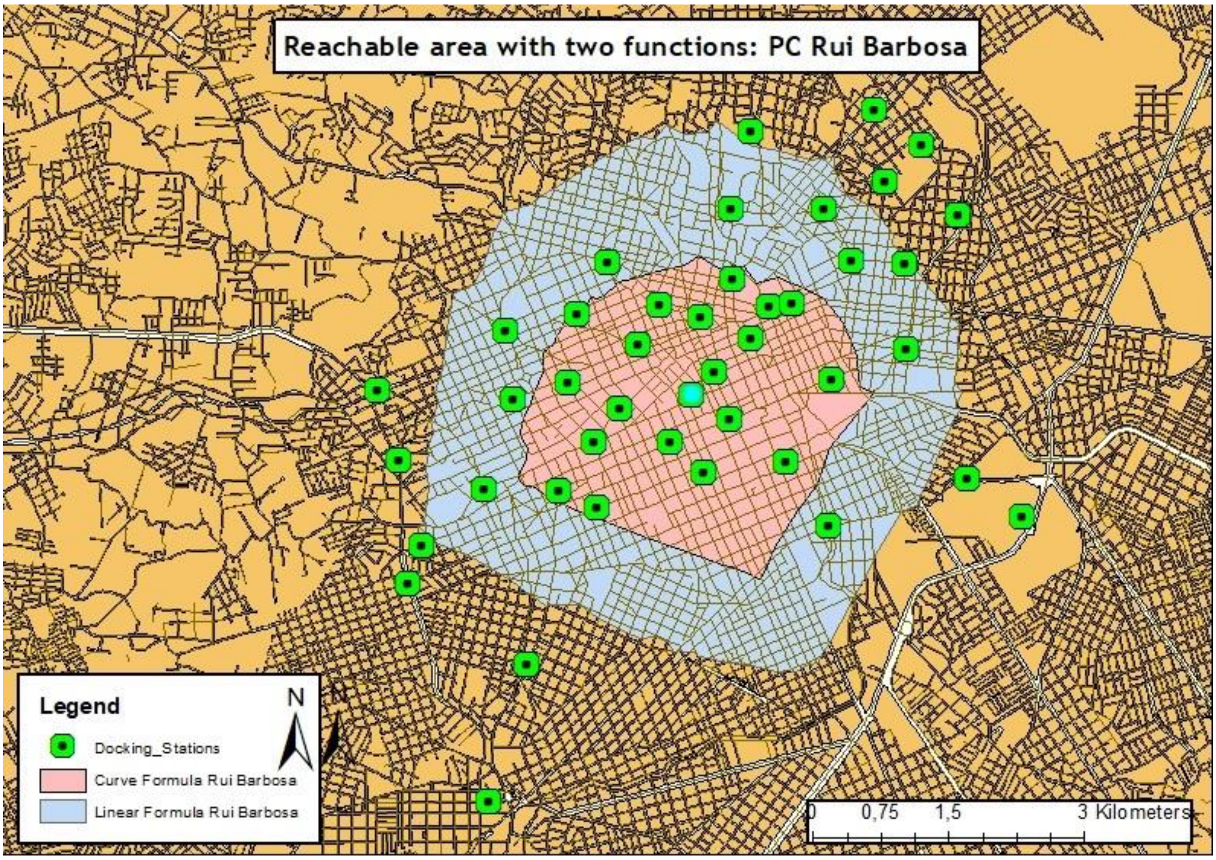


Figure 7-5: Reachable areas with two functions: Praça Rui Barbosa

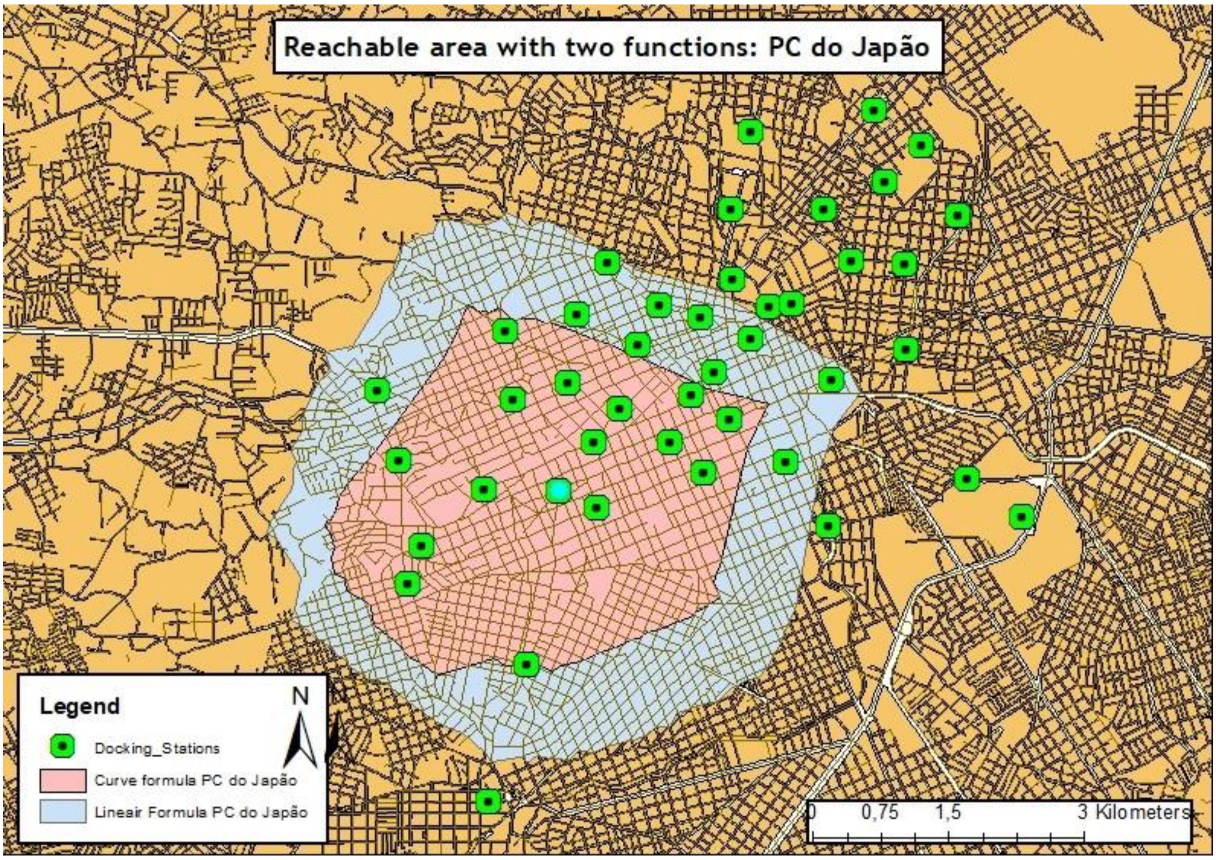


Figure 7-6: Reachable areas with two functions: Praça do Japão

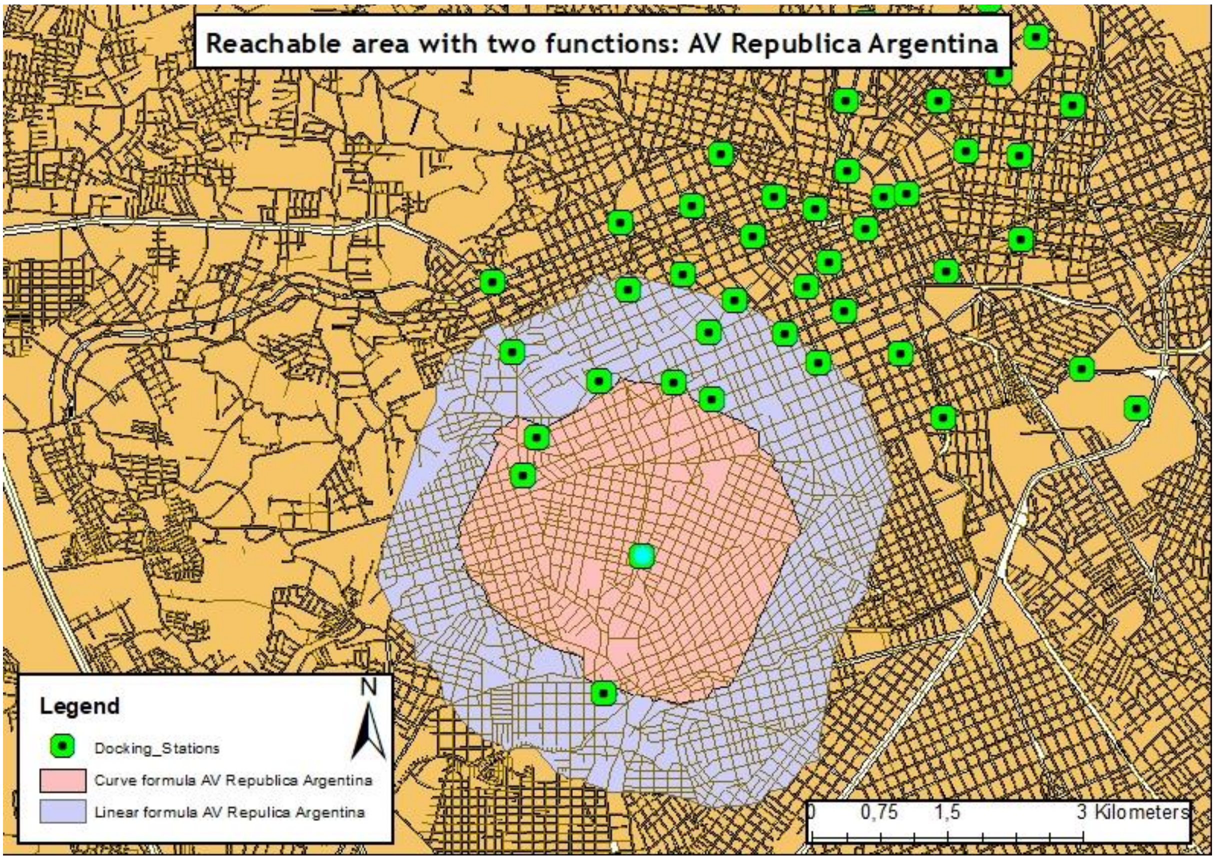


Figure 7-7: Reachable areas with two functions: AV Repuclica Argentina

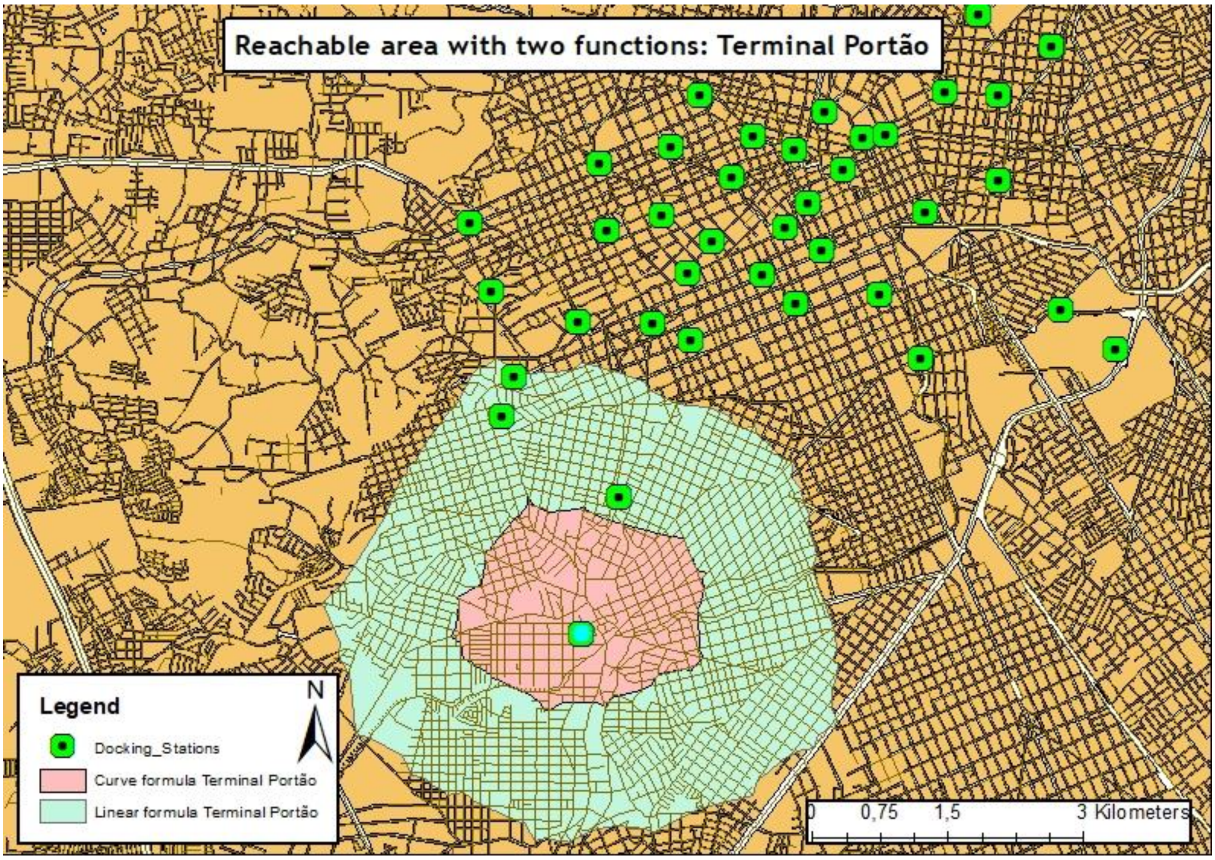


Figure 7-8: Reachable areas with two functions: Terminal Portão

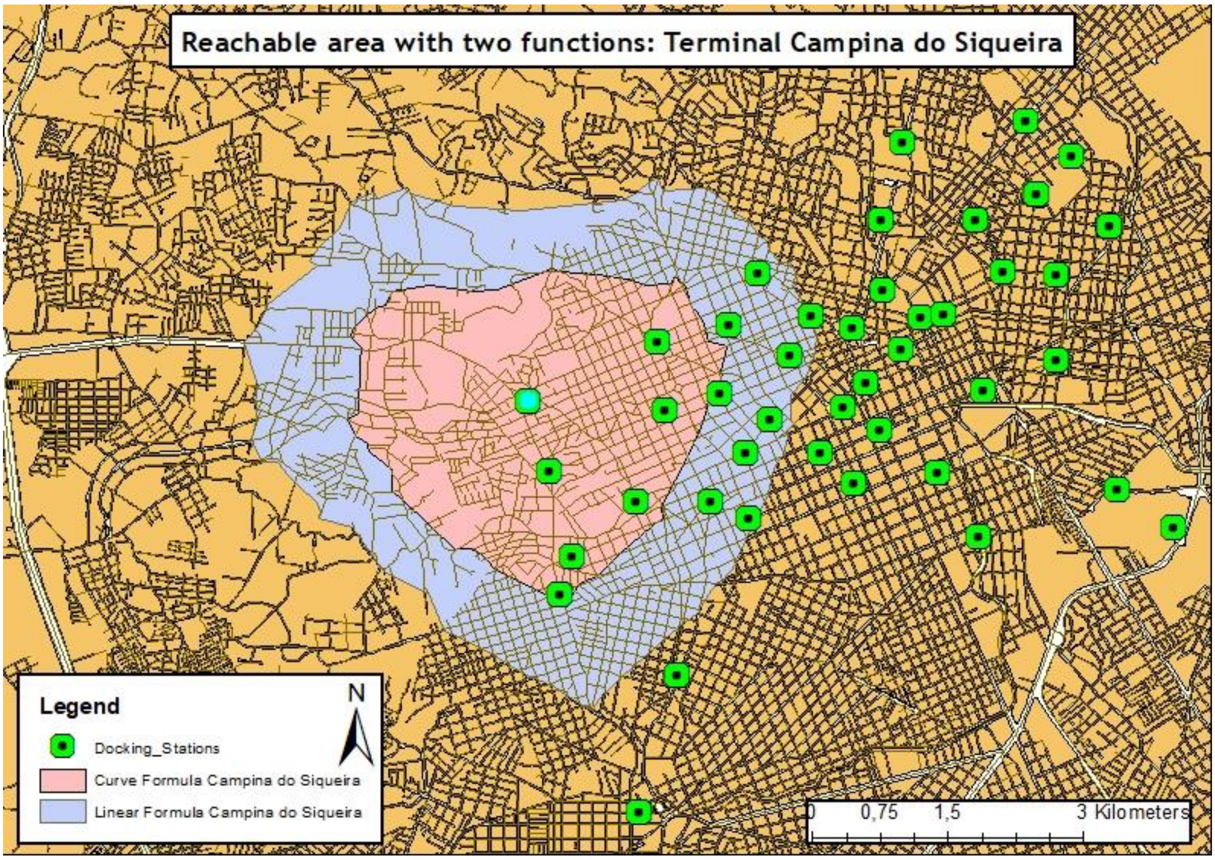


Figure 7-9: Reachable areas with two functions: Terminal Campina do Siqueira

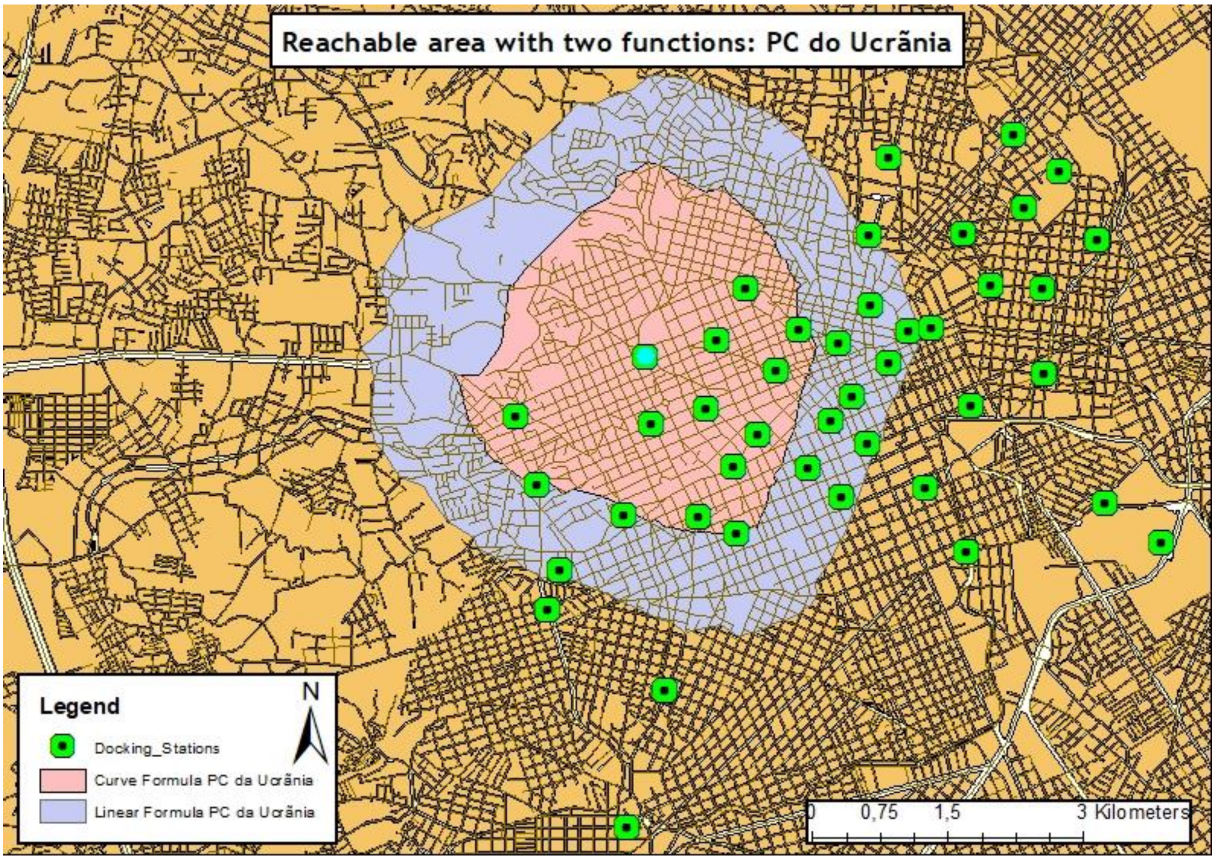


Figure 7-10: Reachable areas with two functions: Praça do Ucrãnia

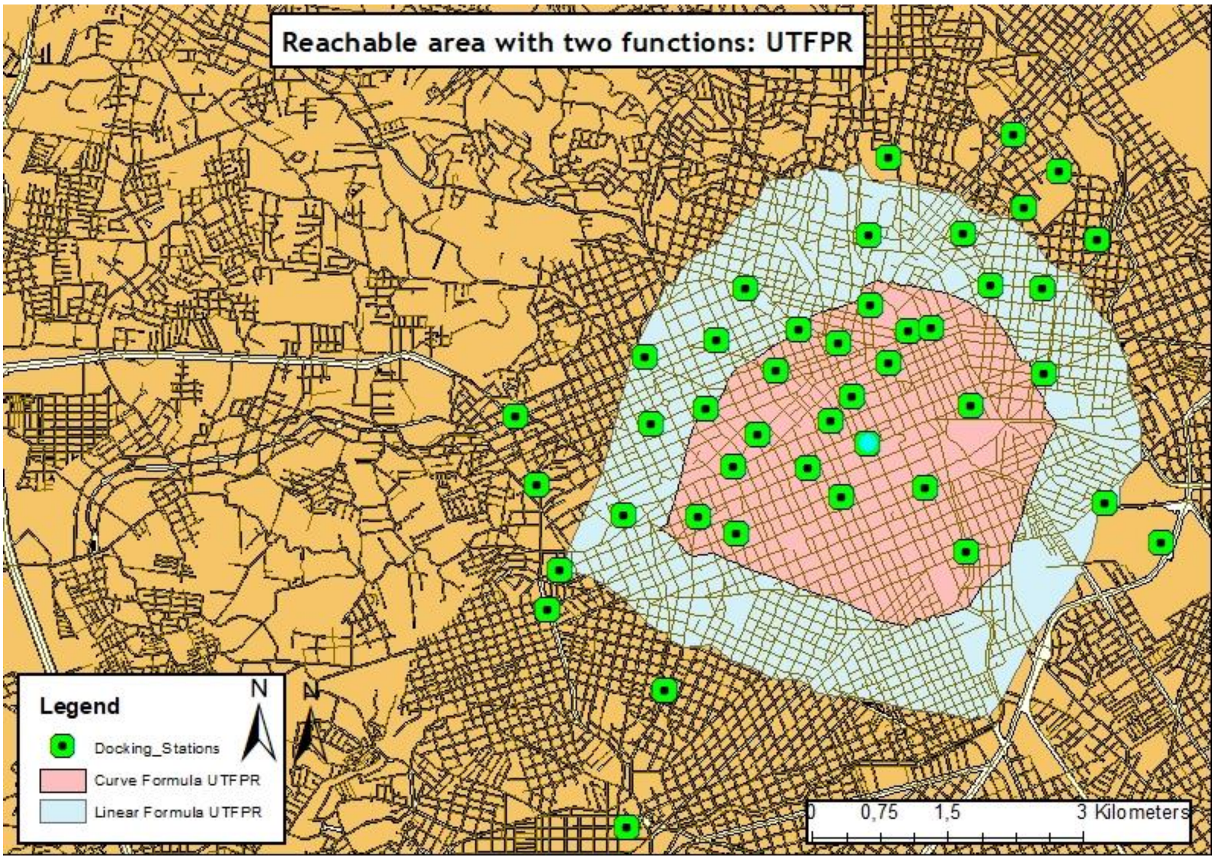


Figure 7-11: Reachable areas with two functions: UTFPR

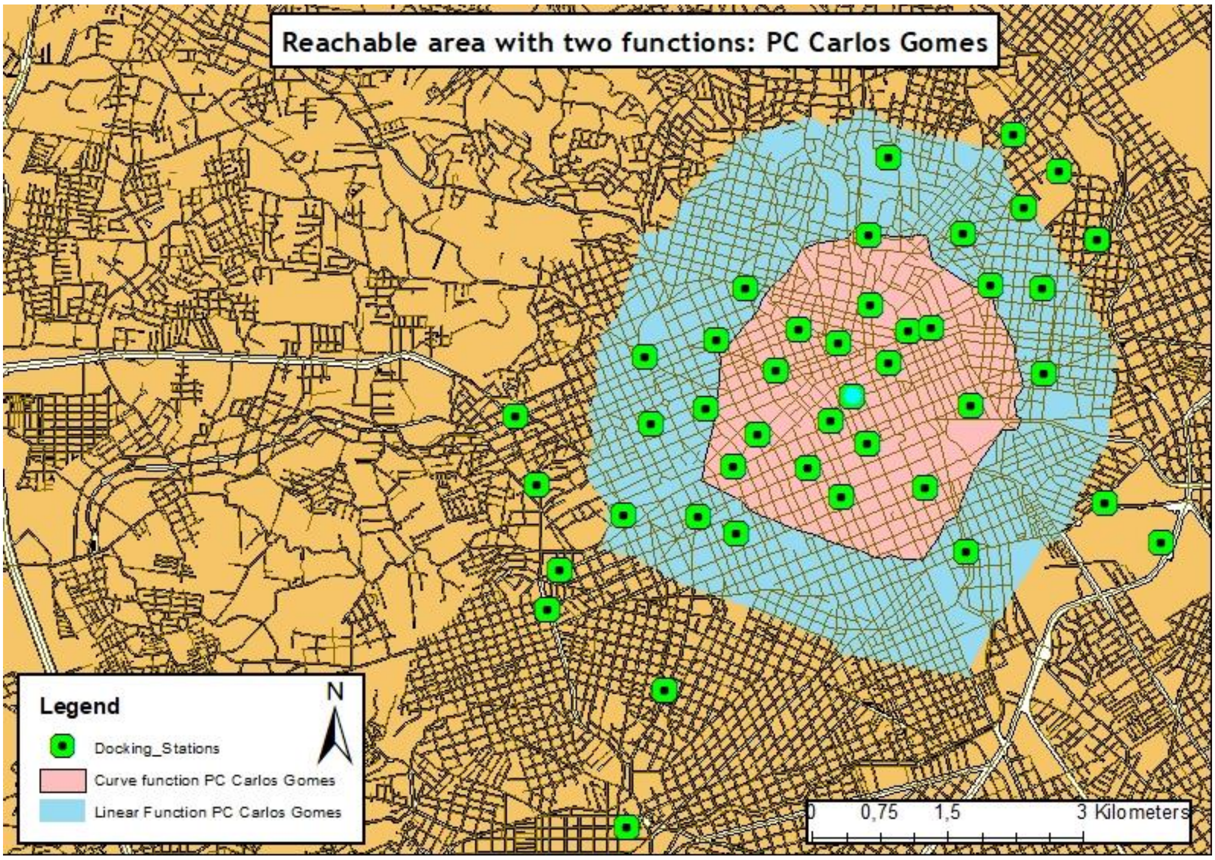


Figure 7-12: Reachable areas with two functions: Praça Carlos Gomes

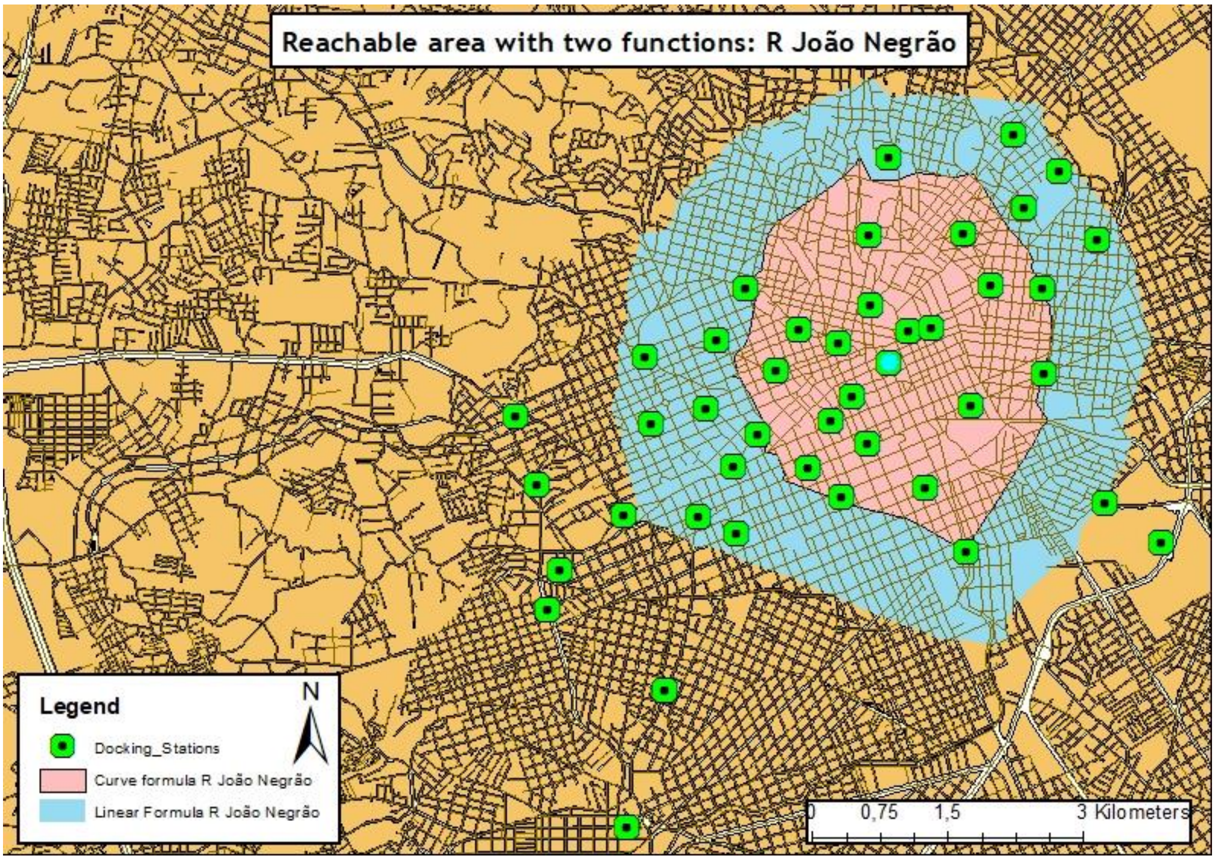


Figure 7-13: Reachable areas with two functions: Rua João Negrão

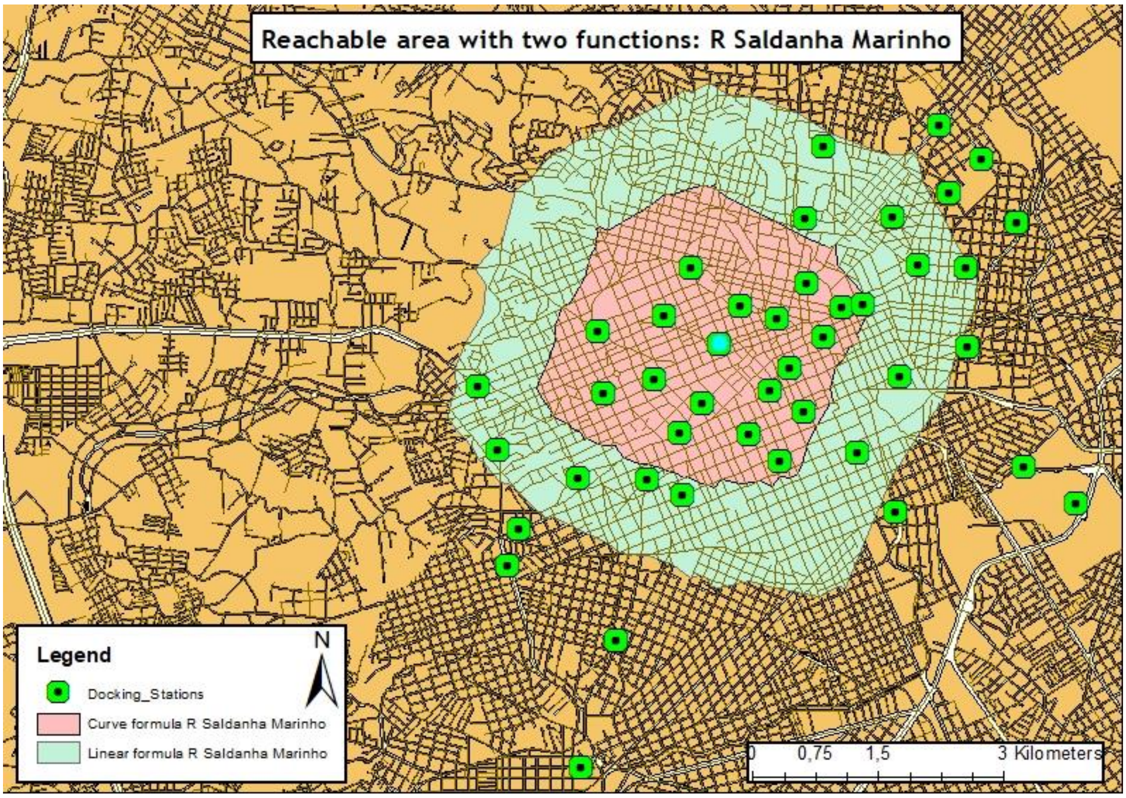


Figure 7-14: Reachable areas with two functions: Rua Saldanha Marinho

ID	Docking station name	Bus lines 200 meters near the docking station		Bikeable distance determined with soft bikeability index		Bikeable distance determined with extreme bikeability index function	
		Type	Busses Mon-Fri[1]	Other docks reachable by bike	Rel. business licenses reachable	Other docks reachable by bike	Rel. business licenses reachable
0	TERMINAL CABRAL	Terminal	64465	16	734	10	389
1	PASSEIO PUBLICO	Bus stop	17584	31	1374	18	1009
2	MERCADO MUNICIPAL	Bus stop	5110	31	1445	16	1016
3	PC OSVALDO CRUZ	Bus stop	6165	30	1341	17	847
4	PR RUI BARBOSA	Bus stop	28548	29	1333	19	1135
5	PC DO JAPÃO	Bus stop	6187	25	1049	14	547
6	AV REPUBLICA ARGENTINA	Bus stop	11728	12	346	2	29
7	ESTAÇÃO TERMINAL PORTÃO	Terminal	32797	3	46	0	0
8	TERMINAL CAM-PINA DO SIQUEIRA	Terminal	54251	14	377	6	96
9	PC DA UCRÂNIA	Bus stop	5636	23	1179	11	342
10	UTFPR	Bus stop	12772	31	1350	18	1106
11	PC CARLOS GOMES	Bus stop	12380	31	1398	15	1049
12	R JOÃO NEGRÃO	Bus stop	14436	33	1424	18	1075
13	R SALDANHA MARINHO	Bus stop	7765	30	1368	18	1113

Table 7-1: Docking stations that are next to a bus stop with passing busses and reachable business licenses

[1]number of (transfer) busses that pass this bus stop during the week from Monday until Friday

The following steps are done to calculate the numbers in Table 7-1:

1. The first calculated column in the table, is the number of busses passing each week from Monday until Friday, on the bus stops 200 meters from the docking stations. As determined in chapter 0, 200 meters is the maximum distance that can be counted as a transfer. In general, this is the size of the biggest terminals.
2. The docking stations that are in the reachable bikeable area of scenario 1, are summed in the next column. For Terminal Cabral, there are 16 docking stations reachable in scenario 1 and 10 docking stations are reachable in scenario 2, as visualized in Figure 7-1.
3. In the next column, the business licenses from these docking stations are summed. For example, in scenario 1 of Terminal Cabral, the business license density at these 16 points are summed. The business license density from all 43 docking stations are shown in Appendix C: Information about the docking stations. In the next two columns, the same steps are repeated for scenario 2.

Docking stations to investigate
In this bachelor thesis, the purpose is to investigate the docking stations that seem to have the most potential using literature. The choice is based on the literature, which leaded to the three scenarios in the GIS analysis. The following docking stations are investigated:

1. **Terminal Cabral**

Terminal Cabral is the terminal with the most passing busses. This terminal is mainly used by people living in the North-East side of the city. The city center can be reached quickly, so probably much people work in the Matriz area. People that make trips including this bus terminal, have potential for shared bicycle users. The shared bicycles can be a feeder mode for Terminal Cabral. There is a BRT line from Terminal Cabral to the city center.

2. **Praça Rui Barbosa**

The Rui Barbosa square is a square where all BRT lines come together. From the GIS analysis, this bus stop seems to have the most potential business locations reachable by bike. The square is a central place, and 19 of the 43 other docking stations are easily reachable, in scenario 2: where the bikeability has huge influence. Therefore, this bus station can have potential for the shared bicycle system.

3. **Rua João Negrão (Estação Tubo Central)**

Estação Tubo Central is a slightly smaller bus stop. Concluded in the GIS calculations, the most locations are reachable from this bus stop in the scenario 1: with the soft barrier factor formula. The docking station here is not directly connected to the bus stop, and therefore the name of the docking station is different (Rua João Negrão). But the docking station can be reached easily from the bus stop.

These three bus stops seem to have the most potential for shared bike users in combination with a BRT bus. But this potential is not enough to know what barriers people experience, and what motivates people to use the shared bike system. Therefore, in the next chapter, a survey is carried out to users of these three bus stops. The goal is to investigate what barriers and triggers people experience to use the shared bike as a part of their trip. Then, there can be concluded to what extent the potential from the GIS study is feasible and which measures can have a positive effect on the number of shared bike users in combination with a BRT bus.

7.2 Survey results and statistics

As described in chapter 6, a survey can determine what barriers people experience to use a shared bike in combination with a BRT bus. Also, with this survey, there can be concluded what can motivate people to use a shared bike in combination with a BRT bus. The results of the survey from chapter 6.2 are shown in this chapter. The first paragraph describes the general results, the second paragraph shows the statistics. In the third sub chapter, the specific information for the bus stations that will be investigated are shown.

General results

There are 237 useful respondents that filled in the survey. In Table 7-2, the averages and summarized information is shown. In Appendix E: Graphs from survey results, the associated diagrams and tables are shown.

Question	Answers					
Gender	Female: 57%	Male: 43%				
Age	<25: 57%	25-40: 29%	41-55: 11%	56-70: 3%	>70: 0%	
Income (R$)	<1760 19%	1760-3520 24%	3520-8820 33%	8820-17600 14%	>17600 3%	No answ: 7%
Education	No educ: 0%	Elem. Sch 0%	High sch 7%	Tech Sch 4%	Higher Ed 68%	Post Gr 21%
Other transport mode than bus	Walking: 44%	Other bus: 41%	Car/Motor: 8%	Bicycle: 5%	Taxi/Uber: 2%	
Frequency of trip	≥4x per week 81%	1-3 per week 15%	1-3 per month 2%	6-11 per year 1%	1-5 per year 2%	<1 per year 0%
Trip reason	University: 62%	Work: 32%	Other:6%			

Table 7-2: Survey respondent's user characteristics and trip information

Slightly more than half of the respondents is female. Most of the respondents are younger than 25 years old. The reason for this is probably the digital way of approaching people to fill in the survey. Almost 9 out of 10 from the respondents attended higher education or post graduated. This means that the group of lower education groups are smaller than in reality (EP-Nuffic, 2015). All income groups are represented, only 7 percent did not answer this question.

To determine which current transport modes (or transport mode combinations) have potential to be replaced by a shared bike, there is asked if people use other transport modes as well. Most of the respondents use another bus and/or walk a part of their trip. Small groups use bus in combination with the car, motorcycle, bicycle or taxi. 81% of the people make the trip 4 or more times per week, 15% 1-3 times per week. The other 4% make this trip less than 1 time per week. More than half of the respondents make the trip to go to university, 32% for work and 6% for other reasons: church, family, doctor, hospital and shopping.

Because of the high percentage of higher education and post-graduate group, the results of this research are not always conclusions for lower education groups. Therefore, there will be analyzed if these lower education groups differ from the high education groups in the probability of the use of the shared bikes. This is done with an independent T-Test, in Appendix

F: Statistic differences between groups. Also, an ordinal linear regression test is carried out, which is explained later in this chapter.

For 5 kinds of barriers, people were asked to answer how important they were on a Likert scale. 1 means not important, and 5 means very important. They were also asked to say how likely it is that they will use the new shared bicycle system in the future, both for the electrical and for the non-electrical version. The results are showed in Table 7-3.

Barriers/triggers	*Not important*	*Little important*	*Moderately important*	*Important*	*Very important*	*Mean*	*Median*
Price of the bike	3%	5%	18%	22%	52%	4,16	5
In/decreasing of time	3%	7%	17%	32%	40%	3,99	4
Insecurity in traffic	2%	8%	12%	17%	61%	4,26	5
Facilities for cyclists	5%	3%	20%	25%	46%	4,03	4
Presence of cycle paths	3%	3%	7%	21%	66%	4,45	5
Probability to use bike	*Very unlikely*	*Unlikely*	*Maybe*	*Likely*	*Very likely*	*Mean*	*Median*
Non-electrical bike use	15%	14%	23%	22%	27%	3,32	3
Electrical bike use	23%	14%	26%	19%	18%	2,95	3

Table 7-3: Respondent's barriers and probability to use a shared bike as a part of the trip

The respondents were asked to say if they would use the shared bicycle system as a part of their trip in the future on a Likert scale (with 1=very unlikely and 5=very likely). This is question was divided in 2 sub questions: for the electrical bike and for the non-electrical bike. The non-electrical bike seems more popular. As explained in the literature study, the non-electrical bike is more popular than electrical bikes in high-density areas (city centers) in other cities. Most respondents have their trip destination in the city center, so therefore the non-electrical bike is probably more popular than the electrical bike. 49% of the respondents says that it is likely or very likely that they will use the non-electrical shared bike as a part of their trip in the future, and 37% of the respondents says that it is likely or very likely that they will use the electrical shared bike as a part of their trip in the future. In general, with these numbers there can be concluded that there is potential for the system. In the next paragraphs, there will be investigated in which circumstanced the system will be used, and what changes can lead to a higher rate of users.

From the 5 kinds of barriers, the presence of cycle paths is answered as the most important trigger to use a shared bike. 66% find this very important, and the average score is 4,45 (where 4 is important and 5 is very important). The insecurity of traffic is answered as very important by 61% of the respondents, with an average of 4.26. The price of the bike and the facilities for cyclists have a mean that is slightly higher than 4: respectively 4,16 and 4,03. The difference in travel time (decreasing or increasing) is answered as the littlest important: 3,99. In general, all these 5 barriers are answered as important or very important. This was expected in the literature study, because these triggers and barriers are the most important in other cities and therefore chosen to ask in this survey.

There was also an open question in the survey to mention the most important barrier or trigger for the use of the shared bike system, to see if there are specialties in Curitiba different from other cities. These results are grouped and are shown in Table 7-4.

Mentioned barrier/trigger	Times mentioned
Climate	20
Public Safety	13
Bike conditions	12
Locations of the docks	10
Easiness of the system	7
Price is too high	7
Impact on health	7
Number of docks	6
Availability of bikes	5
Time Saving	4
Distance to the docks	4
45 minutes too short	4
Cycle paths	3
Insurance	3
Unable to ride a bike	3
Traffic safety	3
Theft Protection of bikes	2
Trip length	2
Enjoy to cycle	2
No slopes on the route	2
Maintenance points	1
Staff at the docks	1
decreasing of traffic jams	1
Impact on the environment	1
Car driver's behavior	1
No need to search car parking	1
Availability of helmets	1
More other people cycling the same route	1
Bus capacity	1
Secure registration process	1
Facilities for deaf people	1
Bus ticket price	1
Free bike when paid the bus ticket	1

Table 7-4: Answers from the open question about the barriers and triggers for the use of the shared bikes

Climate

The climate as a barrier is mentioned the most in this open question about triggers and barriers to use the shared bike as a transport mode. As reviewed in the literature study, the weather conditions only have impact on days colder than 0°C and warmer than 30°C, or days with more than 1,3 cm rain. Curitiba has more colder days than other Brazilian cities, but days colder than 0°C are rare. In average, the worst months of the year can have more than 10 days with more than 1,3 cm rain (weather-and-climate.com, 2016). To compare with other shared bike systems in Brazil, this is more than average. For example, São Paulo has less rain (but more hot days). On these ‘bad climate’ days, people will use other transport modes. For example, the yellow feeder busses. One of the reasons to implement the shared bicycles, was to reduce these number of feeder busses, because they are expensive. It is important to know that this can be a problem on rainy days.

Statistics
To determine if different groups experience different barriers, independent T-tests and regression tests are conducted by IBM SPSS Statistics. The related t-test tables are shown in Appendix F: Statistic differences between groups.

There are statistic differences between men and women. Women experience much more barriers than men (t-values: Travel time 2,2, insecurity -,2, facilities 4,3). Only in the price as a barrier, no statistical differences are found. So, measures that increase the cycle infrastructure, safety and facilities have more impact on the number of female users.

Statistic differences between age groups and how they experience barriers are found in the following barriers: the price, travel time and insecurity in traffic. Respondents younger than 25 experience the price and travel time (t values 2,2 and 2,0) more as a barrier than people older than 25. The people older than 25 experience traffic insecurity more as a barrier than the younger group (t-value 2,4).

In the different income groups, no statistic differences are found in what barriers are experienced, and no statistic differences are found in the probability to use an electrical or non-electrical bike as well. In the different education levels, statistic differences are found in the probability to use an electrical bike (t-value 2,8) and a non-electrical bike (t-value 2,7). High educated people are much more likely to use both an electrical and a non-electrical bike.

There are no significant differences found between the trip frequency levels and the use of a shared (electrical) bike. Also, no significant differences are found between the trip frequency and the experienced barriers. People that travel every day experience the same barriers as people that do not make the trip daily.

96% of the respondents make their trip for work or university. Therefore, only those 2 groups are tested on correlation in the trip reason. Statistic difference are found in the price as a barrier to use the shared bike system (t-value -2,4). Students experience the price more as a barrier than people that make the trip for their job. This can be interesting for future price changes. A price decrease will have more impact on students than on working people.

To see which feeder modes for the BRT system can be changes by shared bikes, the other transport modes people use are analyzed. Most respondents use another bus than the BRT in their trip, or walk to or from the BRT bus stop. There is only found statistical difference in the probability to use a non-electrical bike. People that use walking as another transport mode as the bus, are more likely to use a non-electrical bike than people that use another bus (t-value 2,7). This means that the target group is on people that use one BRT line for their trip and walk the last part. People that transfer to another BRT or normal bus line, slightly have less potential for the shared bike.

Ordinal Logistic Regression
An ordinal regression test is used to see for the survey questions answered on an ordinal scale (income, age, education, trip frequency and the 5 barriers). The threshold variables are the last two questions: how likely is it that you would use an electric or non-electric bicycle (as a part of) your trip? This regression test concludes which groups are potential shared bicycle users, and what barriers are experiences by the different groups. The table in ‘Appendix G: Ordinal Logistic Regression’ shows results of the regressions. Only the ordinal values are shown,

which means that gender, transport modes and trip reason are excluded from this Table. They are only tested with a t-test. The important significant conclusions from this test are:

- The education levels ‘high school’ and ‘technical school’ are less probable (resp. -1,632 and -1,620) to use a non-electrical bike. And, also less probable (resp. -2,250 and -1,964) to use an electrical bike. So, the higher the education level, the higher the probability to use a shared bike. There is no data from people without education or only elementary school, so this conclusion is only based on high school, technical school, higher education and post-graduate levels. This difference is not found in the literature about other cities. Further research is needed to find out why these groups differ.
- A conclusion about the income is that the group with the highest income (>R$17600), has more potential than the other groups to use a non-electrical bike, and the second highest income group (R$8820-R$17000) has less potential for both electrical and non-electrical bikes. This could mean that in Curitiba lower incomes have more potential. However, when splitting the incomes in 2 groups, there is no statistical difference found between the income and the use of the shared bikes. So, a clear relation is not found. In the literature, there was found that higher incomes have slightly more potential to use shared bikes.
- The age group 25 years old or younger, has the most potential to use an electrical shared bike. Also in the literature, there was showed that younger people relatively use electrical bike more than people older than 25 years old. But, in other cities, the trip locations of electrical bikes are mainly outside the city center. In the current plans in Curitiba, the docking stations are mostly in the city center. In other cities, the city center is not the place where electrical bikes are popular. If more docking stations will be implemented in the future, this can be an important consideration.

7.3 Location based results: Terminal Cabral

To determine what changes can have a positive impact on the number of users of the shared bicycle system, the three bus stops that seem to have the most potential, are investigated separately. The respondents mentioned which bus stop they used for the trip they made. Therefore, the results can be location based. In this paragraph, suggestions for Terminal Cabral are shown, based on survey results, the GIS study, and literature.

Properties of Terminal Cabral

To determine if there are differences between terminals and normal bus stops, some conclusions about Terminal Cabral are given. In Figure 7-15, the start or end location of the respondents is shown (the one that is the closest to Terminal Cabral). The blue dot on the map ( ) is the place of Terminal Cabral. As shown, also for the neighborhood Ahu, Boa Vista and Bacacheri the terminal is important.

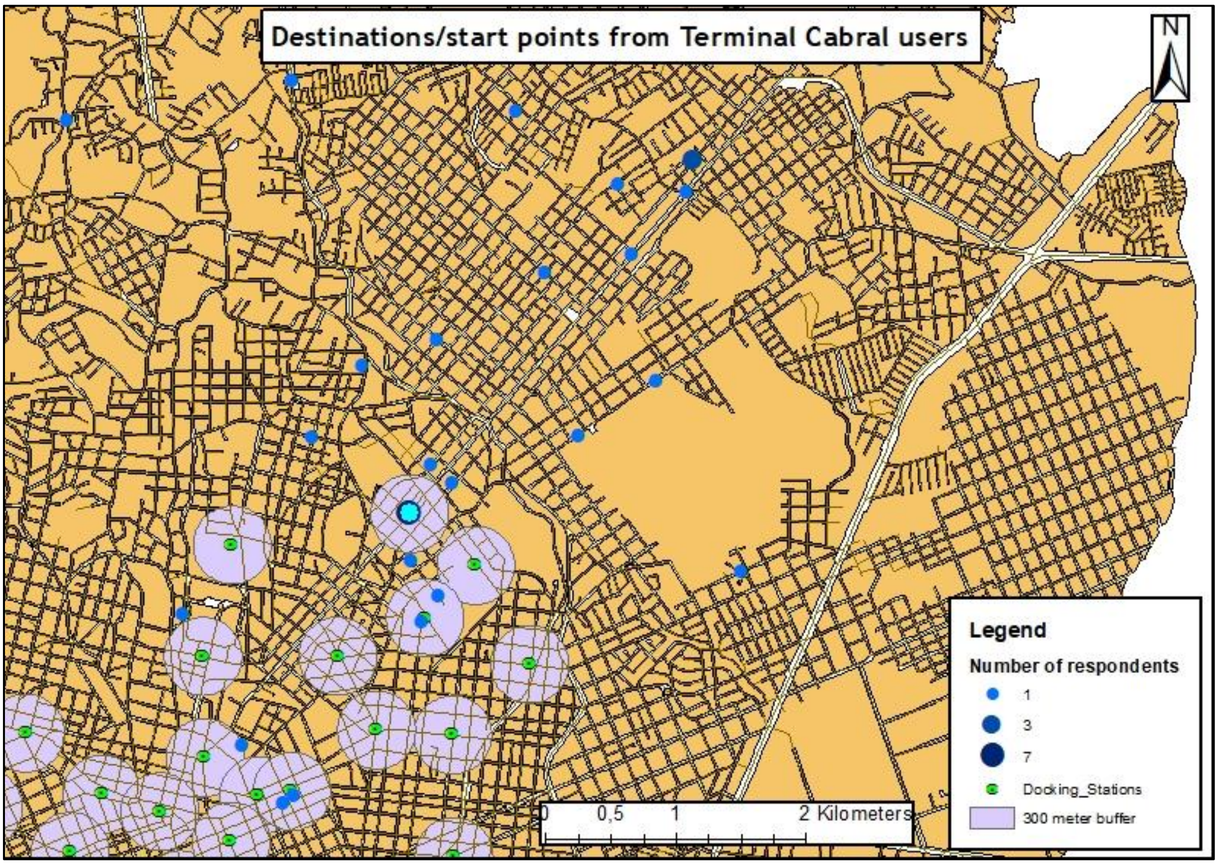


Figure 7-15: Destination/start points from people that use Terminal Cabral

Statistic information about Terminal Cabral users from the survey

Terminal Cabral is the only research location that shows statistic differences in the probability to the use of shared bikes compared to the other research locations. The probability of the shared bicycle use is 3,76 for terminal Cabral users, compared to the average of 3,25 for all 237 respondents. Terminal Cabral users experience the traffic insecurity as a more important barrier than people who use the other bus stops. The average for Terminal Cabral is 4,68, compared to the average of all respondents: 4,19. From the open question about triggers and barriers are no exceptional differences found for Terminal Cabral compared to the other bus stops. The numbers from this statistical test are shown in Appendix H: Location specific statistics.

Possible changes for Terminal Cabral

Following these statistics, Terminal Cabral has potential for shared bikes as a feeder mode for the BRT busses. But, in the survey, the locations of the docking stations were not mentioned. In the GIS study, Terminal Cabral seemed to be not as reachable as the big bus stops in the city center. This means that Terminal Cabral has less potential in the current situation: with the docking stations mainly implemented in the city center. Therefore, the suggestions for Terminal Cabral are mainly in category 1: add services. Before a shared bicycle system can operate smoothly as a feeder mode for the BRT line on Terminal Cabral, more docking stations are needed in the neighborhoods Cabral, Ahú, Boa Vista and Bacacheri. With the current docking station places, for most people it is not possible to use a shared bike. Their destination or home is not within the 300-meter buffer area. As shown in the literature study, ITDP (2013) investigated this, and concluded that a docking station every 300 meter is necessary to create a system that is reachable for everyone. In cities with “blocks” (rectangles), the best place for the docking stations is on the intersections. People mentioned in the survey that cycle paths and cycle facilities are the most important barrier. So, good cycle infrastructure from these docking stations to Terminal Cabral will let the shared bikes work as a feeder mode for the BRT busses.

Influence on the number of users

The influence of these changes depends on the density of the docking stations that will be implemented in these areas. But, when the suggestion will be followed (docking station every 300 meters, in neighborhoods Cabral, Ahú, Boa Vista and Bacacheri, with cycle paths from all docking stations to Terminal Cabral), the terminal will be accessible by bike for all inhabitants of these neighborhoods: 12000 + 12000 + 29000 + 24000 = 77000 inhabitants. Now, the other neighborhoods only are covered for less than 30% by the buffer areas of the docking stations. So, the use of the shared bikes can be three times more, when the neighborhoods are covered well. 49% from the current Terminal Cabral users is likely or very likely to use a shared bike. There is now known how much they will use the shared bikes, so a number cannot be given. In the map from the municipality, which is shown in Appendix B: Locations of shared bike docking stations, 300-meter buffer zones should be used. Now, the areas outside the city center are bigger than 300 meters. This lead to unreliable cover percentages.

As explained in the literature study, Campbell et al. (2016) investigated that the locations outside the city center, with a lower population density, have relatively more potential for the electrical version of the shared bikes. So, when this suggestion will be followed, the use of electrical shared bikes will probably increase relatively more than the non-electrical bikes.

7.4 Location based results: Praça Rui Barbosa

The location of the Rui Barbosa square is in the (high populated) city center (Figure 7-16). The blue dot on the map ( ) is the place of the PC Rui Barbosa docking station. The red lines display the BRT lines, which shows that the 5 BRT directions all come together at the PC Rui Barbosa square. The blue lines display the cycle infrastructure.

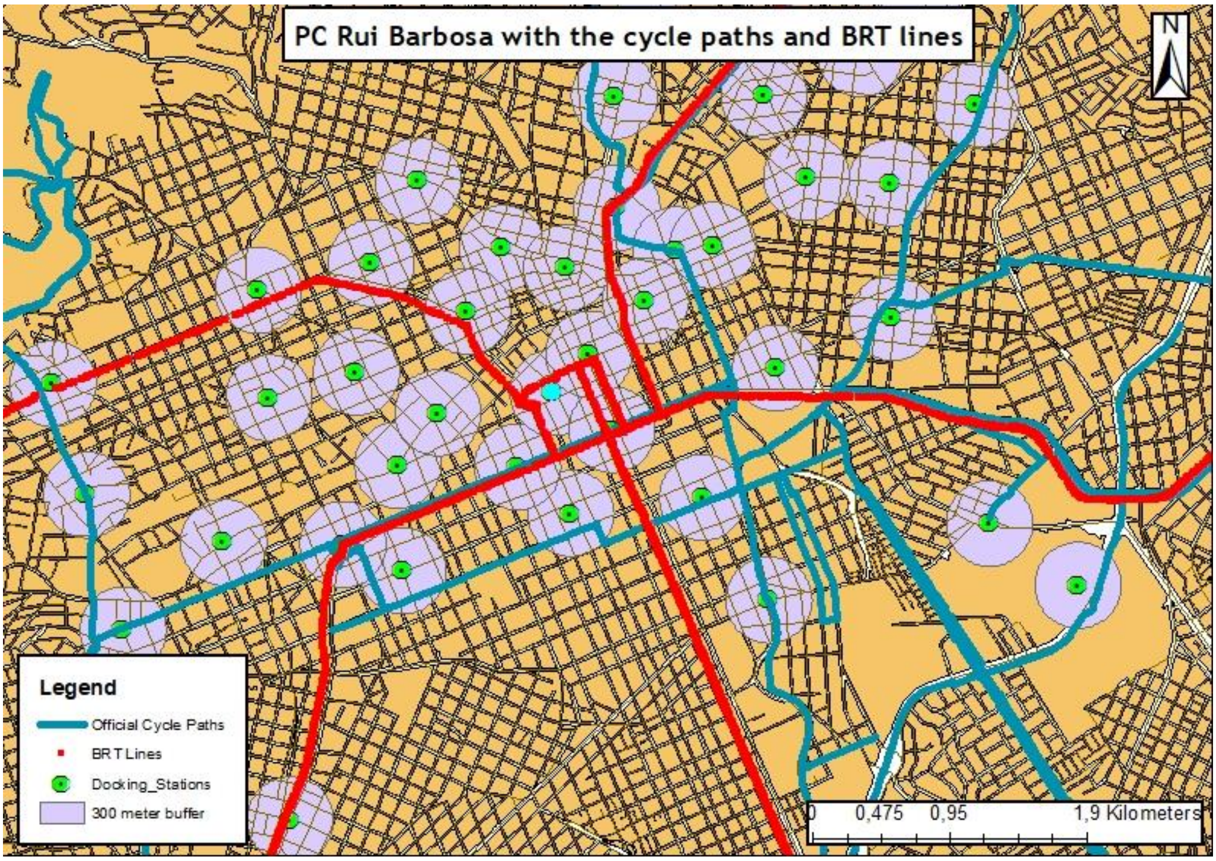


Figure 7-16: Rui Barbosa square with the cycle network and BRT lines

Statistic information about PC Rui Barbosa users from the survey

To analyze if there are statistical differences between the travelers that use a bus stop on the Rui Barbosa square and users of other bus stops, an independent statistic t-test is used. The table with the results is shown in Appendix H: Location specific statistics. There is no significant difference found in the probability to use a shared bike, between users of the Rui Barbosa square and users of other bus stops. There are also no statistical differences in the experienced barriers, between users of the Rui Barbosa square and users of other bus stops. From the open question to barriers and triggers, people mentioned the availability of the bikes as a barrier often. This is mentioned relatively more than people who do not use the Rui Barbosa square bus stop to transfer, departure or exit.

Destination of the PC Rui Barbosa users

The map of Figure 7-17 shows the destinations of the users that use the Rui Barbosa square on their trip. The two most dark/big dots are two campuses of the UTFPR, the most respondents are from there. 15,4% of the destinations is within a walkable distance (on or around the Rui Barbosa Square), from these respondents, everyone mentioned that they walk from the bus stop to their destination. For destinations further away, most people use another bus.

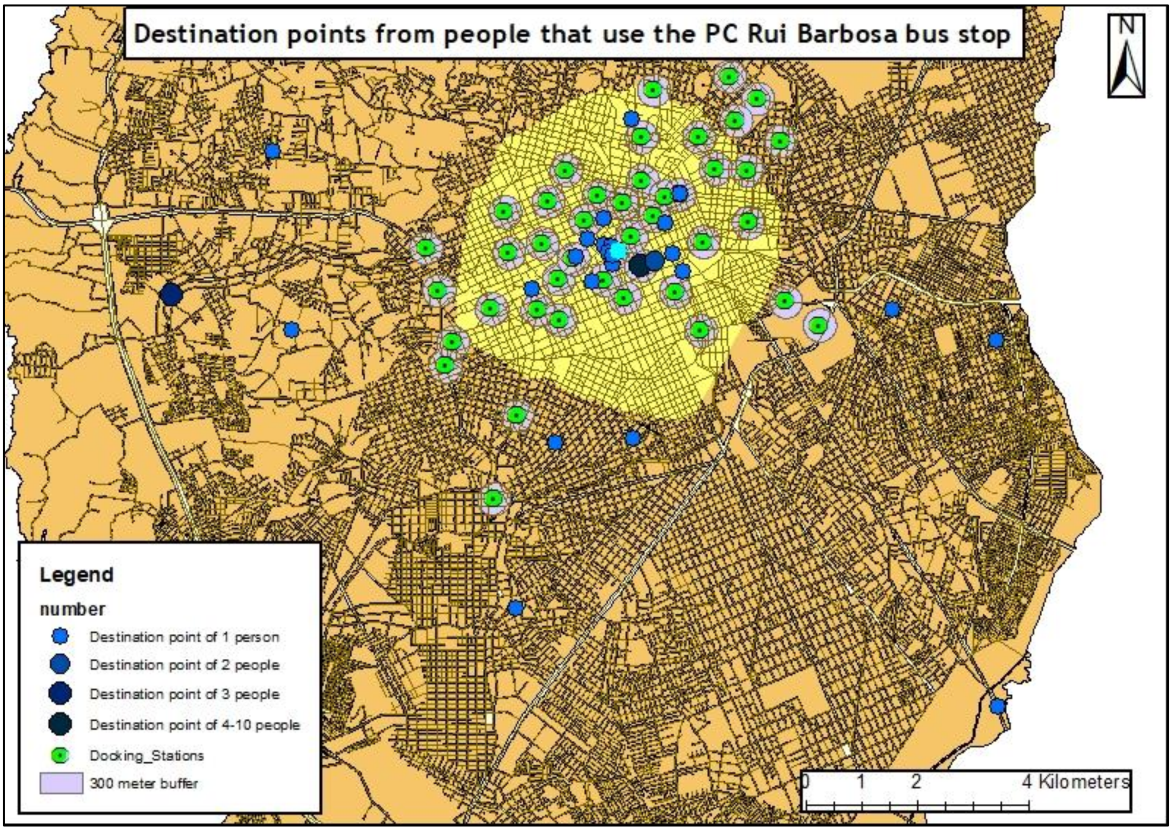


Figure 7-17: Destination/start points from Rui Barbosa square users

On Figure 7-18, there is zoomed in on the bikeable area from the Rui Barbosa square, with the cycle paths included. A big part of the destinations is within an acceptable distance from a docking station.

Possible changes for the Rui Barbosa square

The changes for Rui Barbosa are mainly in the category 2: design changes. As shown in chapter 7.2, the cycle insecurity, cycle paths and the cycle facilities were experienced as the most important barriers. Connecting the Rui Barbosa square to the cycle network is relatively easy, and can be a motivator for people that for example go to the 'UTFPR centro' campus. An example of a simple addition like this that can be added is shown in yellow in Figure 7-20.

The respondents that have their destination in the North direction of the square, all experience the presence of cycle paths and insecurity in traffics as very important. An example of the roads in this area looks like Figure 7-19: No facilities for cyclists.

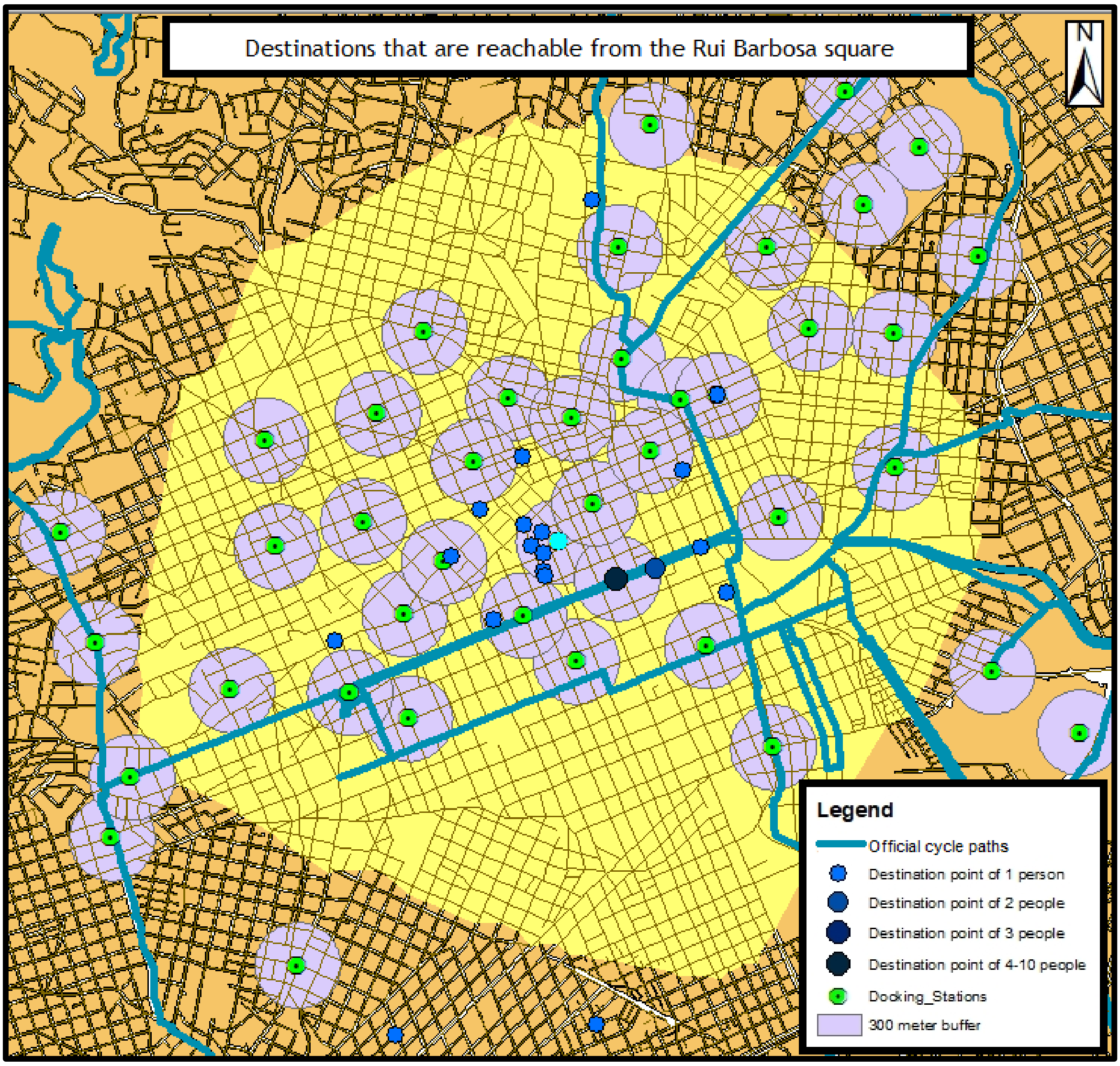


Figure 7-18: Reachable destinations Rui Barbosa square

Figure 7-19: Example of a street in the area

This area consists of the new and old city center, between the 2 BRT lines that come together at the Northside of the Rui Barbosa square. In this area, 5 docking stations are planned. An addition to the cycle network can have a positive impact on the number of users that cycle from the Rui Barbosa square. In Figure 7-20, this area is shown in green.

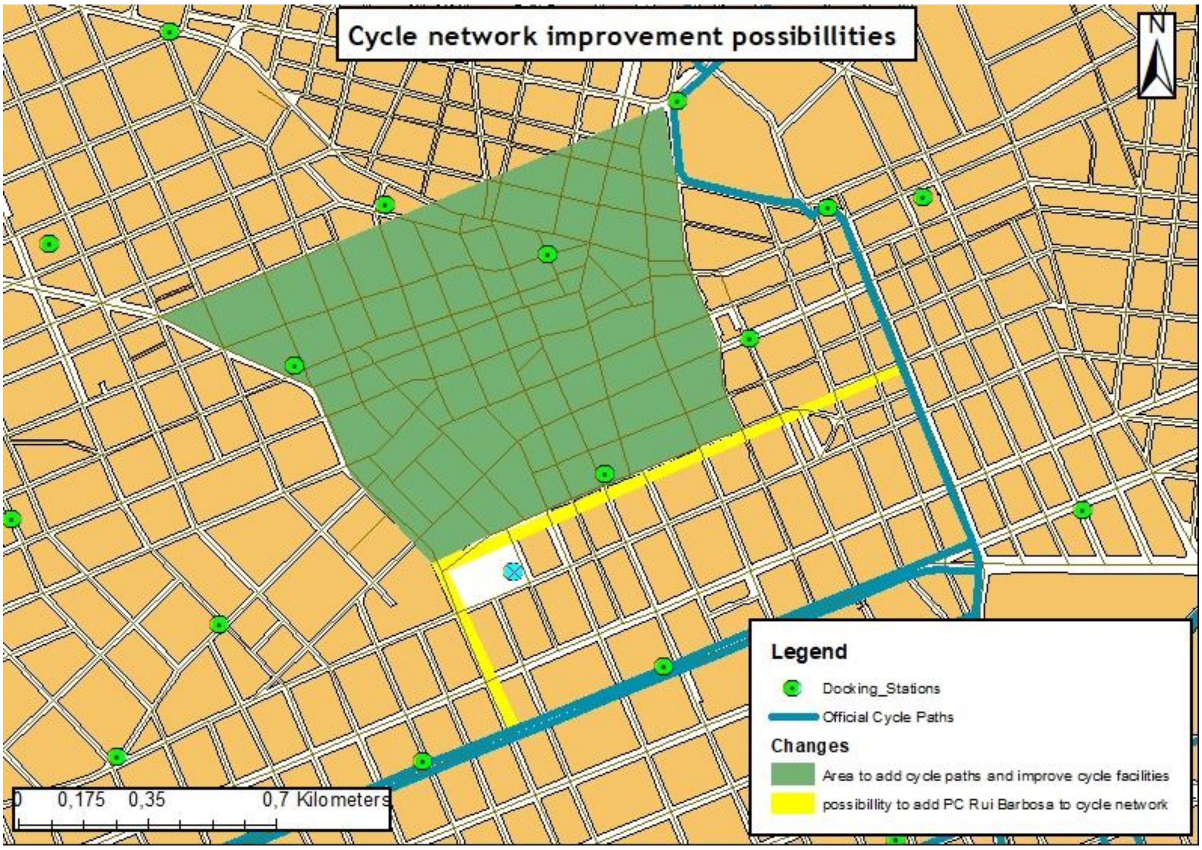


Figure 7-20: Possible improvements

Types of cycle infrastructure
Motta (2017) investigated the cycle infrastructure of Curitiba. The respondents were asked to give their opinion about the different types of cycle infrastructure that are currently present in Curitiba. These different design types are described in the literature study. He concluded that people experience bicycle paths (roads only for bikes) and bicycle lanes (bike lane physically separated from the car lanes) as the most likely to cycle on. Bicycle paths are hard to implement in the city center, because they need a lot of space. Therefore, cycle lanes are the best solution for the addition of the cycle network (yellow lines in in Figure 7-20).

At intersections, more attention for cyclists is necessary. Car drivers that turn right do not give priority to cyclists often. A simple design as viewed in Figure 7-22 can be a solution, so that crossing an intersection for cyclists is safer.

Figure 7-21: Bicycle lane

Figure 7-22: A simple example of an intersection in The Netherlands where cyclists can cross the intersection safer (Pucher & Buehler, 2008).

Influence on the number of users

89% of the Rui Barbosa users experience cycle paths as an important or very important barrier to use a shared bicycle. 52% of the Rui Barbosa square users answered 'likely' or 'very likely' to use a shared bike in the future. So, for 46% of the Rui Barbosa square users, these extra cycle infrastructure changes might be a trigger to switch to a shared bike. But, this will not lead to 46% more users, for example the climate as a barrier will always have influence for some people. After implementing the system, the Rui Barbosa square can be compared to docking stations that are connected to the cycle network, and next to a BRT bus stop. Then, the difference in users between docking stations that are connected to the cycle network, and docking stations that are not connected to the cycle network can be calculated. The following docking stations are connected well to the cycle network: UTFPR, PC. Osvaldo Cruz, PC. Do Japão and Passeio Publico.

7.5 Location based results: Rua João Negrão (Estação Tubo Central)

From the GIS study, the Rua João Negrão seemed a good place to take a bike and cycle to the destination. The location of this bus stop, the BRT lines, cycle paths and docking stations are showed below. (The blue dot on the map ( ) is the place of the Rua João Negrão docking station).

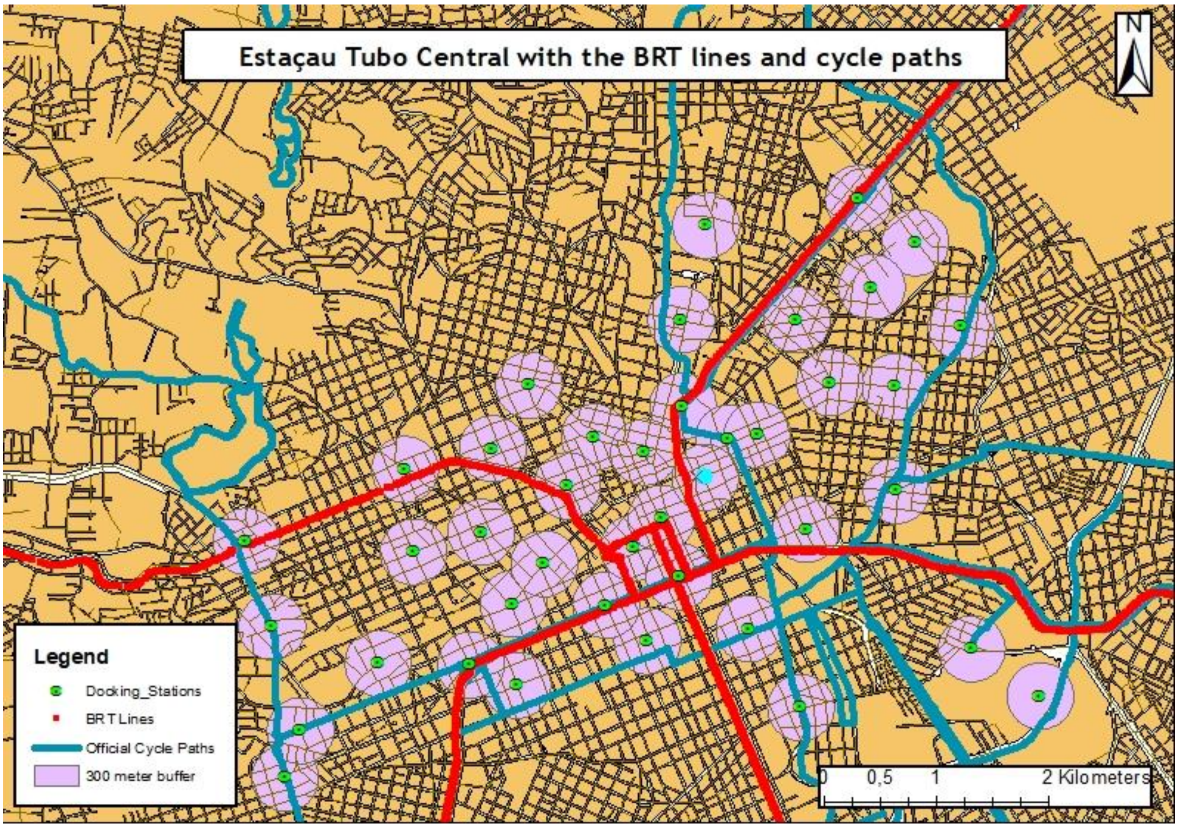


Figure 7-23: Estação Tubo Central with BRT lines and cycle infrastructure

Statistic information about Estação Tubo Central users from the survey

Also for this bus stop, an independent statistic t-test is done to see if there are statistical differences between the travelers that use Estação Tubo Central and the other places. The table with the results is shown in Appendix H: Location specific statistics. There are no statistical differences found between the probability in the users of Estação Tubo Central and other bus stops in the use of an electric or non-electric bike. In the barriers, no statistical differences are found between Estação Tubo Central and other bus stops. From the open question to barriers and triggers, public safety is mentioned more than average.

Destination of Estação Tubo Central users

The destinations/start locations of the respondents (the one that is the closest to the (Estação Tubo Central) is showed below: (The blue dot on the map ( ) is the place of the Rua João Negrão docking station). Most of the destinations are in the Matriz area.

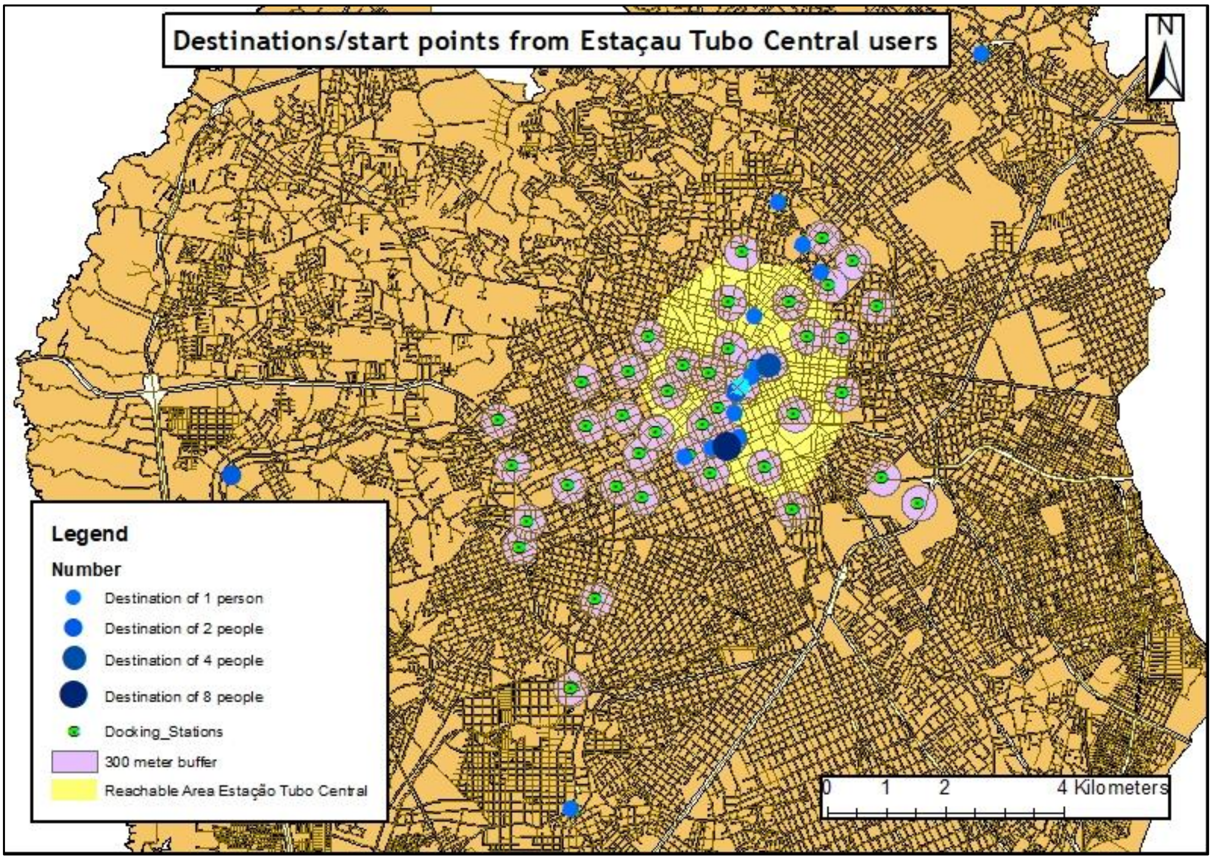


Figure 7-24: Destination/start points from respondents using Estação Tubo Central

From these respondents, 21 of the 29 respondent's destinations/start points are within the cyclable area which is calculated in the GIS study of chapter 7.1. These locations are viewed in Figure 7-25. From these 21 respondent locations, 20 are within a 300-meter buffer zone of the docking stations. This means that for the Estação Tubo Central users, the system can be useful.

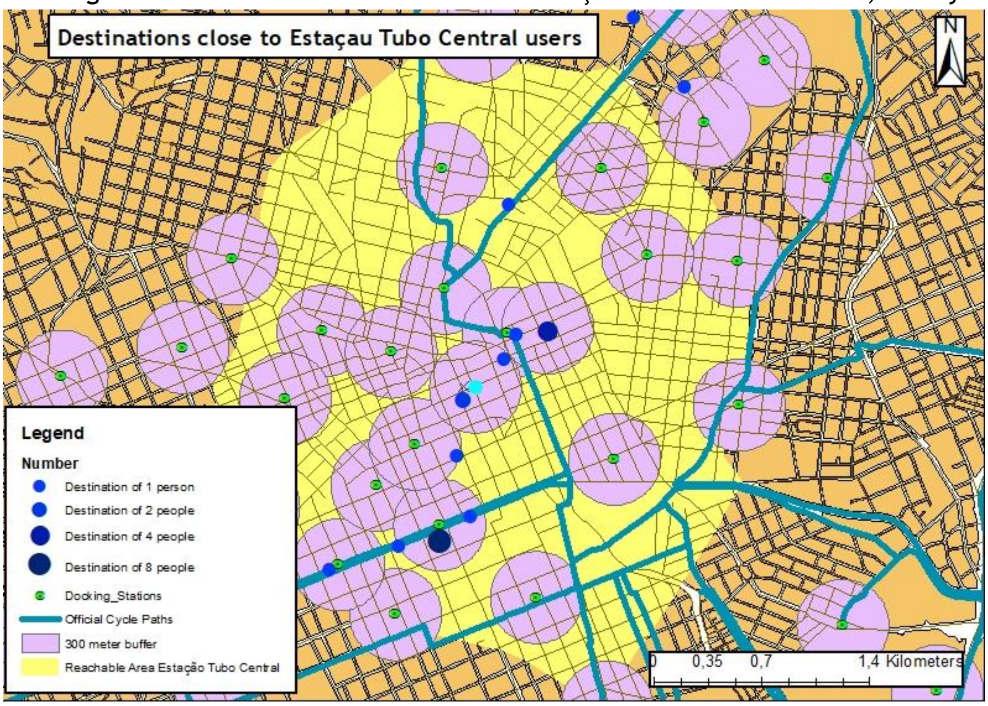


Figure 7-25: Reachable area by bike with destination points

Possible changes for Estação Tubo Central location

The changes for Estação Tubo Central are also mainly in the category 2: design changes. With the current docking station locations, the bus station Estação Tubo Central has potential for users that travel by bus from other neighborhoods the center to this bus stop. Some of them must travel from there to a place that is too far to walk. The presence of cycle paths was the most experienced trigger of the respondents. So, connecting this docking station to the cycle network is essential. Therefore, some suggestions are done in Figure 7-26. The yellow lines are the possible cycle network additions. There is not much space here for extra roads. Therefore, also here, bicycle lanes will be the best kind of cycle infrastructure. This is described in paragraph 7.4, about PC Rui Barbosa.

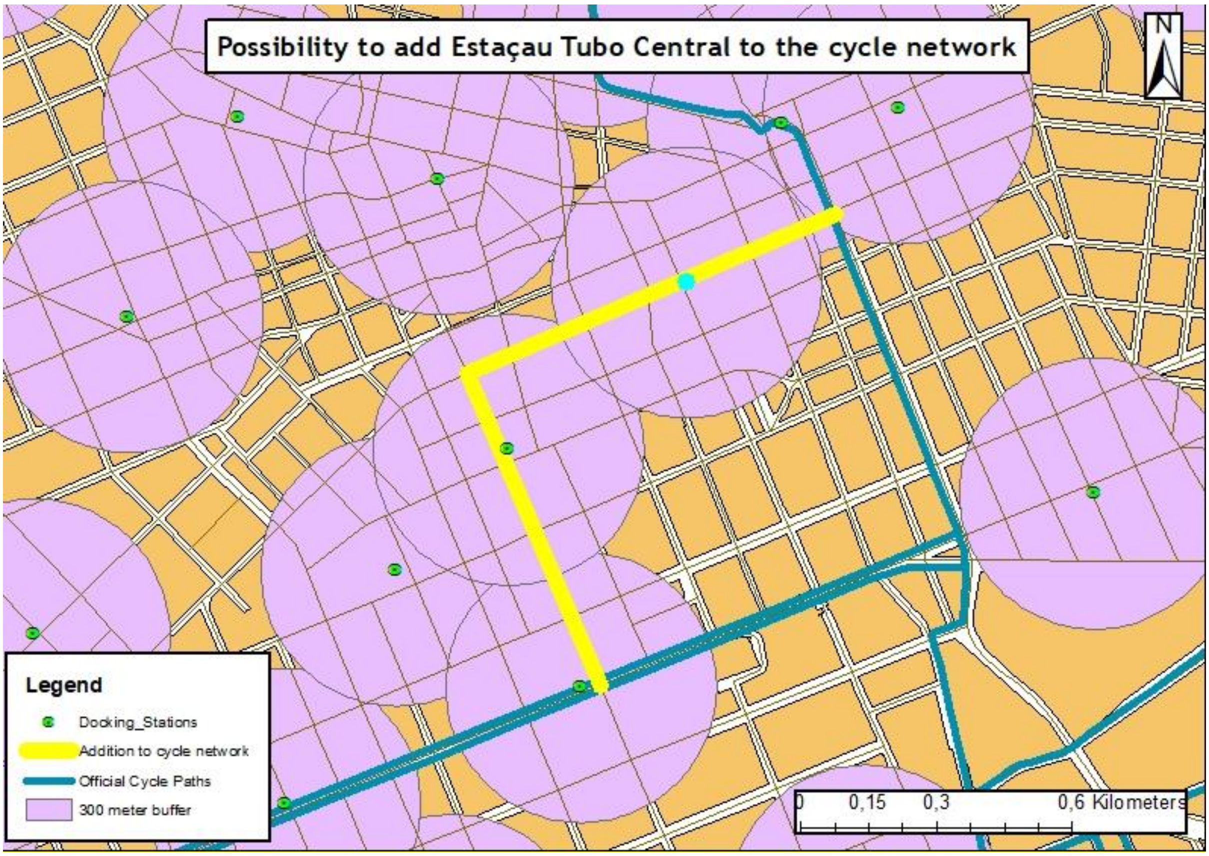


Figure 7-26: Infrastructural possible changes for Estação Tubo Central

Influence on the number of users

87% of the Estação Tubo Central users experience cycle paths as an important or very important barrier for the shared bicycles. 54% of the Estação Tubo Central users answered 'likely' or 'very likely' to use a shared bike in the future. So, for 47% of the Estação Tubo Central square users, these extra cycle infrastructure changes might be a trigger to switch to a shared bike. Therefore, also this docking station should be compared with the docking stations that are connected well to the cycle network: UTFPR, PC. Osvaldo Cruz, PC. Do Japão and Passeio Publico.

8 Discussion

In this chapter, the limitations and boundaries of this research are discussed. First, some general points about the setup of this research are described. Second, some of the methods used in the GIS study are discussed. Third, the discussion points from the survey are discussed.

8.1 Research setup

The aim of this research is to find changes that can have a positive impact on the number of users of the shared bicycle system. When someone starts using a shared bike to cycle to a BRT bus stop, his trip route might change. It is possible that they do not use the investigated bus stop anymore, because another bus stop saves time.

8.2 GIS study

The GIS study of chapter 6.1 shows a reachable area that is created for all bus stations that are close to a docking station. This is done with 2 scenarios: with a formula where the bikeability has less influence, and a formula where the bikeability has much influence. These formulas are created using the bikeability index of Motta (2017), and literature from other cities to determine what is reachable and what not. But, of course, this area is different for all people. There cannot be determined a border. Therefore, another way to investigate this, is for example to ask all respondents to perform information about which points of interest they would cycle to and which not. For example, ask people on the bus stops to determine for a set of popular locations in the city if they are willing to cycle to it. But, this is not a real possibility to ask in a survey, especially not for people that have never cycled before.

8.3 Survey

The survey strategy change has led to a different scatter of the respondents. The income groups, education levels and age is not representing the reality. Therefore, there cannot be determined in real numbers or percentages what the positive influence of the changes can be. The conclusions are only based on the types of users that filled in the survey. This are mainly young people, and people that are much higher educated than average. Statistics are done to determine if there is difference between groups, but there are too many other factors that play a role to be able to give conclusions. Therefore, also convert this numbers to scale them with the actual numbers is not possible.

The survey was spread using locations where the shared bikes can have potential. For example, because the universities seemed to have potential in the literature review, all universities were asked to spread the survey. Therefore, in reality, there is less potential than the respondent's average in this survey. The survey was carried out on existing bus users. As explained in the literature study, this is only a part of the possible transport mode switches that are possible. Car drivers and cyclists should be investigated as well.

Also, the start location of the trip is not the exact location for everyone. Because of privacy, people could give their bus stop start location, instead of their house. This can for example have influence on conclusions about number of users that live in a docking station buffer area. The statistics are done as accurate as possible, but depending on the sample set of each group, the final conclusions can be different if all groups had a higher number of respondents. To solve this, to test the income and education statistics, there is made use of an independent T-Test on groups that are big enough, to test if the regression tables are reliable. A more reliable result can be created by obtaining respondents with a higher age and with lower education.

9 Conclusions

The results of chapter 7 are combined in this chapter, to answer the research question and the sub research questions.

The research question is: Which infrastructural measures can have a positive effect on the number of users of the new electrical shared bicycle system to cycle from a Bus Rapid Transit bus stop to their destination and back? To answer this question, three sub questions are answered first.

The first sub question is: Which bus tube stations have the most potential users for the shared bikes in combination with the BRT busses? From the 43 docking stations, only 14 are located next to a BRT bus stop. From these 14, the bikeability index is used to determine how much business licenses are reachable from each docking station. The business license data seems a good way to estimate where people are traveling to. The docking stations are mostly concentrated in the city center. So, with the current docking station plans, the docking stations in the city center seemed to have the most potential. The docking stations outside the city center are not covering the whole area. To cover the whole area, there should be a docking station every 300 meters. In other cities, shared bicycles lead to more users on big terminals (metro/bus/train) as a feeder mode for these high-density lines. Therefore, from the terminals, Terminal Cabral seemed to have the most potential to investigate.

To see if people experience barriers and triggers to use a shared bike on these 3 bus stops, the second sub question is: What barriers do people experience to use shared bikes in combination with the bus? The survey result shows that there are a lot types of barriers, where the combination of the barriers withhold a large group of people to use the system. The respondents were asked to say if they would use a shared bike in the future. Only 29% of the respondents answered 'unlikely' or 'very unlikely'. For the electrical bike, only 37% answered 'unlikely' or 'very unlikely'. That means that the system has potential, mainly for the non-electrical bike. The presence of cycle paths is experienced as the most important barrier (mean score: 4.45 on 1 to 5 Likert scale), but also important are the price of the system, the time increasing or decreasing, the traffic insecurity and the cycle facilities. They are answered respectively: 4.16; 3.99; 4.26 and 4.03 (on a 1 to 5 Likert scale, with 1 = not important, and 5 = very important).

The system seemed to have more potential for men, they give a higher score on the question: How likely is it that you will use a shared (electrical) bike in the future as a part of your trip? Men also experience less barriers (besides from the price) than women. As explained in the literature study, in other cities men use the shared bike systems more than women as well. So, infrastructural measures will have more influence on the women. People younger than 25 years old have slightly more potential to use a shared (electrical) bike as a part of their trip. In other cities, there is found a negative correlation between the age and the use of shared bikes as well, explained in the literature study. Higher educated people are more probable to use a shared bike. Also, they relatively prefer the electrical version of the bike more than lower educated people. Therefore, campaigns, promotions and demand choices should focus on students, and people younger than 25. It is important to say that potential for the shared bike system does not directly mean that the frequency of feeder busses can be reduced. There are groups that are not able to use the system, for example, because of physical disabilities. Also, there are days that cycle is impossible, because of the weather conditions in Curitiba.

The third sub question is: Which infrastructural measures can have a positive effect to reduce these barriers? For the Rui Barbosa square and Estação Tubo Central, the suggestion is to connect these two docking stations to the bicycle network of the city, because the presence of cycle paths seemed to be the most important barrier. The type of cycle infrastructure that fits the best in this area, is the bicycle lane. for 46% of the Rui Barbosa square users, these extra cycle infrastructure measures might be a trigger to switch to a shared bike. for 47% of the Estação Tubo Central square users, these extra cycle infrastructure changes might be a trigger to switch to a shared bike. These bus stops should be compared with bus stops that are connected to the cycle network, to see what the travel enlargement can be.

For Terminal Cabral, the suggestion is to implement more docking stations in different neighborhoods outside the city center (Cabral, Ahú, Boa Vista and Bacacheri), to let the shared bicycle system work as a feeder mode for the BRT line that connects Terminal Cabral with the city center. If these neighborhoods are covered well, 3 times more people have access to a docking station. So, the number of users can be three times higher. There should be placed a docking station every 300 meters.

The results from the sub questions, lead to an answer to the main research question. The main research question is: Which infrastructural measures can have a positive effect on the number of users of the new electrical shared bicycle system to cycle from a Bus Rapid Transit bus stop to their destination and back? For the bus stops in the city center with a high number of travelers, the shared bikes can have a positive impact on the number of travelers, when these docking stations are connected to the cycle network. For PC Rui Barbosa and Estação Tubo Central, this can be done by implementing bicycle lanes. This seemed fit the best in these areas. For the big terminals outside the city center, the shared bicycles can be a feeder mode for the BRT lines. But, only when more docking stations in the areas close to the terminal will be implemented. The shared bikes cannot be used as a good feeder mode for Terminal Cabral, Terminal Portão and Terminal Campina with the current docking station location plans. These results are based on the literature study, survey, and GIS study. These suggestions only consider existing BRT users. The survey was carried out for BRT users. For example, car drivers and cyclists can have different motivators to use a shared bike in combination with the BRT busses. As shown in paragraph 5.2, the car, bus and bicycle are the 3 most used transport modes.

The electrical shared bike is more popular than the non-electrical bike in the survey. Probably people expect to make short trips in the city center, and do not see advantages of the electrical bike. The electrical bikes can have more advantages when more docking stations are spread in the neighborhoods outside the city center. The electrical shared bikes can be a feeder mode for a bigger area than for non-electrical bikes. For example, for the big terminals like Terminal Cabral. In other cities with electrical bikes, they are mainly used outside the city center.

10 Recommendations

For further research, some suggestions and recommendations are given.

10.1 Investigate barriers and triggers with different methods

To investigate the potential of the system, car drivers should be investigated as well. This is harder, because they often are less interested in cycling. But, to decrease the number of cars in the city center, the bus in combination with a shared bike can help. Triggers should be determined in other ways than surveys only. For example, with experiments. Surveys cannot determine all influencing factors, because it is very hard to determine what barriers and triggers there are if you never used a bike. Maybe for example the system can be experimented on a university: let all different kinds of students that need to go from one campus to another do that for free with a shared bike, and ask after that what would trigger them to use it, and what barriers they experience.

10.2 Other data

As explained in chapter 6.1, the shared bikes will all have a GPS device. In further research, this GPS data can be used to locate trips. Then, there can be concluded which docking stations and roads are used to cycle. The docking stations that are connected to the cycle network can be compared with PC Rui Barbosa and Estação Tubo Central. Then, there can be calculated the number of extra shared bike users after connecting these docking stations to the cycle network. There can also be determined which locations are popular, and which areas need more docking stations.

Also, public transport card data can be used to determine demand choices for the shared bike system. With public transport data, there can be gained more information about the bus stops. There can be calculated how much extra users a docking station can have, when the suggestions of this research are followed. The potentially that is determined in this research, is only rough estimation. To calculate the extra number of users, it is necessary to know how often people will use the shared bikes.

11 Bibliography

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. doi:10.1016/j.trc.2016.03.004

Chatterjee, K., Sherwin, H., & Jain, J. (2013). Triggers for changes in cycling: the role of life events and modifications to the external environment. *Journal of Transport Geography, 30*, 183-193. doi:10.1016/j.jtrangeo.2013.02.007

CityHall. (2016). *Business Licenses*. Table.

Daddio, D. W. (2012). *Maximizing bicycle sharing: an empirical analysis of capital bikeshare usage.* (Master), University of North Carolina at Chapel Hill.

Demery, L. W. (2004). Bus Rapid Transit in Curitiba, Brazil - An Information Summary. *publictransit.us, 1*.

Duarte. (2014). 'No bicycle lanes!' Shouted the cyclists. A controversial bicycle project in Curitiba, Brazil. *Transport Policy, 32*, 180-185.

Duarte, & Rojas. (2012). Intermodal Connectivity to BRT: A Comparative Analysis of Bogotá and Curitiba. *Journal of Public Transportation, 15*.

EP-Nuffic. (2015). Onderwijssysteem Brazilië.

IBGE. (2017). Education levels.

IPPUC. (2017). *Mapa Bicicleta Pública*.

ITDP. (2013). *The Bike Share Planning Guide*. Retrieved from New York:

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. doi:10.1016/j.apgeog.2013.05.010

LDA. (2012). *Capital Bikeshare 2011 Member Survey Executive Summary*. Retrieved from Washington, DC:

Lindau, L. A., Hidalgo, D., & Facchini, D. (2010). Curitiba, the Cradle of Bus Rapid Transit. *Built Environment (1978-), 36*(3), 274-282.

Lv, T., Lin, L., & Li, W. (2011). *Analysis of public bicycles' impact on residents' trip chain*. Paper presented at the Proceedings 2011 International Conference on Transportation, Mechanical, and Electrical Engineering, TMEE 2011.

Martens, K. (2007). Promoting bike-and-ride: The Dutch experience. *Transportation Research Part A: Policy and Practice, 41*(4), 326-338. doi:10.1016/j.tra.2006.09.010

Martin, E. W., & Shaheen, S. A. (2014). Evaluating public transit modal shift dynamics in response to bikesharing: a tale of two U.S. cities. *Journal of Transport Geography, 41*, 315-324. doi:10.1016/j.jtrangeo.2014.06.026

Mosquera, J., Parra, D. C., Gomez, L. F., Sarmiento, O., Schmid, T., & Jacoby, E. (2012). An inside Look at Active Transportation in Bogotá: A Qualitative Study. *Journal of Physical Activity and Health, 9*(6), 776-785. doi:10.1123/jpah.9.6.776

Motta, B. G. (2017). A bikeability index for Curitiba (Brazil).

Sagaris, L. (2015). Lessons from 40 years of planning for cycle-inclusion: Reflections from Santiago, Chile. *Natural Resources Forum, 39*(1), 64-81. doi:10.1111/1477-8947.12062

Schilte, P. G. (2016). Curitiba bikeways quality mapping index.

URBS. (2017a). Bike Sharing Curitiba. Curitiba: URBS.

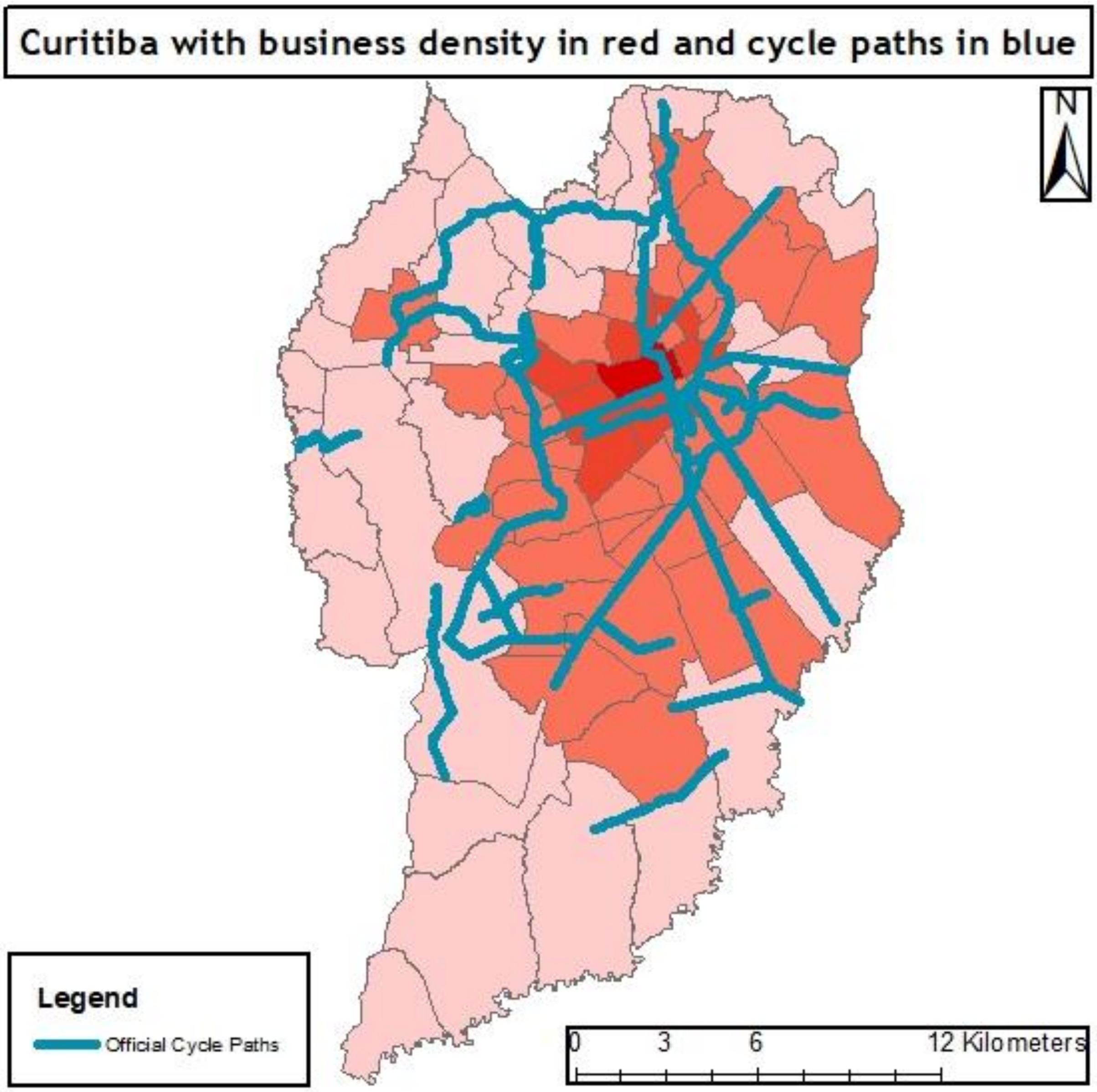
URBS. (2017b). *Public Transport Bus Data* [Shape files and tables].

weather-and-climate.com. (2016). Average monthly snow and rainfall in Curitiba (millimeter). Retrieved from https://weather-and-climate.com/average-monthly-precipitation-Rainfall,curitiba,Brazil

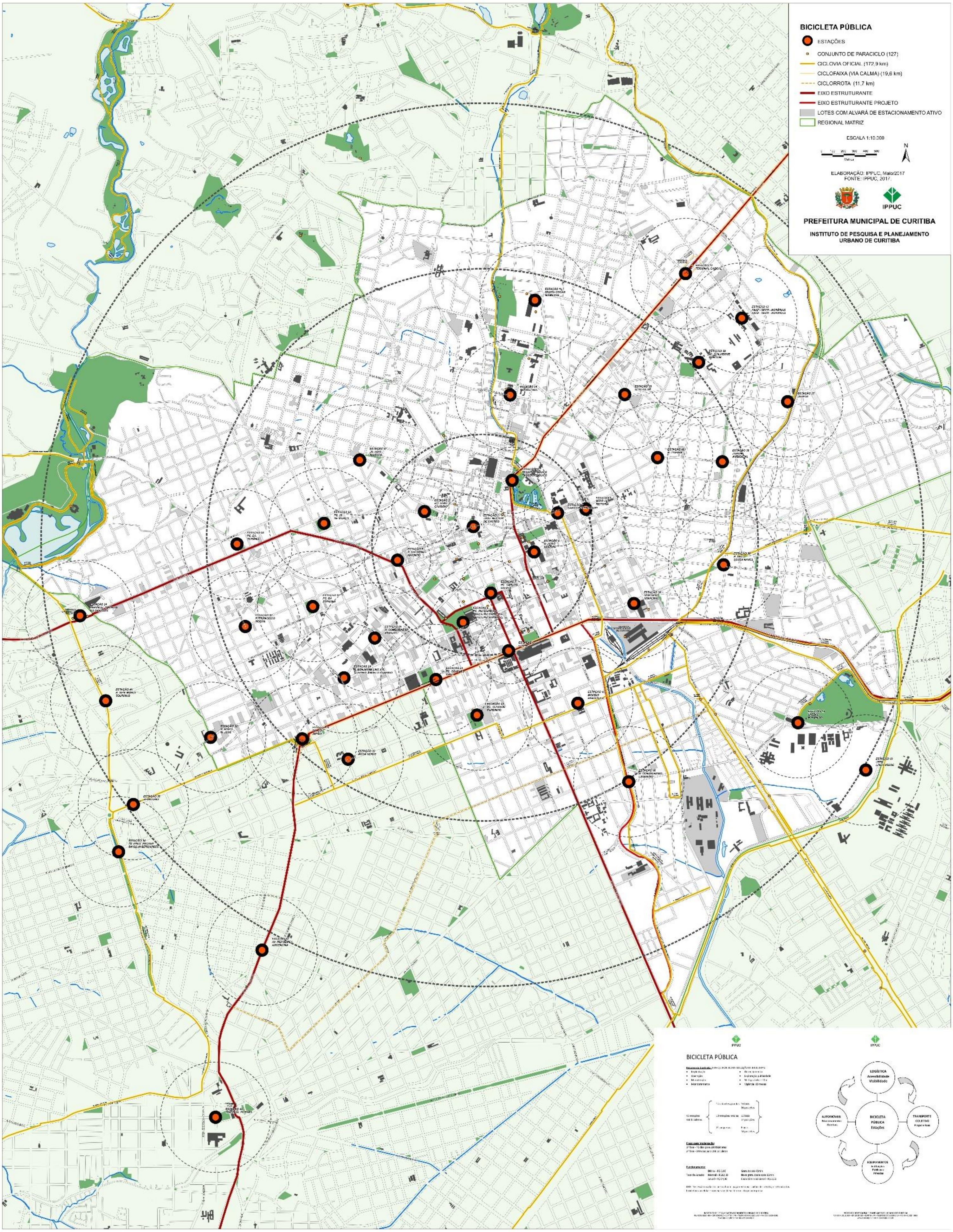
wisselkoers.nl. (2017). Wisselkoersen. Retrieved from https://www.wisselkoers.nl/

Zhang, Y., Thomas, T., Brussel, M., & van Maarseveen, M. (2017). Exploring the impact of built environment factors on the use of public bikes at bike stations: Case study in Zhongshan, China. *Journal of Transport Geography, 58*, 59-70. doi:10.1016/j.jtrangeo.2016.11.014

Appendix A: Cycle network



Appendix B: Locations of shared bike docking stations



Appendix C: Information about the docking stations

ID	Shared bike dock name	Business density in the neighborhood (licenses/ HA)	Near BRT bus stop (within 200 meters)
1	TRAV NESTOR DE CASTRO	11.3	No
2	LARGO BITTENCOURT	11.3	No
3	UFPR REITORIA	24.1	No
4	R JOÃO NEGRÃO	13.8	Yes, near BRT bus stop
5	UTFPR	13.8	Yes, near BRT bus stop
6	PR RUI BARBOSA	24.1	Yes, near BRT bus stop
7	PC CARLOS GOMES	24.1	Yes, near BRT bus stop
8	R SALDANHA MARINHO	41.3	Yes, near BRT bus stop
9	PC JOÃO CÂNDIDO	41.3	No
10	PASSEIO PUBLICO	97.7	Yes, near BRT bus stop
11	MUSEU OSCAR NIEMEYER	97.7	No
12	TERMINAL CABRAL	97.7	Yes, near terminal
13	FAAP UFPR AGRÁRIAS	17.1	No
14	MERCADO MUNICIPAL	6.3	Yes, near BRT bus stop
15	MOINHO REBOUÇAS	6.3	No
16	R CONSELHEIRO LAURINDO	6.3	No
17	JD FREI TIMÓTEO	7.4	No
18	JARDIM BOTÂNICO	24.9	No
19	UFPR LINHA VERDE	24.9	No
20	PC OSVALDO CRUZ	97.7	Yes, near BRT bus stop
21	PC DO JAPÃO	97.7	Yes, near BRT bus stop
22	PC DA ESPANHA	25.0	No
23	PC 29 DE MARÇO	25.0	No
24	TERMINAL CAMPINA DO SIQUEIRA	42.3	Yes, near terminal
25	PREFEITURA	16.7	No
26	R FRANCISCO ROCHA	16.7	No
27	AV REPUBLICA ARGENTINA	18.5	Yes, near BRT bus stop
28	PC DA UCRÂNIA	10.8	Yes, near BRT bus stop
29	R BENJAMIM LINS X R ALFERES ÂNGELO SAMPAIO	10.8	No
30	R SEN SOUZA NAVES	9.1	No
31	R COMENDADOR ARAÚJO	9.1	No
32	R BISPO D JOSÉ	23.3	No
33	ÁGUA VERDE	23.3	No
34	AV PRES ARTHUR SA SILVA BERNARDES	23.3	No
35	SEMINÁRIO	12.8	No
36	ALTO DA XV	12.8	No
37	JUVEVÊ	28.3	No
38	JARDIM AMBIENTAL	97.7	No
39	JD GUILHERME RONCONI	97.7	No
40	R ITUPAVA	97.7	No
41	R GEN MÁRIO TOURINHO	97.7	No
42	ESTAÇÃO TERMINAL PORTÃO	97.7	Yes, near terminal
43	PC OUVIDOR PARDINHO	42.3	No

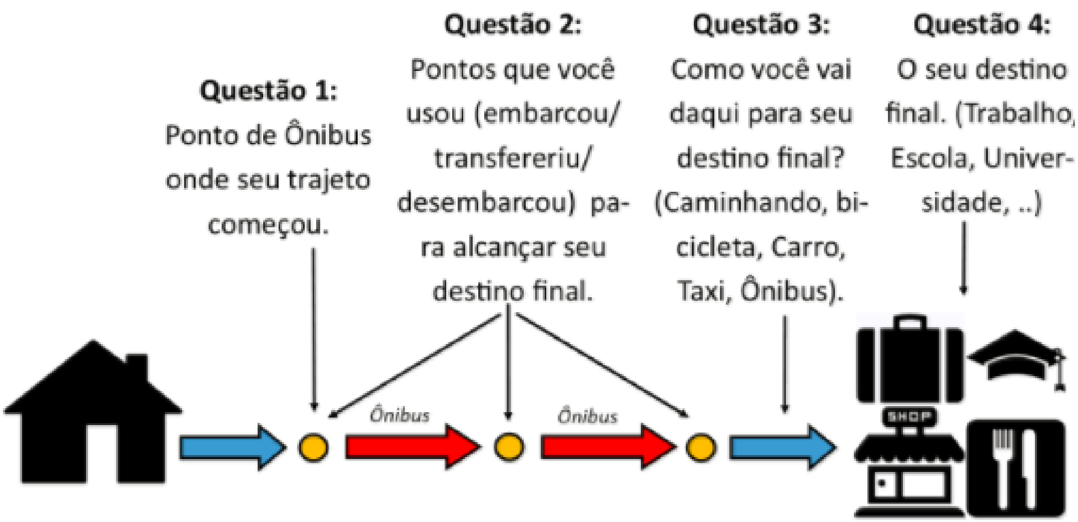
Appendix D: Survey in Portuguese

Fatores que influenciam o uso de bicicleta compartilhada em Curitiba

Obrigado pelo seu tempo em responder esse questionário! Os dados deste questionário serão usados apenas em uma pesquisa da UTFPR sobre bicicleta compartilhada.

Esse ano será implementado um sistema de bicicleta compartilhada em um Curitiba. Você poderá pegar uma bicicleta em 43 lugares e devolvê-la em até 45 min., em qualquer um desses 43 lugares. O custo será de R$5 por dia, R$12 por mês ou R$54 por semestre. Pelo dobro do preço você pode pegar uma bicicleta elétrica, praticamente eliminando a necessidade de pedalar.

Por favor, responda essa pesquisa SOMENTE se você utiliza ônibus regularmente como meio de transporte.



1: Em qual ponto de ônibus você começa o trajeto que está fazendo agora? *

Por exemplo, o ponto de ônibus do lado da sua casa: "Ponto Nilo Peçanha"

2. No seu trajeto, você usou algum dos pontos abaixos para embarque, conexão ou desembarque? Se sim, por favor especifique quais. (Pode incluir o mesmo ponto da questão 1) *

- [ ] Terminal Cabral
- [ ] Praça Rui Barbosa
- [ ] Estação Tubo Central
- [ ] Estação Tubo Passeio Público
- [ ] Mercado municipal/Rodoferroviária
- [ ] Estação Tubo Praça Oswaldo Cruz
- [ ] Estação Tubo Bento Viana (PC Do Japão)
- [ ] Estação Tubo Vital Brasil
- [ ] Terminal Portão
- [ ] Terminal Campina do Siqueira
- [ ] Estação Tubo Praça Ucrânia
- [ ] UTFPR
- [ ] Estação Tubo Praça Carlos Gomes
- [ ] Estação Tubo Visconde de Nacar
- [ ] Não usei nenhum destes pontos

3: Como você vai daqui para seu destino final? *

você pode marcar mais de uma opção

- [ ] Caminhando
- [ ] De bicicleta
- [ ] De carro
- [ ] De táxi
- [ ] Com (outro) ônibus
- [ ] ______________

4: Qual o seu destino final? (CEP / Endereço com o Número / Referência) *

Por exemplo, a localização do seu trabalho: "Rua Paraíba, n. 32" ou "Shopping Estação"

5: Com que frequência você faz o trajeto que você está fazendo agora? *

- ○ 4 vezes por semana ou mais
- ○ 1- 3 vezes por semana
- ○ 1- 3 vezes por mês
- ○ 6-11 vezes por ano (menos de uma vez por mês)
- ○ 1-5 vezes por ano
- ○ Menos de uma vez por ano

6: Por que motivo você está fazendo este trajeto? *

- ○ Trabalho
- ○ Escola
- ○ Universidade
- ○ Anders: ____________

7: Qual sua idade? *

- ○ menos de 25 anos
- ○ 25 – 40 anos
- ○ 41- 55 anos
- ○ 56-70 anos
- ○ 71 anos ou mais

8: Qual o seu sexo? *

- Masculino
- Feminino

9: Qual é a sua renda familiar mensal? *

- Menos que R$1.760,00
- Entre R$1.760,00 e R$3.520,00
- Entre R$ 3.520,00 e R$8.800,00
- Entre R$8.800,00 e R$17.600,00
- Mais de R$17.600,00
- Prefiro não responder

10. Qual foi o curso de nível mais elevado que você frequentou? *

- Nunca frequentei
- Ensino Fundamental
- Ensino Médio
- Ensino Técnico
- Ensino Superior
- Pós-graduação

Fatores que influenciam o uso de bicicleta compartilhada

Para os fatores seguinte, indique por grau de importância como cada um influencia a sua decisão em usar o sistema de bicicleta compartilhada.

11: O preço do aluguel da bicicleta *

	1	2	3	4	5	
Não importante	○	○	○	○	○	Muito importante

12: O tempo do trajeto que vou usar a bicicleta *

	1	2	3	4	5	
Não importante	○	○	○	○	○	Muito importante

13: A insegurança no trânsito *

	1	2	3	4	5	
Não importante	○	○	○	○	○	Muito importante

14: A facilidade de atravessar cruzamentos com uma bicicleta *

	1	2	3	4	5	
Não importante	○	○	○	○	○	Muito importante

15: Presença de faixas ou vias especiais para ciclistas *

	1	2	3	4	5	
Não importante	○	○	○	○	○	Muito importante

16. Há outros fatores importantes na sua decisão sobre usar ou não o sistema de bicicletas compartilhadas?

17: Qual a probabilidade de você mudar seu trajeto (ou parte dele) para usar uma bicicleta convencional (sem ser elétrica) do sistema compartilhado? *

A R$5 por dia ou R$54 por semestre

	1	2	3	4	5	
Muito improvável	○	○	○	○	○	Muito provável

18: Qual a probabilidade de você mudar seu trajeto (ou parte dele) para usar uma bicicleta elétrica do sistema compartilhado? *

A R$10 por dia ou R$100 por semestre

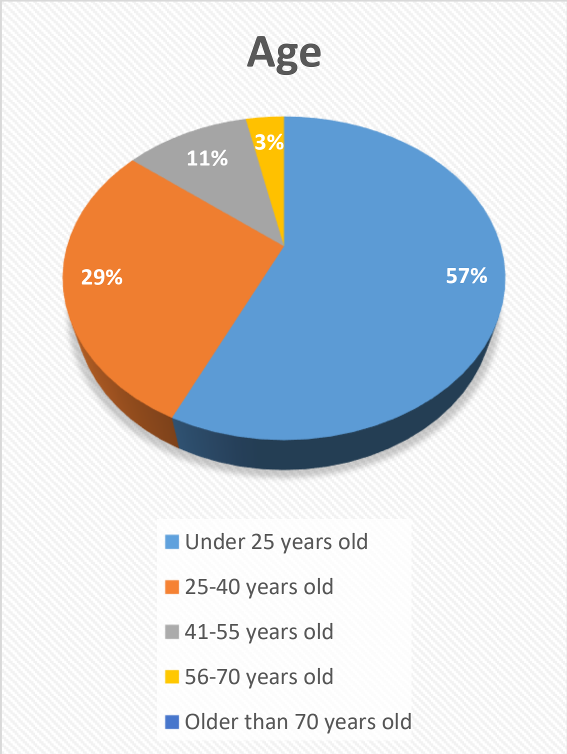
	1	2	3	4	5	
Muito improvável	○	○	○	○	○	Muito provável

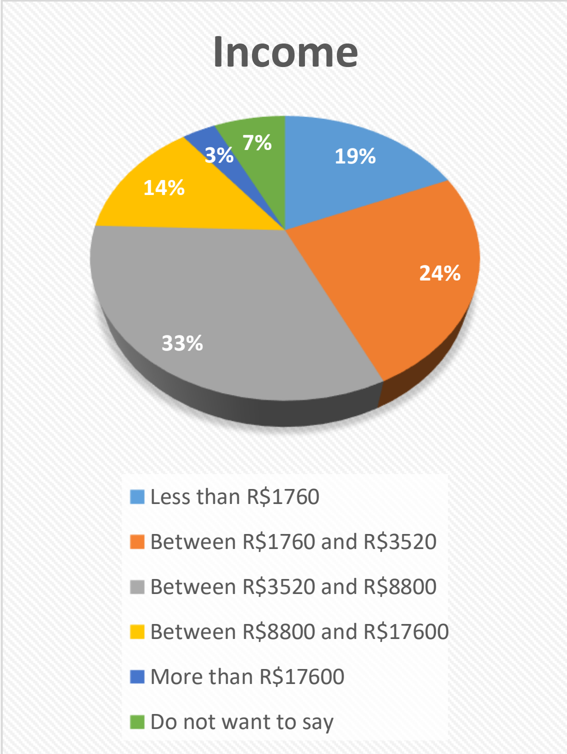
Obrigado pelo seu tempo em responder esse questionário!

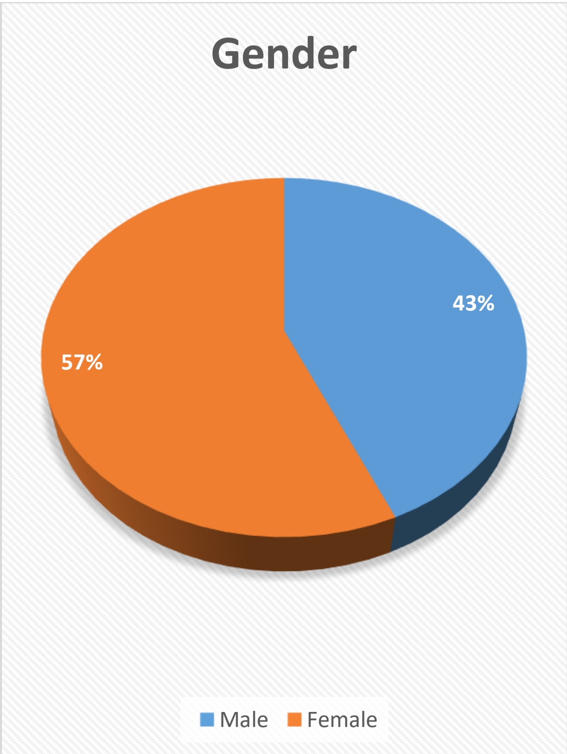
Os dados deste questionário serão usados apenas em uma pesquisa da UTFPR sobre bicicleta compartilhada.

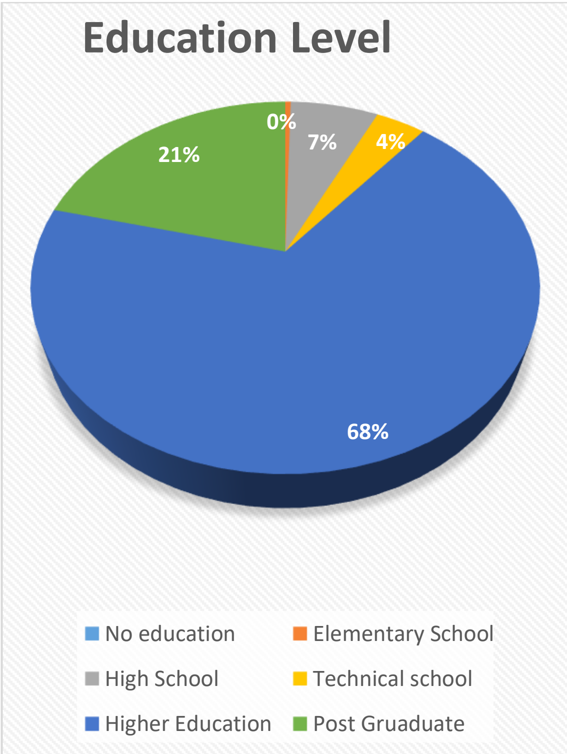
Appendix E: Graphs from survey results

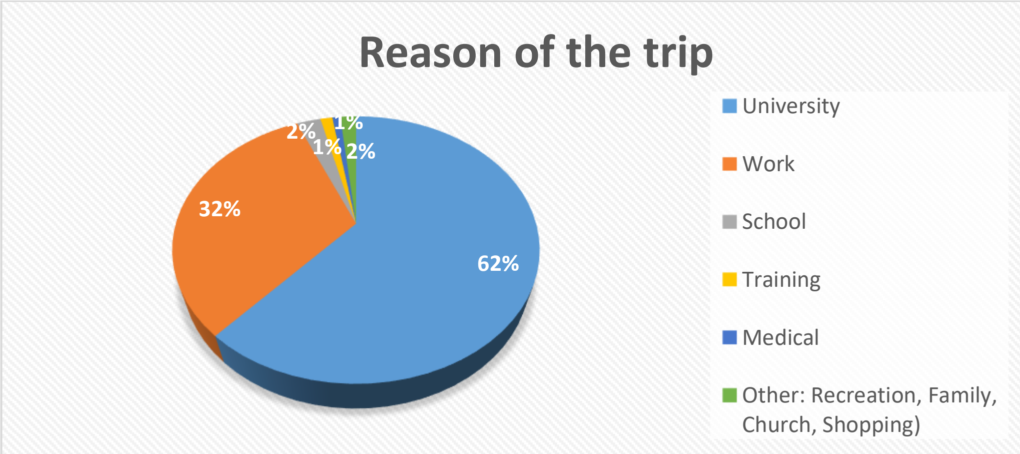
N=237 for all graphs below

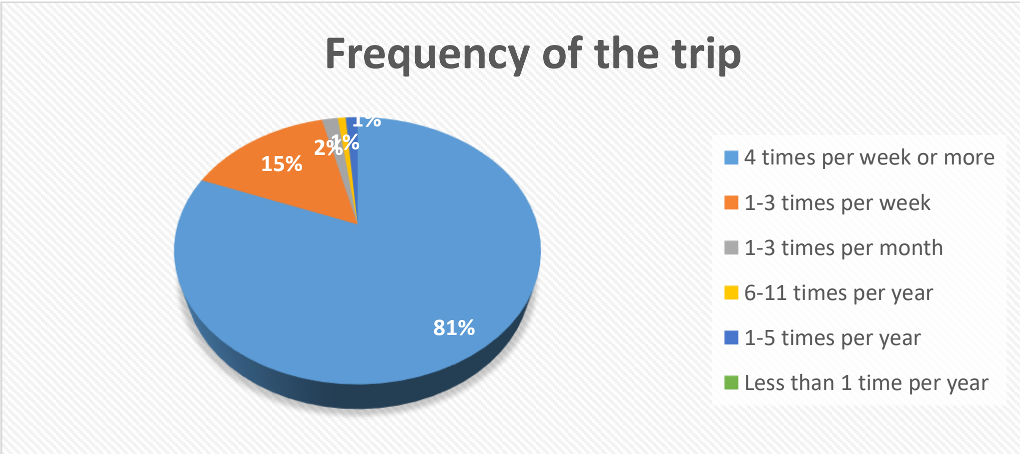


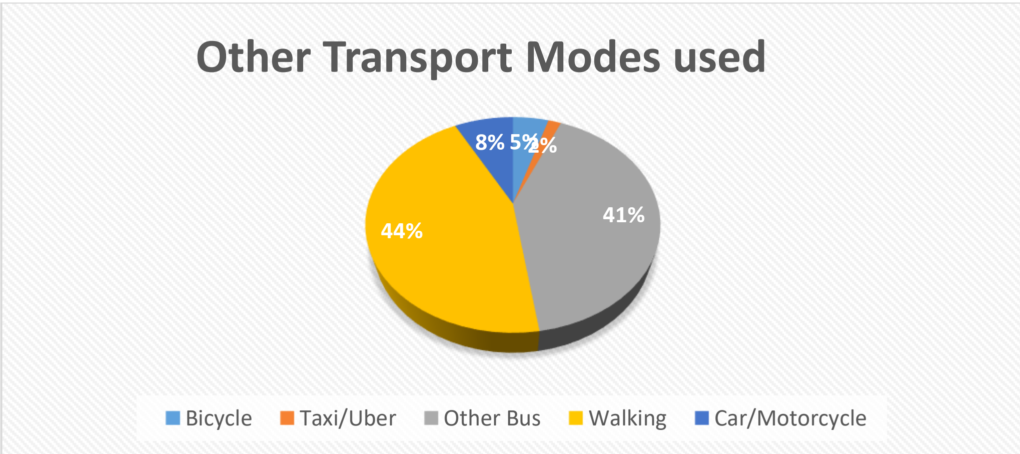


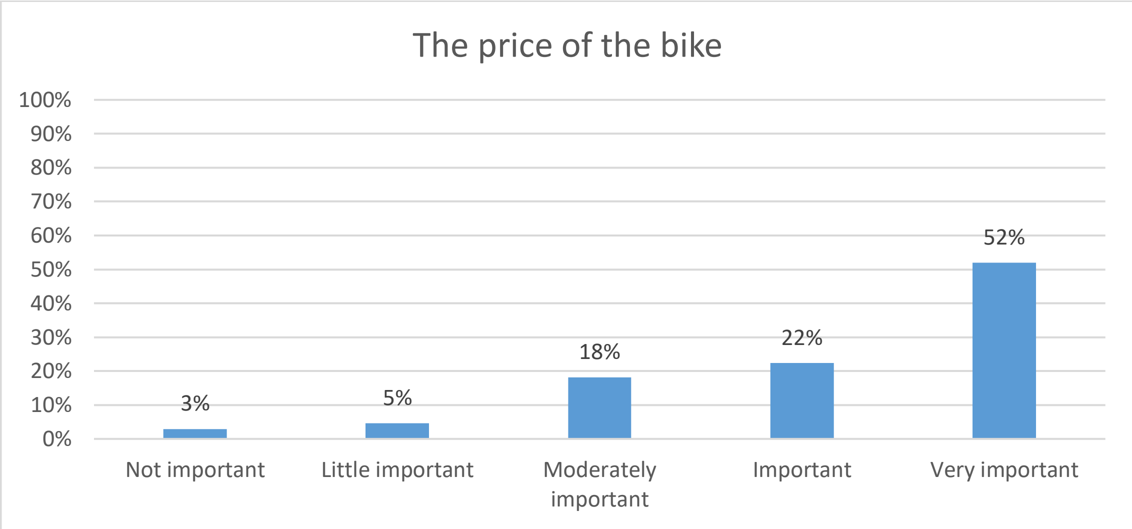


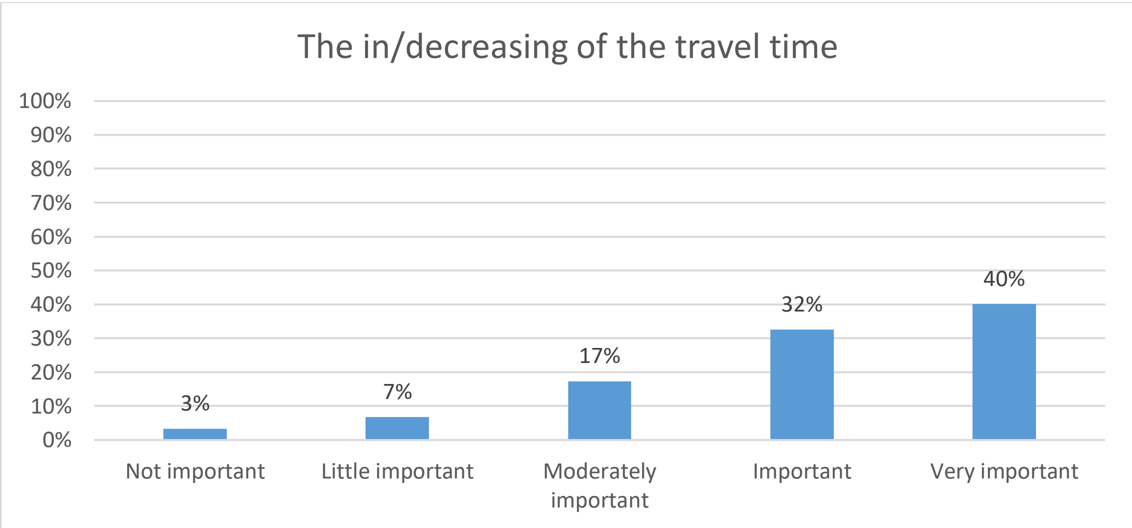


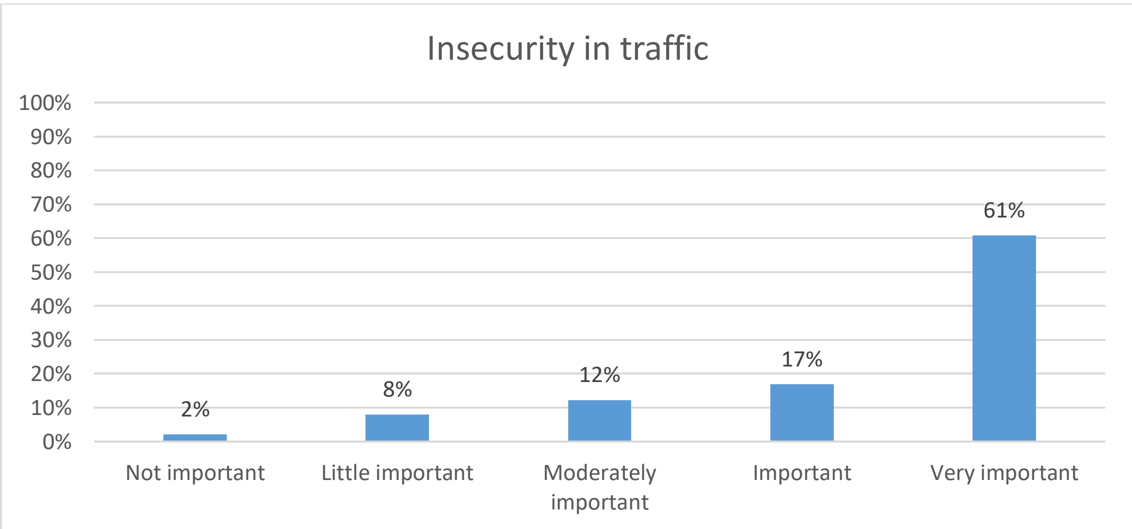

Reason of the trip
62%
32%
2%
1%
1%
2%
University
Work
School
Training
Medical
Other: Recreation, Family, Church, Shopping)

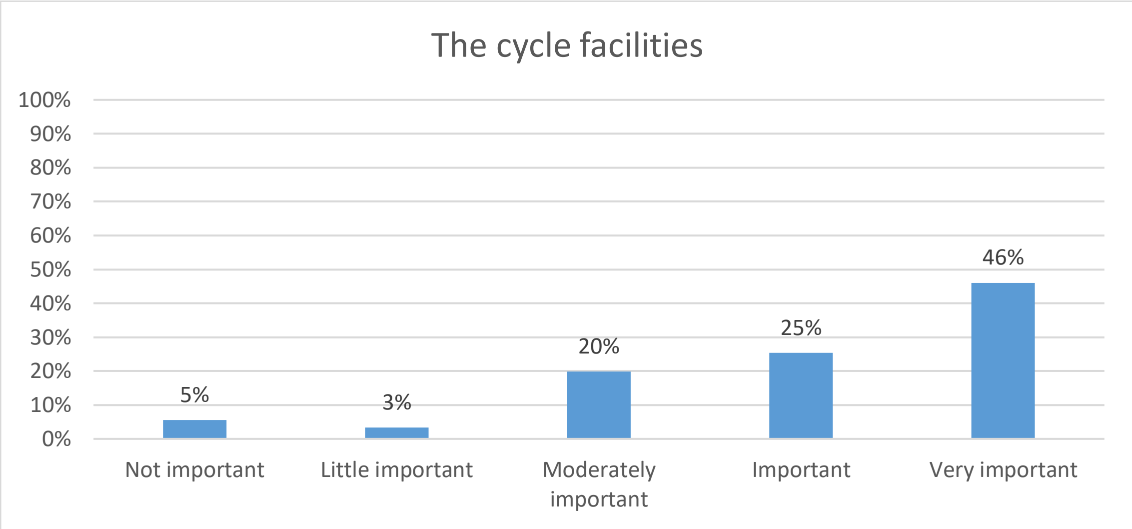

Frequency of the trip
81%
15%
2%
1%
1%
4 times per week or more
1-3 times per week
1-3 times per month
6-11 times per year
1-5 times per year
Less than 1 time per year

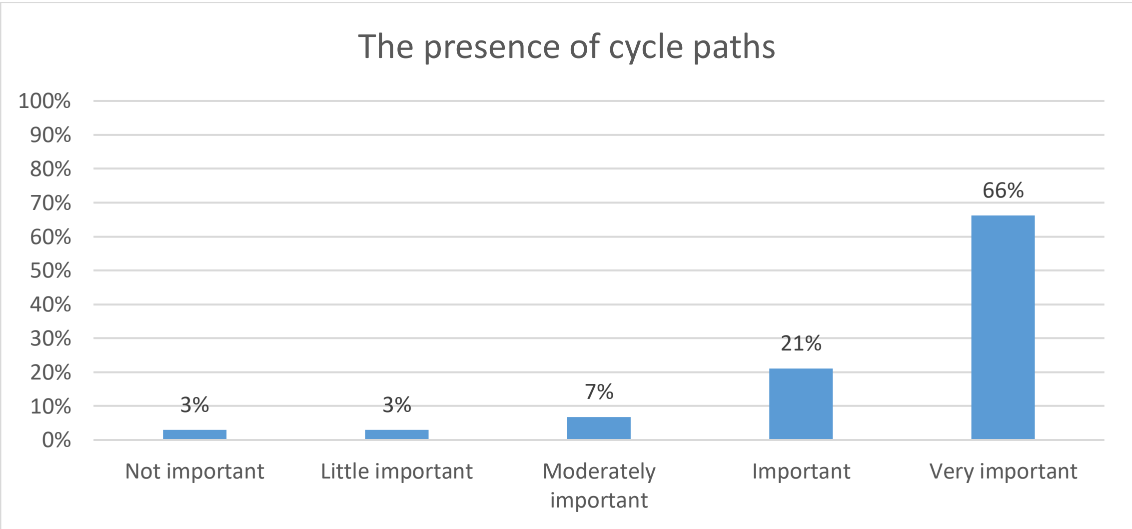

Other Transport Modes used
44%
41%
8%
5%
2%
Bicycle
Taxi/Uber
Other Bus
Walking
Car/Motorcycle

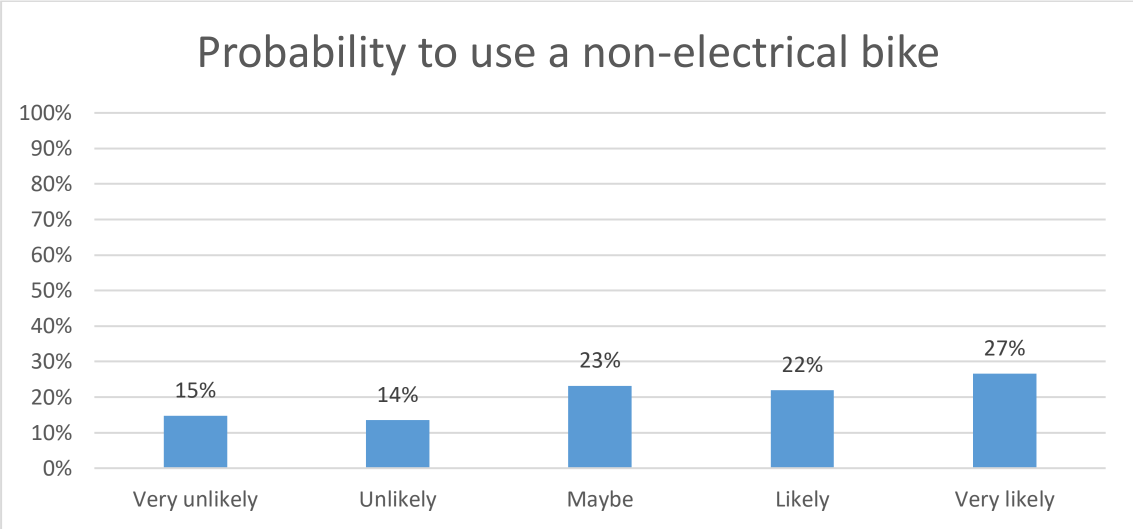

The price of the bike
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
3%
5%
18%
22%
52%
Not important
Little important
Moderately important
Important
Very important

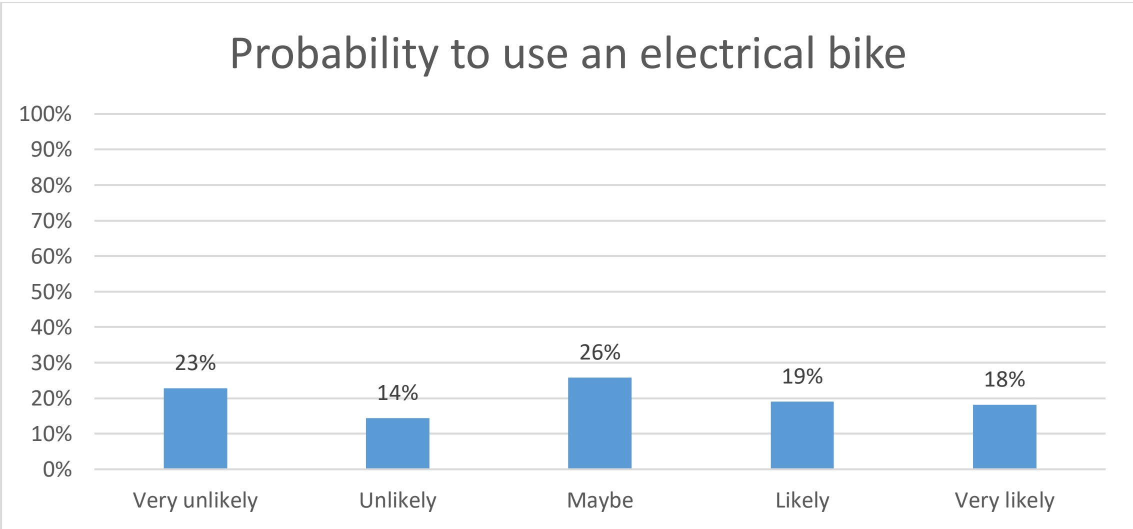

The in/decreasing of the travel time
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
3%
7%
17%
32%
40%
Not important
Little important
Moderately important
Important
Very important


Insecurity in traffic
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2%
8%
12%
17%
61%
Not important
Little important
Moderately important
Important
Very important


The cycle facilities
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
5%
3%
20%
25%
46%
Not important
Little important
Moderately important
Important
Very important


The presence of cycle paths
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
3%
3%
7%
21%
66%
Not important
Little important
Moderately important
Important
Very important


Probability to use a non-electrical bike
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
15%
14%
23%
22%
27%
Very unlikely
Unlikely
Maybe
Likely
Very likely


Probability to use an electrical bike
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
23%
14%
26%
19%
18%
Very unlikely
Unlikely
Maybe
Likely
Very likely

Appendix F: Statistic differences between groups

Differences in gender

Tested factor	Gender	N	Mean	St. Dev	t-value	Significance (2-tailed independent sample test)	
						Groups do not differ >0,05	Groups do differ <0,05
Price of the bike	Men	103	4,26	1,029	1,347	0,179	
	Women	134	4,07	1,087			
In/decreasing of travel time	Men	103	3,82	1,144	-2,232		0,027
	Women	134	4,13	0,999			
Insecurity in traffic	Men	103	3,93	1,239	-4,245		0,000
	Women	134	4,51	0,873			
Cycle facilities	Men	103	3,68	1,262	-4,308		0,000
	Women	134	4,30	0,950			
Cycle paths	Men	103	4,15	1,216	-4,413		0,000
	Women	134	4,68	0,608			
Probability to use non-electrical bike	Men	103	3,46	1,334	1,325	0,186	
	Women	134	3,22	1,416			
Probability to use electrical bike	Men	103	2,89	1,475	-0,579	0,563	
	Women	134	3,00	1,354			

Differences in age

Tested factor	Freq-uency	N	Mean	St. Dev	t-value	Significance (2-tailed independent sample test)	
						Groups do not differ >0,05	Groups do differ <0,05
Price of the bike	≤25	135	4,29	0,897	2,228		0,027
	>25	102	3,98	1,235			
In/decreasing of travel time	≤25	135	4,11	0,928	1,985		0,048
	>25	102	3,83	1,227			
Insecurity in traffic	≤25	135	4,12	1,159	-2,358		0,019
	>25	102	4,45	0,951			
Cycle facilities	≤25	135	3,99	1,172	-0,690	0,491	
	>25	102	4,09	1,091			
Cycle paths	≤25	135	4,40	0,971	-0,873	0,383	
	>25	102	4,51	0,941			
Probability to use non-electrical bike	≤25	135	3,40	1,306	1,016	0,311	
	>25	102	3,22	1,480			
Probability to use electrical bike	≤25	135	2,98	1,357	0,304	0,761	
	>25	102	2,92	1,474			

Differences in income

Tested factor	Income	N	Mean	St. Dev	t-value	Significance (2-tailed independent sample test)	
						Groups do not differ >0,05	Groups do differ <0,05
Price of the bike	Low	179	4,23	1,048	1,662	0,098	
	High	41	3,93	1,058			
In/decreasing of travel time	Low	179	4,03	1,035	0,955	0,340	
	High	41	3,85	1,131			
Insecurity in traffic	Low	179	4,23	1,087	-1,387	0,167	
	High	41	4,49	0,898			
Cycle facilities	Low	179	4,03	1,154	-0,991	0,323	
	High	41	4,22	0,936			
Cycle paths	Low	179	4,44	0,936	-1,576	0,116	
	High	41	4,68	0,756			
Probability to use non-electrical bike	Low	179	3,37	1,394	0,726	0,469	
	High	41	3,20	1,327			
Probability to use electrical bike	Low	179	2,96	1,424	-0,060	0,952	
	High	41	2,98	1,369			

Differences in education level

Tested factor	Edu-cation	N	Mean	St. Dev	t-value	Significance (2-tailed independent sample test)	
						Groups do not differ >0,05	Groups do differ <0,05
Price of the bike	Low	26	4,50	0,949	1,754	0,081	
	High	211	4,11	1,072			
In/decreasing of travel time	Low	26	4,08	0,845	0,429	0,668	
	High	211	3,98	1,100			
Insecurity in traffic	Low	26	4,27	0,919	0,038	0,970	
	High	211	4,26	1,106			
Cycle facilities	Low	26	3,96	1,113	-0,323	0,747	
	High	211	4,04	1,142			
Cycle paths	Low	26	4,31	1,011	-0,787	0,432	
	High	211	4,46	0,952			
Probability to use non-electrical bike	Low	26	2,62	1,444	-2,795		0,006
	High	211	3,41	1,354			
Probability to use electrical bike	Low	26	2,27	1,313	-2,664		0,008
	High	211	3,04	1,397			

Differences in trip frequency

Tested factor	Freq-uency	N	Mean	St. Dev	t-value	Significance (2-tailed independent sample test)	
						Groups do not differ >0,05	Groups do differ <0,05
Price of the bike	Not daily	45	4,11	1,112	-0,315	0,753	
	Daily	192	4,17	1,055			
In/decreasing of travel time	Not daily	45	4,07	1,031	0,521	0,603	
	Daily	192	3,97	1,085			
Insecurity in traffic	Not daily	45	4,13	1,120	-0,881	0,379	
	Daily	192	4,29	1,077			
Cycle facilities	Not daily	45	3,84	1,296	-1,215	0,226	
	Daily	192	4,07	1,095			
Cycle paths	Not daily	45	4,29	1,141	-1,233	0,219	
	Daily	192	4,48	0,909			
Probability to use non-electrical bike	Not daily	45	3,49	1,359	0,906	0,366	
	Daily	192	3,28	1,390			
Probability to use electrical bike	Not daily	45	2,91	1,328	-0,225	0,822	
	Daily	192	2,96	1,427			

Differences in trip reason

Tested factor	Trip reason (only work/ university)	N	Mean	St. Dev	t-value	Significance (2-tailed independent sample test)	
						Groups do not differ >0,05	Groups do differ <0,05
Price of the bike	Work	76	3,92	1,252	-2,444		0,015
	University	146	4,29	0,947			
In/decreasing of travel time	Work	76	3,91	1,133	-0,923	0,357	
	University	146	4,05	1,039			
Insecurity in traffic	Work	76	4,41	0,996	1,141	0,159	
	University	146	4,19	1,122			
Cycle facilities	Work	76	3,97	1,131	-0,511	0,610	
	University	146	4,05	1,119			
Cycle paths	Work	76	4,38	1,107	-0,900	0,369	
	University	146	4,50	0,824			
Probability to use non-electrical bike	Work	76	3,26	1,446	-0,334	0,739	
	University	146	3,33	1,360			
Probability to use electrical bike	Work	76	3,05	1,413	0,670	0,503	
	University	146	2,92	1,426			

*Because these 2 groups where 96% of the respondent's choice, the other groups are not measured in this table

Other transport modes used

Tested factor	Other transport modes* (Only bus/walk)	N	Mean	St. Dev	t-value	Significance (2-tailed independent sample test)	
						Groups do not differ >0,05	Groups do differ <0,05
Price of the bike	Walking	101	4,28	0,929	0,836	0,404	
	Other Bus	91	4,15	1,115			
In/decreasing of travel time	Walking	101	3,90	1,015	-1,685	0,094	
	Other Bus	91	4,15	1,064			
Insecurity in traffic	Walking	101	4,25	1,135	-0,455	0,650	
	Other Bus	91	4,32	1,021			
Cycle facilities	Walking	101	3,90	1,162	-1,619	0,107	
	Other Bus	91	4,16	1,088			
Cycle paths	Walking	101	4,45	0,943	-0,622	0,534	
	Other Bus	91	4,53	0,874			
Probability to use non-electrical bike	Walking	101	3,55	1,284	2,747		0,007
	Other Bus	91	3,01	1,457			
Probability to use electrical bike	Walking	101	3,07	1,373	1,395	0,165	
	Other Bus	91	2,79	1,387			

*People that used another transport mode or used the bus and walked as well are not added in this correlation table

Appendix G: Ordinal Logistic Regression

Ordinal Logistic Regression table with personal characteristics, trip frequency and barriers				
	Probability for use of non-electrical bike		Probability for use of electrical bike	
	Parameter estimates	*Std. Error*	Parameter estimates	*Std. Error*
Threshold: Probability for use of bike				
1 Very unlikely	-2,914	*0,959*	-1,996*	*0,907*
2 Unlikely	-1,899	*0,948*	-1,184	*0,901*
3 Maybe	-0,677	*0,940*	0,035	*0,897*
4 Likely	0,485	*0,939*	1,087	*0,900*
5 Very likely	0		0	
Education[1]				
3 High school	-1,632*	*0,679*	-2,250**	*0,709*
4 Technical school	-1,620*	*0,765*	-1,964*	*0,787*
5 Higher education	-0,103	*0,435*	-1,170**	*0,446*
6 Post graduate	0		0	
Income				
1 <R$1760	-1,652	*1,070*	-1,427	*1,007*
2 R$1760-R$3520	-2,464*	*1,057*	-1,676	*0,988*
3 R$3520-R$8820	-2,596*	*1,029*	-1,631	*0,968*
4 R$8820-R$17600	-3,169**	*1,065*	-2,280*	*1,003*
5 >R$17600	0		0	
Age[2]				
1 ≤25	1,806	*1,115*	2,571*	*1,119*
2 26-40	1,511	*1,098*	2,066	*1,085*
3 41-55	1,701	*1,077*	1,655	*1,039*
4 56-70	0		0	

Trip frequency[3]					
2	1-5 times per year	1,174	*1,299*	1,986	*1,220*
3	6-11 times per year	0,475	*1,376*	0,870	*1,383*
4	1-3 times p. month	-0,860	*1,083*	-0,856	*1,109*
5	1-3 times per week	0,528	*0,369*	-0,210	*0,359*
6	≥4 times per week	0		0	
The price of the bike					
1	Not important	-4,060*	*1,226*	-1,489	*0,908*
2	Little important	0,169	*0,674*	-0,188	*0,667*
3	Mod. important	-1,250*	*0,380*	-0,358	*0,371*
4	Important	-0,365	*0,352*	-0,040	*0,349*
5	Very important	0		0	
In/decreasing of time					
1	Not important	0,424	*0,888*	1,195	*0,867*
2	Little important	1,768**	*0,623*	0,542	*0,571*
3	Mod. important	0,675	*0,398*	-0,037	*0,393*
4	Important	0,394	*0,333*	0,078	*0,330*
5	Very important	0		0	
Traffic insecurity					
1	Not important	0,764	*1,411*	0,078	*1,237*
2	Little important	0,169	*0,603*	0,870	*0,609*
3	Mod. important	1,114*	*0,489*	1,199*	*0,490*
4	Important	0,274	*0,418*	0,634	*0,412*
5	Very important	0		0	
Cycle facilities					
1	Not important	-0,041	*0,794*	-2,055*	*0,812*
2	Little important	-1,858*	*0,864*	-3,136*	*0,994*
3	Mod. important	0,137	*0,421*	-0,785	*0,418*

4	Important	0,145	*0,369*	-0,162	*0,366*
5	Very important	0		0	
Presence of cycle paths					
1	Not important	-0,916	*0,980*	1,057	*0,973*
2	Little important	-0,239	*0,907*	-0,154	*0,915*
3	Mod. important	-0,234	*0,565*	-0,462	*0,563*
4	Important	-0,177	*0,374*	-0,292	*0,374*
5	Very important	0		0	
R^2 (Cox and Snell)		0,271		0,186	
Observations		220		220	

* *significance level: 0,01<p<0,05*
** *significance level: p<0,01*
[1]*No respondents answered: 'No education' or 'primary school'*
[2]*No respondents answered: '>70'*
[3]*No respondents answered: 'Less than 1 time per year'*
Note: This Table shows the results of ordinal regressions. The dependent variables are 'probability to use an electric bike' and 'probability to use a non-electric bike', which are measured on ordinal scales indicating whether current bus users in Curitiba have the intention to make use of an electric or a non-electric bike as (a part of) their trip. The independent variables included in the model are: 5 barrier/trigger statements: how important respondents find the price of the system, time in/decreasing, insecurity in traffic, the presence of cycle facilities and the presence of cycle paths. The characteristics of the respondents that are included in this regression test are the income, age, education level and trip frequency. The independent variables are measured on an ordinal scale.

Appendix H: Location specific statistics

Independent t-test between PC Rui Barbosa users and people who do not

Tested factor	Used bus stop of respondent	N	Mean	St. Dev	t-value	Significance (2-tailed independent sample test) Groups do not differ >0,05	Groups do differ <0,05
Price of the bike	Other	198	4,16	1,067	0,015	0,998	
	Rui Barbosa	39	4,15	1,065			
In/decreasing of travel time	Other	198	4,01	1,076	0,598	0,550	
	Rui Barbosa	39	3,90	1,071			
Insecurity in traffic	Other	198	4,26	1,103	-0,129	0,898	
	Rui Barbosa	39	4,28	0,999			
Cycle facilities	Other	198	4,01	1,135	-0,592	0,554	
	Rui Barbosa	39	4,13	1,151			
Cycle paths	Other	198	4,43	0,983	-0,650	0,517	
	Rui Barbosa	39	4,54	0,822			
Probability to use non-electrical bike	Other	198	3,30	1,392	-0,442	0,659	
	Rui Barbosa	39	3,41	1,352			
Probability to use electrical bike	Other	198	2,88	1,415	-1,728	0,085	
	Rui Barbosa	39	3,31	1,321			

Independent t-test between Terminal Cabral users and people who do not

Tested factor	Used bus stop of respondent	N	Mean	St. Dev	t-value	Significance (2-tailed independent sample test) Groups do not differ >0,05	Groups do differ <0,05
Price of the bike	Other	203	4,12	1,102	-1,342	0,181	
	Ter. Cabral	34	4,38	0,779			
In/decreasing of travel time	Other	203	3,97	1,110	-0,912	0,363	
	Ter. Cabral	34	4,15	0,821			
Insecurity in traffic	Other	203	4,19	1,116	-2,434		0,016
	Ter. Cabral	34	4,68	0,768			
Cycle facilities	Other	203	3,98	1,171	-1,801	0,073	
	Ter. Cabral	34	4,35	0,849			
Cycle paths	Other	203	4,42	0,999	-1,121	0,263	
	Ter. Cabral	34	4,62	0,652			
Probability to use non-electrical bike	Other	203	3,25	1,389	-2,036		0,043
	Ter. Cabral	34	3,76	1,281			
Probability to use electrical bike	Other	203	2,95	1,418	-0,208	0,836	
	Ter. Cabral	34	3,00	1,348			

Independent t-test between Estação Tubo Central users and people who do not

Tested factor	Used bus stop of respondent	N	Mean	St. Dev	t-value	Significance (2-tailed independent sample test)	
						Groups do not differ >0,05	Groups do differ <0,05
Price of the bike	Other	208	4,16	1,069	0,284	0,777	
	T. Central	29	4,10	1,047			
In/decreasing of travel time	Other	208	4,00	1,065	0,139	0,889	
	T. Central	29	3,97	1,149			
Insecurity in traffic	Other	208	4,23	1,092	-1,173	0,242	
	T. Central	29	4,48	1,022			
Cycle facilities	Other	208	3,98	1,148	-1,955	0,052	
	T. Central	29	4,41	0,983			
Cycle paths	Other	208	4,44	0,966	-0,419	0,675	
	T. Central	29	4,52	0,911			
Probability to use non-electrical bike	Other	208	3,27	1,399	-1,393	0,165	
	T. Central	29	3,66	1,233			
Probability to use electrical bike	Other	208	2,92	1,417	-1,036	0,301	
	T. Central	29	3,21	1,320			