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Master of Transportation Sciences

Master's thesis

Attitudes, Perceptions and Willingness to Pay for a Dedicated, Interconnected Cycling Lane in Administrative Beirut

Hassan Harajli

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

SUPERVISOR :
Prof. dr. Elke HERMANS

CO-SUPERVISOR :
Prof. dr. Muhammad ADNAN

2023
2024

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Master Thesis – DL4593

MSc Transportation Sciences (DL)

Prof. Dr. Elke Hermans
Prof. Dr. Muhammad Adnan

Attitudes, Perceptions and Willingness to Pay for a Dedicated, Interconnected Cycling Lane in Administrative Beirut

15th January 2024

Student:

Hassan Harajli

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This was my opportunity to partially rewrite my story and say thank you.

Contents

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List of Abbreviations

AggWTP	Aggregate willingness to pay
ANOVA	Analysis of Variance
CAS	Central Administration of Statistics (of Lebanon)
CE	Choice Experiment
CM	Choice Modelling
CO	Carbon monoxide
CV	Contingent Valuation
CVM	Contingent Valuation Method
DV	Dependent variable
g	Grams
GBA	Greater Beirut Area
GDP	Gross Domestic Product
ICCT	international Council on Clean Transport
ITDP	Institute for Transportation and Development Policy
IV	Independent variable
Km	Kilometers
MOE	Margin of error
MoE	Ministry of Environment (of Lebanon)
MoPWT	Ministry of Public Works and Transportation
NMVOC	Non-methane volatile organic compounds
NOx	Nitrogen Oxides
NPV	Net Present Value
PM	Particulate Matter
SO_2	Sulphur dioxide
TPB	Theory of Planned behavior
TTM	Transtheoretical model
UMD	University of Maryland
UK	United Kingdom
UNDP	United Nations Development Program
UNHCR	United Nations Higher Council for Refugees
UNICEF	United Nations Children's Fund
US	United States
USD	United States Dollar
WTA	Willingness to accept
WTP	Willingness to pay

1. Introduction

1.1 External cost of transportation in Lebanon

Transportation is the second largest source of greenhouse gas (GHG) emissions in Lebanon, contributing to 25% of the 30,089 Gg CO2eq. emissions emitted in 2019 (MoE *et al*., 2022). Most of the emissions were due to the consumption of gasoline in passenger cars. The overall fleet emission factor, which includes passenger cars, motorcycles, light duty and heavy-duty vehicles, was 258 grams (g) CO_{2eq} per kilometer (km), whereas the passenger cars only emission factor was 194 g CO_{2eq} per km (MoE *et al*., 2022). This value is above any European country, as can be seen in Figure 1. In fact, Lebanon's car fleet emission factor is higher than most European countries' average emissions in 2001.

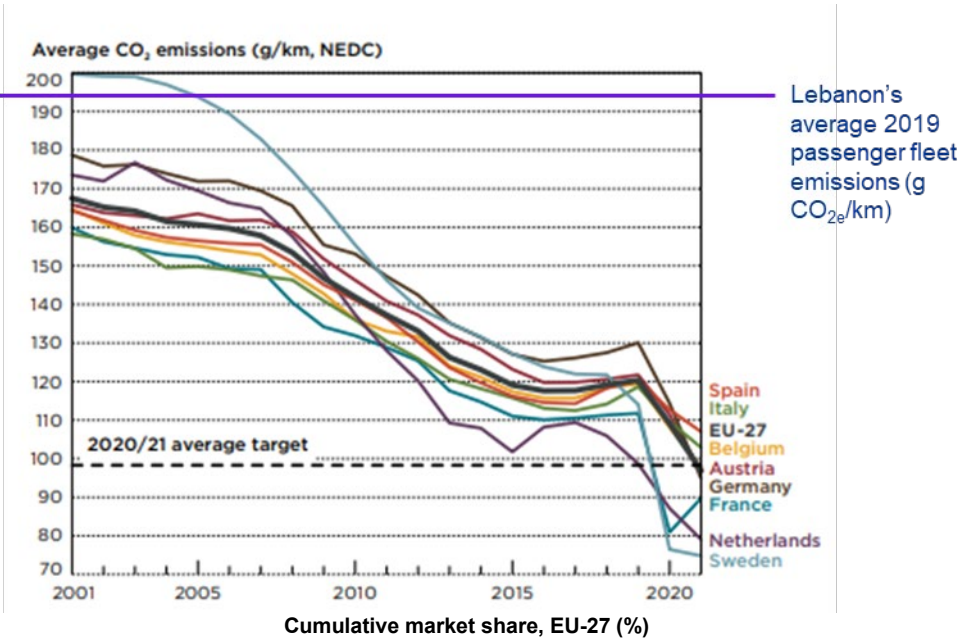


Figure 1. Average 2001 - 2021 CO_2 emissions from various European countries (ICCT, 2021)

Lebanon's poor performance with respect to GHG emissions of the road vehicle fleet is due to several reasons, most notable among them is the relatively old age of the passenger car fleet. Analyzing the fleet up to 2015 (Table 1), a study has shown that 70.4% of vehicles were at least 10 years old or more (relative to 2015) (MoE & UNDP, 2017). Furthermore, Lebanon 'possesses a very low vehicle occupancy of 1.2 compared to average standards for computing travel time reliability which is 1.7' (Saroufim & Otayek, 2019).

	Total Vehicles	Percent (%) of Total	Cumulative Percentage
Pre-1980	167779	11.7	11.8
1980 - 1993	378575	26.3	38
1994 - 2004	466517	32.4	70.4
2005 - 2008	204318	14.2	84.6
2009 - 2011	104152	7.2	91.8
2012 - 2015	117570	8.2	100

Table 1. Age category of Vehicles in Lebanon
(MoE & UNDP, 2017)

GHG emissions are not the only externality that road transport in Lebanon causes. There are several other externalities, such as, yet not limited to, congestion, accidents, air pollution, water pollution, and noise. A study by the Ministry of Environment and the United Nations Development Program (UNDP) estimated the external costs from road transportation in Lebanon, findings of which are indicated in Figure 2 (MoE & UNDP, 2015).

Externality	Cost (USD cents/liter)
Accidents	51.03
Congestion	47.07
Pollution	11.43
Carbon	0.034

Figure 2. Externality cost of road transport in Lebanon
(MoE & UNDP, 2015)

As shown in Figure 2, GHG emissions have the smallest relative cost value compared to other externalities, with larger costs attributed to accidents, congestion and pollution, respectively. According to Saroufim and Otayek (2019), total congestion costs represented approximately 0.51% of Lebanon's Gross Domestic Product (GDP), using 2017 as year of analysis. The World Bank assessed the costs of congestion for the city of Beirut (as opposed to a national average) and calculated the costs to be 2% of Beirut city's GDP (Anas *et al*., 2017).

With respect to pollution, emissions of nitrogen oxides (NOx), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), Sulphur dioxide (SO_2), and particulate matter (PM) cause significant health-related and ecosystem damage, with damages from urban air pollution estimated at 0.87% of GDP (IPTEC *et al.,* 2016).

With respect to accidents, Lebanon recorded 16.4 deaths per 100,000 population from road accidents (WHO data[1]), however with male deaths recording 26.8 deaths per 100,000, while female deaths per 100,000 recorded 6.1. This is an indication that a lot of improvements in road safety need to be implemented on Lebanese roads.

The above statistics and indicator values only aim to show that Lebanon needs a more sustainable transportation system from all angles (infrastructural, economic, social, and environmental), and active transport is one component that should be given due consideration.

[1] WHO application online; https://apps.who.int/gho/data/view.main.51310?lang=en, accessed 13.01.2024.

1.2 Active transport in Beirut: the status of cycling

Middle East countries in general, and Lebanon in specific, are not known for their cycling infrastructure or cycling culture. A study conducted on 150 countries acro ss the world categorized Middle East countries in the group with the least bicycles per household (Oke *et al*., 2015). An UN-Habitat report indicated that most cities in Lebanon have become unfriendly to cyclists and pedestrians, citing the below a s the main reasons for this reality (UN-Habitat, 2021):

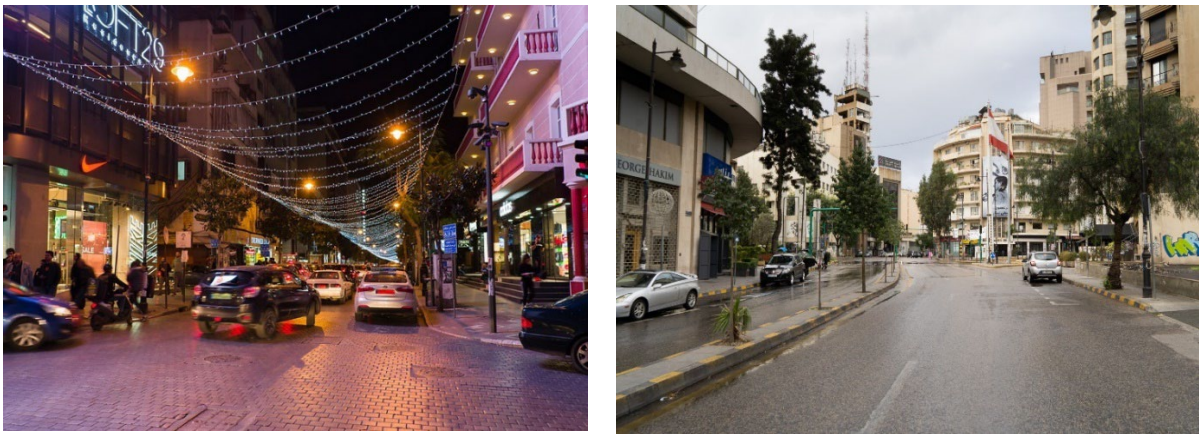
- No use of zoning or land-use planning to encourage walking and cycling in Lebanon.
- Lack of sidewalks beside most roadways, and a poor state of use for the majority of existing ones, in addition to common infringement by cars parked over most sidewalks, and random obstructions, such as unofficial signposts and barriers for illegally reserving curbside parking spots in front of residential buildings and commercial establishments.
- Lack of marked pedestrian crosswalks at intersections, and lack of pedestrian walkways, bridges, tunnels and other structures to provide safe pedestrian crossing of roadways.
- Near absence of parks and public squares for walking, bicycling and scootering, with the few available becoming inaccessible to the public due to security measures.
- No dedicated bicycle lanes in or around the Greater Beirut Area (GBA), with only temporary bike trails in limited areas made available for biking on occasions.
- Dominance of highways and roadways over urban space.
- Priority to the automobile and high risk of accidents as a result of the long-standing car culture in Lebanon, meaning that car drivers feel entitled to the road and typically fail to stop for crossing pedestrians, or maintain a safe clearance with bicycles at the edge of the roadway.

A Ministry of Environment (MoE), Global Environment Facility (GEF) and UNDP study confirms the above, indicating that 'non-motorized modes of transportation are not popular in Lebanon due to the lack of regulations that protect the safety of pedestrians and cyclers on one hand, and due to the underdevelopment of the pedestrian and cycle route network infrastructure on the other' (MoE *et al.,* 2022). The main challenges according to this assessment towards increasing the share of active modes in Lebanon are (MoE *et al.,* 2022):

- The lack of suitable pavements and dedicated bike lanes,
- The absence of a national non-mobilized transport strategy that establishes an overall vision for coordinating policies and targets for cycling and walking, and;
- The lack of adequate traffic enforcement.

The Municipality of Beirut, before the 2019 financial collapse of the Lebanese economy, had plans for a 28 kilometers inter-linked cycling lane. However, this plan was never implemented. To date, the administrative city of Beirut, housing 430,000 citizens (City Population, 2019), does not have any cycling lanes and its pedestrian infrastructure is in need of major investments. Figure 3 exhibits two famous streets in Lebanon, Hamra Street and President Elias Sarkis Street. As you can see from the pictures, trees and poles stand in the middle of pavements and

cars park on each side. These are among the better designed and maintained streets of Beirut, while most other streets require major reconstruction to improve the infrastructure and facilities for active transport.



Hamra Street *Pres. Elias Sarkis Street*

Figure 3. Famous streets in Beirut

Beirut's cultural, political and spatial development was mainly driven by the history and the politics of Lebanon, a country in almost constant crisis. Nasr & Verdeil (2008) provide a concise historic view of the reconstruction of Beirut up to present. According to the authors, Beirut's reconstruction is 'a series of moments in a political balance of power' as the 'city has to be placed within political, socio-demographic and economic turmoil in its gradation and in the steps onwards and backwards from peace to war.' In the post-war era (post-1990), 'physical schemes, such as major infrastructure and large-scale redevelopment, dominated the plans put in place or the projects that were launched' (Nasr & Verdeil, 2008). These infrastructure and large-scale developments were vehicle focused, as opposed to people focused, and lacked any appropriate planning in terms of sustainability. This includes a lack of pedestrian friendly and cycling promoting infrastructure.

1.3 Research objective and questions

Active transport has never been high on the policy makers' agenda in Lebanon and its capital Beirut. Since the end of the civil war, the focus of infrastructure was fixing highways and roads and thereby all efforts were private vehicle centric. With the problems of transportation as explained in the previous sub-sections, focusing on the potential value of sustainable transportation systems merits focus as a potential new paradigm to improve mobility and reduce mobility externalities. Active transport, as part of any sustainable transport strategy, has the potential to bring about many benefits that far outweigh its costs. A thorough examination of possible costs and benefits of active transport are provided in Litman (2022), summarized in Table 2.

	Improved active transport conditions	Mode active transport travel	Reduced automobile travel	More compact communities
Benefits	Improved user convenience, comfort and safety	User enjoyment	Reduced traffic congestion	Improved accessibility, particularly for non-drivers
	Improved accessibility for non-drivers, supporting equity objectives	Improved public fitness and health	Road & parking facility cost savings	Transport cost savings
	Option value	More local economic activity	Consumer savings	Reduced sprawl costs
	Higher property values	Increased community (increase interactions between neighbors)	Reduced chauffeuring burdens	Open space preservation
	Improved public realm	More neighborhood security	Increased traffic safety	More livable communities
			Energy conservation	Higher property values
			Pollution reduction	Increased security
			Economic development	
Costs	Facility costs	Equipment costs (bikes…)	Slower travel	Increases in some development costs
	Lower traffic speeds	Increased crash risk		

Table 2. Benefits and costs of active transport
(Litman, 2022)

The objective of our research is to elicit, for the first time, the potential value that citizens residing in Beirut, the capital of Lebanon, place on active transport, and in specific on cycling. The key research questions that are aimed to be responded to are as follows:

- What are the welfare benefits of investing in an inter-linked and fully separated cycling lane for 'administrative Beirut', an area of approximately 18 km^2?
- What are the perceptions and attitudes of Beirut citizens for such an investment? Do they value it, and if yes, by how much?
- What are the determinants of this valuation and what does this mean to policy making?
- How do the overall welfare benefits compare with potential overall costs for such an investment?

The research herein has the potential to be important for several stakeholders. These stakeholders are listed below, along-side a description as to why the analysis herein may be beneficial to them.

- Municipality of Beirut: the Municipality of Beirut has attempted to construct a cycling lane across the city, however that plan was not implemented due to the economic collapse of the country.
- Ministry of Public Works and Transportation (MoPWT): the MoPWT is responsible for the national policies related to transport and setting the national priorities. It is the main institution that take all transport-related decisions to the Council of Minister (CoM), the highest executive branch of government. The study could be important for them to begin considering sustainable transport options that don't only focus on large infrastructure projects
- International finance and development agencies: Major finance institutions have traditionally focused on granting financial resources for highways, roads and bridges, and this is especially the case from the World Bank and Arab-related finance institutions. Showcasing the value of active mobility and its related infrastructure could support in the diversification of their investment portfolio and make them more climate-friendly.
- Civil society and non-governmental organization: Civil society and non-governmental organizations, like the Chain Effect (https://thechaineffect.me/), who can potentially use the results of the study to provide science-based evidence on value of cycling infrastructure for local citizens.
- Residents of Beirut: residents of Beirut are the target of this assessment and yet they can also make use of its results to raise self-awareness on the topic and to assess its community value.

To the best of our knowledge, no former study conducted in Lebanon has addressed the research questions being addressed herein.

1.4 Methodology

The methodology followed in our research, details of which are presented in Chapter 3, is based on a stated preference technique or method with related descriptive and regression analysis, that will be guided by an intensive review of existing literature. The latter is vital for our analysis as it draws our attention to what could be the possible determinants of value towards cycling and/or cycling infrastructure, and therefore guides the survey design.

Stated Preference techniques or methods are defined as follows (Shange & Chandra, 2023):

"Stated preference methods are economic evaluation tools that allow scholars, practitioners, and policymakers to understand the preference and priority of decision-makers (e.g., consumers, citizens, investors, entrepreneurs, parents, or patients) in relation to the evaluation of a variety of goods or services or ideas or policies. Broadly speaking, stated preference methods involve collecting data on respondents' preferences and estimating changes in utility associated with a proposed change in quality or quantity of a product or service or idea or policy by direct elicitation."

In the stated preference method, the aim is to elicit the willingness to pay (WTP) of citizens for a certain attribute, herein being cycling infrastructure, using contingent valuation (CV). Contingent valuation is defined as *"a survey-based method to estimate the monetary valuation of non-market products, which are products and services not traded in markets and do not have a market price (e.g.,*

clean air and water), by obtaining an individual's willingness to pay (WTP) for acquiring or improving the quality of a product or service" (Shangra & Chandra, 2023).

A face-to-face survey of approximately 210 respondents was conducted in administrative Beirut during the summer months of 2023, aimed at surveying Lebanese citizens to elicit their attitudes, perceptions and willingness to contribute (pay) for expanded, interconnected and high-standard cycling lanes for administrative Beirut. Socio-demographic and individual specific statistics such as sex, age, health, prior transport characteristics, education and income was also collected. The findings of the survey are inputted into the Statistical Software (SPSS) and through Linear regression and logistic regression models provide an analysis on the outcome of variables with significance on willingness to pay for cycling lanes and the overall monetary values of cycling lanes for administrative Beirut.

To provide expert judgement and reflect on the results of the statistics and regression analysis, an interview was conducted with a transport specialist, Ms. Zeina Hawwa, who is also an activist for the promotion of active transport in Lebanon via a non-governmental organization known as The Chain Effect. The feedback of Ms. Hawwa provides additional context to our research.

1.5 Structure of Thesis

The structure of our thesis is divided into the following chapters:

- ***Chapter 2***: Literature review. In this chapter several peer-reviewed articles on the subject matter on stated preference techniques used for eliciting value of respondents to cycling and/or cycling-related infrastructure. The findings of this Chapter guide the design of our research survey and supports our analysis in evaluating why and how certain determinants (independent variables) may impact WTP (dependent variable).

- ***Chapter 3***: Methodology. In this chapter, the steps that are taken to conduct a contingent valuation, the regression model specification, and how the data collected will be organized, is presented.

- ***Chapter 4***: Results. In this chapter the descriptive and regression analysis findings of our research are presented. The descriptive analysis focuses on the mean, median, standard deviation, and minimum and maximum values of these variables. The descriptive analysis also includes important elements on the respondents' perceptions and attitudes towards the research questions, enabling for a comparative analysis and a more thorough evaluation of the research objective. The regression analysis presents the relative importance of certain determinants on the stated value of WTP, paving the way for policy recommendations. Results will also provide an overall welfare benefit estimate of cycling infrastructure for Beirut and compare to potential costs of setting up a cycling infrastructure.

- ***Chapter 5***: Discussion and Conclusion. In this chapter, a discussion and analysis of the findings and what they can mean for policymakers and urban planners are presented. The chapter also includes the perspective of a

transportation specialist and activist for active transport, adding expertise knowledge to our research. The chapter is concluded with a summary of the research and a recommendation on future research in the related subject matter.

2. Literature Review

2.1 Introduction

Findings of an extensive literature review are provided herein. Literature review serves two main purposes for our research. The first is to provide essential reference points and confidence in the research that is conducted. Through observing similar research, a better formulation of the research hypothesis can be presented, as well as better design of the methodology and its execution, and better analysis and comparison of results. From similar case studies we assess design parameters, lessons learned, policy recommendations, among other important yardsticks. The second purpose for literature research is to provide important information and data that should be considered when constructing the contingent valuation survey to assess the willingness to pay (WTP) for using bicycles and/or investing in cycling infrastructure. Independent variables that have been discovered to impact, positively or negatively and to varying extents, perceptions, attitudes and WTP for cycling and/or cycling infrastructure need to be included in the survey. This is particularly the case as the explanatory power of several independent variables, as described below, are region and/or country dependent.

Several studies have investigated perceptions, attitudes and/or determinants for cycling in different settings and with different focus groups or sample populations. Several peer-reviewed research papers on the subject below are presented, covering different groups of people and different regions of the World.

2.2. Summary of several related studies

2.2.1 University students' surveyed studies

Although our study does not target university students per se, there are approximately 34.5% of those surveyed, or 76 out of the 220 respondents (see Chapter 4.1 on descriptive statistics), who identified themselves as university students. This is not unusual as Administrative Beirut is also a hub for universities and academic institutions. To that end, reviewing research targeting this group of people will add specific insights to our findings.

Attard *et al.* (2021), Akar & Clifton (2009), Cantillo *et al.,* (2020) focused on university students and faculty members' perceptions and perspectives. Akar & Clifton (2009) investigated the opportunities and challenges of cycling in the University of Maryland (UMD). UMD students and staff have a low cycling mode share when compared to other United States (US) universities, relying mostly on private vehicles. An email survey was sent out to UMD members and 1500 complete responses were recorded. Descriptive statistics collected information on the following:

- Degree being studied
- Gender
- Age
- Mode of transport
- Whether they own a bicycle and when was the last time they rode a bicycle
- Living location and distance to campus
- Whether they have driving license, and;
- If they have a parking permit.

Findings from the descriptive analysis indicated that the percentage of car commuters increased with increasing distance from campus, an expected outcome. It was also found that even if the distance to campus is less than 5 miles, the main mode of transport was still driving. Akar & Clifton (2009) asked the respondents of reasons that prevent cycling and what cycling infrastructure improvements would encourage them to cycle. For the former question, responses ranged from 'not feeling safe about the vehicle traffic, lack of cycling lanes or paths, to not knowing how to cycle and needing to change clothes and carry things, worry about crime or simply not being interested. For the latter question, the main improvements that may nudge them to cycle is a campus map showing cycling routes, dedicated and separate lanes on campus and off campus, secure bicycle parking, and better lighting around campus for travel. Akar & Clifton (2009) also focused on attitudes regarding travel characteristics. Correcting for multi-collinearity and adopting a sequential approach where more and more variables are added in sequence, they assessed the impacts of status (undergraduate, graduate, staff...), gender, time of travel and cost of travel, and various attitudes (perceptions on cost of gasoline, congestion on campus, availability of travel options, perceptions of health benefits of cycling, perceptions on the cost of the car parking at campus, perceptions on flexibility of departure time, and weather-related issues. Findings highlighted the importance of time and cost. If time can be lowered for cycling, it would encourage more cycling, just as higher costs of operating a vehicle will also encourage cycling. Furthermore, cycling was more favored by those who had a stronger perception or knowledge as to cycling's health benefits, relating it to exercise. Last, well-lit roads positively impacted the sense of safety of respondents and thus their attitude towards cycling.

Attard *et al*. (2021) focused on finding out the determinants of walking and cycling of university students and staff in the University of Malta. The methodology adopted by Attard *et al.* (2021), known as Active Travel Workshop, was based on a workshop for 34 participants and real-life walking of 4 routes during this workshop, taking photos and expressing the participants' opinions on various road or path characteristics. The outcome of the study was grouping the written observations of the participants under four 'experience variables' being safety, comfort, pleasantness, and vibrancy. Both positive and negative observations were recorded under this exercise. For example, under Safety, the positive elements were wide pavements whereas the negative ones were obstacles on the pavements and absence of proper street lighting. Under pleasantness, the positives where green spaces and absence of traffic, whereas the negatives where cars invading pedestrian areas and heavy traffic. The outcome of Attard *et al.* (2021) serves to provide important parameters that will undoubtedly impact citizens' perspectives and consequent WTP for cycling and cycling infrastructure.

Cantillo *et al.* (2020) conducted a stated preference technique on university students in Barranquilla, Colombia, to study the factors that influence WTP for a dedicated bikeway. Barranquilla is a tropical city with an average temperature and humidity of 27°C and 79.8%, respectively (Cantillo *et al*., 2020). A final dataset of 335 individuals was collected. The survey consisted of three main parts, as below (Cantillo *et al.,* 2020):

- *Collecting socio-economic characteristic information*
- *Asking students to rate different statements related to their perceptions and attitudes towards the environment using a Likert scale*

- *Presenting two opposing types of policies and asking individuals to choose their level of acceptance of each policy*
- *Downward iterative contingent valuation to estimate WTP for a bikeway. A standard fully separated bikeway (two-ways, 2.5 meters wide) was (hypothetically) constructed from their home to the university and a toll was to be established. A started toll of approximately 0.5 USD per trip was used, and respondents were asked if they were WTP for this. If yes then their WTP is 0.5 USD or more per trip, and if no, a lower amount is displayed until they say yes.*

Descriptive statistics included distance to campus, gender, socioeconomic stratum, monthly expenses (as proxy for income as they are students), degree being studied, car ownership, and motorcycle ownership. For the attitudinal and perceptions questions asked through a Likert scale, some examples of the questions asked are as follows (Cantillo *et al*., 2020):

- *Atmospheric contamination is affecting my life*
- *I would never consider throwing solid waste in public spaces*
- *I prefer to use low consumption vehicles*
- *If there were secure roads for cycling, I would go to work in a bicycle*
- *The climate keeps me away from cycling and walking*
- *I prefer to buy environmentally friendly products, even if they are more expensive*
- *To invest in green areas is better government policy than investing in public roads and bridges*
- *To invest in pedestrian platforms and bikeways is better government policy than investing in additional roads and parking lots…*

Cantillo *et al*., 2020 reduced the number of factors and grouped them into either environmental friendliness or pro-car attitude. Results indicated that 31.3% of respondents had a WTP of 0.5 USD per trip and the remaining percentages of respondents had lower amounts than this. The mean WTP was 0.367 USD per trip, while the median was 0.315 USD per trip. Some of the major results are as follows (Cantillo *et al*., 2020):

- *The propensity to have a pro-car attitude increases with car and motorcycle ownership and use, and low-income students have the lowest vehicle oriented attitudes*
- *WTP is a quadratic function of the distance (starts low, increases, reaches maximum and decreases). Maximum with maximum WTP before declining was 25 kilometers*
- *Students studying humanities and education have a higher WTP, while those from politics and law had the lowest WTP.*
- *Students that walk, use a motorcycle or motorcycle taxi have a lower disposition to pay than those who use the public transit system (buses) and cars.*
- *Students with higher expenses have a lower deposition to pay for a bikeway (consistent with theory that high income individuals are the least likely to choose the bicycle mode)*
- *Findings with respect to environmentally friendliness or being pro-car did not have any statistically significant result.*

2.2.2 Research from related studies on general population

Rietveld & Daniel (2004) analyzed the determinants of bicycle use with a special focus on municipal policies as one explanatory factor to describe the difference between countries or even between cities within one country. A data set with 103 municipalities was collected, some relying on available statistical sources while others were collected via the Dutch Cyclists' Union. Rietveld & Daniel (2004) adopted a general framework of factors, shown in Figure 4, that may explain bicycle use.

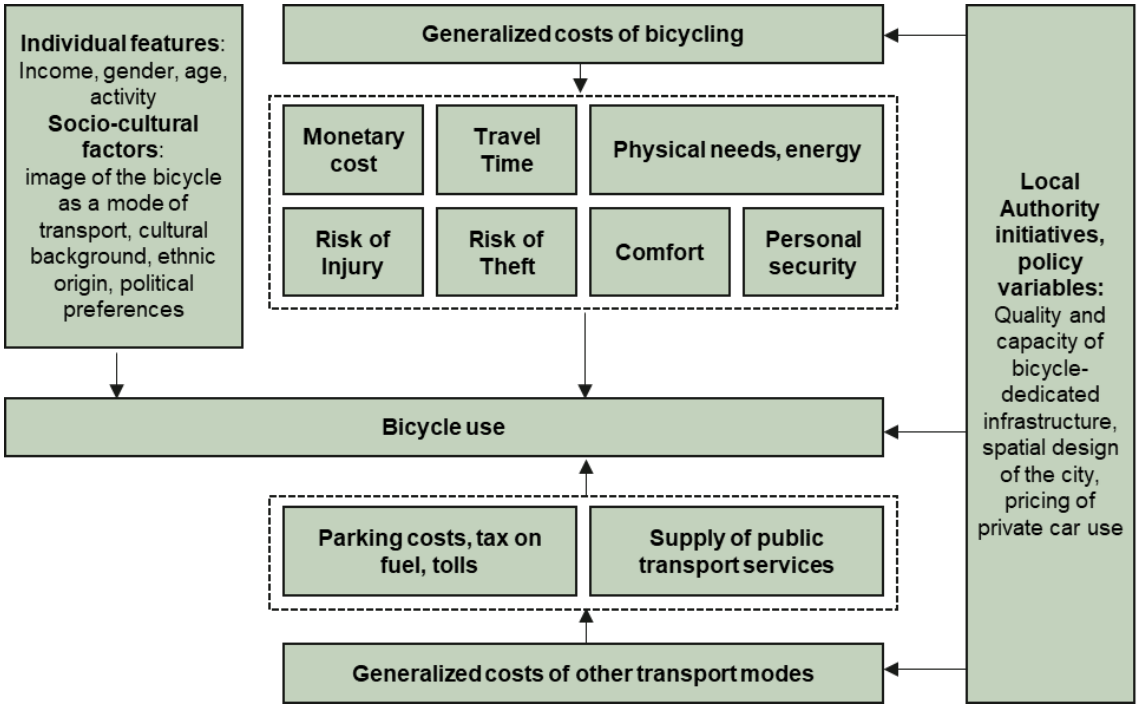


Figure 4. General framework of factors explaining bicycle use
(Rietveld & Daniel, 2004)

Figure 4 indicates that generalized costs of cycling have an impact on cycling use. These are travel time, physical needs needed, comfort, travel safety, and risk of theft. These on the other hand depend on the efforts and policies of the municipality and in particular on the adequacy of the cycling infrastructure, as well as on physical conditions such as flatness of surface and pollution levels. The municipality also impacts the costs of the alternative mode through tolls, parking prices for cars and other similar financial instruments. Rietveld & Daniel (2004) adapted this general framework and included the following variables in the analysis of cycling determinants:

- *Physical features; topography of the city, meteorological conditions (specifically wind and rain as the study is focused on the Netherlands).*
- *Population and individual features; size of the city (as a proxy for quality and level of development of public transport network), risk of theft and damage, density of human activity (approximates number of addresses per square kilometers), speed of car mode, proportion of younger generation, income, socio-cultural factors (share of non-native residents), religion, and political affiliation of municipality.*

- *Efforts in implementing bicycle-friendly policies; number of stops or turns per unit distance, proportion of time spent walking or biking slowly, obligation to give priority at a cross road, frequency of hindrances on a trip, ratio of bicycle trip duration, ratio of car trip duration, noise nuisance, satisfaction levels with municipality bicycle policies, parking prices*

Major results of Rietveld & Daniel (2004) indicated the following important points:

- *Improving attractiveness of a transport mode is done by reducing its generalized costs and making competing modes more expensive (a combination of push and pull policies)*
- *Time travel is an important factor of travel demand, therefore provision of direct routes and small number of stops will contribute to the attractiveness of the bicycle as a transport mode*
- *Accident risks, real and perceived, play a role in travel demand*
- *Potential risk of theft or vandalisms negatively impacts bicycle use*
- *Topography (presence of hills) is a deterrent to cycling use*
- *Potential wind speed negatively impacts cycling use*

Ton *et al.* (2019) identified the determinants influencing the choice for active transport, focusing on a comprehensive set of modes (car, public transport, bicycle and walking) for the Netherlands, a country that is a pioneer in active transport. A discrete choice model was used, based on consensus data, to elicit the influence of different categories of determinants on mode choice. Ton *et al.* 2019 filtered and assessed 1864 individuals all over Netherlands. From the literature, Ton *et al.* (2019) included all possible influences on active transport (Figure 5).

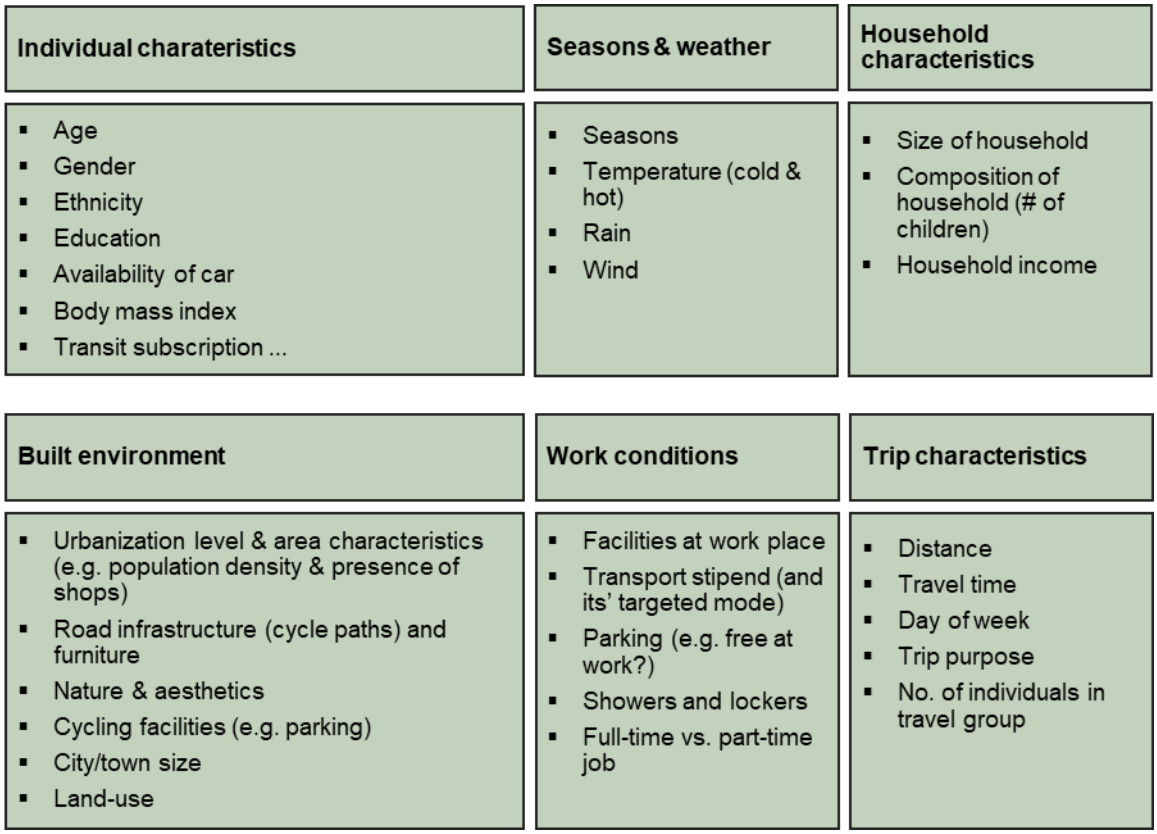


Figure 5. Determinants known to influence mode choice in literature
(Ton *et al.*, 2019)

In summary, Ton *et al.* (2019) indicated the following:

- *Socio-demographics variables are found less important in explaining active mode choice compared to literature.*
- *They found no significant relationship between gender, age, and ethnicity and active mode use.*
- *Car and bicycle availability on household levels do not influence mode choice, whereas the existing body of literature identifies this as an important variable.*
- *Having children is not significantly related to active mode use, whereas other studies suggest a negative relationship.*
- *Weather characteristics are not relevant for active mode choice, which contradicts the general body of literature.*
- *Travel time has a positive association with cycling, which in comparison to the other modes could be explained by the relationship between modal shares in different travel time categories.*
- *They found that the travel group size and moment of travel are relevant for mode choice, which has not been identified insofar in the active mode literature.*
- *Active mode infrastructure was found to be of limited relevance in explaining active mode choice, whereas literature states this as important determinants for cycling and walking.*
- *Mixed land use is found important for active mode use*

Forward (2014) explored people's willingness to bike using two different social cognitive theories, the theory of planned behavior (TPB)[2] and the transtheoretical model (TTM)[3]. Approximately 414 people were filtered from a response pool of 1133 participants that responded to a mailed survey in Sweden. In the survey, the participants were asked to consider a trip that they most often take every week, and then evaluate how this trip would be if it was done using a bike. Attitudes were assessed through a Likert scale by including a combination of behavioral beliefs such as, yet not limited to, the following (Forward, 2014):

- Improved physical fitness
- Experiencing stressful journey
- Feeling free
- Worried about being involved in car crash
- A quick journey
- Unnecessary exhausting
- Travelling in a cheap way
- Mode choice is respected by others
- Having parking problems
- Contribute to a better environment
- Worry that car will be stolen
- Worry about being assaulted or threatened by others
- Being able to enjoy surroundings
- Being sweaty when travelling
- Going from A to B without unnecessary detours

Subjective norms were assessed, for example, through asking how partners, colleagues and friends perceived of them biking, while perceived behavioral control was assessed through asking if 'for me to (bike) is possible/impossible and very easy/hard'. Habit was captured through asking 'my choice of transport during this

[2] TBD explains the formation of intention via three antecedents, namely attitudes, subjective norms, and perceived behavioral control, and these account for considerable variance in actual behavior (Ajzen, 1991).

[3] TTM TTM describes behavior change as a sequence of the stages through which individuals progress toward a desired kind of behavior. The TTM consists of two main constructs: the stages of change and the processes of change and five major stages (precontemplation, contemplation, preparation stage, action and maintenance stages) (Prochaska and DiClemente, 1981).

part of the year is more or less automatic'. Forward (2014) then asked questions to place the participant on one of the 6 stages of the TTM, from precontemplation to termination.

Results indicated that three major components, from which the above list of behavioral beliefs were combined, being 'fast and efficient' (a reflection of the trip itself), 'well-being and environmental concern' (a reflection of general longer-term effects), and 'discomfort' (a reflection of anxiety such as road crashes, theft and assaults) captured more than half of the variance in the model.

Forward (2014) provided recommendations to tailor interventions to individuals depending on where they were in the TTM stages. For example, individuals in the first pre-contemplation stage require in person contact and persuasion. Those in the last stage need certain interventions to ensure their behavior is maintained through, for example, improvement of infrastructure to make biking faster, safer and more convenient.

Heinen *et al.* (2010) present a thorough overview of literature to date (2010) focused on determinants for commuting to work via cycling. Determinants are divided into five groups, being:

- *Built environment, specifically urban form, infrastructure & facilities at work*
- *Natural environment, specifically hilliness and landscape, seasons and climate, and weather*
- *Socio-economic factors, specifically household characteristics such as income, employment status, gender, and age*
- *Psychological factors, specifically attitudes and norms, perceived behavioral control, and habits*
- *Cost, travel time, effort and safety*

Heinen *et al.* (2010) reviewed several literature sources that targeted part of several of the above five groups. The main findings of Heinen et al.'s literature review is summarized in Figure 6.

Built environment	Natural environment	Socio-economic factors	Psychological factors	Cost, travel time, effort & safety
▪ Type of cycling infrastructure matters, with bicycle paths most preferred, following curb lanes, linking this to safety (esp. subjective or perceived safety). ▪ Having a continuous cycling path / network also lends support to more cycling ▪ Shorter distances, a greater mix of functions and access to good parking facilities contribute to more cycling ▪ A denser network layout & higher densities seems to have similar impact, yet this is not clear ▪ Cyclists have negative perception of traffic lights and stop signs, yet impact on cycling unclear	▪ Hilliness has been found to have a negative effect on cycling ▪ The chance of rain, low temperatures and darkness result in people choosing to cycle less ▪ Some research lends support that people view cold weather as more limiting to cycling than hot weather ▪ Attractive landscape is mentioned as important to stimulating walking and cycling, yet in many cases not found to be statistically significant	▪ Impact of gender on cycling appears to be country specific, with men cycling more than women in countries with low cycling rates, whereas it is more equal in countries with high cycling rates ▪ Relationship between cycling and age and income is ambiguous ▪ Employment status seems to impact cycling, with part-time workers commuting more than full-time workers ▪ Household structure also seems to impact cycling, with high social status and having a young family reducing the probability of cycling	▪ Attitudes, social norms and habits influence a person's decision to cycle to work ▪ The more positive an attitude is towards cycling, the more the likelihood of cycling to work ▪ In some cases, social norms explained partially inclination to cycling, in other cases it did not ▪ Ecological beliefs and altruism also influence mode choice, with people with more environmental beliefs tending to cycle more ▪ Individuals that do not commute by bicycle perceive more barriers towards cycling ▪ Habits impact mode choice and frequency	▪ Cost, travel time, effort needed and safety all seems to affect mode choice ▪ If another transport mode choice become expensive, then levels of cycling increase ▪ Subjective safety is very important ▪ The perceived value of cost, time and effort (convenience) is important, not only the real value of these attributes ▪ Reasons for cycling quoted as health benefits, exercise/ fitness, flexibility, convenient and enjoyment of scenery. ▪ Reasons not to include too dangerous, traffic, bad weather, lack of daylight, inconvenience, lacking sufficient fitness, lack of time, too much effort…

Figure 6. Outcome of literature review on determinants of cycling to work
(Heinen *et al.*, 2010)

Cole-Hunter *et al.* (2015) focuses on the built environment elements to describe participant propensity to cycle, specifically the urban environmental characteristics (including noise and greenness) along the entire pathway (from origination to destination) of the respondent commute. Research is focused on the Mediterranean city of Barcelona, Spain, and forty data collection points were selected throughout the city. Cole-Hunter *et al.* (2015) logic is that, in addition to time and cost of travel, the built and natural environments should be considered to understand travel mode choices. Characteristics include noise and nitrogen dioxide, elevation, greenness, bicycle lanes, bicycle racks, presence of public bicycles, presence of close public transport stations, among other factors. A total of 18,469 people were systematically approached across the forty sampling points of Barcelona city between June 2011 and May 2012 and of these, 6701 participants accepted to answer initial screening questions, 1406 participants fulfilled the inclusion criteria and 769 participants completed the travel survey by phone (Cole-Hunter *et al.*, 2015). Results found the following main outcomes (Cole-Hunter *et al.,* 2015):

- *Quantity of public bicycle stations positively impacted cycling propensity*
- *Amount of greenness positively impacted cycling propensity*
- *Public transport stations and hilliness negatively impacted cycling propensity*
- *Age, education level, gender, nationality, vigorous exercise and commute distance impact cycling propensity*

Aldred & Dales (2017) investigated, among other parameters, the extent to which protected infrastructure is associated with greater diversity and normalization of cycling. Specifically, their research analysed through visual surveys, compared 'light segregation' cycle tracks to parallel busy roads with mixed cycling and vehicles. Findings show that women and older people were more likely than men or younger people to wear high-visibility clothing and helmets, supporting the literature that (1) women and older people are more sensitive to perceived cycling risks, and (2) tend to express stronger stated preference for cycling away from motor traffic (Aldred & Dales, 2017).

Botes & Zanni (2021) adopted a more holistic or wide-ranging approach to test Taipei people's perceptions and preferences for various essential street elements, namely, trees, ground vegetation, sidewalks and cycleways. They applied Choice Modeling, a type of economic valuation technique, to analyze people's preferences and WTP (in the form of an environmental improvement tax) for different elements of street design, taking one particular street in Taipei, Xin Yi Road, as a case in point. Botes & Zanni (2021) selected one road only (to reduce cognitive burden) and presented the choice modeling survey to 129 individuals. The choice model included attributes and different respective levels and presented visual support for these choices. The survey choice also indicated that results of the study will be provided to the local council. This was done to reduce hypothetical bias. For cycling infrastructure, the choice model indicated the following choices:

- *On sidewalk (marked lane for cyclists)*
- *On the road in a cycle lane*
- *Protected cycleway on the road*

Results revealed a positive attitude towards green space and adequate walking and cycling facilities. Deploying two different types of econometrics models, the willingness to pay, significant at a 5% level, was shown to be between $61 - $75 per year for a cycleway on the road fully protected and separated from traffic (Botes & Zanni, 2021). No significant result was seen from presenting on 'sidewalk marked lane' and on 'road in the cycle lane' options. Botes & Zanni's (2021) study shows the importance of separated cycleways, yet it also shows the added value of adopting a comprehensive approach when upgrading street infrastructure, namely valuing several complimentary investments together as opposed to evaluating one aspect at a time.

Research on assessments done for cycling infrastructure from the Netherlands and Denmark also point to the importance of dedicated and separated cycling lanes (Goeverden *et al.,* 2015). The summary findings of the research review for these two pioneer countries (in terms of cycling rates), conclude that cyclists generally prefer the following characteristics (Goeverden *et al.,* 2015):

- *Direct routes*
- *Connectivity and colored pavement that marks the route*
- *No or minimal exposure to hindrance of motorized traffic (e.g., dedicated infrastructure and routing through traffic calming areas)*
- *Sufficient width of bicycle path*
- *Smoothness and quality of pavement*

Song *et al.* (2017) explored panel data collected over the span of three distinct years (2010 – 2012) from the same population sample in three selected sites in the United Kingdom (UK), investigating the effect of infrastructure in promoting transport modal shifts with a focus on walking and cycling. The three selected sites have upgraded in terms of walking and cycling infrastructure and Song *et al.* (2017) examined the before and after impacts of these upgrades. Results indicated that exposure to new infrastructure was significantly associated with a modal shift towards active transport, after controlling for personal and household characteristics (e.g., a higher income for the same household between the studied years impacts transport mode choice). However, the impact of infrastructure to households that live further away from the infrastructure upgrade was not associated with a modal shift. Conclusions of Song *et al*. (2017) indicate that 'while infrastructure provision may not be a sufficient condition to achieve modal shifts, it is a necessary condition in that the people who shifted towards more active travel tended to be those who were using the new infrastructure.' Other statistically relevant variables impacting mode choice was gender and minority groups, education, employment status, cost of vehicle use and income (Song *et al*., 2017).

Ruiz & Bernabe (2014) deploy an interesting method based on multiple surveys to study how drivers and transit users value nonmotorized transport improvement. Building on a literature review of identified factors that influence cycling use (namely cycling safety, land use and walking and cycling built environment, hilliness, travel time, trip distance, costs of competing transport modes, on-trip cycling facilities, post-trip cycling facilities, weather, gender, age, income, education, employment status, car ownership, attitude, habit, trip characteristics, and incentives), Ruiz & Bernabe (2014) deploy a willingness to change and stated tolerance survey as a contingent valuation experiment for inhabitants in Valencia, Spain. They begin by gathering important information through focus group, and

then build their survey. Respondents were asked if they would consider changing their usual travel mode (car or transit) for the current journey they are undertaking by walking or cycling. Respondents who were willing to change to walking or cycling were asked to select an improvement measure from a list shown on a card, in such as way as that if it was implemented they actually would have taken the bicycle or walked (Ruiz & Bernabe, 2014). The showcard had the following cycling improvement measures which the respondents had to select one or additionally more until they were willing to switch (Ruiz & Bernabe, 2014):

- Cycling lanes connected throughout the city and fully segregated
- Cycle lanes clear of obstacles, motorized vehicles and pedestrians
- Priority actions for cyclists
- Bike rental system in operation
- Maintenance improvements in the existing cycling lanes
- New cycle lanes in low traffic streets (lower pollution)
- Provision of shower/changing facilities at destination

From the improvements above, Ruiz & Bernabe (2014) turn to valuation questions. An important variation to similar research was carried out by Ruiz & Bernabe (2014), in that the payment was unrelated to any walking and cycling improvement measure that people are used to utilize for free and secondly that it was as familiar as possible to the respondents. Respondents were presented the following scenario; ''Imagine that the measure(s) you have selected is/are implemented, and you are doing your current journey cycling/walking. A new policy permits that car/transit costs are reduced. Would you keep cycling/walking if car/transit costs are reduced by 10%, and your current costs would be *X* euros?''. The question was "customized considering the nonmotorized travel mode to which respondent was willing to change, the usual travel mode used for the current journey and the estimated monthly travel costs" (Ruiz & Bernabe, 2014). Framing the question in this way meant that the researchers are not asking the respondents to pay for the improvement measure on cycling, yet they are asking them that if the costs of their current mode of transport becomes 10% cheaper, will they revert back to it after indicating a shift to cycling due to the implemented improvement in cycling.

Result implications from Ruiz & Bernabe (2014) indicated the following:

- *Higher education results in more willingness to cycle;*
- *Long distance and travel time are a deterrent to cycling;*
- *Cycle lanes connected throughout the city and fully segregated are the most important improvement measure that would push respondents to consider cycling;*
- *Those using mass transit systems are more likely to switch to cycling than if they were using a vehicle;*
- *Car users and transit users are more willing to consider cycling if they are going to work or school;*
- *Availability of bicycle and knowledge of bike rental are related to higher propensity to cycle, highlighted the concept of knowledge and habit;*
- *Those who pay their own travel costs are more willing to cycle;*
- *Shopping journeys are less related to cycling than non-shopping ones;*
- *Employed people are more likely to cycle than unemployed ones;*

- *Degree of valuation of cycling improvements may be related to the stage of change in which people are willing to cycle with respondents who declared lowest valuations never tried cycling.*

Chatterjee *et al.* (2013) provided insights on what triggers changes in cycling through in-depth interviews repeated over 3 years in 12 towns across the United Kingdom (UK). Chatterjee *et al.* (2013) believe that longitudinal studies compliment cross-sectional ones given the weakness of the later approach. The weakness is in the form of potentially attributing current behavior to prevailing circumstances when in fact they may have been driven by past experiences and events. Their hypothesis indicates that turning points in travel behavior are triggered by contextual change which can be a life event and/or a change in external environments encountered. Their findings indicate, among other outcomes, the following (Chatterjee *et al.,* 2013):

- *Young adults taking up regular cycling were prompted by changes in educational and employment status or location.*
- *Changes in employment status or location gave opportunities to start regular cycling throughout working lives.*
- *Relationship and residential changes influenced cycling across the age span.*
- *Children had a strong influence on the cycling of parents, especially the daily travel of mothers.*
- *For older adults health problems can cause physical difficulty to cycle but can also prompt increased cycling due to greater appreciation of health benefits.*
- *Perceived improvements in the environment for cycling (especially off-road cycle routes) could be seen to prompt people to take action to start cycling*

Buehler & Dill (2016) provide an updated literature review on determinants of cycling and bikeway networks, specifically focusing on the links between bikeway networks and cycling. The review performed a meta-analysis and included 84 peer-reviewed studies.

The outcome of the Buehler & Dill (2016) indicated the following:

- *Most studies suggest a positive relationship between bikeway networks or aspects of the network and cycling levels.*
- *Stated- and revealed-preference studies suggest a hierarchy of cyclist and non-cyclist preferences may exist, favoring separate paths and/or lanes over cycling in roadways with motorized traffic — particularly with high volumes of fast-moving motorized traffic.*
- *Among bike facilities, cyclists and non-cyclists seem to prefer physically separated bike paths or cycle tracks to bike lanes or wide shoulders on roadways.*
- *When riding on roadways with motorized traffic, cyclists seem to prefer traffic-calmed residential neighborhood streets, lower car traffic volumes, slower car traffic speeds, and roadways without car parking (with exceptions to some experienced cyclists that reported a preference for riding in traffic with cars over cycling on separate facilities.*
- *Revealed- and stated-route-choice studies indicate that intersections have negative effects on the cycling experience, but that certain characteristics can offset this, such as having a signal when motorized traffic volumes are high*

Importantly, Buehler and Dill (2016) also compiled a list of identified gaps from their literature review. Some of these gaps are as follows (Buehler & Dill, 2016):

- *First, individual-level studies often relied on samples of volunteers, members of university communities, or avid cyclists. There were only a few individual-level studies based on statistically representative samples;*
- *Second, a majority of studies was from the USA or Canada where cycling levels are low, motorized traffic volumes are high, and bikeway networks are typically fragmented;*
- *Third, almost all quantitative analysis reviewed used cross-sectional data, analyzing correlations between bikeway supply and cycling levels at one point in time. Studies tracking cycling levels and trends in bikeway networks over time could move research toward providing a causal link between bikeway networks and cycling levels;*
- *Fourth, while descriptive case study analysis and historical accounts point toward the importance of policy packages in promoting cycling, quantitative studies typically fail to control for many of these policies geared at promoting cycling. Ideal studies would investigate the role of bikeways as determinants of cycling levels while controlling for promotional programs, cycling training, safety training for cyclists and motorists, bike-transit integration, enforcement of traffic laws, and the other control variables;*
- *Fifth, only a few studies analyze the role of specific types or features of bikeway facilities or intersection treatments;*
- *Sixth, more research is needed on the effect of bicycle-specific treatments such as yet not limited to bike boxes, traffic signals, and two-stage queue boxes on cycling levels. Furthermore, evaluation of where cycle tracks reach, bicycle boulevards availability and characteristics and other traffic-calming infrastructure is needed to evaluate and estimate impacts on cycling perceptions and cycling levels;*
- *Seventh, using network measures instead of single pathways or parts can reveal whether the effect of the network is greater than the sum of its parts.*

Wang *et al.* (2016) provide a similar and yet more comprehensive literature review on the effects of the physical environment on enhancing walking and cycling levels. Papers (with impact factors equal to or more than 1.5) published between 1977 to 2015 were reviewed. The aim was to identify the major environment barriers that hinder walking and cycling activities, and secondly to identify the general and specific characteristics of the major physical built environment attributes of residential neighborhoods that can support overcoming the identified barriers and enhancing cycling and walking. Identified factors that influence an individual's physical activity levels were collected from the literature and these fall into four main categories, as shown in Figure 7.

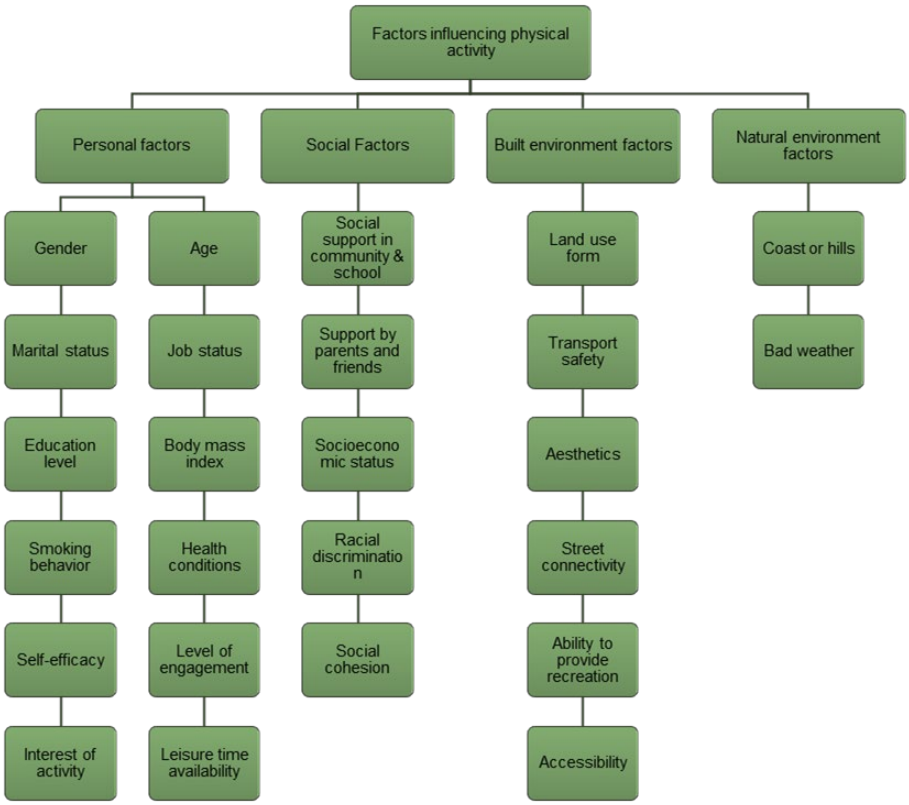


Figure 7. Factors influencing an individual's level of physical activity
(Wang *et al.,* 2016)

Wang *et al.* (2016) identified the physical built environment barriers to walking and cycling within residential neighborhoods and thereby recommendations of needs to be done to overcome these barriers, based on the literature review. Wang *et al.'s* (2016) barriers and consequence interventions are categorized under four barriers, adopting Lee and Moudon's (2014) categorization:

- *Opportunity barriers: are the barriers created as a result of lack of appropriate main facilities for people to undertake walking and cycling activities, or the presence of alternatives that can lower walking and cycling activity levels. Examples are lack of recreational facilities, parks, playgrounds, sidewalks, bike lanes, presence of steep elevation, residential density*
- *Access and distance barriers: are the physical and/or economic barriers created as a result of low accessibility to walking and cycling facilities. Examples are roads with redundant intersections and distance barriers.*
- *Safety barriers: are the barriers created as a result of fear of crime, traffic accidents, or personal injuries in relation to the built environment. For example, fear of traffic accidents and increasing exposure to automobile exhaust discouraged people from cycling.*
- *Physical setting barriers: are barriers created from lack of high quality natural and built environment, inducing a feeling of discomfort or unpleasantness*

The main outcomes of Wang *et al.* (2016) review is summarized as follows:

- *Greenery, public leisure space (e.g. roof garden, fitness club, public space), specific road, trail and path design, safety and security provisions, a wider choice of facilities (e.g. sidewalks, cycling paths, treadmills, stairs) as well as some*

specific design provisions inside buildings can help overcome some barriers that hinder walking and cycling activities within a residential neighborhood.

2.3. Main literature findings in context of our objective

The literature review presented above, building on approximately 15 peer-reviewed journals, two of which are in themselves thorough literature reviews on the subject matter (being Wang *et al.* 2016 & Heinen *et al.* 2010), provides a strong foundation to understand the various determinants that may impact cycling and cycling rates.

In relation to our objective, it is noteworthy to note the following key deductions that can be derived at:

- There are many determinants that fall under various categories that are found to be important to investigate and include in any assessment or evaluation of individual perceptions and willingness to pay towards cycling, cycling infrastructure and/or active transport. These 'determinant' categories that can be adopted from the literature are, to a large extent, similar to one another. For example, the below authors categorize cycling and/or walking determinant categories as follows;
    - Rietveld & Daniel (2004) indicate generalized costs of bicycling, local authorities initiatives and policies, individual features, socio-cultural factors, and generalized cost of other transport modes;
    - Ton *et al.* (2019) indicate individual, season and weather, household, built environment, work conditions and trip conditions;
    - Heinen *et al.* (2020) indicate built environment, natural environment, socio-economic factors, psychological factors, and costs, travel time, efforts and safety;
    - Wang *et al.* (2016) indicate personal, social, built environment, and natural determinants.

- Many of the results of Ton *et al.* (2019) are not in conformity with the literature on the determinants of cycling, for many of the determinants as above mentioned. This is likely due to the fact that the Netherlands is a pioneer in cycling infrastructure and cycling levels and offers a high standard in terms of amenities and safety considerations that cyclists need or expect. This brings out two important outcomes in relation to our objective of evaluating willingness to pay for cycling infrastructure in Lebanon;
    - The first is that different countries in different stages and environmental, cultural, and physical (infrastructure) contexts will yield different results and therefore generalizing results from one country or locality to another is not advisable;
    - The second is that our study is all the more important to undertake given that tailored research on countries is needed to better internalize those countries' specificities and uniqueness.

In the research and assessment presented herein, several determinants based on the above literature will be adopted. The determinants are categorized under the following headings:

- Trip characteristics, including weather, travel costs, travel time, slope of road and safety;
- Trip built and natural environment, including perceptions on air pollution, noise pollution, infrastructure, and public transport provision quality across the 'common' trip pathway that is taken;
- Environmental attributes to elicit respondents' attitudes and behavior with respect to the environment;
- Socio-demographic characteristics

With respect to the methodology used, the literature is diverse in the methods. Choice modelling (e.g., Botes & Zanni, 2021), contingent valuation (e.g., Ruiz & Bernabe, 2014), and real-life workshops (e.g., Attard *et al*., 2021) were used to capture the value respondents have for cycling and/or cycling infrastructure. In the research and analysis herein, a contingent valuation method is adopted as it is a more applicable method to the research objectives. This is mainly because the research herein does not aim to value different attributes of a cycling network, yet it aims to value a case of a cycling network versus the baseline case of no cycling network.

To the best of the author's knowledge, this is the first time that the subject of cycling perception and possible WTP for cycling infrastructure has been addressed to an Arab country, let alone to Lebanon. Therefore, the perceptions on cycling and WTP for cycling enablers are not known and there is no prior research that will allow to narrow down the focus. The challenge will be to collect as much data as possible to begin understanding cycling perceptions in Lebanon and doing so without overwhelming the respondents with too many questions that require a lot of time to complete. The survey was constructed to be scientifically robust, i.e., to include all possible explanatory factors as learned from the literature, while ensuring the survey is not too long and overwhelming for respondents.

3. Methodology

In this chapter, a description of the contingent valuation method, the survey design and questions to be asked (building on the literature review of Chapter 2), the sampling procedure followed, and the model specification for the econometric analysis are presented.

3.1 Market failure and non-market valuation

In a competitive marketplace, people generally have relatively clear information about the product(s) they wish to purchase to base their valuation and choices upon. The product tends to be clear with generally well-known characteristics, and it has a market price that is clearly visible. This enables the individual to weigh up the quantity desired and assess the quality and price on offer. However, almost every product or service has an external effect or impact on the environment throughout its lifecycle, from mineral extraction and processing, to transportation, usage and final disposal – effects that are not taken into consideration when analyzing the costs of products (Kahn, 1998), and effects that are not well and visibly priced (unless there is, for example, an environmental tax). This is an example of market failure.

Land transportation, in many of its conventional fossil fuel powered modes, similarly causes environmental externalities. For Lebanon, land transport externality was costed in one study (see Figure 2). If a policymaker wishes to evaluate the benefits of alternative and cleaner transportation choices, then he/she will need to know what are the social (i.e., the private and external) cost and social benefits of this alternative, in order to justify (or not) the investment and any operational and maintenance costs required to enhance the alternative choice. In this case, if less fossil-fuel powered modes are used, there are benefits that do not have a marketplace price signal, such as reduction of air pollution, reduction of congestion and reduction of noise. However, these benefits need to be evaluated to provide a thorough assessment of any alternative plan.

Non-market valuation attempts to estimate consumer demand for a particular non-marketed benefit in monetary terms. There are generally two main types of valuation methods that can elicit values of consumer demand from non-marketed goods and/or services; revealed preference and state preference techniques.

Revealed preference methods infer environmental benefit values from observed consumer behavior that may be reflected in the market of a related good (Boardman *et al.,* 2011). A typical example of deploying the revealed preference method is for evaluating natural sites or parks. The evaluator assesses how many, from where, and at what associated costs (including the time value of arriving to and returning from the park, the cost of transport, and any entrance fees to the park) do visitors devote and spend on their visit. Evaluators apply statistical analysis to estimate the value of the natural site/park.

On the other hand, stated preference methods infer non-marketed benefit values from a hypothetical scenario administered through a survey, i.e., through directly asking survey respondents about their willingness to pay (WTP) for a particular environmental or other non-marketed good or service amenity, or their willingness

to accept (WTP) an environmental or other disbenefit. As examples of this can be WTA to have an airport or a landfill near the place of residence.

There are two main types of stated preference techniques, mainly the Contingent Valuation Method CVM, which is the main tool deployed in the analysis (and thereby a separate section on CVM is provided below), and Choice Modelling (CM) or Choice Experiment (CE) method.

CM or CE approaches rely on the notion that a good may be described by its attributes. For example, a forest can be illustrated by its flora and fauna diversity, age structure and recreational facilities (Bateman *et al*. 2002). The focus will then turn to evaluate the impact on value from these attributes, with the aim to value non-market related goods and services.

The CVM is selected to carry out the analysis to elicit WTP for cycling infrastructure for Administrative Beirut. The author believes this is a better suited analysis given a comparison between a condition without a cycling infrastructure to one with a cycling infrastructure, defined in a general manner; "an inter-connected, separate and smooth cycling lane across the city of Beirut" (see Annex 1). A comparison between different design types of cycling infrastructure that may influence WTP, which would then lend more support to using CM, is not followed in this research.

3.2. Contingent Valuation Methodology (CVM)

The steps for implementing a full CVM study are shown in Figure 8, adopted from Champs *et al.* (2017).

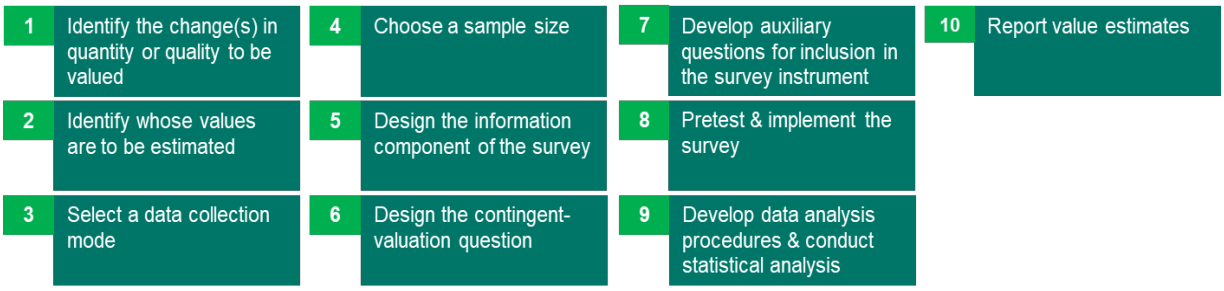


Figure 8. CVM Process
(Champs *et al.,* 2017)

Figure 8 indicates the full process of implementing a CVM study. An explanation of each of these steps (again adopted from Champs *et al.,* 2017) is presented below, as well as the adopted approach of the study herein.

3.2.1 Step 1: Identification of changes in quantity or quality to be valued

The first step of CVM is to determine the change that is to be valued. In our analysis, the aim is to determine if individuals will be willing to pay (WTP) to change the quantity and quality of cycling infrastructure in Beirut, Lebanon, from a baseline situation where no cycling infrastructure, specifically an inter-connected and separate cycling lane, exists to a situation where one such infrastructure provision is provided.

3.2.2 Step 2: Identify whose values are to be estimated

Step 2 involves translating the policy change into effects on people, and identifying who will be affected (Champs *et al.,* 2017). Our analysis focuses geographically on Administrative Beirut, the population of which is more than 430,000 citizens (City Population, 2019). Although any improvements to cycling infrastructure in Beirut will also benefit non-Beirut residents, for example, local or international tourists coming to the city, the focus is on those that will directly benefit from the change on a daily basis.

Furthermore, the analysis herein is focused on individual residents of Beirut, and thereby the aim is to elicit values for individuals and not household values. Throughout the survey, questions asked target specific information and data about the individual being asked, with one exception being income. As many of the respondents could be unemployed, students, or volunteers, household income better reflects economic capability and enables better correlation between WTP and income.

3.2.3 Step 3: Select a data collection mode

Step 3 of the contingent valuation study requires the collection of primary data. Primary data in contingent valuation methods can be collected via in-person, telephone, mail or email/internet surveys. Each one of these methods has its pros and cons, as detailed in Table 3.

	Costs per completed interview	Ease of identifying & reaching respondents	Risk of interviewer bias	Maximum complexity of provided information
In Person	Very high – depends on questionnaire length & geographic spread	Medium – depends on availability of lists and access	High – personal presence, monitoring difficult	Very high – interactive communication and visual aids possible
Telephone	High – depends on questionnaire length and callbacks	Very high – random digit dialing	Medium – interviewer cues	Low – verbal communication limits complexity of content
Mail	Low – depends on number of follow-ups	High – depends on availability of appropriate lists	Low – uniform presentation	High – visual aids possible
Internet	Low – marginal costs very small	Low – 'spamming' restrictions require panels of willing respondents	Low – uniform presentation	Very high – visual aids and interactive questions possible

Table 3. Survey administration options, their relation to costs, ease, interviewer bias & complexity
(Boardman *et al.*, 2011)

Different administration options have their own specific benefits and costs. The vehicle used in our CVM analysis is the in-person option. As indicated in Table 3, in-person surveys require significant time to administer. The survey was conducted in the months of July and August, 2023, requiring a total of approximately 18 days to complete.

The decision to follow an in-person survey method lends support to the fact that a hypothetical situation is provided and thereby the information presented is important to guide the survey respondent, and in-person is a more effective way to do so (Champ *et al.,* 2017). Furthermore, literature on CVMs unambiguously supports in-person interviews relative to other data collection methods. This is because although in-person surveys do not solve for non-responses, they do offer higher response rates than other alternative survey modes (Pattanayak *et al*., 2006).

3.2.4 Step 4: Choose a sample size

Step 4 requires the selection of a sample size. The selection of a sample size is a matter of choosing an acceptable level of precision within a given budget (Champs *et al.,* 2017). One standard formula that is applied to obtain an optimal sample size is as follows[4];

$$n = \frac{Z_{\frac{\alpha}{2}}^{2} * p * 1-p}{MOE^2}$$

Where:

- n: sample size
- $Z_{\alpha/2}$: critical value of the normal distribution (i.e., 95% confidence interval, α is 0.05 and the critical value is 1.96.
- MOE: Margin of error
- P: sample population

As aforementioned, the population of Administrative Beirut is more than 430,000 (City Population, 2019). The optimal sample size for this population, assuming a confidence interval of 95%, a targeted population proportion of approximately 58% (given that the population targeted are between the ages of 18 and 64 – estimated through data on age distribution from the Lebanese Central Administration of Statistics – CAS, 2022) is approximately 364 surveys. If the confidence interval is relaxed to 90%, the optimal size sample becomes 266 samples. However, given budget constraint, manifested also by time constraints in our case, the sample size eventually obtained was 220 samples. This is one limitation of the study (see Chapter 5).

3.2.5 Step 5: Design the information component of the survey

Step 5 focuses on the information provided to respondents in the survey instrument. This includes telling respondents what it is they are being asked to value, how it would be provided, and how they would pay for it (Champs *et al*., 2017). What is

[4] https://select-statistics.co.uk/calculators/sample-size-calculator-population-proportion/

important in this step is to provide information in a neutral manner, without impacting or influencing the decision and responses of respondents.

In Step 5, there are several sub-steps that require action, based again on Champs *et al.* (2017). These are listed and described below:

- ***Describe the item being valued:*** This step involves informing respondents on what is being valued. In our case it is the change in infrastructure provision for cycling in Beirut, namely the introduction of a separate and inter-connected cycling lane. The research did not include any visual aidance to what a separate cycling lane looks like, as we believe such an exercise will be better suited to when and if an actual cycling lane is being designed for Beirut and the administrators would like feedback on various options. The survey item described kept the question concise and clear, again being a separated and interconnected cycling lane. Importantly, the survey executed made sure not to portray any encouragement or discouragement for this initiative.
- ***Explain the method of provision:*** The method of provision is the process that will lead to the change that respondents are being asked to value. In the case of the research herein, the valuation question indicated that the initiative will be carried out by the Municipality of Beirut, supported and in coordination with an international organization that will ensure transparency and high standards in procurement (please see full questionnaire in Annex 1). The question indirectly elicits to the fact that competitive procurement for the execution of works will take place, and directly indicates that the Municipality of Beirut will execute this procurement. However, given the low trust in the Lebanese Government and related institutions, the execution was indicated to be in collaboration with an international organization to ensure transparency. In one study, only 26% of Lebanese respondents indicated that they trust their government, and this relatively low trust in crucial institutions is a deteriorated figure due to the 'acute economic crisis ongoing since 2019 (Bertelsmann Stiftung, 2022).
- **Select the payment vehicle:** The payment vehicle is the mode of payment respondents are being asked to consider when answering the elicitation question. Respondents may reject the valuation scenarios even if they value the change in the attribute being evaluated on account of not believing the payment mechanism is credible (Champ *et al.,* 2017). In our case of cycling infrastructure for Beirut, the payment vehicle is a monthly additional tax fee to be deployed by the Municipality of Beirut. The Municipality of Beirut already collects several taxes from Beirut citizens. Within the mandate and capacity of any municipality in Lebanon, municipalities are allowed to charge "fees on rental value of built real estate; fees on public places and gambling clubs; fees on advertising; fees on public property; fees on fuel distribution; fees on industrial firms; fees on auctions; fees on mobile vendors; fees on slaughterhouses; fees on tourism sites; fees on registration of contracts; fees on construction permits; fees on building and maintenance of sewage network and pavements; fees on certificates and technical studies; fees on structural improvements; and fees on explosive materials" (Manassian & Majdalany, 2011). To that end, the payment mechanism as an additional tax by the municipality is something that can be considered a common payment vehicle.
- **Select the decision rule:** The decision rule is the 'mechanism by which the results of the CVM study, individual valuation responses, or summary statistics on valuation responses are used to inform the decision as to whether the item will be provided' (Champs *et al.,* 2017). It is important to set the decision rule as an

input to public decision makers (Municipality of Beirut in our case) on whether the change that is being evaluated is worthy of investment. In a democracy, the simple majority could be one yardstick to rely on. If public policy decision-makers want an overwhelming majority, then a 70% minimum majority is required. In the analysis conducted, respondents were asked whether they will be willing to pay for the change or not, before continuing to ask those that are WTP, how much they are WTP? Thereby the Decision Rule could be a simple majority (i.e., greater than 50%) or an overwhelming one (i.e., greater than 70%).

- **Select the timeframe of payment:** This step tells respondents how many payments they will be required to make and how frequently the payments are required for the policy, for example, through a one-time payment, or forever payments, or a payment over an 'X' amount of time (Champs *et al.,* 2017). In our analysis, a payment (additional tax) over a timeframe of three years was selected. The timeframe of three years was selected as it is reasonable to assume that the design, procurement, and implementation of an interconnected cycling lane will take at least this amount of time to execute from planning to commissioning. An additional WTP question is asked using 'forever' payments to elicit value to maintain the cycling lane, and if yes, by how much per month? In this way there is clear differentiation between investment and maintenance requirements.

3.2.6 Step 6: Design the contingent valuation question

There are three primary formats for the contingent valuation question and they are open ended, payment card, and/or dichotomous choice (Champs *et al*., 2017). Each of these formats has their own pros and cons, as indicated in Table 4.

Characteristics	Open-Ended	Payment Card	Dichotomous Choice
Theoretically incentive compatible	No	No	Has some desirable properties
Bid design required	No	Yes	Yes
Responses/ statistical efficiency	Continuous	Interval	Interval
Potential problems	Zero bids, fair share responses	Anchoring	Anchoring, yea saying, voting as good citizen

Table 4. Comparison of Contingent Valuation Response Formats
(Champs *et al*., 2017)

An open-ended question asks respondents "how much they would pay" for the specified change in a resource, and this is the choice of question adopted in our CVM. The downside of using this method is that it leaves the respondents complete liberty to put the value they want, without any anchoring to the required investment(s) needed to make the change happen. On the other hand, payment card and dichotomous choice can be used by analysts to place certain values that may reflect better the amount needed to undertake the change evaluated, however it runs the risk of anchoring, meaning that the stated values may influence how respondent answer (anchoring bias) and the problem of 'yea saying', meaning that respondents just answer yes for the value presented to them (Champs *et al.,* 2017).

Another downside to open-ended questions is that they potentially yield a relatively high percentage of responses of $0, which may be due, at least in part, to the lack of incentive compatibility and a difficulty of coming up with a specific dollar amount for policies, programs or projects which they are not too familiar with (Champs *et al.*, 2017).

3.2.7 Step 7: Develop auxiliary questions for inclusion in the survey

Step 7 calls for the 'development of auxiliary questions, which are questions that are designed to collect data to be used in the analyses of responses to the contingent valuation questions' (Champs *et al.,* 2017). The auxiliary questions are really those that will help explain the different responses on WTP for the change required. In our case, the questions are derived from the literature review presented in Chapter 2. Basically, and as can be seen in the questionnaire itself (see Annex 1 and Table 5 below), our questions cover socio-demographic variables, personal environmental attributes, trip characteristics, including the built and natural environment surrounding this trip, and psychological factors. These are the factors that may explain what is behind the support (or lack of) of respondents, expressed through the valuation questions, and to what extent.

3.2.8 Step 8. Pretest and implement survey

Pretesting the survey can happen through one-on-one interviews, focus groups or a field trial (Champs *et al.,* 2017).

During the survey execution, especially during the first few surveys, it was found that the respondents understood well the survey and the questions being asked and the execution of the survey went smooth. There was no need to amend the survey execution or clarify/edit the questions accordingly. Cycling and cycling infrastructure are a relatively easy concept to comprehend.

3.2.9 Step 9. Develop data analysis procedures and conduct statistical analysis

Step 9 is a critical step where the statistical analysis, including regression analysis, will take place. The center of research is found herein, where the data findings and outcomes, including a relation between willingness to support the change aimed for (cycling infrastructure herein), and the determinants of this support (or lack of), can be extrapolated. A portion of the analysis is related to statistical analysis, specifically on the various data collected, including the data's respective mean, median, standard deviation, and the largest and smallest units recorded per respective variable (see Chapter 4.1). Descriptive analysis provide for a qualitative assessment of the research objective and captures many items that cannot be captured through the regression analysis.

For the regression analysis, a common approach is developed for the analysis and the theoritically plausible explanatory (or independent variables) variables to the independent variable, herein being Willingness to Pay (WTP) for the change (cycling infrastructure), are included.

The regression analysis is divided into three distinct methods.

The first is the application of a binary logistic regression method. Binary logistic regression method is used when the Y (dependent) variable is a categorical variable with two categories (Fritz & Berger, 2015). In our case, the dependent variable here is either WTP = 0 or WTP > 0. A code of '0' is indicated for those respondents that are not WTP and a '1' for those that are, regardless of the amount. This is important as 38.2% of those surveyed indicated that they are not WTP any amount for the cycling infrastructure. This approach has been followed in Dagher and Harajli (2015) and Harajli and Gordon (2015). A more applicable model would be the Tobit Model in this case. The Tobit Model combines 'Probit and Truncated models into one, imposing the assumption that the decision to participate and the level of participation are determined by the same process' (Dagher & Harajli, 2015, based on Tobin, 1958). However, such analysis requires econometric expertise and the use of an alternative software to SPSS, and to that the Tobit model could not be deployed, relying instead, as above-mentioned, on a binary logistic regression method, including all the sample respondents who were WTP or not.

Given that we have several independent variables and one categorical dependent variable, the formula for the binary logistic regression is as follows (Schüpper, 2009):

$$\boldsymbol{P(Y) = \frac{e^{b_0+b_1x_1+b_2x_2+\cdots+b_nx_n}}{1 + e^{b_0+b_1x_1+b_2x_2+\cdots+b_nx_n}}}$$

Where:
P: is the probability of Y occuring (herein meaning WTP is > 1)
e: natural logarithm base
b_o: interception at y-axis
b_1: line gradient
b_n: regression coefficieny of X_n
X_1: predictor variables (see Table 5)

The second method is a multinomial logistic regression. Although our dependent variable, being WTP, is a continuous variable, we transform this variable into a categorical one with more than two options (see Chapter 4, Section 4.2.3, Table 17). We apply the same formula as the binary logistic regression, however P(Y) is now the probability that a case is in a particular category.

The third method is to apply the multivariate linear regression using the dependent variable WTP in its original continuous variable format (Schüpper, 2009):

$$\boldsymbol{Y_i = b_0 + b_1X_1 + b_2X_2 + \cdots + b_nX_n + \varepsilon_i}$$

Where:
Yi: Dependent variable (WTP – continuous variable)
b_o: interception at y-axis
b_1: line gradient
b_n: regression coefficieny of X_n
X_1: predictor variables (see Table 5)
ε: Error

The long-list of the independent variables that possibly explain levels of WTP, including zero valuations, are as defined in Table 5. Table 5 also lists the coding of

the variables and the theoretical reasoning for including them as independent variables to possibly explain WTP. It is important to note that we undertake an iterative process of adding and removing independent variables in our regression analysis, in order to obtain the outcome that provides the best explanatory power to the dependent variable. Therefore, not all the long-listed independent variables in Table 5 will appear in the regression analysis results.

Survey question # (refer to Annex 1)	IV code	Independent variable (IV)	Possible Answers	Coding	Theoretical reasoning
Trip and Trip Environment Characteristics (TC)					
A1	**TC1**	**Purpose of trip**	▪ Work - related ▪ University - related ▪ Entertainment, sports facility or leisure ▪ Errands and shopping ▪ Visiting family/friends	Split into three variables; **IV 1:** 1 = Work 0 = All other purposes **IV2:** 1 = University 0 = All other purposes **IV3:** 1 = Entertainment, leisure, errands, visits 0 = all other	Most of the common trips done were for work (56% of total respondents) and university (36.6% of respondents). Therefore our analysis is focused on whether a work-related trip or a university-related trip increases WTP. We will include a third variable to isolate impact on WTP if the trip is non-work and non-university.
A2	**TC2**	**Mode** 0 = Private Vehicle or motorcycle 1 = Public bus/taxi 2 = Walking & cycling	▪ Private vehicle ▪ Motorcycle ▪ Public Bus ▪ Public Taxi ▪ Walking ▪ Cycling	Split into five variables; **IV 1:** 1 = Private vehicle 0 = All other purposes **IV2:** 1 = Private motorcyle 0 = all other **IV3:** 1 = Public transport 0 = All other purposes **IV4:** 1 = Cycling/walking 0 = all other IV5: 1 = Walking 0 = all other	We hypothesize that those that already walk or cycle (approximately 23% of respondents) will be more inclined to pay for cycling infrastructure, followed by those that take public transport, to finally those that use a private motorcycle or vehicle.

A3	**TC3**	**Time**	Time in minutes to take the trip (one-way) – continuous variable	Not needed	Time here is taken as proxy for distance, therefore the more time it takes the more the distance of the common trip can be assumed to be.
A4	**TC4a**	**Cost**	Cost in USD to take trip one-way	Not needed	Cost is expected to be important, where higher costs may incline the respondent to select a cheaper alternative, here being cycling.
A5	**TC4b**	**Perception of Cost**	Perception of Cost – Likert scale	1 = not expensive at all to; 5 = very expensive	The correlation between actual costs and perception of costliness of trip is approximately 0.6. This is below the 0.7 threshold we have set for multicollinearity. Thereforefore we use only perception of costs. This supports the fact that income may play a major role in perception of costs. In other words, a trip that costs more (as indicated in TC4a) may not be perceived as costly by a respondent who is relatively well off, compared to one that is not.
A6	**TC5**	**Weekly Frequency**	▪ Almost daily (6 – 7 days per week) ▪ Often (4 – 5 days per week) ▪ Not often (Equal or less than 3 days per week)	0 = Up to 5 days a week 1 = 6 – 7 days per week	There is no particular expectation here as to whether or not this IV has any impact towards any of the two directions or options.
A8	**TC6**	**Alone or accompanied**	Dichotomous choice	0 = Accompanied 1 = Alone	Expectation is that the common trips done alone will yield higher WTP than if common trip is always accompanied
B1	**TC7**	**Congestion**	Perception on congestion on this common trip: Likert-scale (1 – 5)	1 = Least congestion 5 = Very congested	Expectation is that the more congested the more is the WTP for cycling infrastructure
B2	**TC8**	**Slope**	Perception on slope of road (hilliness) on this common trip: Likert-scale (1 – 3)	1 = Straight 2 = Slightly hilly 3 = Very hilly	Expectation is that the more hilly the common trip road is, the lower the WTP

B3	**TC9**	**Aesthetics**	Perception on beauty of environment around common trip: Likert-scale (1 – 5)	1 = Not aesthetics at all 5 = Very aesthetically beautiful	Expectation is that the more beautiful the common trip surrounding environment, the more will be the WTP
B4	**TC10**	**Air pollution**	Perception of air pollution on this common trip: Likert-scale (1 – 5)	1 = Not polluted at all 5 = Very polluted	Expectation is that the more polluted the air is through the common trip, the lower the WTP
B5	**TC11**	**Noise Pollution**	Perception on noise pollution on this common trip: Likert-scale (1 – 5)	1 = Not noisy at all 5 = Very noisy	Expectation is that the more noisy the common trip environment, the lower the WTP
B6	**TC12**	**Public transport provision**	Perception on public transport provision in Beirut: Likert-scale (1 – 5)	1 = Very poor quality 5 = Excellent quality of public transport	Expectation is that the more poor the perception of public transport, the higher the WTP
B7	**TC13**	**Infrastructure Provision**	Perception on public road infrastructure in Beirut: Likert-scale (1 – 5)	1 = Very poor quality 5 = Excellent quality of infrastructure	Expectation is that the more poor the perception of infrastructure provision, the higher the WTP
Cycling on this trip (OT)					
C9	**OT1**	**Ownership of bicycle**	Dichotomous choice	0 = Do not bicycle 1 = Own bicycle	Expectation is that respondents who own a bicycle may have higher WTP
C18	**OT2**	**Safety concern**	Likert-scale (1 – 5)	1: Not concerned at all 5: Very concerned	No clear expectation here. On the one hand, the more the safety concern will lead to less likelihood to cycle, on the other hand, it may lead to more WTP to create cycling infrastructure to improve safety
C19	**OT3**	**Theft concern**	Likert-scale (1 – 5)	1: Not concerned at all 5: Very concerned	Expectation is that the more the concerns on cycling theft, the lower the WTP

C20	**OT4**	**Personal security concern**	Likert-scale (1 – 5)	1: Not concerned at all 5: Very concerned	Expectation is that the more the personal security concern, the lower the WTP
C21	**OT5**	**Family & friends perception**	Likert-scale (1 – 5)	1: Very inappropriate 5: Very appropriate	Expectation is that the more inappropriate is the WTP, the lower the WTP
C22	**OT6**	**Beirut Weather (conducive to cycle)**	Dichotomous choice	0 = No 1 = Yes	Expectation is that those who believe weather is conducive to cycling would be WTP more
Environmental Attributes (EA)					
E31	**EA1**	**Lights off when lea ving room**	Likert-scale (1 - 5)	1: Not likely at all 5: Very likely	Expectation is that the more the likelihood to turn off the lights, the more will be the WTP
E32	**EA2**	**Other people littering**	Likert-scale (1 - 5)	1: Not likely at all 5: Very likely	Expectation is that the more the likelihood to be bothered by other people littering, the more will be the WTP
E33	**EA3**	**Recycling effort**	Likert-scale (1 - 5)	1: Not likely at all 5: Very likely	Expectation is that the more the likelihood to recycle, the more will be the WTP
E34	**EA4**	**Energy efficiency vehicle purchase**	Likert-scale (1 - 5)	1: Not likely at all 5: Very likely	Expectation is that the more the likelihood to purchase efficiency vehicle, the more will be the WTP
E35	**EA5**	**More expensive Environment al product purchase**	Likert-scale (1 - 5)	1: Not likely at all 5: Very likely	Expectation is that the more the likelihood to purchase environmental products, even if they are more expensive, the more will be the WTP
Socio-demographic variables (SD)					
F36	**SD1**	**Gender**	Dichotomous	0 = Female 1 = Male	No expectation on impact of gender on WTP
F37	**SD2**	**Age**	Continuous	Not needed	Expectation is that the younger generation may be WTP more
F38	**SD3**	**Married status**	Dichotomous	0 = No 1 = Yes	No expectation

F42	**SD4**	**Education**	▪ High school/technical school ▪ Doing bachelor at the moment ▪ Bachelor degree ▪ Masters degree ▪ PhD	▪ 1 = High school/technical school ▪ 2 = Currently undertaking or completed bachelor degree ▪ 3= Masters degree or PhD	Expectation is that the higher the education attained, the more is the WTP
F43	**SD5**	**Employment**	Dichotomous	0 = No 1 = Yes	Expectation is that employed people would be WTP more
F44	**SD6**	**Household income**	Continuous (monthly income)	Not needed	Expectation is that the higher the income, the higher is the WTP
Other variables (OV)					
F45	**OV1**	**Perception on health**	Likert-scale (1 – 5)	1: not healthy at all 5: very healthy	Expectation is that the more healthy a person feels, the higher the WTP
F46	**OV2**	**Perception on sportiveness**	Likert-scale (1 – 5)	1: Not sportive at all 5: very sportive	Expectation is that the more sportive a person is, the higher the WTP
F47	**OV3**	**Religion**	▪ Muslim ▪ Christian ▪ Druze ▪ Athiest ▪ Prefer not to say	Split into two variables; **IV 1:** 1 = Muslim 0 = All other **IV2:** 1 = Christian 0 = All other	There is no expectation of explanatory power for religion on cycling infrastructure WTP, yet any result that indicates that one religious group has a higher WTP will then merit further research on the reasons. We have used only muslims and all others and christians and all others because, together, they constitute 80% of the respondents.
F48	**OV4**	**Immigration**	Likert-scale (1 – 5)	1: Not wanting to immigrate at all 5: Very much wanting to immigrate	Expectation is that the more the respondent wants to immigrate from Lebanon, the less will be his/her WTP (and vice versa).

Table 5. Long-list of independent variables

Many of the variables indicated in Table 5 may be correlated to one another. For example, the environmental attributes (EA1 – EA5) are likely to be correlated, although there is a separation of environmental attributes in terms of valuing the environment in general through EA1, EA2, and actual intent on making environmental actions (EA3, EA4, and EA5).

In Chapter 4, a multicollinearity exercise is conducted in order to filter independent variables and sharpen the analysis, short-listing to a certain extent the independent variables that will be used to explain WTP.

3.2.10 Step 10. Report value estimates

All studies should include proper documentation of the procedures used to collect the data and summary statistics on all measures elicited in the survey (Champs *et al.,* 2017). In the analysis, all the data and results are presented, including yet not limited to:

- Research background setting the stage for survey design and content;
- Descriptive analysis of all datasets from questions asked;
- Regression analysis on the datasets, with WTP as the dependent variable.

The main element in reporting the outcome of a CV study to support decision making is the aggregate welfare estimate (AggWTP). The calculation for aggregate willingness to pay could be demonstrated as follows:

$$AggWTP = WTP_{\text{mean or median}} \text{ x } \mathrm{N}$$

Where WTP is either the estimated mean or median willingness to pay and N is the size of the affected population. According to Champ *et al.* (2017), the following issues need to be addressed before using the equation set above:

- Whether to use mean or median WTP
- Whether to weight respondent sample characteristics to ensure it matches the affected population characteristic
- Whether to consider the data of respondents who refuse to complete the survey or answer the valuation question

In the analysis, the median value is adopted to reduce the impact of outliers. Furthermore, the analysis weight only targets the age categories 18 – 64 of Beirut residents. To arrive at a cumulative result, we multiply the median value with the total number of residents in Administrative Beirut that are aged between 18 – 64 years old, multiplied by 61.8%. The latter is done because 38.2% of respondents were not WTP anything, therefore not presenting any value towards cycling infrastructure.

In the next Chapter, both descriptive analysis and regression analysis results are presented, including the aggregate WTP result.

4. Results

4.1. Descriptive Analysis

In this section the results of the survey are presented, providing a description on how surveyees responded to the questions covering their most common trip characteristics, individual and household characteristics, the built environment, and psychological factors, particularly related to attitude towards the environment, as well as their willingness to pay for cycling infrastructure for Administrative Beirut.

The analysis also provides, qualitatively, the perceptions of respondents on the barriers and challenges towards cycling in Beirut, and what can be done to make them more inclined to cycle, i.e., what types of interventions are needed for this aim. Furthermore, what respondents consider to be the benefits of cycling is reflected upon.

4.1.1 Sample size, sample process, and location

The survey was executed in July and August of 2023, however only a target sample of 220 respondents (n = 220) was achieved due to time (and budget) constraints. Furthermore, due to incomplete data for several surveys[5], the final sample was composed of 191 respondents (n = 191), covering all the major regions of administrative Beirut, as shown in Figure 9[6].

Figure 9. Location of 191 Respondents in Administrative Beirut region

The sampling method executed, although aimed at being a random sampling method, combined elements of systematic sampling and quota sampling. The third person passing by in any of the targeted neighborhoods of Administrative Beirut was stopped and asked if he/she was willing to take part in a survey for university

[5] A few respondents received a phone call during the survey or indicated that they are in a rush before the survey was over, and apologetically left the survey before completion. Other respondents did not wish to respond to several key questions in the interview, such as income or the valuation question itself, making their inclusion incomplete. All in all however, these respondents were a minority.

[6] The surveys were distributed according to Beirut's administrative areas, shown in the left-side of Figure 9. We did this to ensure that we capture our respondents from different areas of Beirut, although we do not assume that this will impact the responses on WTP and thereby this was not included in the regression analysis as a potential explanatory variable.

research on cycling infrastructure. This is the random yet systematic sampling components. If found convenient, the survey took place. If not convenient by the respondent, or if the respondent is non-Lebanese / non - resident or is less than 18 years old, then the next person was asked. Once interviewed, the third person would be targeted again, and so forth. The survey was amended on a few occasions to maintain a gender balance (quota sampling component), keeping to at least 10 respondents from each region as shown in Figure 9.

4.1.2 Socio-demographic characteristics

The sample (n = 191) was composed of 46.6% females and 53.4% males. This is in line with the general reality of the male-female ratio, being 101.49 males per 100 females (CAS, 2022 data), however it slightly exceeded it.

In terms of age, Figure 10 shows the distribution of the age of the surveyees.

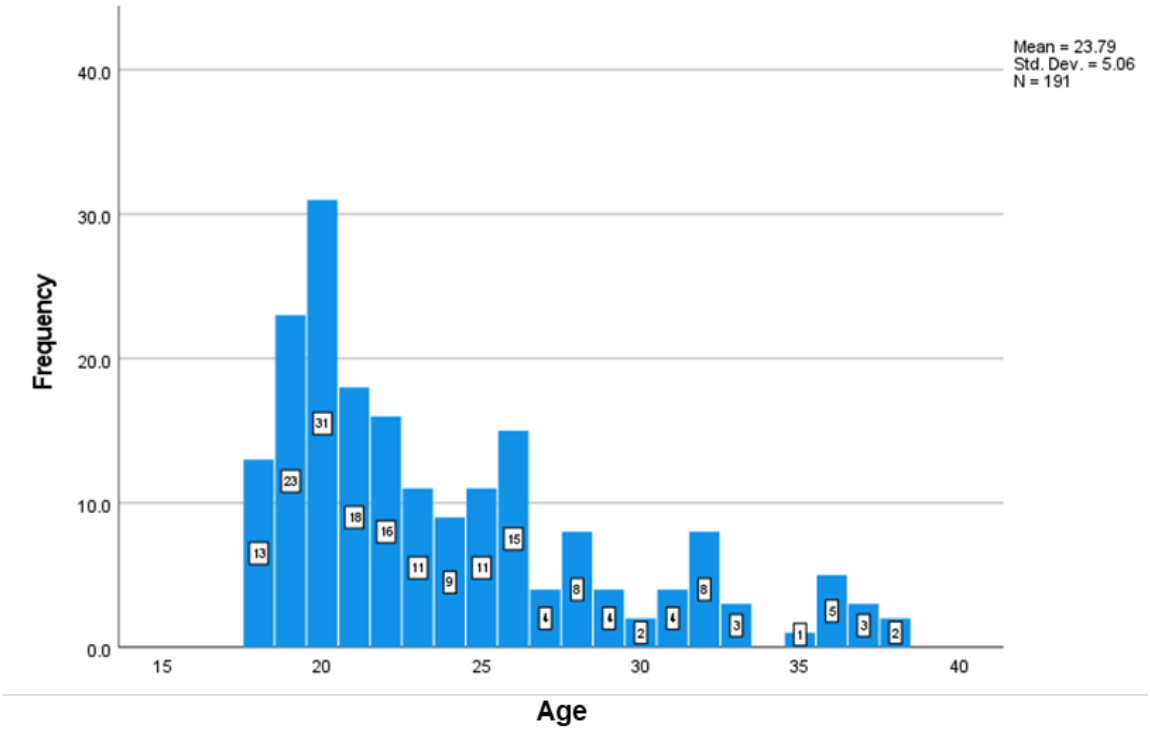


Figure 10. Age distribution of respondents

The average age of the sample is approximately 24 years old (median is 22 years old), while the Lebanese population's median age is approximately 29 years (Worldometer, 2023). Thereby the sample does not exactly represent the Lebanese population's average age and it could be said that the reflections of the respondents reflect more the characteristics and attitudes of Lebanon's relatively younger generation. This is further confirmed by the fact that 81.7% of the respondents indicated that they are not married, whereas only 18.3% are married. The average number of children from married households was 0.6, whereas the median is 0. This further attests to the 'young age' of the sample. One possibility of having a young sample is that the survey was conducted in summer during the day. The weather

was notably hot and thereby the citizens sampled were those that could better withstand the heat and humidity. However, this is a short-coming of the sample.

In terms of household characteristics, the respondents indicated the total number of individuals within their respective place of residence. Figure 11 shows the distribution of responses.

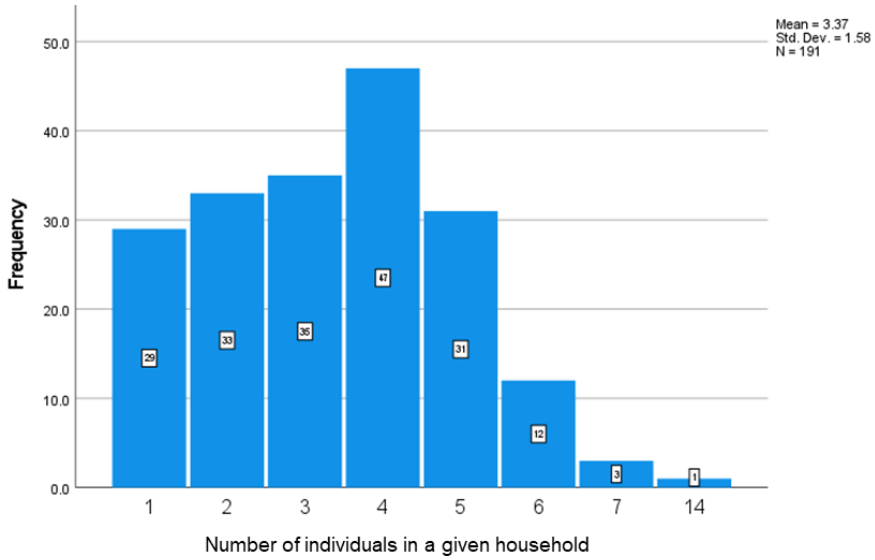


Figure 11. Number of individuals residing per household of interviewees

The mean number of individuals per household is 3.37 (median is 3). This is in line with national statistics on average household sizes in Beirut, which is 3.5 (CAS, 2022). In fact, Beirut has the lowest number of individuals per households, on average, across Lebanon. The average household size in Lebanon as a country is 4.1 individuals per household (CAS, 2022).

In terms of education, Figure 12 shows the highest degree obtained, with an additional category being currently studying at a university for a bachelor's degree which showed the highest count, equaling approximately 42% of the respondents. This is followed by those with a bachelor's degree (25% of the sample), a high school or technical school degree (19.4% of the sample), master's degree (10% of the sample), and a PhD (3.6% of sample).

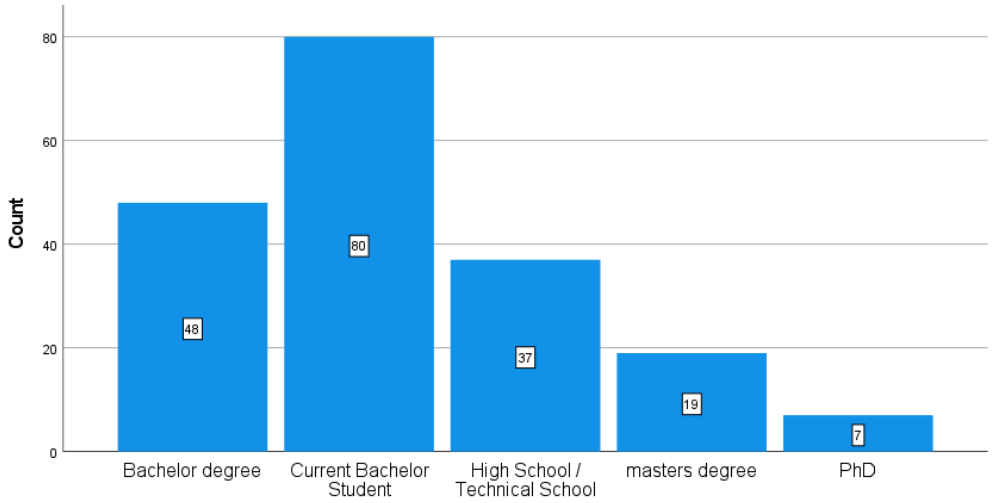


Figure 12. Education level of sampled respondents

Approximately 67% of those interviewed are employed (33% are not employed). This is in line with the latest statistics on unemployment (29.6% in 2022 according to the World Bank, 2022), however it is a further result of the relatively young average age of the sample and the respective high number of university students.

With respect to income, Figure 13 provides the household income distribution of the sampled respondents. The mean monthly income is approximately 1256 USD, the median is 900 USD, and the standard deviation is 1392 USD.

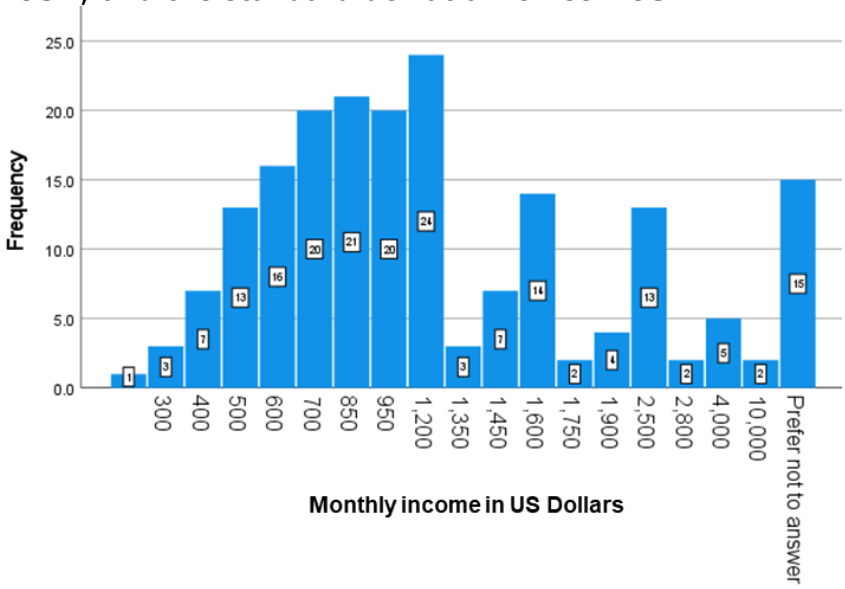


Figure 13. Monthly household income of respondents

It is difficult to compare the results of income distribution to any published report or database. The reason is that most Lebanese get paid in Lebanese Lira, however they were obliged to respond in US Dollar values. The values indicated in the sample thus correspond to their salaries in USD at the time of surveying. The reason being that the Lebanese currency has depreciated from 1500 LBP to 1 USD in 2020, to around 90,000 LBP per 1 USD (average exchange rate during survey time period), i.e., a 98.3% depreciation. It is to be expected that the exchange rate will change significantly in the future.

In terms of religion, the distribution of the surveyees according to religious affiliation is shown in Figure 14. The reason for including the question on religious affiliation is to gauge whether there can be any inherent cultural elements (captured through religious identity) to the responses made, noting that evidence to link religion and cycling attitudes in the literature was not found.

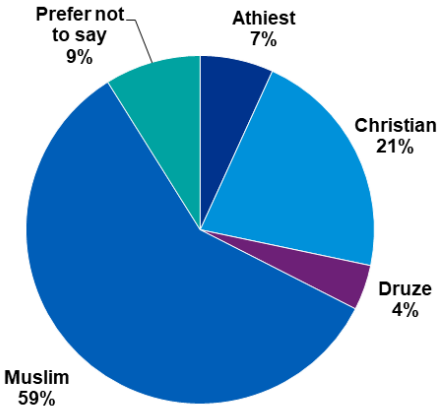


Figure 14. Religious affiliation of surveyees

4.1.3 Trip and trip's built environment characteristics

In this section, the responses of the surveyees with respect to the most common trip they made are presented. The background presented to the surveyees to the questions that were sequentially asked was:

"*We would like you to think about the most common trip you take from your place of residence to your work, university or any other common trip you routinely make, such as visiting a relative on a regular basis, that is unrelated to leisure*"

The main purposes of the common trip made by the respondents are shown in Figure 15.

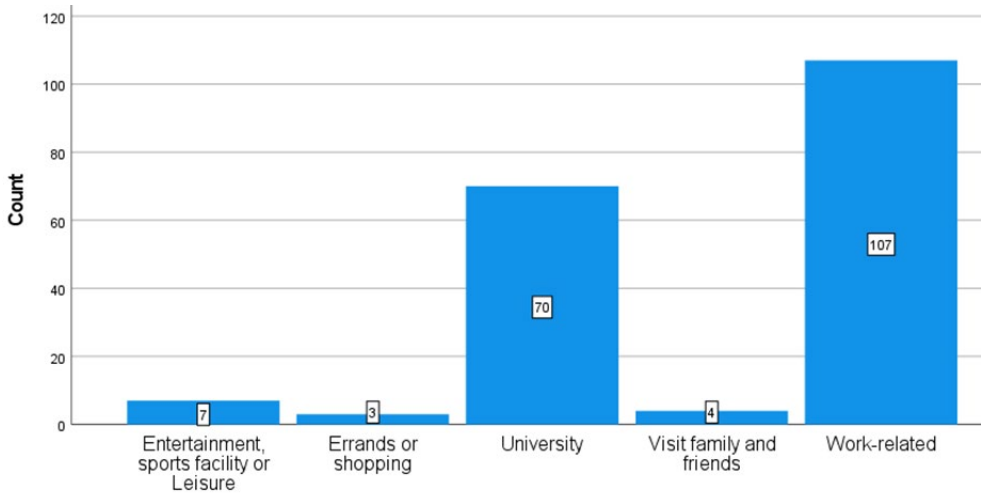


Figure 15. Main purpose of common trip made by respondents

Approximately 56% of the trips were done for work-related purposes, followed by 36.6% for university (studies), 3.6% for entertainment, sports or leisure, 2.1% to visit family and/or friends, and 1.6% for errands and/or shopping. Leisure was thus one of the responses provided, however its relative share was small.

Approximately 53% of the respondents indicated that they make this common trip daily throughout the week, 44% make this trip between 4 to 5 times per week, whereas the remaining 3% make this trip between 1 to 3 times per week.

The majority of respondents indicated that they made this trip all year round (73.3%), whereas 16.75% made this trip in every season except summer (given mostly that universities are closed in summer months). Approximately 8.4% made this trip in the summer month only, whereas 1.05% made this trip only half the year. The smallest percentage (0.5%) made the trip in all seasons except winter.

The mode of transport on this common trip was asked next. Figure 16 shows the results, indicating that 41.4% of the trips were done via private vehicles, 21.5% were done walking, 16.2% through public transportation (taxis or service[7]), 10% via public bus transport, 9.4% via motorcycles, and 1.5% through cycling.

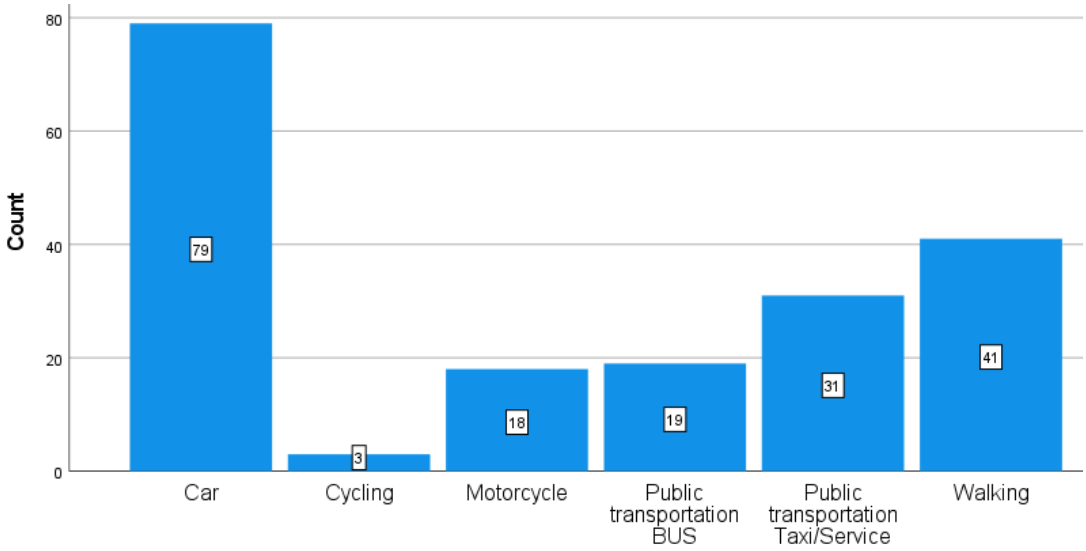


Figure 16. Main mode of transport adopted for the common trip

It is important to note that the more time a trip took, measured in minutes, the slightly more chance that the trip was made by a vehicle. The unstandardized coefficient for time of trip as a function of private vehicle ownership was 0.012, significant at the 5% level. It could be expected that this would increase had the analysis related the mode taken to distance travelled, which was not the case in the current survey. This is a common finding, for example from Akar & Clifton (2009) it was estimated that the greater the distance between campus and home, the greater the chance to drive a vehicle (see Chapter 2).

[7] Taxis in Lebanon are usually taken by individuals wishing to ride alone in the cab from origin to destination, whereas Service is the name used for when riders, who are not affiliated to one another, share the cab. The Service picks up riders along the way if the additional passenger's destination is within the route or range of the existing passenger.

The overwhelming majority, 81.2% indicated that they make this common trip alone, whereas only 18.8% make this trip in the company of others.

Furthermore, the time it takes for the trip (one-way), the associated costs, and the perception held by respondents on those costs are indicated in Table 6.

Category	Min.	Max.	Mean	Median	Std. Dev.
Minutes it takes, on average, to make trip one way	1	60	13.7	10	8.8
Approximate cost of this trip (one-way)	0	20	3.1	3.0	2.5
Rate perception of costs of making this trip on scale from 1 - 5 (1 being not expensive at all, 5 being very expensive)	0	5	3.2	4.0	1.9

Table 6. Trip times, costs and perception on costs

Table 6 shows that most of the trips made took approximately 10 minutes (median is 10 minutes), whereas the costs are around $3 per one-way. Respondents tend to believe, on average, that the costs associated with their respective trip are rather expensive (median is 4 on a Likert scale).

A further set of questions was asked as to whether the respondents owned a vehicle, motorcycle or a bicycle. The responses are shown in Table 7.

Category	Own (%)	Do not own (%)
Vehicle	51%	49%
Motorcycle	13%	87%
Bicycle	38%	62%

Table 7. Ownership of vehicle, motorcycle and bicycle

An unexpected statistic is that 38% of the respondents (n = 73) own a bicycle, as shown in Table 7. This is higher than data presented in Oke *et al.* (2022) which placed Lebanon in a group of countries where ownership of bicycles in households was less than 20%. However, of these 38% of respondents that own a bicycle, 67% indicated that they do not cycle often, whereas 33% indicated that they 'often' cycle. Therefore, from the total number of respondents, 12.6% indicated that they cycle often, and it would be important to assess whether they are more willing to thus support in cycling infrastructure. However, it is important to note that many residents of Beirut are originally from rural villages where they go on weekends and holidays. It could be the case that they have their bicycles in those villages, rather than having them in Beirut.

Questions on the respondents' perception with respect to the environment directly or indirectly surrounding the common trip they make were asked next, results of which are provided in Table 8.

#	Trip Environment Characteristics	Min.	Max.	Mean	Median	Std. Dev.
1	On average, how congested is the traffic on this trip? (1 – 5, with 1 not congested at all & 5 extremely congested)	1	5	3.10	3.00	0.938
2	How hilly is the road you take for this common trip? (1 = Straight, 2 = slightly hilly, 3 = very hilly)	1	3	1.57	1.00	0.652
3	How aesthetically beautiful do you consider the urban environment around this trip you make to be? (From 1 to 5, with 1 being not aesthetically beautiful at all and 5 being very beautiful)	1	5	1.56	1.00	0.849
4	How polluted do you think the air is, on average, around the road you take when you take this trip (1-5, with 1 not polluted at all and 5 being very polluted)	1	5	3.72	4.00	0.975
5	How noisy is the environment around the road you take for this trip? (1-5, with 1 being not noisy at all and 5 being extremely noisy)	2	5	3.85	4.00	0.888
6	How would you rate the public transport services of Beirut? (1-5, with 1 being very poor and 5 being excellent, 0 = No idea)	1	5	1.57	1.00	0.771
7	How would you rate the transport infrastructure provision (1-5, with 1 being very poor, and 5 being excellent, 0 = no idea)	1	2	1.25	1.00	0.432

Table 8. Respondents' perception on the surrounding environment

Table 8 shows a clear negative perception with respect to public transport and transport infrastructure provision in the city of Beirut, where almost all respondents indicated a 'very poor' rating (rating 1 on a Likert Scale, with 1 being very poor and 5 being excellent). This is not surprising, as investment in transport infrastructure has been absent for several years now, exacerbated by the 2019 financial collapse, with the minimal available funding going only for urgent maintenance work of existing infrastructure. As for public transport, the approach adopted by the Government of Lebanon, since the end of the civil war in 1990, was car-centric and thereby focused on building and expanding high-ways and roads as opposed to mass transit systems. Private passenger cars make up 86% of the total of 1.73 million vehicles on the roads of Lebanon (MoE *et al*., 2021).

In terms of aesthetics, pollution and noise, the perception of respondents is that the surroundings of the common trip they make are not aesthetically beautiful, and are polluted and noisy. This is not unexpected, as Lebanon has been ranked 142 out of 180 countries world-wide in 2022 according to the Environmental Performance Index (Yale Center for Environmental Law & Policy, 2022).

In terms of congestion, the respondents, on average, view the trip they make as being fairly congested. This is in line with reported descriptions, although congestion is rather seen as a major (as opposed to 'fairly') problem for Beirut, equating its

external costs to approximately 2% of the city's gross regional product (World Bank, 2017).

Last, in term of hilliness, the simple majority of respondents indicated that the slope of the trip they make is relatively flat (approximately 52%). Approximately 9% of the respondents indicated that their trip is very hilly, whereas 39% indicated it is slightly hilly. Although Beirut has many flat areas, it is also characterized by a lot of moderately inclined hills. The trip characteristics of the sample respondents in terms of slope can be regarded as thereby an accurate representation of Beirut. A study of the Greater Beirut Area indicated that approximately 52.8% of residents live in areas characterized with 'very gentle' slopes, whereas 4.82% are characterized with steep to very steep slopes (Faour & Mhawej, 2014).

4.1.4 Perceptions on cycling

In addition to the characteristics of the trip and the trip's surrounding built environment, the survey asked respondents on certain attributes and/or perceptions they hold if they were to consider (or not) taking this common trip via bicycle.

Approximately 66.5% of the respondents indicated that they have never thought of making this 'common' trip on a bicycle, whereas 33.5% indicated that they have thought of doing so. These respondents were then asked what the main reasons were that have stopped them from thinking about making this trip by bicycle or what stopped them from making this trip by bicycle (after indicating they have thought of it), respectively. The qualitative responses (i.e., we did not offer a list of possible responses, however we kept to the respondents the freedom to indicate what they thought) were categorized and results are shown in Figure 17.

A. Respondents that never thought of cycling (n = 127)

B. Respondents who thought of cycling yet did not get to cycling (n = 64)

Figure 17. Main reasons for not cycling

(separated between respondents who never thought of cycling and those that actually thought about it yet never did)

The most frequent response in Figure 17 is safety, and specifically the perception that they will not be safe (from accidents and harm) if they cycle. For sure, the lack of safety is also a consequence of poor infrastructure and poor traffic management, among other reasons indicated. Importantly, perceptions of culture and acceptance,

such as acceptance by parents and acceptance of women to cycle, were also notable reasons for not cycling (in total app. 8.4% of the 191 cases).

The survey then asked the respondents specific questions on cycling related to safety, theft, personal security, and perception of family and friends. Table 9 indicates the results.

#	Perceptions in cycling on 'common' trip	n	Min	Max	Mean	Median	Std. Dev.
1	How safe from traffic accidents do you think cycling would be on this trip? (1: Not safe at all, 5: Extremely safe)	191	1	5	1.25	1.00	0.615
2	Do you think theft of the bicycle will be a worry you will face? (1: Not worried at all, 5 very worried)	191	1	5	3.74	4.00	1.291
3	How strongly do you believe that your personal security will be threatened? (1: Not threatened at all, 5 very threatened)	191	1	5	3.97	4.00	1.122
4	If you cycle on this trip, how do you think your family or friends will think of your choice? (1: extremely inappropriate, 5 very appropriate)	191	1	5	2.08	2.00	1.153

Table 9. Specific perceptions on cycling on common trip related to safety, theft, security, and perceived social acceptance

Table 9 shows, clearly, that perceived low safety, threatened personal security, and probability of theft (of bicycle) are potentially important deterrents to cycling. Perceptions on cycling is also a major concern, as most of the respondents indicated that family and friends will perceive their cycling as inappropriate (median is 2 on the Likert scale). When asked whether the weather in Beirut is conducive to cycling, 94.2% indicated that it is, whereas only 5.8% indicated it is not (6.7% of women and 4.9% of men indicated that the weather is not conducive).

The survey turned next to gain some insight on whether respondents, in general, perceive any benefits from cycling. They were asked if they thought there would be any benefits to commuting on their respective 'common' trip via cycling. Approximately 31.4% indicated there are no benefits, whereas 68.4% indicated there will be. From the latter group, Figure 18 shows the categories made based on their open answers as to those perceived benefits.

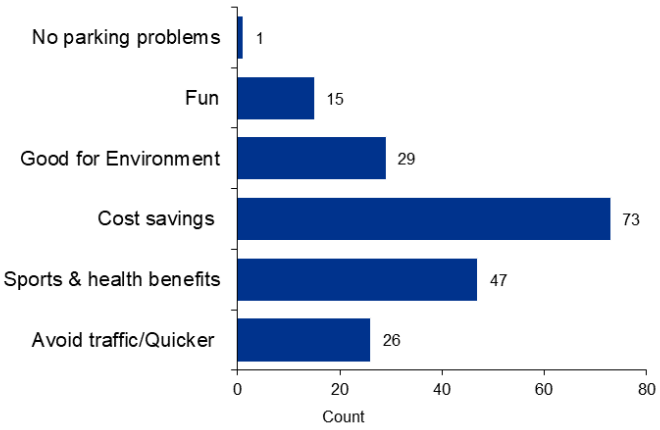


Figure 18. Perceived benefits from cycling (n = 130)

The cost savings from switching to cycling could be a prime motivator for potential participants, followed by health/sports benefits, environmental benefits, and avoiding traffic, respectively.

A last question in this section asked the respondents about their respective opinions on what major interventions would be needed to encourage more cycling. Figure 19 shows the results.

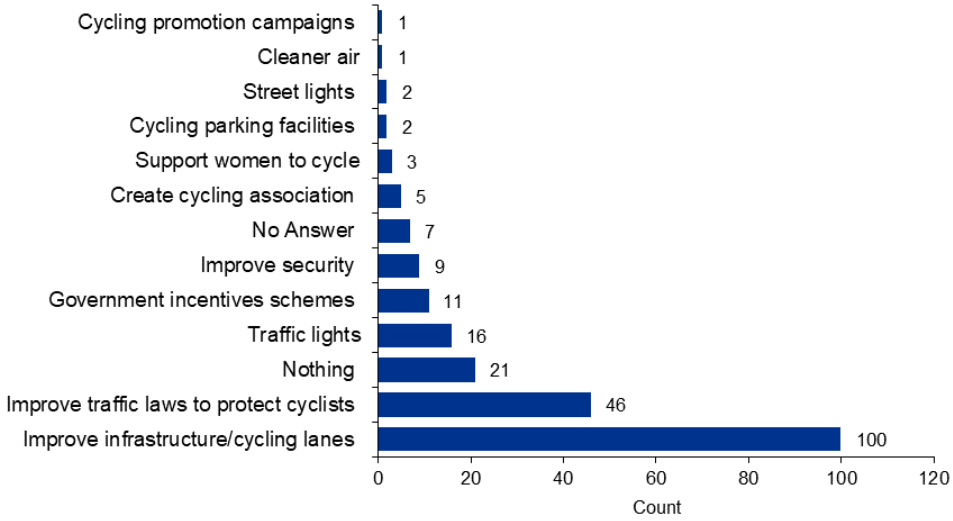


Figure 19. Top interventions required to encourage more cycling in Beirut

By far, improving infrastructure, including building dedicated cycling lanes, and better traffic management (including laws to protect cyclists) were the most frequent answers provided (approximately 76.4% of total respondents).

4.1.5. Willingness to pay for cycling infrastructure

The survey's main objective is to determine whether respondents are willing to pay for cycling infrastructure through an additional tax, and if yes, how much? The survey asked the respondents the below specific question:

"*If the municipality of Beirut, in coordination with an international organization that will ensure transparency and high-standards in procurement and specifications of all civil works and interventions, are seriously thinking of adding a monthly tax fee for a period of three years on all apartments residing in Beirut in order to raise the money needed to construct an inter-connected, separate and smooth cycling lane across the city of Beirut, would you be willing to pay (WTP) to support this initiative?"*

The question indicated the involvement of an international organizational to mitigate, to the extent possible, the trust of Lebanese citizens in their government, especially given the financial, economic and power sector collapse which Lebanese citizens blame the government and government officials for. As aforementioned, only 26% of Lebanese respondents indicated in a study that they trust their government (Bertelsmann Stiftung, 2022).

The second added information is to put a specific timeframe to the tax to be paid, in order to make the question more realistic and for the respondent to be able to mentally formulate the implications and impacts of what they will be responding to in a time-frame that they could well manage to conjecture in terms of their respective future wealth, risks that may occur, and personal conditions.

Approximately 38.2% of respondents (n = 73) indicated that they would not be WTP any added amount to cycling infrastructure as described. Of these 73 non-paying respondents, approximately 37% indicated that they are not interested in cycling, 31.5% indicated that they will not pay due to being unemployed or due to financial constraint reasons, 16.4% indicated that it is the government that should pay, not them, and 13.7% indicated that they have no trust in the Government. Only one respondent (1.37% of total in this sub-case) indicated no reason. Using an open-ended question for our valuation, as mentioned in Section 3.2.6, also positively influences the chances of receiving a zero valuation.

For the 61.8% of the respondents that are willing to pay, Table 10 indicates the results in terms of mean, median, minimum, maximum and standard deviation WTP.

	n	Min.	Max.	Mean	Median	Std. Dev.
WTP in cycling infrastructure	118	1	75	7.39	5	8.81

Table 10. WTP results (USD per month over 3 years) from respondents who are WTP

Table 10 shows that the mean WTP of the 118 respondents (who indicated they are WTP) is approximately 7.39 USD, however the median is 5 USD. The standard deviation is 8.81 USD. This result is not far from results obtained in some literature. For example, Botes and Zanni (2021) obtained a WTP of between $61 - $75 per year for a cycleway on the road fully protected and separated from traffic. Results of Table 10 indicate a median WTP of $60 per year.

To these 118 respondents, a further question was posed on maintenance of the cycling lane. Specifically, we asked: "*How much would you be willing to pay per month to keep this cycling lane well maintained after the 3 years?*"

Responses are shown in Table 11.

	n	Min	Max	Mean	Median	Std. Dev.
WTP in cycling infrastructure maintenance	118	0	25	5.6	5	5.94

Table 11. Results of WTP for maintenance from respondent who are willing to pay for constructing cycling infrastructure

As expected, respondents had a slightly lower WTP for maintenance, with the mean being 5.6 USD, although the median is similar to WTP for investing in cycling infrastructure capex. It is important to indicate that only 4.2% (of the 118 respondents) were not WTP any amount for maintenance. This is a strong indication that the respondents actually will value cycling infrastructure and its upkeeping and sustainability in the future.

4.1.6. Personal, environmental and other attributes

The final section focused on environmental attributes that the respondents express, as well as perceptions on their respective health and sportiness. A final question on immigration was also asked as a reflection of hope or hopelessness in the Lebanese political and economic environment, and the possibility of this reflection to impact willingness to invest in Lebanon.

Table 12 provides some proxies for environmental attributes. Importantly, questions 1 and 2 of Table 12 reveal respondents general temperament towards the environment with minimal efforts required and/or with potential cost savings to them, whereas question 3 indicates some effort, however with government support (of providing recycling facility near residents), and questions 4 and 5 indicate their willingness to actually implement/do things that are better for the environment that require more efforts and are potentially more costly.

#	Category *(1: not likely at all/5: very likely)*	n	Min.	Max.	Mean	Median	Std. Dev.
1	How likely are you to put off the lights when you leave the room?	191	1	5	4.28	5	1.24
2	How likely would it bother you when you see other people littering on the streets?	191	1	5	4.61	5	0.94
3	How likely are you to use a solid waste recycling facility should one become available near your residence?	191	1	5	3.29	3	1.44
4	How likely are you to buy a more energy efficiency vehicle on your next purchase?	191	1	5	2.49	2	1.51
5	How likely are you to buy environmentally friendly products, even if they are more expensive?	191	1	5	2.51	2	1.60

Table 12. Environmental attribute proxies of the respondent

Table 12 shows that the respondents generally care about the environment, however that is only through general expression or when the effort required is

minimal. When it comes to actually undertaking more efforts or requiring more costs to do so, the responses tend to be on the 'not so likely side'.

Table 13 shows the last set of questions related to how sportive and healthy they judge themselves to be, as well as their thoughts on immigrating away from Lebanon.

Category ***(1: not at all/5: very much)***	**n**	**Min.**	**Max.**	**Mean**	**Median**	**Std. Dev.**
Do you consider yourself to be healthy?	191	1	5	2.66	3.00	1.20
Do you consider yourself to be sportive?	191	1	5	2.43	2.00	1.36
How strongly do you think of immigrating from Lebanon?	191	1	5	4.17	5.00	1.23

Table 13. Health, sports and immigration perceptions and thoughts

The respondents generally perceive themselves to have an average health status, and a below average perception of being sportive.

In terms of immigration, there are overwhelming thoughts towards immigrating from Lebanon. This is a sad reality of Lebanese young people and has been expressed in other surveys undertaken (for example, the Arab Barometer survey in 2022 which indicated that Lebanese are the most pessimistic about their country's economic future from all Arab countries surveyed). Although it is outside the scope of this research to detail why this is the case, it is an important attribute to include in the analysis as it can be hypothesized that those that are thinking more of immigrating from Lebanon would be less willing to invest in Lebanon, in cycling infrastructure or any other societal activity or action.

4.2. Regression analysis results

In this section the results of the regression analysis are presented. Several methods of regression analysis are provided, as aforementioned:

- Binary logistic regression analysis: given a relatively high response rate (app. 38.2%) indicating that they are not willing to pay anything, we conduct a binary regression analysis where the dependent variable is binary, being either willing to pay or not.
- Multinomial logistic regression analysis: We transform the continuous variable (WTP) by categorizing it into 5 distinct values. This will add value to our analysis, on top of conducting a linear regression.
- Linear Regression: Given that the dependent variable is originally a continuous variable, we conduct a multivariate linear regression analysis.

However, we first assess the independent variables to explore and deal with any multicollinearity.

4.2.1 Multicollinearity analysis

Before beginning the assessment and presenting the regression results, the evaluation should make sure that independent variables are not correlated with one another above a certain threshold. Multicollinearity is a situation in which "independent/predictor variables are highly correlated" (Ho, 2006; Daoud, 2017). Should multicollinearity exist, this would imply that one "is using redundant information in the model, which can easily lead to unstable regression coefficient estimates" (Raykov & Marcoulides, 2006). Multicollinearity can be tested in several ways, such as Correlation Analysis, Value of Tolerance, Variance Inflation Factor, and Condition Index (refer to Annex 2). These methods are used to decipher whether there are any multicollinearity concerns and whether there is a need to mitigate the outcome by, for example, excluding a particular variable from the analysis.

There are five sets of concerns in the independent variables which may be subject to correlation within each set. These five sets are shown in Table 14.

Set 1		**Set 2**		**Set 3**		**Set 4**		**Set 5**	
Trip environment characteristics - 1		**Trip environment characteristics - 2**		**Cycling on the trip**		**Environ-mental attributes**		**Other variables**	
TC9	Aesthetics	TC12	Public transport provision	OT3	Theft concern	EA1	Lights off when leaving	OV1	Perception on health
TC10	Air pollution	TC13	Infra-structure Provision	OT4	Personal security concern	EA2	Other people littering	OV2	Perception on sportive-
TC11	Noise Pollution					EA3	Recycling effort		
						EA4	Energy efficiency vehicle purchase		
						EA5	More expensive Environ-mental product purchase		

Table 14. Independent variables' set possibly concerned with multicollinearity

Results of our multicollinearity analysis indicate that, in general, there are no major multicollinearity concerns with the independent variables within the sets except for Set 3. The Pearson correlation between 'theft concern' and 'personal security' is 0.716, above the 0.7 threshold we have decided to adopt. We will thereby utilize the 'theft of bicycle concern' independent variable only. The analysis conducted, using the four multicollinearity methods in SPSS, is presented in Annex 2.

4.2.2 Binary Logistic regression

Given that there is a relatively large number of respondents who indicated that they are not willing to pay any amount for cycling infrastructure (approximately 38.2% of the sample), a binary logistic regression analysis is implemented to identify whether there are any major predictors of being willing to pay (WTP > 0) or not (WTP = 0).

In the binary regression analysis, a forward stepwise regression analysis is adopted. Using a stepwise forward selection, SPSS automatically enters and removes predictors in a stepwise manner until there is no 'statistically valid reason to enter or remove any further predictors', leaving only the predictor variables that are statistically significant in relation to the dependent variable (Statology, 2022).

Results of the binary logistic regression indicate that approximately 12.9% of the results of the variation, based on the Nagelkerke Pseudo-R Square, in the dependent variable (to pay or not to pay) can be explained by independent variables that are significant, based on the forward stepwise method and, as shown in Table 15.

The model's explanatory strength can be considered relatively good when we assess the Hosmer and Lemeshow Chi-square value. Given that the Hosmer and Lemeshow Chi-square is statistically not significant, it indicates that our model is fitting the data relatively well (see Table 15) (Sinthupundaja *et al*., 2017).

The independent variables that were statistically significant to the 5% significance level are those related to environmental product purchase, gender, and perception of sportiveness (see Table 16). The following results can be deducted:

- **Environmental product purchase** (1 = not likely to purchase; 5 = highly likely to purchase): statistically significant at the 5% level and with a positive coefficient. Respondents that purchase products with better environmental properties, even if they are more expensive, is an indication of the strong environmental attributes of the individual which highly likely leads to more action for the benefit of the environment.
- **Gender** (0 = female, 1 = male): is statistically significant at the 5% level and the coefficient is negative. This means that females have a relatively higher probability of paying for cycling infrastructure than males. This is line with some of the literature, namely Aldred & Dales (2017) that indicated that women tend to express stronger stated preference for cycling away from the motor traffic, and Cole-Hunter *et al.* (2015). However, other literature sources did not find gender as statistically significant (e.g. Ton *et al*., 2019).
- **Perception of sportiveness** (1 = not sportive at all; 5 highly sportive self-perception) is statistically significant at the 5% level and the coefficient is positive. This means that the more 'sportive' the respondent thinks he or she is, the more likely they will be willing to pay for cycling infrastructure.

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	242.759[a]	.048	.065
2	237.290[a]	.074	.102
3	233.161[a]	.094	.129

a. Estimation terminated at iteration No. 4 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	.000	0	.
2	4.968	6	.548
3	7.106	8	.525

Table 15. Binary logistic regression: model summary and Hosmer & Lemeshow

Binary Logistic Regression: Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	SD1. Gender	-.936	.313	8.949	1	.003	.392
	Constant	1.054	.242	18.954	1	<,001	2.870
Step 2[b]	EA5. Env.al Product	.235	.103	5.228	1	.022	1.265
	SD1. Gender	-.828	.319	6.726	1	.010	.437
	Constant	.430	.355	1.470	1	.225	1.538
Step 3[c]	EA5. Env.al Product	.209	.104	4.033	1	.045	1.233
	SD1. Gender	-1.100	.354	9.636	1	.002	.333
	OV2. Sportive perception	.245	.123	3.949	1	.047	1.277
	Constant	.035	.409	.007	1	.931	1.036
a. Variable(s) entered on step 1: SD1. Gender.							
b. Variable(s) entered on step 2: EA5. Env.al Product.							
c. Variable(s) entered on step 3: OV2. Sportive perception							

Table 16. Binary logistic regression; Statistically significant independent variables

4.2.3 Multinomial regression analysis

The willingness to pay responses are converted into five distinct categories, as summarized in Table 17. This allows the analysis to implement a multinomial logistic regression. Although results from the binary logistic regression analysis and the multinomial logistic regression analysis should be, to a certain extent, similar, given that the latter will use the group respondents that are not willing to pay as the reference group, however it adds to the analysis in detailing the determinants against rising WTP values.

WTP Response range (USD)	Rank/Category	Percent of respondents in this category
0	1	37.1%
1 – 3	2	24.0%
5 - 8	3	16.2%
10 – 15	4	14.1%
> 15	5	8.4%

Table 17. Transformation of continuous dependent variable to categorical variable

A stepwise forward method is likewise adopted for the analysis, as with binary regression analysis. In this case, SPSS automatically provides results only for the statistically significant independent variables.

The model fitting information, indicated in Table 18, contains a Likelihood Ratio Chi-Square test that compares the model with the predictors against a null model with no predictors. Given that the p-value is less than 0.001, this shows that the model represents a significant improvement in fit over the null model. The Pseudo R-Square results are also shown in Table 18. Although with logistical regression these should be interpreted with caution, the results indicate, generally, a satisfactory explanatory power of our model in terms of WTP responses (the McFadden R-Square is 30.7%). This is validated by Peterson (2023):

"An R-squared that is between 0.10 and 0.50 (or between 10 percent and 50 percent when expressed in percentage) is acceptable in social science research only when some or most of the explanatory variables are statistically significant."

Model Fitting Information

	Model Fitting Criteria	Likelihood Ratio Tests		
Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	569.228			
Final	503.456	65.772	16	<,001

Pseudo R-Square

Cox and Snell	.291
Nagelkerke	.307
McFadden	.116

Table 18. Multinomial logistic regression model information & Pseudo R-Square

More importantly than the Pseudo R-square, which passes the minimum threshold, is the assessment of independent variables' explanatory power over the responses on the levels of willingness to pay. The Likelihood Ratio test results, shown in Table 19, show the overall contribution of each independent variable included in the

model. The Likelihood Ratio test indicates that gender, aesthetics, theft of bicycle concerns and recycling efforts are statistically significant at the 5% level.

Likelihood Ratio Tests

	Model Fitting Criteria	Likelihood Ratio Tests		
Effect	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	503.456[a]	.000	0	.
SD1. Gender	513.667	10.211	4	.037
TC9. Aesthetics	517.870	14.414	4	.006
OT3. Theft bicycle concerns	523.876	20.420	4	<,001
EA3. Recycling efforts	522.232	18.776	4	<,001

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Table 19. Multinomial logistic regression Likelihood Ratio test

The testing of the parameters of the model takes the reference point of WTP Category of 1, meaning those that were not willing to pay for cycling infrastructure in Administrative Beirut. The analysis compares the responses to this reference category. The full results of the parameter (independent variables) coefficient estimates are shown in Annex 3, whereas the below highlights the key findings:

- **Respondents with Category of WTP of 2** (1 – 3 USD per month payment for cycling infrastructure) in relation to Category 1 (0 USD payment): All the parameters indicated in Table 19 are not statistically significant when comparing respondents of WTP of 2 with the reference Category of WTP of 1.
- **Respondents with Category of WTP of 3** (5 – 8 USD per month payment for cycling) in relation to WTP Category 1 (0 USD payment):
    - **Gender** (0 = females, 1 = male): Significant at the 5% for females, indicating that females are more likely to be in WTP Category 3 than Category 1. This is in line with some of the literature, namely Aldred & Dales (2017) that indicated that women tend to express stronger stated preference for cycling away from the motor traffic, and Cole-Hunter *et al.* (2015).
- **Respondents with Category of WTP of 4** (10 - 15 USD per month payment for cycling infrastructure) in relation to WTP Category 1 (0 USD payment):
    - **Theft of bicycle concern** (1 = Not concerned at all; 5 = Very concerned): Significant at the 5% level with a positive β, indicating that the more concern there is for bicycle theft, the more the likelihood of the respondent to be in Category WTP 4 than reference WTP Category of 1. Theft has been mentioned as a deterrent to cycling (e.g., Rietveld & Daniel (2004) and Forward (2014)), however in this case it could be that the respondents see cycling infrastructure provision as one countermeasure to reduce theft probability (see WTP Category 5 below for counter argument that is aligned to Rietveld & Daniel, 2004).

- **Recycling efforts** (1 = not likely at all; 5 = highly likely to recycle): statistically significant at the 5% level and with a positive coefficient. Respondents that will highly likely recycle if recycling facilities are provided in their respective neighborhoods are more likely to invest in cycling infrastructure. This is again an indication of the linkages between having strong environmental attributes and investment in a low-carbon active transport modes, herein being cycling lanes.

- **Respondents with Category of WTP of 5** (> than 15 USD per month payment for cycling infrastructure) in relation to WTP Category 1 (0 USD payment):
  - **Aesthetics** (1 = Not aesthetic at all; 5 = Very aesthetically beautiful): Significant at the 5% level, with a positive β value of 1.1, indicating a relatively significant impact on the odds of being in WTP Category 5 compared to reference WTP Category of 1 if the aesthetics of the 'common' trip are relatively better. This is in line with some of the literature, notably Cole-Hunter *et al.,* (2015);
  - **Theft of bicycle concern** (1 = Not concerned at all; 5 = Very concerned)**:** Significant at the 5% level with a negative β, indicating that the more concern there is for bicycle theft, the less the likelihood of the respondent to be in Category WTP 5 than reference WTP Category of 1. Explanation of this finding is opposed to what was concluded for Category WTP 4 above yet more aligned to the literature. In this case, the respondent's fear of having the bicycle stolen, which is also linked to personal safety, dampens WTP for cycling infrastructure.
  - **Recycling efforts** (1 = not likely at all; 5 = highly likely to recycle): statistically significant at the 5% level and with a positive coefficient. Respondents that will recycle if the facilities are provided in their respective neighborhoods are more likely to invest in cycling infrastructure. This is in line with analysis of WTP Category 4 relative to WTP Category of 1.

4.2.4 Linear Regression

To ensure a thorough analysis on the explanatory power of the independent variables on WTP, it is imperative also to conduct a linear regression analysis given that the dependent variable, WTP, is originally a continuous variable. Furthermore, linearity testing revealed a linear relationship with some of the independent variables, being income (p-value < 0.001), aesthetics (p-value = 0.002), and environmental attribute product purchases (p-value < 0.001). It is worthy to mention that only the independent variables that are continuous or categorical on a 5-point Likert scale can be tested for linearity. Therefore the analysis excludes categorical variables such as gender and employment status.

The linear regression model summary indicates an adjusted R-square, entailing that, overall, the significant explanatory variables can explain 17.8% of the variance of the dependent variable, being willingness to pay (Table 20). This is an indication that the multinomial logistic regression is likely the better model fit for the data collected for the research. A forward stepwise approach was also adopted for the liner regressions model. With respect to the ANOVA analysis (Table 20), the model returns a significant value of less than 0.001, indicating a rejection of the null hypothesis (that the slope is equal to zero) and therefore the R-square result can be concluded to be significant. The model can predict the outcome better than

chance. The statistically significant independent variables were found out to be recycling efforts, income, taking the common trip usually alone or accompanied by other people, and immigration (Table 20).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.305[a]	.093	.089	7.513	.093	19.448	1	189	<,001
2	.364[b]	.133	.123	7.368	.039	8.498	1	188	.004
3	.415[c]	.172	.159	7.216	.040	8.991	1	187	.003
4	.442[d]	.196	.178	7.133	.023	5.404	1	186	.021

a. Predictors: (Constant), EA3. Recycling efforts

b. Predictors: (Constant), EA3. Recycling efforts, Normalized Income

c. Predictors: (Constant), EA3. Recycling efforts, Normalized Income , TC6. Alone/Company

d. Predictors: (Constant), EA3. Recycling efforts, Normalized Income , TC6. Alone/Company, OV3. Immigration

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1097.722	1	1097.722	19.448	<,001[b]
	Residual	10668.068	189	56.445		
	Total	11765.791	190			
2	Regression	1559.069	2	779.534	14.358	<,001[c]
	Residual	10206.722	188	54.291		
	Total	11765.791	190			
3	Regression	2027.276	3	675.759	12.976	<,001[d]
	Residual	9738.515	187	52.078		
	Total	11765.791	190			
4	Regression	2302.238	4	575.559	11.312	<,001[e]
	Residual	9463.553	186	50.879		
	Total	11765.791	190			

a. Dependent Variable: WTP USD Amount

b. Predictors: (Constant), EA3. Recycling efforts

c. Predictors: (Constant), EA3. Recycling efforts, Normalized Income

d. Predictors: (Constant), EA3. Recycling efforts, Normalized Income , TC6. Alone/Company

e. Predictors: (Constant), EA3. Recycling efforts, Normalized Income , TC6. Alone/Company, OV3. Immigration

Table 20. Linear regression analysis; Model summary and ANOVA

The analysis of the coefficients of the independent variables are listed in Table 21. The major findings, focusing on the fourth iteration with all the statistically significant independent variables included for best model results, are as follows:

- **Alone/Company** (0 = accompanied; 1 = alone): Significant at the 5% level with β being negative, meaning that those that travel alone are less likely to pay for cycling infrastructure. This is counterintuitive to the expectation, where a respondent traveling alone could be more at liberty to cycle;
- **Recycling efforts** (1 = Not likely at all; 5 = Highly likely to recycle): Significant at the 5% level with the coefficient β being positive, entailing that those that will make more effort to recycle will likely pay more to cycling infrastructure. This is aligned to our result in the multinomial logistic regression, specifically in the WTP Categories 4 and 5, providing further power to the link between environmental preferences and WTP for cycling infrastructure.
- **Income**: We have normalized income by dividing all the values of income by 1000, in order that we align better to the scales of the independent variables used in the analysis. The result of income indicates that it is significant at the 5% level with a positive coefficient β, and an odds-ratio of approximately 1.24. This result is not in line with the binary and multinomial regression analysis, the latter two of which have found income not to be statistically significant. Income was found significant in some studies, such as Song *et al*., 2017, however not in others (e.g., Ton *et al.,* 2019). Cantillo *et al*., 2020 indicated higher income usually means lower propensity to cycle, given affordability to select more expensive transport modes.
- **Immigration** (1 = Not wanting to immigrate at all; 5 = Very much wanting to immigrate): Significant at the 5% level with the coefficient β being negative, indicating that for every unit increase on the scale from 1 to 5 in the desire to immigrate from Lebanon, we will expect a drop in WTP for cycling infrastructure.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.867	1.363		-.636	.526
	EA3. Recycling efforts	1.681	.381	.305	4.410	<,001
2	(Constant)	-1.658	1.364		-1.216	.226
	EA3. Recycling efforts	1.498	.379	.272	3.950	<,001
	Normalized Income	1.163	.399	.201	2.915	.004
3	(Constant)	2.116	1.835		1.153	.250
	EA3. Recycling efforts	1.312	.377	.238	3.484	<,001
	Normalized Income	1.278	.393	.221	3.254	.001
	TC6. Alone/Company	-4.069	1.357	-.203	-2.998	.003
4	(Constant)	6.268	2.546		2.462	.015
	EA3. Recycling efforts	1.273	.373	.231	3.418	<,001
	Normalized Income	1.236	.388	.213	3.183	.002
	TC6. Alone/Company	-3.881	1.344	-.193	-2.889	.004
	OV3. Immigration	-.992	.427	-.154	-2.325	.021

a. Dependent Variable: WTP USD Amount

Table 21. Linear regression model coefficient estimates

From the above linear regression analysis, additional information to the logistic regression analysis that cannot be discarded is that of immigration and income. The general sentiments and hope of Lebanese citizens in general, and the youth in particular, could be a driving force behind willingness to invest in one's own country for the betterment of society. Furthermore, higher income translates in this case to higher ability to pay and therefore willingness to pay.

4.3 Welfare Benefits of cycling infrastructure for Beirut

It is important to provide an approximate estimate of the overall welfare benefit of constructing a cycling network for Administrative Beirut, based on the analysis. This implements the final step of the study (see Section 3.2.10) through applying the following formula:

$$AggWTP = WTP_{\text{mean or median}} \times N$$

In order to estimate an aggregate WTP, the following assumptions are adopted:

- In the analysis of 191 respondents, 38.2% indicated that they will not be WTP anything, whereas 61.8% indicated that they will be WTP;
- The median estimate for WTP, based on the 61.8% of those willing to pay, is $5 per month (over a 3-year payment period);
- The population of Administrative Beirut is 430,000 citizens;
- The targeted population proportion is approximately 58%, being those citizens from Administrative Beirut who are aged between 18 and 64 (CAS, 2022). This will yield a conservative estimate only for this age bracket as the younger generation (below the age of 18) and the older generation (> 64) were not targeted in this analysis.

From the above assumptions, the aggregate WTP is the following;

AggWTP = $5 x (430,000 x 61.8% x 58%)
= $770,646 per month or $9.25 million per year

Given the assumption of a three-year payment plan, the overall welfare value for the construction of a cycling infrastructure in Administrative Beirut is 27.7 million USD. Using a discount rate of 5%, the net present value (NPV) of the cycling infrastructure, as a proxy for value to Administrative Beirut citizens, is approximately $25.2 million.

However, and as evident through the willingness to pay for the maintenance of the cycling network being very close to the value of payments for constructing the cycling network, it could be said that the annual value of cycling infrastructure to Lebanese citizens is approximately $9.25 million per year.

The costs of building cycling infrastructure vary significantly across regions, largely due to differences in the cost of materials, labor, as well as depending on design features of the cycling network itself. For example, a 'protected cycle lane can be

double the cost per kilometer of an unprotected lane, but they provide much more safety and comfort' (Cycling Cities & ITDP, 2022). A good comparative analysis that reveals the range of construction costs of cycling lanes that can be expected, is shown in Figure 20.

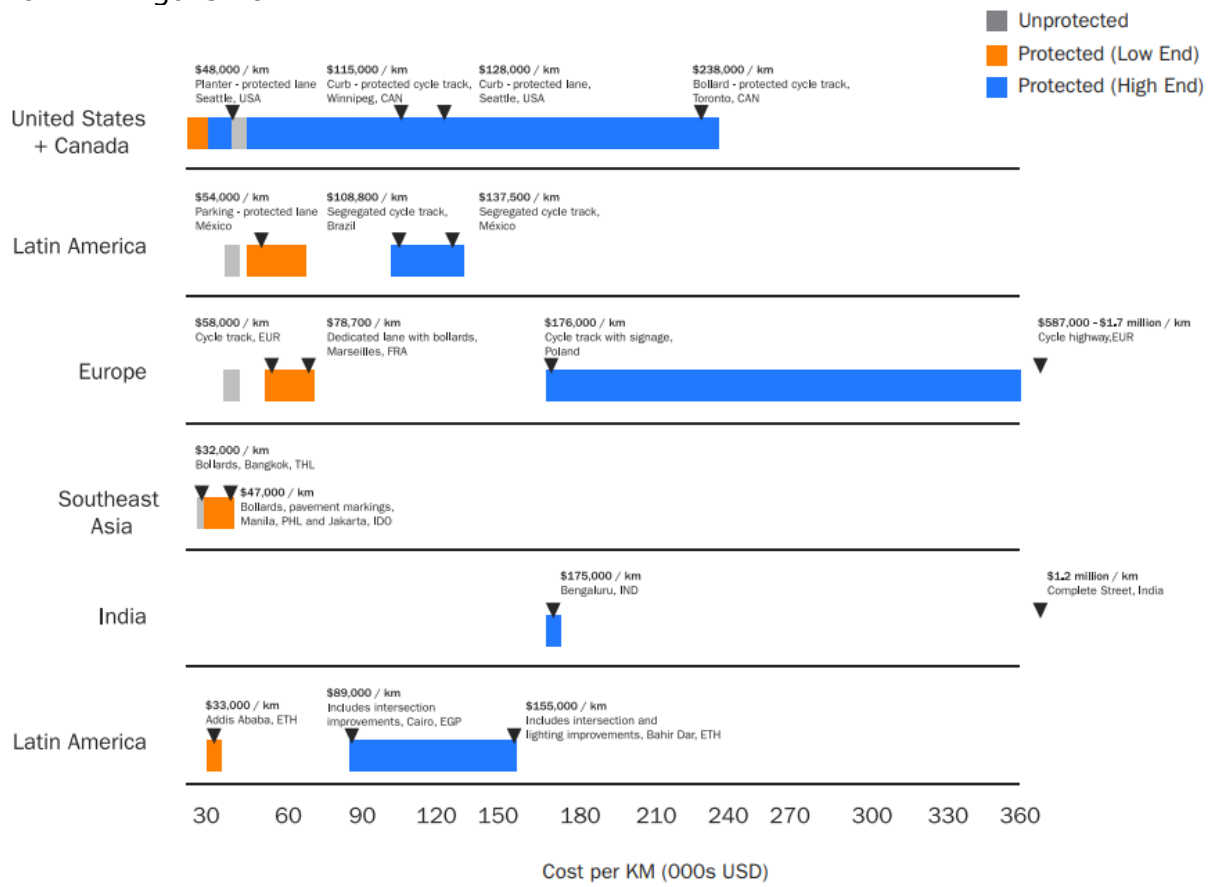


Figure 20. Cycle lane costs per kilometer, by Type and Region
(Cycling Cities & ITDP, 2022)

Adopting India's 'high end' cycling lane construction value of $176,000 per kilometer will translate to Beirut being able to construct 143.2 kilometers of cycling lanes, 5 times the length of the pre-financial crisis planned cycling network proposed by the Municipality of Beirut.

There is no information on the road density of Beirut, and it was difficult to find road density data published for other cities. However, one particular study indicated the road density of Barcelona being 16.88 km/km^2 (Nemchinov, 2016). Assuming a similar road density as Barcelona, Administrative Beirut will have 303.84 kilometers of roads. The value of cycling lanes can thus cover 47% of the roads of Beirut. If a 'lower end' estimate for the cost of cycling lanes (of approximately $30,000 per km) is adopted, then the welfare value equates to more than all Beirut roads having a cycling lane on both sides.

Again, the above analysis is a rough and simplified indication to provide an order of magnitude of welfare value that citizens of Beirut have for the construction of cycling lanes.

5. Discussion and Conclusion

5.1 Discussion

Lebanon is currently, and since 2019, passing through one of the worst economic and financial crises in its history; the World Bank Lebanon Economic Monitor (LEM) indicated it is likely to rank in the top 10, possibly top 3, most severe crises episodes globally since the mid-nineteenth century. Lebanon's Gross Domestic Product (GDP) has plunged from 55 billion USD in 2018 to approximately 23.13 billion USD in 2021 (World Bank data[8]). The multidimensional poverty rate in Lebanon has nearly doubled from 42% in 2019 to 82% in 2021[9]. The Government of Lebanon is currently unable to invest in any infrastructure or developmental project, struggling only to continue paying public sector wages.

However, the deterioration of living conditions of Lebanese citizens lends support for alternative modes of transport than the private vehicle. Hatoum & Barraj (2023) investigated Lebanese citizen mobility behavior during the economic crisis that is impacting Lebanon. Based on their literature review, they expected that the economic crisis will reduce private vehicle use. In specific, their study focused on the Greater Beirut area and aimed to evaluate the impact of the ongoing crisis on travel behavior, specifically on the number of trips and the modes of transportation used (Hatoum & Barraj, 2023). Interestingly, they presented their findings through a Sankey diagram, comparing frequency and mode of trips taken by 408 respondents of the survey for different travel purposes (work/study, shopping, and recreational trips) before and after the economic crisis. Figure 21 presents their results in relation to the mode of transport (before and after economic crisis) for work/study related trips (Hatoun & Barraj, 2023).

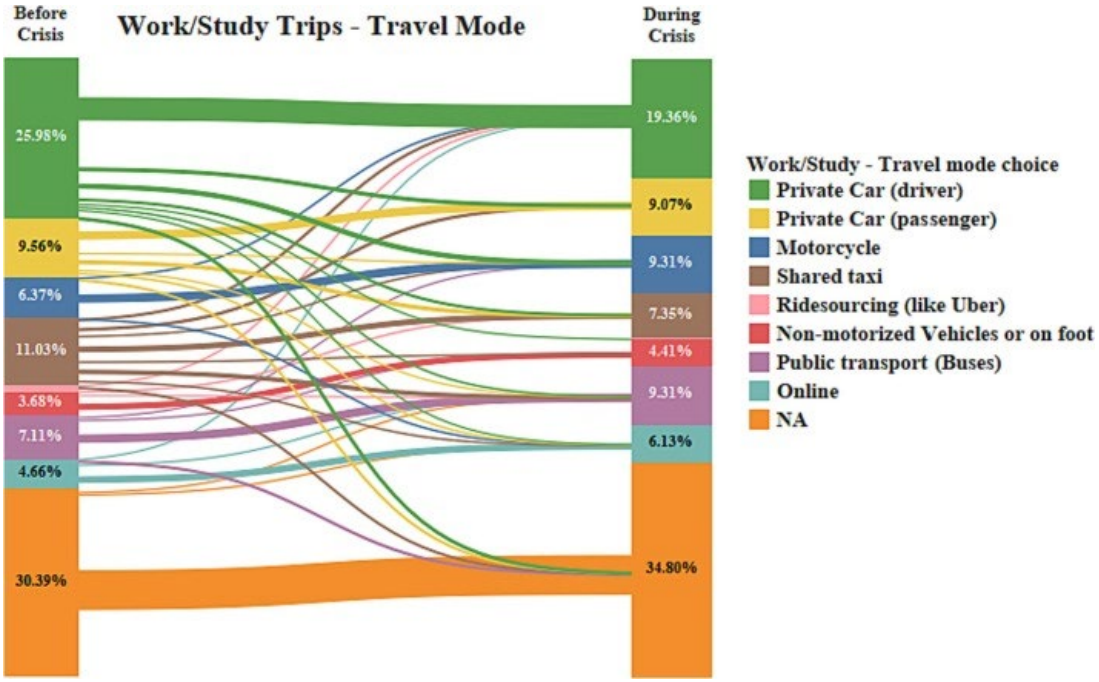


Figure 21. Travel mode for Greater Beirut citizens before & after economic crisis (Hatoum & Barraj, 2023)

[8] https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=LB; accessed 27.12.2023
[9] Lebanon: Almost three-quarters of the population living in poverty | UN News; accessed 27.12.2023

Figure 21 shows a clear reduction of private vehicle use from approximately 26% to 19% after the economic crisis. This finding was validated by daily news reports. For example, Gulf news (2021) indicated that "with the financial and economic crisis currently facing Lebanon… coupled with high transport fuel prices, an increasing number of car owners are finding it hard to maintain their cars due to an excessive increase in car operating and ownership costs. This is leading to a change in the country's car-centric culture and consumer travel choice preferences and priorities where walking and cycling have re-emerged as necessary options for commuting short trips within city boundaries, whereas auto-rickshaws (tuk-tuk), electric scooters, carpooling, and affordable bus rides have gained more popularity as an alternative to private cars and taxis for longer distances" (Gulf News, 2021).

Although motorcycle use increased significantly (from 6.37% to 9.31% of total work/study trip mode), this still provides a clear message to Lebanese policy makers to begin planning and investing in active transport policies and infrastructure. At the same time, further study and analysis should also focus on the potential of the electric bicycles market for Lebanon to overcome distance concerns and reduce motorcycle use.

5.1.1. Policy implications from descriptive analysis

The descriptive analysis (Chapter 4.1) provides a strong basis for policymakers to respond to citizen concerns with respect to cycling. Respondents that were not willing to cycle quoted safety as one of the most important factors for deciding against cycling, followed by poor infrastructure provision. Even those that thought of cycling yet did not cycle yet indicated safety and infrastructure provision as prime reasons, on top of distance and time required (see Figure 17). What is of value to note is that the provision of cycling infrastructure can in and by itself provide the right incentive for increased cycling rates. This was evident from the study by Song *et al*. (2017), in which results pointed to the fact that "exposure to new infrastructure was significantly associated with a modal shift towards active transport, after controlling for personal and household characteristics…" and from results of the study from Ruiz & Bernabe (2014), in which they indicated that "cycle lanes connected throughout the city and fully segregated are the most important improvement measure that would push respondents to consider cycling". Furthermore, Cole-Hunter *et al.* (2015) found that the quantity of public bicycle stations positively impacted cycling propensity. Deploying a separate and safe cycling network with related infrastructure, such as safe parking spaces for bicycles, can respond to both the lack of infrastructure and the safety concerns. It will undoubtedly also increase the social acceptability of cycling as a reliable mode of transport. Necessary interventions needed, in the view of the respondents, to encourage cycling was the improvement of cycling infrastructure, followed by traffic laws that protect cyclists (Figure 19). A cultural transformation is thus required in Lebanon, away from a car-centric historic paradigm towards a more sustainable transport system, an important part of which is the encouragement of active transport. This was further validated by studies undertaken by UN-Habitat and the UNDP (see Chapter 1), in which the following corrective measures were mentioned to be needed to encourage active transport:

- Better land-use planning and zoning to favor walking and cycling;
- Better sidewalks and dedicated cycling lane infrastructure;
- Better crossing, walkways, bridges and tunnels for pedestrians and cyclists;

- Increase in parks and public spaces;
- Adequate traffic policies and enforcement

Encouraging cycling does not stop on the above measures yet is also impacted by overall security concerns, both personal and concerns of bicycle theft. Necessary protection for bicycle users is needed even if cycling infrastructure is put in place. This was also evident from the literature. For example, Attard *et al.* (2021) indicated that positive safety elements, such as proper street lighting, encouraged cycling.

A large proportion of the respondents in the study herein showed a clear understanding of the benefits of cycling as a transport mean to undertake their common trip. Savings on costs were the main benefit they quoted, followed by health and sports benefits, environmental benefits, and time saved benefits.

5.1.2 Policy implications from regression analysis

The regression analysis provides additional insights on which determinants have a likely impact on the willingness to pay and the respective level of WTP. From the regression analysis, the overall policy recommendations that can be deducted are as follows:

- Females have shown more willingness to invest in cycling infrastructure. This was evident in the binary logistic regression and the multinomial regression analysis (specifically for WTP Category 3 compared to reference WTP Category of 1). Policymakers should focus on **gender** empowerment and translate this preference in any cycling infrastructure and related cycling-promoting policies. For example, increasing the acceptability of cycling for women, through media campaigns, is important to change some of the negative perceptions citizens have on women cycling. Furthermore, a dedicated and separate cycling infrastructure with overall increased cycling and personal safety in accordance with international norms and standards will further encourage citizens to cycle, especially women.
- **Concerns of theft** of bicycles was statistically significant at the 5% level, with the more concern from theft, the less the WTP for cycling infrastructure as per the multinomial logistic regression analysis results (specifically WTP Category 4 and 5 in relation to reference WTP Category 1). Therefore policies and programs that increase safety and allay concerns from theft can support the likelihood that citizens value active transport more.
- Improving the **aesthetics** of the roads of Beirut, for example through increasing greenery, will potentially yield a higher likelihood for cycling in the future. This was evident in the multinomial logistic regression analysis, specifically for WTP Category 5 in relation to reference WTP Category 1, as it was in the binomial regression. The importance of this parameter cannot be understated. Mohsen *et al.* (2020) stated the following on Beirut; "Green spaces count for only 0.8 m^2 per capita of the city, while the World Health Organization recommends a minimum of 9 m^2 per capita… The city has been recently becoming denser and deprived of green spaces". Improving the aesthetics of Beirut, through greenery and other measures, has multitude of benefits and will not only impact willing to cycle and invest in cycling infrastructure.
- Promoting sports for all ages is important to encourage active transport. As **perception of sportiness** was found statistically significant in the binary

logistic regression analysis, promoting sports and encouraging people to do sports will likely have a positive implication on cycling frequency in the future.
- Those that are more **environmentally active** (as expressed through their willingness to purchase products for their relative environmental attributes, even if they were more expensive, and/or willing to undertake environmentally beneficial actions, as expressed through solid waste recycling) have been found to be more likely to invest in cycling infrastructure, as per results from both the logistical and linear regression models. Encouraging citizens to be proactive for environmental purposes will generally thus lead to choices that are better for the environment, including cycling.

One final result, obtained from the linear regression analysis, was the negative relationship found between desire to immigrate and WTP for cycling infrastructure. This is an overarching problem for Lebanon. Cycling infrastructure is perhaps not on the minds of Lebanese citizens, given the multitude of key socio-economic and political problems they are facing since and before the economic and financial collapse of 2019, however the results presented herein indicate that investing in cycling infrastructure cannot be taken in isolation. It is a key part of willingness to remain and invest in the betterment of Lebanon.

5.1.3 Reflections from an activist transport specialist

To reflect on the findings of the research and have some on-ground perspective on the subject matter, an interview with a transport activist and expert was conducted online via Teams on the 3rd of January, 2023. The expert is Zeina Hawwa, co-founder of the Chain Effect (www.thechaineffect.me), a local Lebanese non-governmental organization with the mission to introduce and expand active transport in Lebanon, including walking and cycling, through awareness raising and education, solutions and interventions, and policy and planning assessments and contributions.

According to Zeina, the main obstacles to cycling in Beirut are:

- The lack of appropriate and dedicated infrastructure
- The lack of traffic management and planning, especially given the car-centric approach that Lebanese planners have historically adopted
- Training, education and culture
- Financial and market barriers, specifically in the form of a relatively small market potential for bicycles that obstruct any scale effects on prices of bicycles
- Political will and lack of strategic direction, and;
- Topography and weather, although to a lesser extent.

Zeina's responses validate the views of the surveyed respondents (see Figure 17), specifically on safety concerns, poor infrastructure and traffic management, and culture, yet adding financial and market barriers as well. One of the main focuses of Zeina's feedback was on culture. Specifically, Zeina indicated how cycling is seen by many Lebanese as something that children do or something that is for those that are relatively less well off, and aspiration of Lebanese citizens rest largely with owning a private vehicle. This is a major obstacle to cycling in Beirut, an obstacle that will require investment, time, and effort to slowly begin to change.

One key element that Zeina confirmed, which is aligned to the literature (for example Ruiz & Bernabe, 2014 and Song *et al*., 2017), is the expectation that if

dedicated infrastructure for cycling is put in place, this will, in and by itself, induce people to take cycling seriously as a mode of transport. Zeina touched on the citizen's imagination. If citizens, like those in Beirut, have grown in a car-centric city all their respective lives, it would be difficult to imagine an alternative without a long process of transformation, with education, awareness, training, subsidies for cycling, and infrastructure provision to alleviate the perception of safety concerns, among other consistent initiatives required for the change to happen.

Zeina has concluded with the important reality that transportation systems don't work in silos. Constructing a dedicated cycling lane is important, however not without the overall transportation planning and context being analyzed and evolved as well. Beirut, as Zeina confirmed, receives hundreds of thousands of vehicles every day from outside its geography, with most people coming in for work. These vehicles compete for road and parking spaces and, combined with a commercial road economy relying on passing vehicles, meaning shops that cater for passing cars, causing significant congestion (and a possible collision course with any dedicated cycling lane in the future), it would be difficult to simply overlay a cycling lane on this complex and chaotic mesh.

5.2 Limitation of the study and future recommendations

There are a few limitations to the study undertaken and these limitations call for further research in the future on the subject matter. These limitations are indicated below:

- Sampling timeframe: the survey was conducted during the summer of 2023 in Beirut. The weather was hot and humid, and this could have had an impact on the categories of people that were sampled. The sample did not end up with a proportion of older people. Thereby our results are not indicative of all Beirut citizens within the target age group of working people (18 – 64 years old).
- Sampling size: Given the time constraint (only a few weeks available in Beirut to conduct the survey) and budget constraint (specifically in not being able to procure an experience surveying company), the sampling size of approximately 220 was relatively small, and the ideal sample size would have been approximately 364 samples (see Chapter 3.2.4). This is particularly the case as we have used many independent variables (approximately 35 independent variables, see Table 5) to explain the variation in the dependent variable.
- Conservative estimate: Excluding the below 18-year-old citizens and the above 64-year-old citizens was done to focus on the legally employable category of people that are more likely to be able to pay (as a working age group). However, this does not mean that the excluded citizen groups do not place a value on cycling infrastructure or that their value does not matter. To that end, any future assessment should also include all citizens, whether falling in the workable age or not. To that end, the aggregate WTP could be assumed to reflect a conservative estimate of the value citizens of Administrative Beirut place on cycling and cycling infrastructure.
- Regression analysis: regression analysis is a discipline in and by itself, and it will also be best for an experienced econometrician to undertake the regression analysis.

Another shortcoming of the study is the time when the survey was conducted. Being in a major economic recession is not the standard socio-economic environment which Lebanese citizens and their economy experience. This undoubtedly pushes the priority of investing in cycling infrastructure further down the scale. Conducting the study in 'normal' economic times may thus yield different overall results, with the probability being that citizens will value more investments in their respective country and towards cycling infrastructure. The linear regression points to this regards, specifically as stronger immigration desire was linked to lower WTP values. However, this cannot be confirmed unless the survey is conducted again in the future once Lebanon recovers from its current economic conditions.

A final shortcoming of our research is the fact that this study investigated cycling lanes value to Beirut citizens as one standalone intervention. However, and as expressed by Zeina Hawwa, it is really a combination of interventions and transport modes, including land-use and urban planning, that work in synergy that is needed. Thereby, and as a future recommendation, discerning the value of active transport in a system that is more likely to cater for the success and ease of such transport modes is needed.

5.2 Conclusion

Since the end of the civil war in 1990, Lebanon and Lebanese policymakers adopted a car-centric approach to land transportation, focusing on building and maintaining roads and highways of all categories for the benefit of private vehicle transport. This approach did not serve Lebanon well with time, as building and expanding roads only encourages more people to drive more, thereby not alleviating congestion problems, yet exacerbating them. This 'induced traffic' effect is well known in transport research and literature. Furthermore, not only was the focus on private vehicle road transport, yet there was a lack of investment and planning in mass transit systems and active transport. The outcome was a high externality cost of road transport in Lebanon, as was described in Chapter 1.

In the study carried out in this research, the aim was to value one component of a more sustainable transport system, being cycling, to citizens of Administrative Beirut. The research aimed to respond to the following questions:

- What are the welfare benefits of investing in an inter-linked and fully separated cycling lane for 'administrative Beirut', an area approximately 18 km^2?
- What are the perceptions and attitudes of Beirut citizens for such an investment? Do they value it, and if yes, by how much?
- How do these overall welfare benefits compare with potential overall costs for such an investment?
- What are the determinants of this valuation and what does this mean to policy making?

Building on existing literature (Chapter 2) on the subject matter, the analysis surveyed what may be potential determinants that influence the value people have for cycling and cycling infrastructure. Although the literature was not aligned on the matter, meaning, for example, some determinants of value in a certain country were found not significant in another country, the literature review provided for an array of possible influencers on value. This enabled the research conducted to construct the survey questionnaire and include, to the extent possible, all potential determinants of value, as expressed through the WTP concept. A contingent valuation method was adopted for the research, a method widely used to elicit value for non-market goods and services. This is likely to be a more applicable method to serve our research objectives, as the analysis conducted aimed to compare a baseline of no cycling infrastructure to one with a cycling infrastructure. In specific, the valuation question was as follows:

"If the municipality of Beirut, in coordination with an international organization that will ensure transparency and high-standards in procurement and specifications of all civil works and interventions, are seriously thinking of adding a monthly tax fee for a period of three years on all apartments residing in Beirut in order to raise the money needed to construct an inter-connected, separate and smooth cycling lane across the city of Beirut, would you be willing to pay to support this initiative.. and if yes, how much per month?"

The contingent valuation method, explained in Chapter 3, was followed through its 10 recommended steps, with the final step being the total welfare value as expressed through an aggregate WTP.

A face-to-face survey of approximately 210 respondents was conducted in administrative Beirut during the summer months of 2023, aimed at surveying Lebanese citizens to elicit their attitudes, perceptions and willingness to contribute (pay) for an expanded, interconnected and high-standard cycling network for Administrative Beirut. Socio-demographic and individual specific statistics such as sex, age, health, prior transport characteristics, education and income data were collected. The findings of the survey were inputted into the Statistical Software (SPSS) to evaluate the outcome of the data, both descriptively and through binomial and multinomial logistic regression analysis and linear regression analysis.

Descriptive analysis, provided in Chapter 4.1, yielded important results and recommended policy implications. For one, the descriptive analysis enabled the comparison of sample characteristics with national statistics, ensuring that the sample was representative enough of the Lebanese population, or where it diverted and thereby future work should rectify the gaps. For example, the sample's average age was younger that the average age of Lebanese citizens. More importantly, the descriptive analysis revealed the reasons why citizens of Beirut did not think of cycling, or what they saw as challenges to cycling and what could be potential measures that can encourage them to cycle. A summary of what is needed, based on the respondents' feedback, is reiterated below:

- Better land-use planning and zoning to favor walking and cycling;
- Better sidewalks and dedicated cycling lane infrastructure;
- Better crossing, walkways, bridges and tunnels for pedestrians and cyclists;
- Increase in parks and public spaces to improve aesthetics;
- Adequate traffic policies and enforcement
- Improved overall security to ensure personal protection and protection of bicycles from theft.

Importantly, descriptive analysis enabled us to calculate the overall welfare value for cycling infrastructure for Administrative Beirut and relate the findings to the Decision-Rule that the Municipality of Beirut, or any other relevant stakeholders, can adopt when deciding whether the results spur action. In general, and based on the need to clearly indicate a Decision Rule, as per Chapter 3.2.5 on the CVM methodology, there is a clear simple majority of citizens of Beirut that do value the development of a cycling infrastructure, as approximately 62% indicated that they are willing to pay for it. Although this is not an overwhelming majority, as it is short of 70%, it is still a good indication of preference that policymakers can rely on. Furthermore, and as per Chapter 4.3, the overall welfare value for cycling infrastructure construction for Beirut was found to be approximately $25.2 million. Moreover, and just as important, was the willingness of an overwhelming majority (approximately 96%) of respondents that were WTP for the construction of a cycling network, were found WTP for maintenance of the cycling network. Thereby an annual welfare value of $9.25 million could be considered a representative and continuous (i.e., not time bound) value.

From the regression analysis results and the interview with a transport specialist, as presented in Chapter 4.2 and Chapter 5.1.3, the influencing variables on the WTP was determined. The main results that were concluded from this analysis are as follows:

- Cycling infrastructure should be part of an overall sustainable transport strategy and planning;
- Investing in continuous education and awareness on the environment will highly likely yield better perspectives on active transport and/or cycling.
- Females have expressed a relatively higher WTP for cycling infrastructure than males. In a sense women could be connecting a dedicated and separate cycling lane to safer and more diverse options for them to travel by;
- Ensuring safety, which is important for all travelers. Bicycle facilities that are constantly monitored and protecting bicycles from theft can improve the propensity to cycle, just as safety on the cycling lanes is important (for example through ensuring lighting at night).
- Beautifying Beirut, especially through greenery and green spaces, will encourage active transport and encourage people to invest in cycling infrastructure and cycle more. Beirut suffers from a very low green-to-built up ratio, and increasing the green spaces and greenery will motivate people to walk and cycle more.
- Actually investing in and/or rolling out a cycling network with associated infrastructure will, in and by itself, change the perception and attitude of Beirut citizens and their probability of using cycling as a main transport mode.

The overall welfare benefit that are estimated in the study herein could be considered, as aforementioned, a conservative estimate. This is not only because the non-working categories of citizens (i.e., those below the age of 18 and above the retirement age of 64) have been left out of the analysis, yet because the provision of cycling infrastructure can, in and by itself (as abovementioned), encourage people to cycle and thereby to value cycling. Many of those that were not WTP could thus have a change of heart and change of value when and if a cycling network is put in place in front of them.

As of the end of 2023, Lebanon and Lebanese citizens are still coping with a multitude of social, economic and political problems. These problems have created a high percentage of unemployment and have deteriorated the purchasing power of people’s incomes, just as it has also seen their monetary savings in local banks wiped out. It could be argued that investing in cycling infrastructure is not the correct priority or time. However, with problems come opportunities. As we indicated in Chapter 5.1, there was a de facto change in travel behavior brought about by the economic crisis. This has resulted in a drop in private vehicle use. Policymakers need to capture this opportunity and plan for a better transport system for citizens. Such a system should maximize active transport, including cycling, and mass transit transportation. This would not only cater for those that have become less well-off due to the economic collapse, yet it will make transport more affordable to a large section of Lebanese society, freeing valuable income for other living expenses. Moreover, this would reduce road transport externalities of all forms, from greenhouse gas emissions and local air pollution to congestion and accident impacts.

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Annex 1. Full Survey Executed

Perception, attitudes and WTP for cycling infrastructure in Beirut, Lebanon
Target population: Residents of Beirut only
Date of Interview:
Area of Interview:
Interviewee Code:
Introduction

We are conducting an academic survey (as part of a Master Thesis in Transportation Sciences at the University of Hasselt, Belgium – *if asked*) to help us understand the residents of Beirut's opinion, perceptions, and attitudes towards cycling in Beirut

We expect the survey will take no longer than 10 -15 minutes to complete. We will not be asking for your name or disclosing your name to anyone.

A. Trip characteristics

We would like you to think about the most common trip you take from your place of residence to your work, university or any other common trip you routinely make, such as visiting a relative on a regular basis, that is unrelated to leisure.

1	What is the purpose of the common trip you make?	
2	What is the mode of transport that you mostly use for this trip?	a. Walking b. Cycling c. Public Transport Bus d. Public Transport – Taxi or Service e. Other, please specify: _____
3	How much time (in minutes) does this trip take you, on average, one way?	
4	What is the approximate cost of using this mode of transport (if mode is public transport, private vehicle, private motorcycle) (*If walking skip this question, if cycling, ask how much approximately did the bicycle cost & how much is paid on maintenance*?	
5	From 1 to 5, with 5 being extremely expensive and 1 being not expensive at all, how expensive do you consider this trip's costs to be, on average?	
6	What day(s) and what time do you usually make this trip?	
7	Do you do this trip all year around or in specific seasons? (if seasons, which)?	
8	Do you travel alone on this trip or are you usually accompanied by people?	

B. Trip environment characteristics

1 On average, how congested is the traffic on this trip? (1 – 5, with 1 not congested at all & 5 extremely congested)
2 How hilly is the road you take for this common trip? (1 – 3) 1 = Straight, 2 = slightly hilly, 3 = very hilly
3 How aesthetically beautiful do you consider the urban environment around this trip you make to be? (From 1 to 5, with 1 being not aesthetically beautiful at all and 5 being very beautiful)

4 How polluted do you think the air is, on average, around the road you take when you take this trip (1-5, with 1 not polluted at all and 5 being very polluted)
5 How noisy is the environment around the road you take for this trip? (1-5, with 1 being not noisy at all and 5 being extremely noisy)
6 How would you rate the public transport services of Beirut? (1-5, with 1 being very poor and 5 being excellent, 0 = No idea)
7 How would you rate the infrastructure provision (pedestrian pavements, cycling lanes, roads…) to be along the route you take? (1-5, with 1 being very poor, and 5 being excellent, 0 = no idea).

C. Cycling on this trip

8 Do you own a car? Y/N
9 Do you own a motorcycle? Y/N
10 Do you own a bicycle? Y/N
11 If you own a bicycle, how often do you cycle (1-5, 1 being not often at all, and 5 being very often)
12 Did you ever think of making this trip by bicycle? Y/N
13 If yes, what are the main reasons that have stopped you from making this trip by bicycle?

_____

_____

14 If not, what would be the main challenges you think you will face if you take this trip by bicycle?

_____

_____

15 Would there be, in your opinion, any benefits in making this particular trip by bicycle? (Y/N)
16 If Yes, what are these benefits?

_____

_____

17 What are the top interventions that need to be done that may induce you to start thinking about making this trip by bicycle?

_____

_____

18 How safe from traffic accidents do you think cycling would be on this trip? (1 – 5, one being extremely safe and 5 being not safe all, 0 = no Idea)
19 If you buy a bicycle, do you think theft of the bicycle will be a problem you will face? (1-5, one being not worried at all about theft & 5 being extremely worried about theft).
20 If you cycle on this trip, how strongly do you believe that your personal security will be threatened? (1-5, with 1 being not threatened at all and 5 being extremely threatened)
21 If you cycle on this trip, how do you think your family or friends will think of your choice? (1-5, 1 being they would think it is amazing and 5 they would think it is extremely inappropriate)
22 Do you think Beirut's weather is conducive to cycling? Y/N
23 If yes, do you foresee any season(s) or month(s) in a year when it is not conducive? _____
24 If it is not conducive, how strongly do you think weather will negatively impact the willingness to cycling? (1 – 5, with 1 being not too much and 5 being extremely impactful)

D. Valuation

25 If the municipality of Beirut, in coordination with an international organization that will ensure transparency and high-standards in procurement and specifications of all civil works and interventions, are seriously thinking of adding a monthly tax fee for a period of three years on all apartments residing in Beirut in order to raise the money needed to construct an inter-connected, separate and smooth cycling lane across the city of Beirut, would you be willing to pay to support this initiative? (Y/N - if Yes go to 26, if No go to 27)
26 How much would you be willing to pay, as a tax to the municipality, to fund this initiate, per month over a period of 3 years? _____
27 If you are not willing to pay, why not? (and go to QE.31)
28 Would you also be willing to pay an amount to maintain this cycling lane after 3 years? Y/N
29 If yes, how much would you be willing to pay per month to keep this cycling lane well maintained?
30 If you are not willing to pay for maintenance, why not?

E. Environmental Attitudes (1 being not likely at all and 5 being very likely)

31 How likely are you to put off the lights when you leave the room? (1-5)
32 How likely would it bother you when you see other people littering on the streets? (1-5)
33 How likely are you to use a solid waste recycling facility should one become available near your residence? (1-5)
34 How likely are you to buy a more energy efficiency vehicle on your next purchase? (1-5)
35 How likely are you to buy environmentally friendly products, even if they are more expensive? (1-5)

F. Socio-demographic and miscellaneous

36 Gender (F/M)
37 How old are you?
38 Are you married? (Y/N)
39 How many people live in your household?
40 How many children do you have?
41 Where (which area) do you live in Beirut?
42 What is the highest level of education that you attained
43 Are you employed?
44 What is your monthly average household income?
45 Do you consider yourself to be healthy? (1-5, with 1 not healthy at all and 5 being very healthy)
46 Do you consider yourself to be sportive? (1-5, with 1 not being sportive at all and 5 being very sportive)
47 What is your religion, sect? (prefer not to say an option)
48 How strongly do you think of immigrating from Lebanon? (1-5)

Thank you for your participation

Annex 2. Multicollinearity analysis

We use the following evaluation criteria to assess multicollinearity between the indicated sets of independent variables:

- Correlation analysis: Any correlation between 2 independent variables within the datasets that is more than 0.7 will lead to omitting one of the two IVs. Selecting the threshold of the Pearson's correlation coefficient is subject to different views, depending on the discipline being analyzed. For example, Shrestha (2020) uses a Pearson Correlation coefficient threshold of 0.8.
- Variance Inflation Factor (VIF) When correlation exists among predictors, 'the standard error of predictors coefficients will increase and consequently the variance of predictor's coefficients is inflated. The VIF is a tool to measure and quantify how much the variance is inflated' (Daoud, 2017). The following are the rules that are applied to assess correlation (Daoud, 2017):
    - VIF = 1 (not correlated)
    - 1 < VIF ≤ 5 (moderately correlated) – with other sources indicating a threshold above 3 to raise multicollinearity concerns (Gaskin, 2011). This threshold will be used in the analysis.
    - VIF > 5 (highly correlated)

  VIF is only used for Sets 1 & 4, as they are the ones with multiple predictors.
- Tolerance factor: connected to VIF (its inverse), the tolerance factor can also be used. Anything below 0.1 may have a multicollinearity problem (Grande, 2015).
- Condition Index shows the degree of multicollinearity in a regression matrix. It is also undertaken for Sets 1 and 4 as they have more than 2 predictors. The thresholds commonly used are (Regorz Statistik, 2019 & Kennedy, 2003):
    - > 15, possible multicollinearity problems
    - > 30, very strong indication of multicollinearity

Set 1. Trip Environment Characteristics

Correlation analysis

		TC11. Noise Pollution	TC10 Air Pollution	TC9. Aesthetics
TC11. Noise Pollution	Pearson Correlation	1	.559**	-.142
	Sig. (2-tailed)		<,001	.050
	N	191	191	191
TC10 Air Pollution	Pearson Correlation	.559**	1	-.335**
	Sig. (2-tailed)	<,001		<,001
	N	191	191	191
TC9. Aesthetics	Pearson Correlation	-.142	-.335**	1
	Sig. (2-tailed)	.050	<,001	
	N	191	191	191

**. Correlation is significant at the 0.01 level (2-tailed).

Tolerance factor, Variance Inflation Factor (VIF) & Condition Index

a. Aesthetics as dependent variable

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	VIF
1	TC10 Pollution	.687	1.456
	TC11. Noise Pollution	.687	1.456

a. Dependent Variable: TC9. Aesthetics

Collinearity Diagnostics[a]

Model	Dimension	Condition Index
1	1	1.000
	2	9.507
	3	11.304

a. Dependent Variable: TC9. Aesthetics

b. Air pollution as dependent variable

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	VIF
1	TC11. Noise Pollution	.980	1.020
	TC9. Aesthetics	.980	1.020

a. Dependent Variable: TC10 Air Pollution

Collinearity Diagnostics[a]

Model	Dimension	Condition Index
1	1	1.000
	2	3.941
	3	11.219

a. Dependent Variable: TC10 Pollution

c. Noise pollution as dependent variable

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	VIF
1	TC9. Aesthetics	.888	1.127
	TC10 Pollution	.888	1.127

a. Dependent Variable: TC11. Noise Pollution

Collinearity Diagnostics[a]

Model	Dimension	Condition Index
1	1	1.000
	2	3.677
	3	11.029

a. Dependent Variable: TC11. Noise Pollution

The analysis above seems to indicate that there is a relatively moderate correlation between noise pollution and air pollution, however it is under 0.7 under correlation analysis, VIF of less than 3 and below 15 using the Condition Index. Therefore, we conclude that there no need to deploy any collinearity mitigation measure for Set 1.

Set 2. Public transport quality and Infrastructure provision quality perception

Correlation Analysis

Correlations

		TC12. Public transport quality	TC13. Infrastructure provision quality
TC12. Public transport quality	Pearson Correlation	1	.370**
	Sig. (2-tailed)		<,001
	N	191	191
TC13. Infrastructure provision quality	Pearson Correlation	.370**	1
	Sig. (2-tailed)	<,001	
	N	191	191

**. Correlation is significant at the 0.01 level (2-tailed).

Collinearity Diagnostics[a]

Model	Dimension	Condition Index
1	1	1.000
	2	5.954

a. Dependent Variable: TC12. Public transport quality

Using correlation analysis and Condition Index, as above, there seems to be no serious correlation between public transport quality and infrastructure provision quality.

Set 3. Theft of bicycle and personal security concern

Correlation Analysis

Correlations

		OT3. Theft Concern	OT4. Personal security concern
OT3. Theft Concern	Pearson Correlation	1	.716**
	Sig. (2-tailed)		<,001
	N	191	190
OT4. Personal security concern	Pearson Correlation	.716**	1
	Sig. (2-tailed)	<,001	
	N	190	190

**. Correlation is significant at the 0.01 level (2-tailed).

Using correlation analysis, there seems to be a significant correlation between theft of bicycle concern and personal security concern. To that end, we will leave only 'theft of bicycle' concern in the analysis.

Set 4. Environmental Attributes

Correlation Analysis

Correlations

		EA1. Lights off	EA2. Littering annoyed	EA3. Waste recycling	EA4. EE vehicle purchase	EA5. Expensive Env. Products
EA1. Lights off	Pearson Correlation	1	.336**	.448**	.370**	.314**
	Sig. (2-tailed)		<,001	<,001	<,001	<,001
	N	191	191	191	191	191
EA2. Littering annoyed	Pearson Correlation	.336**	1	.239**	.188**	.197**
	Sig. (2-tailed)	<,001		<,001	.009	.006
	N	191	191	191	191	191
EA3. Waste recycling	Pearson Correlation	.448**	.239**	1	.633**	.592**
	Sig. (2-tailed)	<,001	<,001		<,001	<,001
	N	191	191	191	191	191
EA4. EE vehicle purchase	Pearson Correlation	.370**	.188**	.633**	1	.606**
	Sig. (2-tailed)	<,001	.009	<,001		<,001
	N	191	191	191	191	191
EA5. Expensive Env. Products	Pearson Correlation	.314**	.197**	.592**	.606**	1
	Sig. (2-tailed)	<,001	.006	<,001	<,001	
	N	191	191	191	191	191

**. Correlation is significant at the 0.01 level (2-tailed).

Tolerance, VIF and Condition Index

Coefficients[a]

Model		Collinearity Statistics		Condition Index
		Tolerance	VIF	
1	EA2. Littering annoyed	.938	1.067	4,419
	EA3. Waste recycling	.521	1.919	6,433
	EA4. EE vehicle purchase	.516	1.937	8,359
	EA5. Expensive Env. Products	.558	1.791	15,056

a. Dependent Variable: EA1. Lights off

Coefficients[a]

Model		Collinearity Statistics		Condition Index
		Tolerance	VIF	
1	EA3. Waste recycling	.490	2.041	4,650
	EA4. EE vehicle purchase	.511	1.958	6,464
	EA5. Expensive Env. Products	.560	1.786	8,559
	EA1. Lights off	.786	1.271	11,018

a. Dependent Variable: EA2. Littering annoyed

Coefficients[a]

Model		Collinearity Statistics		Condition Index
		Tolerance	VIF	
1	EA4. EE vehicle purchase	.597	1.676	4,244
	EA5. Expensive Env. Products	.620	1.613	6,458
	EA1. Lights off	.782	1.278	10,217
	EA2. Littering annoyed	.877	1.140	15,065

a. Dependent Variable: EA3. Waste recycling

Coefficients[a]

Model		Collinearity Statistics		Condition Index
		Tolerance	VIF	
1	EA5. Expensive Env. Products	.644	1.552	4,649
	EA1. Lights off	.742	1.348	7,883
	EA2. Littering annoyed	.875	1.143	10,468
	EA3. Waste recycling	.571	1.752	15,188

a. Dependent Variable: EA4. EE vehicle purchase

Coefficients[a]

Model		Collinearity Statistics		
		Tolerance	VIF	Condition Index
1	EA1. Lights off	.734	1.363	4,818
	EA2. Littering annoyed	.877	1.140	8,323
	EA3. Waste recycling	.542	1.843	10,472
	EA4. EE vehicle purchase	.589	1.697	15,212

a. Dependent Variable: EA5. Expensive Env. Products

Using correlation analysis, correlation between waste recycling action, energy efficiency vehicle purchase, and expensive environmental products purchase seems to be moderately correlated to one another. However, the Pearson's correlation coefficient is below 0.7.

The VIF indicates that there are either no or at most modest multicollinearity issues, below the threshold value of 3 indicated. This is the case no matter which of the 5 IVs is used as the dependent variable. Furthermore, the Condition Index is just 15, indicating a possible moderate multicollinearity concern between energy efficiency vehicle purchase and the willingness to purchase environmental products even if they are relatively more expensive. Given that the value is just 15, we conclude that the problem is relative minor and thereby we keep all the set's the independent variables as predictors.

Set 5. Other Variables

Correlation analysis

Correlations

		OV1. Health perception	OV2. Sportive perception
OV1. Health perception	Pearson Correlation	1	.676**
	Sig. (2-tailed)		<,001
	N	191	191
OV2. Sportive perception	Pearson Correlation	.676**	1
	Sig. (2-tailed)	<,001	
	N	191	191

**. Correlation is significant at the 0.01 level (2-tailed).

Health and sportive perception are moderately correlated. However, the Pearson Correlation is below 0.7. Thereby we will keep these two predictors in our analysis.

Annex 3. Multinomial Logistic Regression Parameter Estimates

Parameter Estimates

WTP Multi-nomimial[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
2	Intercept	-1.691	.723	5.477	1	.019			
	[SD1. Gender=0]	.634	.403	2.479	1	.115	1.885	.856	4.149
	[SD1. Gender=1]	0[b]	.	.	0	.	.	.	.
	TC9. Aesthetics	.267	.263	1.025	1	.311	1.306	.779	2.188
	OT3. Theft bicycle concerns	.211	.159	1.760	1	.185	1.235	.904	1.687
	EA3. Recycling efforts	-.060	.148	.164	1	.685	.942	.705	1.258
3	Intercept	-1.759	.888	3.922	1	.048			
	[SD1. Gender=0]	1.439	.476	9.155	1	.002	4.215	1.660	10.705
	[SD1. Gender=1]	0[b]	.	.	0	.	.	.	.
	TC9. Aesthetics	-.409	.381	1.152	1	.283	.664	.315	1.402
	OT3. Theft bicycle concerns	.164	.183	.802	1	.371	1.178	.823	1.687
	EA3. Recycling efforts	.052	.167	.099	1	.753	1.054	.760	1.461
4	Intercept	-3.980	1.050	14.368	1	<,001			
	[SD1. Gender=0]	.440	.488	.815	1	.367	1.553	.597	4.038
	[SD1. Gender=1]	0[b]	.	.	0	.	.	.	.
	TC9. Aesthetics	.042	.319	.017	1	.896	1.042	.558	1.948
	OT3. Theft bicycle concerns	.363	.211	2.949	1	.086	1.437	.950	2.173
	EA3. Recycling efforts	.397	.186	4.536	1	.033	1.487	1.032	2.142
5	Intercept	-4.887	1.442	11.489	1	<,001			
	[SD1. Gender=0]	.713	.675	1.115	1	.291	2.040	.543	7.659
	[SD1. Gender=1]	0[b]	.	.	0	.	.	.	.

	TC9. Aesthetics	1.106	.368	9.044	1	.003	3.021	1.470	6.209
	OT3. Theft bicycle concerns	-.791	.267	8.802	1	.003	.453	.269	.765
	EA3. Recycling efforts	.935	.307	9.273	1	.002	2.546	1.395	4.646

a. The reference category is: 1.

b. This parameter is set to zero because it is redundant.