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Summary

The global trend of rapid urbanisation, with over half of the world's population residing in urban areas, presents a pressing challenge in terms of urban mobility. This growth is, in part, driven by socioeconomic factors and intensifies the demand for urban mobility, resulting in a complex set of challenges for cities worldwide. European cities, in particular, face the dual challenge of meeting increased mobility demands while mitigating issues such as traffic congestion, road accidents, and environmental concerns like air and noise pollution. The transportation sector, responsible for nearly a quarter of greenhouse gas emissions, stands as a significant contributor to these urban challenges.

Within this context, this thesis uses Luxembourg City, the capital of Luxembourg, as a case study to explore the individual-specific travel behaviour factors that influence the shift from regular car usage to cycling. Despite a high bicycle ownership rate among city residents, substantial investments in cycling infrastructure, and most trips being within cycling distance, only 2% of the population regularly uses bicycles.

The primary objective of this study is to delve deeper into travel behaviour changes, specifically the active modal shift towards cycling as the primary mode of transportation. It investigates the extent to which individual-specific travel behaviour factors, along with their interactions, incentivise a shift from cars to bicycles beyond the presence of adequate cycling infrastructure, which is often being prioritised to foster such a shift.

This research adopts a mixed-method approach, combining qualitative and quantitative data. Data collection involved a web-based survey and interviews, and key findings reveal that the modal shift from cars to bicycles is more dynamic than binary, with individuals shifting between these modes, often favouring cycling as their primary transport choice. Moreover, this study underscores that individual-specific travel behaviour factors, in isolation and interaction, significantly influence the decision to shift towards cycling. Key determinants facilitating the modal shift include age, weekly travel distance, the interplay between age and travel distance, perceived time efficiency concerning speed and predictability, and the perceived feelings of pleasure and freedom associated with cycling.

In summary, this study demonstrates that while there is room for improving Luxembourg's cycling infrastructure, individual-specific travel behaviour factors and their interactions play a prominent role in driving the modal shift towards cycling as a primary means of transportation in Luxembourg City. This underscores that the transition to bicycles as the primary mode of transport is not a straightforward binary choice but rather a complex interplay of various factors.

Keywords

Urban mobility, Car dependency, Sustainable transport mode, Soft Mobility, Active Modal shift, Travel behaviour.

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Abbreviations

IHS	Institute for Housing and Urban Development Studies
UN	United Nations
GHG emissions	Green house gas emissions
UNEP-CC	United Nations Environment Programme – Copenhagen Climate Centre
ECA	European Court Of Auditors
PNM 2035	Plan national de mobilité 2035 – National mobility plan 2035
EU	European Union
UNFCCC	United Nations Framework Convention on Climate Change
NACTO	National Association of City Transportation Officials
LCTO	Luxembourg City Tourist Office

Chapter 1: Introduction

1.1 Background and Problem Statement

The rapid global urban trend indicates that half of the world's population currently resides in urban settings, and by 2050, this proportion is expected to increase by 10% (UN, 2018). Driven in part by socio-economic landscapes, this growth intensifies the demand for urban mobility, bringing forth a set of challenges in cities worldwide (UNEP-CCC, 2023).

European cities, in particular, find themselves confronted with enhancing mobility demands while simultaneously reducing traffic, road accidents, and air and noise pollution (Focas & Christidis, 2017). Almost a quarter of greenhouse gas (GHG) emissions originate from the transportation sector, the most significant contributor to noise and air pollution in urban areas (Climate Action, 2023). Notably, European cities, as reported by the ECA in 2019, have a marked dependence on private cars. Eurostat (2022a) reported that in 2020, 87.2% of inland/domestic passenger transport in Europe was carried out by cars, while the remainder of inland/domestic passenger transport was either by public transport, cycling, or walking, highlighting the dominance of cars within Europe. For many years, core cities were designed for cars with the recognition of being the primary and ideal mode of transport (Hasselqvist et al., 2016).

Consequently, a life without a car is hardly imaginable for many people. The majority of European households consider owning at least one car as standard practice, resulting in a habitual reliance on cars for daily transportation (Hasselqvist et al., 2016). However, car usage patterns vary significantly across the EU, as each member state has its unique socio-economic circumstances and approach to car dependency (Focas & Christidis, 2017). Nonetheless, about half of all journeys under 5 km in European cities are still made by car, a clear sign that the cycling culture has not been widely embraced or integrated across most European cities, with the notable exceptions of cities as leading examples like Copenhagen and Amsterdam (Ferrari, 2022).

Therefore, more and more European cities have started to promote more sustainable modes of transportation as alternatives to car usage, thereby encouraging a shift away from conventional mobility patterns (Focas & Christidis, 2017). This shift has given rise to the emergence of the so-called soft mobility, like cycling for transport, which offers various new possibilities to enhance the effectiveness, accessibility, and convenience of urban transportation (Reed, 2019). Bicycles are widely recognised as one of the most sustainable and active transportation options (Fernandez-Heredia et al., 2014; Gösling et al., 2016; Pucher & Buehler, 2017), offering cost-effectiveness, health benefits, and reduced environmental impact, while efficiently utilising urban spaces (European Commission, 2023b). Compared to cars, cycling infrastructure such as bike lanes and parking facilities occupy less urban space, mitigating issues related to excessive use of space caused by wide roads and parking areas (Schollaert & Dekoster, 1999). Therefore, a higher proportion of non-motorised transportation modes, such as cycling, contributes to creating more attractive urban environments with increased public space and reduced noise, congestion, and air pollution (Rietveld & Daniel, 2004).

Given these benefits, various initiatives are being undertaken at local, national, and supranational levels across Europe to promote the regular use of cycling as a means of transportation and encourage a shift away from daily car use. As an illustrative example, the

recently adopted European Cycling Strategy, introduced in February 2023, sets forth an ambitious objective of doubling cycling rates by the year 2030 (Brennan, 2023). This goal is to be achieved through the establishment of enhanced cycling infrastructure that prioritises the needs of cyclists and includes, among others, the implementation of continuous and separated cycling lanes and/or cycle paths and existing traffic lights for cyclists (Brennan, 2023).

Cycling infrastructure, which refers to existing physical cycling facilities, encompasses the development and provision of dedicated facilities for cycling, primarily in the form of cycle lanes, and is essentially designed to enhance the position of cyclists in relation to other road users, particularly motorised vehicles (Berghoefer & Vollrath, 2022). Among others, the implementation of continuous and separated cycling lanes and/or cycle paths and existing traffic lights for cyclists are, therefore, often being prioritised (Brennan, 2023). An adequate cycling infrastructure, comprising more than just cycle lanes, has thus been seen as essential to effectively promote cycling as a viable alternative and sustainable mode of transportation and thereby encourage a shift towards cycling for transportation (Fernandez-Heredia et al., 2014). While academic research has compellingly demonstrated the essential role of adequate cycling infrastructure in fostering a shift from cars to bicycles (Sulikova & Brand, 2021), existing research nevertheless also suggests that it alone may not be sufficient in driving a significant modal shift (Moudon et al., 2005, Sulikova & Brand, 2021). Therefore, to effectively promote this soft mode of transportation, it is crucial to prioritise the needs of users and provide them with readily available and accessible alternatives to their current mobility practices (Climate Action, 2023). This underscores the need for a more comprehensive exploration of the various factors influencing modal shifts.

A holistic understanding of individual-specific travel behaviour factors is, therefore, imperative. This includes examining socio-demographics, trip-related factors, and perceptions affecting a change in travel behaviour (Hanson & Hanson, 2016). Perceptions encompass specific socio-psychological aspects that shape how individuals subjectively perceive cycling and their cycling environment (Fernandez-Heredia, 2014). Similarly, trip factors encompass individual travel attributes, such as travel distance and travel purposes, playing a significant role in shaping transportation preferences (Fernandez-Heredia, 2014). Whereas socio-demographic factors are associated with the specific characteristics of individuals or households engaged in regular cycling (Ma et al., 2020).

1.2 Relevance of the Research Topic and Research Objectives

This study aims to investigate the set of individual-specific factors that foster a transition from regular car usage to cycling, focusing on the context of Luxembourg City, the capital of the Grand Duchy of Luxembourg. Despite its small size, the country boasts the highest motorisation rate among EU member states (European Education Area, 2022; Eurostat, 2021) and has recently recognised the role of cycling in fostering a more people-friendly environment, particularly within urban areas like Luxembourg City (PNM 2035, 2022).

The case of Luxembourg (City) stands out due to significant government investments and ongoing efforts to improve Luxembourg's cycling infrastructure to bolster its bicycle modal share of 2% (PNM 2035, 2022). However, it remains uncertain whether enhancing cycling infrastructure alone will encourage a larger portion of the populace to shift towards primarily using bicycles for transport. Given the limited available data on cycling mobility in cities with low cycling rates, this study seeks to expand upon existing literature by examining which individual-specific factors, and their interrelation, have influenced a small minority (less than

2%) of residents in Luxembourg City to opt for bicycles as their primary mode of transport over cars (Barberan et al., 2017).

Following the above, the question arises whether and the extent to which individual-specific travel behavioural[1] factors, as well as their respective interrelationship, play a role in fostering a sustained and voluntary modal shift. Moreover, this inquiry extends to identifying individual-specific perceived barriers that must be surmounted for this modal shift to take root.

Therefore, the primary objective of this study is to examine, beyond the acknowledgement that adequate cycling infrastructure is necessary, which individual-specific travel behavioural factors are relevant for promoting a modal shift from regular car usage to regular cycling, and to quantify their influence.

The study aims not only to uncover the individual-specific travel behaviour factors driving a successful shift towards cycling as a primary mode of transportation but will also seek to propose policy recommendations[2] that can help reshape the urban design, veering it away from car-centric paradigms and towards a forward-thinking and sustainable transportation paradigm.

1.3 Main research question and research sub-questions

How do individual socio-demographics, trip factors and perceptions, and their respective interactions foster an active modal shift from car use to regular cycling?
To provide a substantial answer to this question, the following sub-questions will be considered:

1. Which socio-demographic and trip factors affect the decision of residents in Luxembourg City to choose cycling over cars as their primary mode of transportation?
2. Which perceptions influence most strongly the willingness of Luxembourg City's residents to cycle regularly instead of driving, and what are the main perceived safety barriers that regular cyclists must overcome?
3. Which connections/links exist between individual perceptions, socio-demographic, and trip factors in relation to their influence on the modal shift from cars to bicycles?

1.4 Reading guide

The study is structured into five chapters, each serving a distinct purpose to provide a holistic understanding of the research's scope and outcome. In *Chapter 2*, an in-depth literature review explores key concepts and theories, paving the way for the conceptual framework. *Chapter 3* offers insights into the study's methodology, detailing the research design, data collection methods, and analysis techniques. *Chapter 4* is dedicated to presenting and discussing the collected data. It unpacks findings related to individual-specific travel behaviour factors and their interactions with regard to the modal shift. *Chapter 5* serves as the concluding chapter, offering a comprehensive synthesis of the study's findings in relation to research objectives and existing literature. It explores implications for sustainable urban mobility and concludes with a succinct summary, addresses the limitations, suggests potential directions for future research and proposes policy recommendations.

1 Namely, individual perceptions, socio-demographic factors, and trip characteristics

2 Please note that these recommendations will be modest and aligned with the research's scope.

Chapter 2: Literature Review

The aim of this chapter is to elucidate the most relevant concepts and theories related to travel behaviour within the context of the "modal shift". The literature structure is as follows: The first section will define the term "travel behaviour". The second section will focus on the notion of the "modal shift" and enumerate the different modal shift dynamics towards a more sustainable transport mode, with a more in-depth focus on the modal shift from cars to bicycles. The third section will elaborate on the different determinants that influence or contribute to the decision to use the bicycle as a mode of transportation. The last sections will delineate the study's conceptual framework and working hypotheses based on the various concepts and theories relevant to the transition towards increased bicycle use.

2.1 Travel behaviour

At its core, travel behaviour refers to the complex decision-making processes undertaken by travellers and encompasses a spectrum of travel-related choices, notably the selection of a specific transportation mode (Meng et al., 2019).

When delving deeper, travel behaviour analysis integrates insights from diverse disciplines (Dijst et al., 2008). A prevailing approach involves employing statistical methods within a utility-maximization framework, assuming that preferences are shaped by sociodemographic attributes, ownership, and skills (Dijst et al., 2008). However, it is important to acknowledge that this framework might oversimplify choices by disregarding situational dynamics, a viewpoint emphasised by social psychologists (Dijst et al., 2008). Geographers and sociologists further highlight the omission of socio-material contexts, emphasising the influence of interactions between individuals, objects, and social settings (Dijst et al., 2008). These contexts underscore the intricate interplay between individuals, their environments, and societal structures (Dijst et al., 2008). As a result, a comprehensive understanding of travel behaviour demands a multidisciplinary approach, combining economic, geographical, and psychological factors (Van Wee et al., 2013).

Gouglias et al. (2020) eloquently capture this complex concept, asserting that "*Travel behaviour is about how to go about deciding how to do things*". This statement implies that travel behaviour extends beyond the mere selection of one transport mode over another. Instead, it delves into comprehending the underlying motivations that prompt an individual's choice to shift towards an alternative mode of transportation. As such, the concept introduces the notion of travel behaviour change, which refers to the voluntary change in a traveller's behaviour in terms of mode choice (Davies, 2012). In the context of this research, the change in travel behaviour pertains to travellers' voluntary shift in their transportation mode preferences, aligning with the broader trend in the transportation sector commonly referred to as "modal shift".

2.2 The modal shift towards a more sustainable transportation mode

In the transportation sector, a "modal shift" refers to the transition from one mode of transportation to another more ecologically sustainable alternative. According to the UNFCCC (2020), this "transition", "shift", or "switch" denotes a persistent modal change towards more sustainable means of transportation, like walking, cycling, public transportation (i.e., buses, trains, trams, and metro) or utilising electric transportation modes, (i.e., e-scooters, e-bikes, e-vehicles) for single or multiple trips (Ma et al., 2020). The availability of transit initiatives in a

specific area play, therefore, a crucial role in influencing a modal shift (Kroesen, 2017; Sun et al., 2020).

The concept of "active modal shift"[3] or “shift towards soft mobility” pertains to the transition from using a car toward the use of an active and sustainable mode of transportation, specifically bicycles, including both conventional (c-bike) and electric bicycles (e-bike) (Ma et al. 2020). On the other hand, the term “active” or “active mobility” denotes the physical human exertion involved in using bicycles as a mode of transportation (Demers, 2015). When individuals make such a shift[4] towards more sustainable and active transportation modes, like cycling, it can lead to changes in their daily activities and the locations where these activities are performed (Villhelmson, 2007; Gärling et al., 2007). Therefore, shifting towards cycling requires individuals who typically use gasoline vehicles to adjust their travel patterns and behaviours (Steg, 2006).

To gain a more comprehensive understanding of the modal shift patterns among individual or group travellers, it is essential to analyse the factors influencing the selection of their preferred alternative individual travel modes (Faboya et al., 2020). By identifying these individual-specific travel behaviour factors[5], appropriate interventions can be developed to promote behavioural changes and encourage the shift towards sustainable travel modes (Faboya et al., 2020).

2.3 Factors influencing individual bicycle use

Previous research has identified numerous factors that influence the use of bicycles, with “bicycle use” being a subset of the modal shift. Within the context of the modal shift, bicycle use refers to the use of bicycles as a primary mode of transportation. Consequently, increased bicycle use for transportation can contribute to an active modal shift, which is measured by assessing the frequency of bicycle journeys for transport, specifically for utilitarian purposes like commuting to work, school, running errands[6], or meeting daily travel requirements (Winters et al., 2007; Rodriguez-Valencia et al., 2021). Utilitarian cyclists, also referred to as regular cyclists, encompass individuals who predominantly employ cycling as a means of transportation for utilitarian, meaning practical purposes, facilitating regular travel between distinct locations (De Geus et al., 2014). Nevertheless, the criteria used to define “regularity” in cycling exhibits notable divergence across various studies. Some studies define regular cyclists based on the weekly distance individuals cover by bicycle, while others determine it by the frequency of bicycle use within a week. For instance, Prati et al. (2019) denote cyclists as “regular” cyclists if they cycle at least once a month, whereas Daley & Rissel (2011) categorise regular cyclists as those who engage in cycling at least twice a week. In the context of this study, a “regular cyclist”[7] or “utilitarian cyclist” or “modal shifter” is defined as an individual who undertakes cycling for a minimum of four weekly round-trip journeys and primarily relies on the bicycle as their primary mode of transportation for utilitarian purposes. The four-trip threshold is set as it represents the average number of days in a week and aligns with Luxembourg’s law allowing one remote workday out of the workweek days (Toussaint, 2022).

3 In the following paragraphs/chapters an active modal shift will simply refer to as modal shift

4 Transition or Shift

5 Such as perceptions, trip and socio-demographic factors

6 Any routine activities

7 Utilitarian cyclist/Modal shifter

Heinen et al. (2010) highlight that objective/physical factors associated with the natural environment, such as weather conditions and the urban or rural landscape, can significantly influence bicycle usage. Cyclists are generally more affected *by day-to-day weather variations* than automobile drivers and public transportation passengers (Schoner et al., 2015). Seasonal changes, like cold and snowy winters in northern and central Europe, can lead to fluctuations in cycling levels throughout the year (Pritchard et al., 2019).

Additionally, the *topography* of an urban area and its surroundings can significantly influence individuals' choice to use bicycles as their primary mode of transportation (Dill & Voros, 2007). Specifically, the presence of uphill and downhill altitude differences along commonly travelled routes may affect the levels of utilitarian cycling (Nematchoua et al., 2020). Hilly urban areas may thus be less appealing for utilitarian cycling compared to flat urban areas, such as in the city of Amsterdam, due to the physical demands and additional effort required when cycling uphill (Parkin & Rotherham, 2010; Heinen et al., 2010). According to Behrendt et al. (2021), the use of e-bikes is widely accepted as a facilitator for overcoming uphill gradients. As such, in cities like Liège, with various hillsides, residents prefer using e-bikes for distances exceeding 4 km to tackle altitude differences (Nematchoua et al., 2020).

Another key factor influencing individual bicycle use, and which has been extensively studied, is the connection between the *built environment* and travel behaviour (Heinen et al., 2010). The existing body of literature emphasises that an adequate cycling infrastructure is essential to enable and promote cycling as a mode of transportation. This includes the provision of various bicycle facilities, such as separated or dedicated bicycle lanes (bicycle tracks) or paths that are physically separated from motorised vehicles and pedestrians, and secure bicycle storage and parking facilities (Pucher & Handy, 2010). Bicycle paths are dedicated paths for cyclists, usually located in residential areas, while bicycle tracks, also known as separated bicycle lanes, provide cyclists with exclusive lanes on transport roads, separated from motorised vehicles and sidewalks, by bollards or raised medians (Feuerberg, 2012; NACTO, 2014). According to Pucher & Buehler (2008), countries with well-developed and adequate cycling infrastructure, like in the Netherlands and Denmark, tend to have higher cycling modal split shares and improved bicycle safety.

According to a study conducted by Pritchard et al. (2019) in Oslo (Norway), a city experiencing increasing cycling levels, utilitarian cyclists prefer taking a slight detour to use a safe cycling route, namely a separate bicycle path rather than a marked/painted bicycle lane on a regular road (Bashford, 2021). However, in a study conducted by Aultmann-Hall et al. (1997) in Guelph (Canada), where cycling levels are relatively low, most utilitarian cyclists prefer using bicycle lanes adjacent to the roadway to avoid detours that could impact their travel time.

Furthermore, Mertens et al. (2007) found that areas with fewer separated bicycle lanes are associated with lower likelihoods of residents cycling for transportation purposes, suggesting that the absence of *safe cycling routes*[8] can impact cycling levels. Providing separate lanes along busy routes and intersections can furthermore be considered fundamental for increasing utilitarian cycling levels and enhancing safety (Pucher & Buehler, 2008; Pritchard et al., 2019). Nevertheless, according to Taylor and Mahmassani (1996), some regular cyclists do not prefer separated bicycle lanes and instead opt for wider, shared lanes for vehicles and bicycles.

Additionally, Heinen et al. (2010), Pritchard et al. (2019) and Dill and Voros (2007) noted the importance of establishing *continuous cycling infrastructures* along roads, as segments lacking

8 Bicycle tracks or bicycle paths

cycling amenities can discourage cycling, particularly for utilitarian purposes. For example, in Portland, Oregon, where cycling levels are relatively low, residents living in well-connected areas with bicycle lanes are likelier to cycle for utilitarian purposes (Dill & Voros, 2007). Additionally, Stinson and Bhat (2004) emphasise that the presence of nearby adequate bicycle facilities, such as safe parking facilities, contributes to an increase in the proportion of cyclists. In relation to bicycle facilities, Hunt & Abraham (2007) report that secure parking is more important than the availability of showers at the destination, yet both facilities have a significant impact on the attractiveness of cycling.

Generally, urban policies promoting active cycling often prioritise physical infrastructure initiatives, following the adage of "build it, and they will come" (Snaije, 2022). However, Heinen et al. (2010) argue that increased cycling levels may not solely result from improved physical infrastructure but rather from more frequent cycling itself, which in turn promotes the development of cycling infrastructure. This could lead to a positive feedback loop, where heightened cycling frequency and the advancement of infrastructure might mutually reinforce each other, generating beneficial outcomes and potentially shaping an individual's choice to transition to cycling as their primary mode of transportation (Belabas & Gerrits, 2017).

It should be noted that the enhancement of physical cycling infrastructure does not always align with *individual-specific perceptions* favouring a shift from cars to bicycles as the primary mode of transport (Snaije, 2022). Similarly, Gatersleben and Appleton (2007) highlight that improved bicycle infrastructure alone may not guarantee an increase in cycling levels. While structural factors related to a city's adaptation to cycling are frequently emphasised as leading to a modal shift from cars to bicycles, they may not be the sole determinants for fostering a modal shift (Fernandez-Heredia et al., 2014).

The concept of "human infrastructure"[9] by urban anthropologist Dr Lugo becomes crucial, suggesting the consideration of *individual-specific factors*, including *perceptions, trip factors* and *socio-demographics*, that influence travel decisions and thus may play a role in modal shift decisions (Snaije, 2022; Faboya et al., 2020).
Therefore, individuals' *perceptions* should be considered within the framework of the modal shift, as these encompass various socio-psychological indicators such as knowledge, habits, beliefs, attitudes, concerns, emotions, perceived safety levels and barriers (Clayton & Manning, 2018). Several studies indicate that attitudes strongly influence mode choice and, thus, bicycle usage for transport (Handy et al., 2005; Gatersleben & Appleton, 2007; Van Acker et al., 2010; Heinen et al., 2011). According to Heinen et al. (2010), the notion of *attitude*, in this context, refers to an individual's anticipation of all the outcomes associated with engaging in cycling for utilitarian purposes, such as commuting or running errands, and the personal and social values attached to those outcomes.

These attitudes towards cycling may encompass a wide range of socio-psychological attributes, including time predictability, convenience, environmental and health benefits, among others (Barberan & Monzon, 2016; Gatersleben & Appleton, 2007). For instance, Gatersleben and Appleton's study in 2007 stated that cycling past stationary traffic is one of the most encouraging experiences for those who want to arrive at work on time. Similarly, in Madrid (Spain), where cycling levels are low, Fernandez-Heredia (2014) found that the primary factors influencing bicycle use are time efficiency in terms of time sensitivity, and environmental

9 This concept was first introduced by urban anthropologist Dr. Lugo, emphasizing the importance of looking beyond the mere built environment and to focus more on the “social attitudes and knowledge networks”, namely individual-specific factors, in shaping mobility (Snaje, 2021).

considerations, such as noise and air pollution. Moreover, studies suggest that regular cyclists generally have more positive attitudes towards cycling in general, with utilitarian cyclists who travel longer distances exhibiting more favourable attitudes towards (longer) cycling distances on average (Gatersleben & Appleton, 2007; Heinen et al., 2011).

Beyond the notion of "attitudes", perceived *social values (social norms)* may also influence an individual's travel behaviour, as their social network, relatives, friends, and neighbourhood can play a role in their regular travel patterns (Van Acker et al., 2010). Supportive social environments from relatives or friends have been found to positively impact bicycle usage for transportation (Titze et al., 2008; De Geus et al., 2008). Bamberg and Smidt (1994), as cited in Heinen et al. (2010), nevertheless found that social support does not significantly affect people's choice to use bicycles for transportation. Also, *personal values* associated with cycling tend to influence bicycle use, such as feelings of fun, relaxation, or physical well-being that come with cycling (Barberan & Monzon, 2016; Abrahamse et al., 2009).

Nonetheless, utilitarian cyclists may also face psychological (personal) and physical *perceived* safety barriers that can hinder, rather than increase, their cycling frequency (Useche et al., 2019). According to Fraboni et al. (2022), safety concerns and perceived risks associated with cycling represent significant deterrent factors. In Poland, where the modal bicycle share is relatively low, regular cyclists tend to perceive road safety more negatively due to inadequate bicycle regulations and unruly behaviour of car drivers (Biernat et al., 2018). The perceived risk of crashes is another common barrier that impacts bicycle transportation (Useche et al., 2019). The natural environment and built environment can also be considered as perceived safety barriers that influence bicycle usage for transportation (Félix et al., 2019). For example, the cumulative number of hills and changes in altitudes on regular cycling trips might be perceived as environmental barriers to cycling (Rietveld and Daniel, 2004; Heinen et al., 2010). According to Dill and Voros (2007) and De Kruijf et al. (2021), adverse weather conditions, especially during cold, windy or rainy periods, are frequently perceived as a barrier to cycling. Studies support the idea that distinct categories of cyclists exist, each characterised by differing viewpoints and preferences concerning their perceptions and the respective importance of these factors (Axhausen & Smith 1986; Hunt & Abraham, 2007; Biernat et al., 2018).
Moreover, perceptions may also vary based on/ in relation, or in association, with socio-demographic factors (Dill & Voros, 2007). For instance, in surveys from the US and Australia, where cycling levels are relatively low, reveal that men generally have slightly more positive attitudes towards cycling than women (Garrard et al., 2012).

Socio-demographic factors and *trip factors* emerge as common categories of determinants in numerous studies exploring travel behaviour, as these factors hold the potential to substantially influence an individual's capacity and inclination towards transitioning towards cycling as a primary mode of transportation (Fraboni et al., 2022; Strömgren et al., 2020; Fernandez-Heredia et al., 2014).

Socio-demographic factors include, among others, gender, age, place of residence, employment status, level of cycling experience, and ownership of cars or bicycles (Hunt & Abraham, 2007; Ma et al., 2020; Hook et al., 2023). Research by Fernandez-Heredia et al. (2014) and Heinen et al. (2010) indicate that bicycle ownership is positively correlated with bicycle use. Furthermore, Pucher and Buehler (2008) indicated a decline in cycling rates with age, particularly in countries with lower cycling levels. In countries like the UK with relatively low cycling levels, men tend to cycle for utilitarian purposes more frequently than women, while in countries with high cycling levels like the Netherlands, Denmark, and Germany, women cycle as frequently as men (Aldred et al., 2016; Pucher & Buehler, 2008).

On the other hand, *trip factors* encompass, among other indicators, travel distance and trip purpose (Fernandez-Heredia et al., 2014). Several studies indicate that distance plays a significant role when considering cycling (Barberan & Monzon, 2016). Heinen et al. (2010) state that shorter distances are associated with increased cycling for transport, whereas increased trip distances reduce its likelihood. However, Piatkowski's study (2015) found that an increased trip distance is associated only with a modest reduction in the likelihood of regularly using the bicycle for transportation.

To conclude, the decision to use the bicycle for transport purposes is shaped by multiple factors (Heinen et al., 2010), underscoring the intricate nature of the decision-making process where various interconnected elements are considered when opting for a transportation mode among available alternatives (Heinen et al., 2010; De Witte et al., 2013).

2.4 Conceptual Framework

The study explored various concepts and theories relevant to the transition towards increased bicycle use, as discussed in the literature review presented earlier. Based on this review, a conceptual framework (Figure1) has been constructed to illustrate the interconnectedness between individual-specific factors, namely the combination of perception, trip factors and socio-demographic elements in relation to the built and natural environment, and their impact on the increase in bicycle usage for transportation purposes. These individual-specific factors significantly influence the decision-making process, ultimately influencing the individual's choice to regularly use bicycles as a mode of transport.

The presence of more favourable individual-specific factors increases the likelihood of greater bicycle usage for transportation, thereby facilitating a modal shift towards cycling as a primary means of transportation. Furthermore, as bicycle use increases, it may stimulate the development and enhancement of cycling infrastructure, subsequently reducing perceived barriers to cycling and creating a positive feedback loop (Heinen et al., 2010).

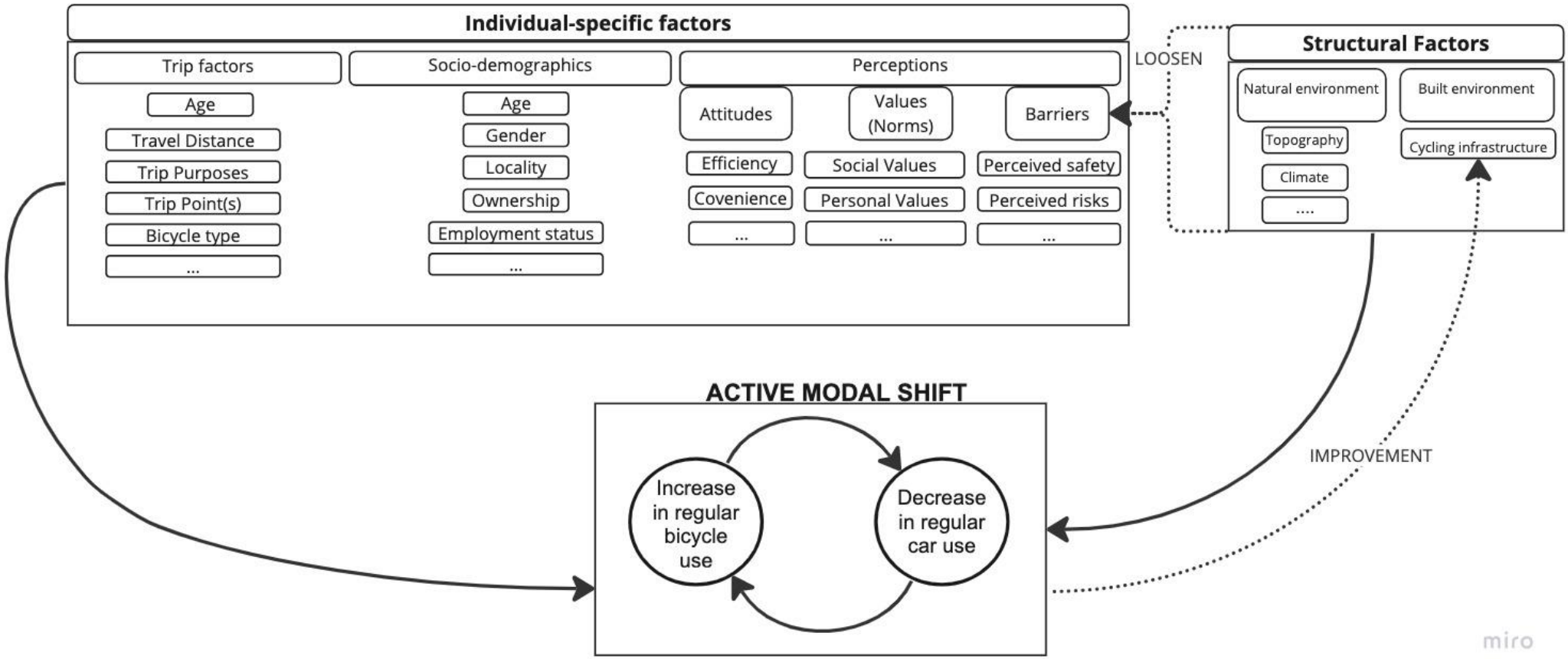


Figure 1: Conceptual framework

(Source : Author, 2023)

2.5 Working Hypotheses

Following the above, the central working hypothesis guiding this research asserts that, beyond the necessity of adequate cycling infrastructure, individual-specific travel behaviour factors, encompassing favourable perceptions, socio-demographic attributes, and trip-related characteristics, significantly contribute to facilitating an active modal shift.

H1: Building upon the observation by Pucher and Buehler (2008) that increased age correlates with a decline in bicycle use, especially in countries with low cycling levels, the author expects that younger populations are more likely to undergo an active modal shift.
H2: Based on Barberan and Monzon's (2016) research highlighting the feeling of relaxation whilst cycling tend to influence bicycle use, the author expects that individuals who feel free from traffic stress when cycling are more likely to undergo an active modal shift.
H3: Based on Garrard et al.'s (2012) research highlighting that men generally have slightly more positive attitudes towards cycling than women, the author expects that men perceive more positive attitudes than women.

Chapter 3: Research design and methodology

3.1 Research type and research strategies

The research design employed in this study is exploratory, and the selected research methodology was a case study approach (Babbie, 2013; Van Thiel, 2014). Specifically, the study extensively focused on the behavioural aspects to investigate the extent to which various individual-specific factors, including socio-psychological, socio-demographic and trip factors, besides structural factors, have contributed to and influenced a change in travel behaviour in a sample of 70 respondents[10]. The main objective was to examine the transition, the active modal shift, from regular car drivers to regular cyclists among a limited number of residents in Luxembourg City. The primary unit of analysis in this research consisted of individual people, specifically Luxembourg City residents, who actively underwent this modal shift.

The main research method for collecting empirical data for the present study consisted of a multi- and mixed-method approach combining a web-based survey and six individual interviews with public representatives (Creswell, 2013). This mixed-method approach proved valuable in acquiring a comprehensive understanding of the diverse and interconnected factors that influenced the intricate decision-making process of transitioning from one transportation mode to a more sustainable and soft transport mode. Regarding the study's design, a cross-sectional approach was employed, which involved collecting data at a single point in time from a particular target group/population, namely Luxembourg City's modal car-bicycle shifters (Babbie, 2013; Bryman, 2012).

The use of the web survey strategy, an increasingly popular strategy, allowed for a random selection of cyclist residing in Luxembourg City who regularly uses the bicycle as a mode of transportation instead of a car to voluntarily participate to portray and generalise most accurately the findings beyond the sample (the small share of regular cyclists in Luxembourg City) (Babbie, 2013; Creswell, 2013). Moreover, this strategy allowed for collecting substantial data from a limited focused group, highlighting the research strategy's efficiency (Van Thiel, 2014).

The interview strategy was employed to gain a deeper and more detailed insight into the personal motivations for transitioning from car to bicycle and the proposed measures for Luxembourg City's potential "Verkehrswende" (Creswell, 2013). The author specifically interviewed public representatives In Luxembourg City who made such a car-to-bicycle modal shift.

3.2 Sample size, selection, and limitations

According to the PNM 2035, the bicycle modal share in Luxembourg and within Luxembourg's capital is 2% (PNM 2035, 2022). Thus, out of the 132 778 inhabitants in Luxembourg City, roughly 2 655 residents use bicycles as a regular mode of transportation in the country's capital (VDL, 2023a). As the purpose of this study was to gather data to gain better insights into the personal motivations influencing the preference shift from motorised vehicles to regular cycling, a representative statistical sample size of 385 respondents would suffice, assuming that all 2 655 residents have made the switch from car use to regular cycling.

[10] It is important to note that the minimum age to drive a car in Luxembourg is 18 (Government of Luxembourg, 2023). As a result, there were no respondents younger than 18 years old.

Due to the relatively low cycling share in Luxembourg City, accounting for only 2%, it was, nevertheless, particularly challenging to reach the specific group of individuals who were part of the 2% but had exclusively switched from cars to bicycles. The difficulties were compounded by time constraints during data collection and a low response rate, mainly due to the summer holiday season and local elections. As a result, the study managed to gather only 99 recorded responses. Out of the 99 responses, 29 respondents did not complete the survey and were considered invalid for data analysis. The remaining 70 respondents formed the basis of the data analysis. Among these, there were two main distinct groups based on their cycling frequency: 55 were classified as modal car-bicycle shifters[11], while the remaining 15 were categorised as non-modal shifters[12]. Considering the sample size of 70, Luxembourg City's cycling residents size of 2 655, and a 95% confidence level, the study has a margin of error of 22.35%[13]. While this research seeks to examine the individual-specific travel behaviour factors and their combination, this notable margin of error reflects the study's exploratory nature, suggesting that results should be approached regarding this preliminary context.

3.3 Data collection methods

This study adopted a mixed-method approach, which involves combining both qualitative and quantitative data collection methods for primary data (Creswell & Creswell, 2018). The researcher chose this approach under the assumption that incorporating various types of data would lead to a more comprehensive understanding of the research problem than using only qualitative or quantitative data, as each method offers distinct and complementary information (Creswell, 2013). The mixed-method approach was thus considered to provide a more robust foundation for analysis and conclusions.

The primary data collection for this study mainly consisted of quantitative data gathered through a web survey. The survey was conducted using the web-based platform Qualtrics and aimed to quantify the personal characteristics and incentives that influence a shift towards regular cycling as a mode of transportation. The survey was accessible through a URL hyperlink and offered respondents the option to complete it in one of four languages: Luxembourgish, French, German, or English, depending on their preference. The author personally prepared/transcribed all four versions of the survey to maximise the number of respondents reached.

To ensure the survey's integrity and usability of the questions while avoiding biases, a preview version (test version) was initially tested and adjusted as necessary before the final survey was published. The survey structure consisted of 30 questions subdivided into three sections: 1) usage patterns, 2) personal motivations and perspectives for bicycle use, and 3) personal information. The estimated time to complete the anonymized survey, as calculated by Qualtrics, was approximately 8 minutes and 2 seconds.

The design of the online survey for this study followed a stated-preference approach, which incorporated four different question formats: multiple-choice questions, Likert-scale questions, two open-text questions, and rank-order questions. This survey design allowed respondents to express their preferences honestly without burdening them with excessive workloads (Cherchi

11 Regular cyclists, those who use the bicycle at the least 4 times back and forth per week

12 Non-regular cyclists, those who use of the bicycle less 4 times back and forth, thus less than 8 times per week

13 Margin of error 1.96 * sqrt [((n/2655)*(1- (n/2655))/70)]

& Hensher, 2015). By using a mix of question formats, the survey aimed to gain insights into individual preferences and motivations for shifting from regular car use to cycling.

To distribute the online survey, several social media platforms were utilised, including Facebook and Instagram. Additionally, distribution was carried out through LinkedIn, and the author reached out to relatives and friends who have switched to cycling from regular car use. The snowballing technique was applied to reach a wider and more diverse target audience (Bryman, 2012). On Facebook, the survey post was re-shared seven times, and the ProVëlo[14] association also published it. Furthermore, initial participants forwarded the survey's URL hyperlink multiple times via email.[15] These distribution methods helped in reaching out to a larger and more diverse group of potential respondents, enhancing the survey's representativeness and validity.

Regarding the selection of survey respondents, only cyclists residing in Luxembourg City across its 24 different districts were approached. The criteria for selection included being a resident of Luxembourg City and having transitioned from regular car use to cycling as their mode of transportation.

For the individual interviews, the author employed a qualitative data collection method using semi-structured interviews, with a pre-prepared interview manual serving as a guideline during the interviews (Van Thiel, 2014). In total, six interviews, comprising three males and three females, were conducted in Luxembourgish, four of which were face-to-face, and the remaining two were conducted virtually due to time constraints. The selection criteria were similar to those used in the survey, namely residing in Luxembourg City, having transitioned from regular car use to cycling as their mode of transportation, and being an elected representative of Luxembourg. The interview questions were designed to capture the participants' perspectives as individuals and as elected representatives. Additionally, the questions aimed to gain an in-depth understanding and nuanced insights into the motivations and perspectives of Luxembourg's City's elected representatives, as well as the policy initiatives towards promoting cycling as a mode of transportation.

In addition to the primary data collection, this research also incorporated secondary data from various sources. The main focus of the secondary data was on information retrieved from the Luxembourg national mobility plan published in 2022 (PNM 2035, 2022). This plan provided valuable insights into the country's long-term mobility strategies and policies.

Moreover, the research made use of bicycle monitoring data obtained confidentially from the Transport Department of the City of Luxembourg and data from the 2020 Mobility Survey, which was also shared confidentially by the Ministry of Transport and Public Works, and the Luxembourg City municipality's 2022 survey "Onse Mobilitéitsplang fir muer"[16].
To further bolster the study's validity, the author referred to relevant websites and academic papers. These external sources were critical in validating and corroborating the primary and secondary data, adding credibility to the research findings.

14 ProVëlo is a non-profit association established in Luxembourg, with the aim to improve cyclists' safety and the overall cycling experience in Luxembourg (ProVëlo, n.d)

15 A significant portion (67.14%) of the survey responses were obtained through a private link, while the remaining responses were collected through a social media link.

16 Luxembourg City's "Onse Mobilitéitsplang fir muer" (Our Mobility Plan for Tomorrow) is a strategic initiative aimed at further developing urban mobility in response to the city's growth and the challenges of climate and environmental protection.

3.4 Data analysis methods and Limitations

The generated data from the web-based survey was imported into Microsoft Excel, transformed from raw to formatted data, and categorised into distinct variables based on perceptual, socio-demographic, and trip-related indicators. The data set was then imported into STATA. A multiple log-level regression model was chosen as the inferential statistical approach for the causal exploratory analysis. This model aimed to explain the interrelation between the dependent binary variable, the modal shift, and a compilation of continuous and categorical independent variables.

To ensure the reliability and validity of the findings, each logistic regression model was subjected to several assumptions, verifying compliance with necessary inferential conditions. The dataset conformed to the requisite statistical assumptions for the analysis. First, it was confirmed that the dependent binary variable used in the logistic regression model exhibited a binary nature. Additionally, the linearity assumption of the logistic model was thoroughly examined and validated by considering the squared terms of the variables within the model, alongside the assessment of their significance levels.

To ascertain the presence of multicollinearity among the independent variables, VIFs[17] were employed. The outcome of this assessment revealed the absence of significant multicollinearity, ensuring the reliability of our model's coefficients. Furthermore, the Hosmer-Lemeshow test[18] rigorously assessed the model's appropriateness and goodness-of-fit. This evaluation demonstrated that the model effectively and accurately depicted the intricate relationship between the predictor variables and the ultimate outcome.

However, the exploratory inferential analysis unveiled possible outliers within the dataset, evident through the examination of deviance residuals. These outliers could be attributed to the relatively modest sample size (n=70) obtained for this study. It is noteworthy that while these outliers may introduce complexities in adhering to certain statistical assumptions, they also have the potential to offer distinctive insights. This is particularly pertinent due to the study's exploratory nature, which seeks to unveil intricate interrelations and patterns inherent within the data.

Moreover, the survey data was harnessed to construct frequency cross-tabulations and employ diverse chart types to comprehensively outline the distinctive attributes of the participants as well as the specifics of their individual trips.

Furthermore, the study's robustness was strengthened through a series of six interviews, each spanning a duration of approximately 20 to 35 minutes. These interviews were recorded and subsequently transcribed[19], ensuring a high level of precision and fidelity to the original conversations. Employing Atlas.ti, the transcriptions underwent a rigorous coding process to establish distinct codes and subcodes. These coding categories were aligned with the underlying research factors and their corresponding indicators, culminating an in-depth content analysis.

17 The variance inflation factors

18 Goodness of fit test for the logistic regression model (Fagerland & Hosmer, 2012)

19 They were first transcribed in Luxembourgish and then translated into English by the author.

3.5 Validity and Reliability

The foundation of a study's reliability rests upon two pivotal dimensions: accuracy, denoting the precision in variable measurement, and consistency, referring to the stability of these measurements across temporal or contextual variations (Van Thiel, 2014). The utilisation of diverse measurement instruments, namely structured questionnaires and semi-structured interviews, harmoniously aligned with the contextual nuances of modal shift (Bryman, 2012). Substantial emphasis was placed on concept definition and precise indicator measurement.
The ambit of validity, encompassing both internal and external facets, was thoroughly addressed (Van Thiel, 2014). At its core, validity pertains to the extent to which selected indicators genuinely capture the intended concepts for measurement (Bryman, 2012). Therefore, attention was dedicated to selecting indicators gauging the modal shift phenomenon in this study.

Internal validity, in accordance with the definitions provided by Bryman (2012) and Van Thiel (2014), pertains to the extent of certainty regarding the genuine causation of observed shifts in a dependent variable by independent variables. This ensures meticulous alignment between the study's intended measurements and outcomes. Consequently, structured questionnaires and semi-structured interviews were systematically administered, featuring inquiries closely attuned to the indicators delineated in the conceptual framework and operationalisation table.

External validity pertains to the extent to which study findings can be extended beyond the confines of the particular research context (Bryman, 2012; Van Thiel, 2014). In this study, which adopts a random sampling approach, external validity is upheld (Bryman, 2012). Nevertheless, it is important to acknowledge that the research is temporally specific and centred on Luxembourg City, thereby constraining the wider applicability of the results. Additionally, the influence of other potentially significant variables, which have not been encompassed within this study, may also impact the broader external validity.

To enhance the comprehensive validity of the study, a triangulation strategy was implemented, involving the cross-validation of findings to fortify their robustness (Bryman, 2012). Despite encountering limitations, the intricately devised research design and integrating a mixed-method approach to data collection and analysis were anticipated to imbue a satisfactory level of reliability and validity into the study's findings.

3.6 Operationnalisation Table

The operationalisation table serves as a comprehensive reference to understand the variables and their indicators used in the study. It includes all the relevant individual-specific travel behaviour variables, socio-demographic and trip factors, perceptions and perceived barriers, and their corresponding indicators that were investigated during data collection. It emphasises their significance and how these variables have been interpreted in relation to a modal shift. (See Appendix 1).

Chapter 4: Background, Results, Analysis and Discussion

4.1 Background

4.1.1 Luxembourg City's car dependency

During the 20th century, car usage in Luxembourg experienced steady growth, establishing cars as the dominant mode of transportation in the country. This shift in transportation preferences led to a concentration on car-oriented planning, which included constructing dedicated roads for automobiles (Francois et al., 2015). Consequently, Luxembourg's contemporary road network reflects more than six decades of consistent planning to enhance convenience for car drivers (PNM 2035, 2022).

Today, Luxembourg City holds a distinctive position in several regards. Firstly, apart from its role as the nation's capital, it is one of Europe's official capitals (PNM 2035, 2022; LCTO, 2023a). Additionally, it stands as the most densely populated urban area in the country, housing approximately 20.7% of Luxembourg's total population (PNM, 2023, 2022; VDL, 2023a). Furthermore, Luxembourg City serves as a central nexus for employment opportunities and offers a high standard of living, making it attractive for economic migrants from across Europe and particularly appealing to cross-border workers from Belgium, France, and Germany (Lambert, 2023). This dynamic has resulted in a significant influx of motorised vehicles, originating not only from daily trips within the city but also from additional car journeys originating from both within wider Luxembourg and neighbouring nations. This inflow carries ramifications for various districts within the urban landscape (PNM 2035, 2022).

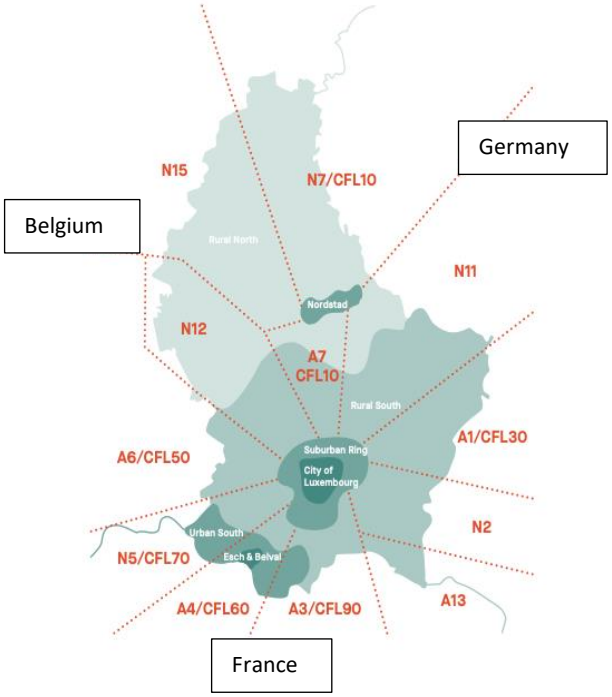


Figure 2: Transport corridors to Luxembourg City

Source: PNM 2035, 2022.

Compounded by the city's high density, a significant portion of daily trips cover short distances (PNM 2035, 2022). Despite the potential for alternate transportation modes, two-thirds of these trips, spanning distances under 5 km, are made by car (PNM 2035, 2022)[20]. The city's generous parking policies, including 18 public parking areas and free parking privileges for residents, contribute to a car modal share of 74% (PNM 2035, 2022). Furthermore, residents holding annual permits enjoy complimentary parking in their residential area and up to 2 hours in any district across the city (VDL, 2023b). This parking policy's generosity reinforces car prevalence, culminating in a substantial 74% car modal share for the city (PNM 2035, 2022). Consequently, the capital contends with poor air quality and heightened congestion, evident in a 28% congestion rate (Obert, 2022). The average 30-minute car journey experiences an additional 8-minute delay due to this congestion issues (Obert, 2022). Notably, despite the introduction of free public transport for residents and non-residents in March 2020, Luxembourg City still ranks among Europe's ten most congested areas, underscoring the nation's reliance on automobiles (Cookson, 2016; O'Sullivan, 2022).

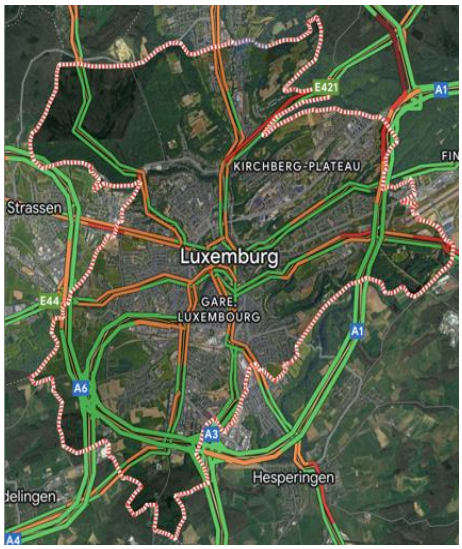


Figure 3: Traffic situation (Morning peak hour at 7:43 am)

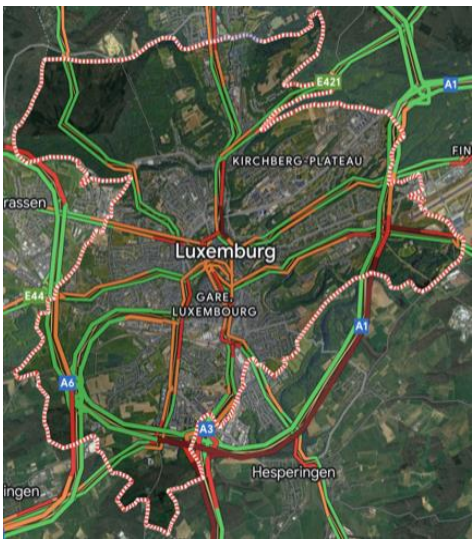


Figure 4: Traffic situation (Evening peak hour at 6:09 pm)

Source: Google Maps Screenshot
by Author (2023).

Adding to the challenge, Luxembourg's population is the fastest growing in the EU, expected to increase by 44% by 2035 (Lambert, 2023; Evans, 2017). This will amplify daily trips by around 40% (PNM 2035, 2022). Without travel behavioral change, the city's ability to accommodate more cars will decline, necessitating urgent traffic flow reorganization, particularly in relation car occupancy (PNM 2035, 2022).

20 Approximately 40% of the trips within the capital cover distances of less than 5 km, with 15% being less than 1 km and 25% ranging from 1 to 5 km (PNM 2035, 2022)

4.1.2 Luxembourg City's cycling infrastructure and its bicycle use

Following the above, it should nevertheless be noted that considerable investments have and continue to be made to enhance and expand soft mobility infrastructures, particularly cycling infrastructure, with the key objectives of curbing congestion, pollution, and ensuring accessibility and liveability within Luxembourg City (PNM 2035, 2022).

Luxembourg City comprises 24 districts, spanning across two plateaus, Plateau Bourbon in the Gare district and Plateau de Kirchberg, which serves as the country's financial hub, and valleys (VDL, 2023c). The focal points within Luxembourg City include the central district referred to as "Ville Haute", the Central Station (Gare), Kirchberg, along with Cloche d'Or and the Ban de Gasperich located within the Gasperich district (Figure 5) (PNM 2035, 2022). To address elevation differences, bicycle-friendly solutions have been implemented (LCTO, 2023b). Bridges with cycle paths connect districts, while lifts and funiculars enhance accessibility (LCTO, 2023b).

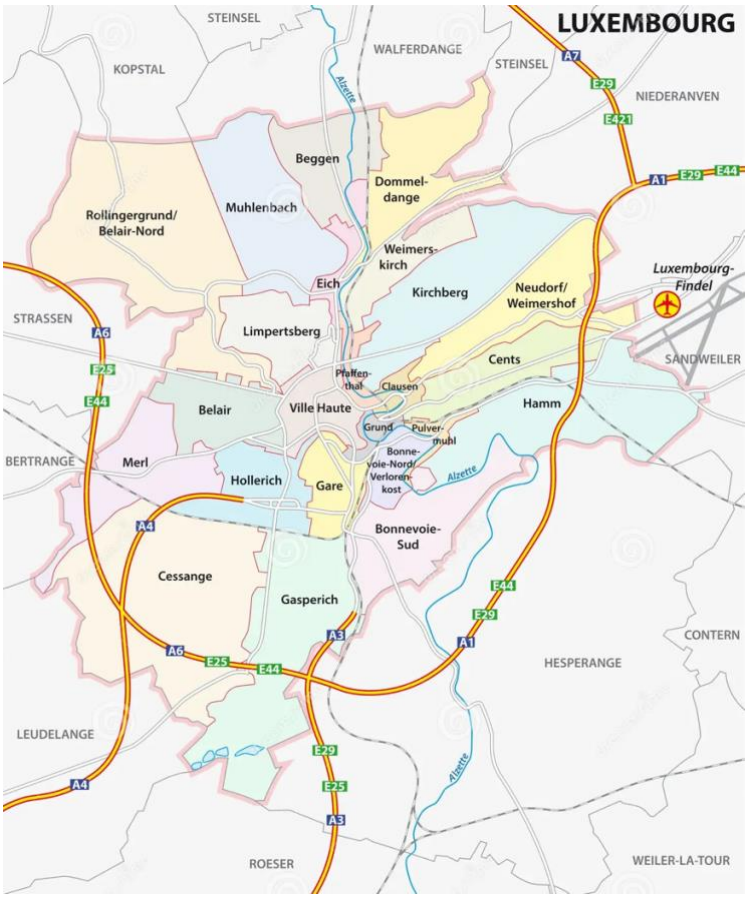


Figure 5: Luxembourg City's districts

Source: Dreamstime, 2023. (Edited by Author)

The national bicycle network spans 640 km and is set to expand to 900 km by 2028 (Government of Luxembourg, 2023b). Within the confines of Luxembourg City, the existing cycling network spans around 140 kilometres, characterised by a diverse array of design components, including distinct bicycle lanes, designated bicycle paths, and streets harmonising mixed traffic (VDL, 2023d; VDL, 2023e). Furthermore, subject to specific conditions and rules, cyclists can utilise bus lanes and navigate pedestrian zones. Furthermore, the capital aims

to promote cycling through bicycle boulevards, parking facilities, and a bike-sharing scheme called Vel'OH (Balgarnov, 2022).

Nevertheless, while 64% of Luxembourg City residents own bicycles and 40% of trips are under 5 km, and despite recent efforts to enhance the capital's cycling infrastructure, only 2% use their bicycles on a regular basis (PNM 2035, 2022). Particularly, it has been noted that the cycling network still faces fragmentation in certain areas of the capital (Morizet, 2023). Henceforth, while efforts have been made and continue to be made to promote cycling as an alternative mode of transportation, cycling has not become a common means of transportation for most residents, and Luxembourg's Minister of Transport and Public Works, François Bausch, emphasised that the government "must concentrate on moving people instead of moving vehicles" (Pedestrian Space, 2021). The aspiration is thus to guide Luxembourg City towards a people-centred and sustainable urban mobility paradigm.

4.2 Survey results

4.2.1 Sample Overview

	NON-MODAL SHIFTERS		MODAL SHIFTERS					
	Non-modal shifters		Occasional Modal shifters		Frequent modal shifters			
BICYCLE USE / CAR USE	Less than 4 times back & forth per week		At least 4 times back & forth per week				Total	
	N	%	N	%	N	%	N	%
Several times a week	13	18,6%	27	38,6%	-	-	40	57,1%
Once week	1	1,4%	-	-	18	25,7%	19	27,1%
Sveral times a month	1	1,4%	-	-	4	5,7%	5	7,1%
Once a month	-	-	-	-	5	7,1%	5	7,1%
Sveral times a year	-	-	-	-	1	1,4%	1	1,4%
Once a year	-	-	-	-	-	-	-	-
TOTAL	**15**	**21,4%**	**27**	**38,6%**	**28**	**40,0%**	**70**	**100%**

Table 1 - Modal shifters and Non-modal shifters

The study's sample included 70 respondents who indicated residing in Luxembourg City and have transitioned from car use towards regular cycling. To investigate the modal shift from regular car use to cycling, which accounts for a proportion of the bicycle use (2%) in the overall transportation mode choice in Luxembourg City, the respondents were classified into two principal groups based on their frequency of bicycle use, as shown in Table 1:

Non-modal shifters (21,4% or 15 respondents): Those individuals who use the bicycle for transport for fewer than four round-trip journeys per week and frequently resort to their cars or alternative modes of transportation.
Modal shifters (Regular cyclists) (78,6% or 55 respondents): Those individuals who have adopted cycling as their primary means of transportation, using their bicycle for a minimum of four round-trip journeys per week. Within this category, respondents were further categorised in two distinct subgroups based on the frequency of bicycle and car usage:

- *Occasional modal shifters:* intermittently incorporate cycling as a mode of transportation and use the bicycle for at least four round-trip journeys per week for specific utilitarian purposes. However, these respondents also rely on their car as a mode of transportation for several occasions per week.

- *Frequent modal shifters:* have a profound commitment to cycling as a primary mode of transportation, using their bicycle for a minimum of four round-trip journeys per week while limiting car usage to no more than once per week. For these respondents, cycling has become a pivotal aspect of their daily lives. Notably, a significant proportion (25.71%) of frequent modal shifters utilise their cars on a monthly basis.

To calculate the modal shift, this study considered how often respondents use bicycles and cars. The modal shift is represented as a binary variable (i.e., dummy variable), where non-modal shifters are assigned '0' and modal shifters, including both frequent and occasional ones, are assigned '1'.

4.2.2 Socio-demographic factors

	0		1					
Bicycle Ownership	Non-modal shifters		Occasional modal shifters		Frequent modal shifters		Total	
	N	%	N	%	N	%	N	%
Yes	13	19%	26	37,1%	27	39%	66	94,3%
No, VEL'OH subscription	1	1,4%	1	1,4%	1	1,4%	3	4,3%
No, I share a bicycle with a family member	1	1,4%	-	-	-	-	1	1,4%
TOTAL	15	20,0%	27	38,6%	28	40%	70	100%

Table 2 - Bicycle Ownership

Among the 70 respondents, a significant majority (94,3%), both modal and non-modal shifters, own a bicycle, as shown in Table 2. These findings align with previous surveys conducted in Luxembourg. The Ministry of Transport and Public Work's 2020 survey "Mobilités actives" found that 64% of respondents residing in Luxembourg City own at least one bicycle. Similarly, the Luxembourg City municipality's 2022 survey "Onse Mobilitéitsplang fir muer" found that 58% of respondents residing in Luxembourg City owned a bicycle. The significant bicycle ownership rate can be attributed to Luxembourg's high standard of living and the financial subsidies provided to residents for bicycle purchases from March 2019 to March 2024 (Government of Luxembourg, 2023c)[21].

	0		1					
Car Ownership	Non-modal shifters		Occasional modal shifters		Frequent modal shifters		Total	
	N	%	N	%	N	%	N	%
Yes	11	16%	18	25,7%	17	24%	46	65,7%
Yes, several cars	2	2,9%	7	10%	5	7,1%	14	20%
No	2	2,9%	2	2,9%	6	8,6%	10	14,3%
TOTAL	15	21,4%	27	38,6%	28	40%	70	100%

Table 3 - Car ownership

Regarding car ownership, a considerable majority of the respondents (85,7%) own at least one car, while a mere 14,3% do not own a car. These findings align with the 2020 "Mobilités actives" survey, in which only 8% of the respondents reported not owning a car. As such,

21 In this study, a considerable portion (62.86%) of respondents purchased their bicycles using the subsidy, while the remainder did not take advantage of the grant.

despite transitioning from car use to regular cycling, the vast majority of modal shifters still own at least one car.

Age	0		1					
	Non-modal shifters		Occasional modal shifters		Frequent modal shifters		Total	
	N	%	N	%	N	%	N	%
18 - 25 years	1	1,4%	3	4,3%	3	4%	7	10,0%
26 - 35 years	3	4,3%	6	8,6%	11	16%	20	28,6%
36 - 45 years	1	1,4%	10	14,3%	6	9%	17	24,3%
46 - 64 years	9	12,9%	8	11,4%	5	7%	22	31,4%
≥ 65 years	1	1,4%	-	-	3	4%	4	5,7%
TOTAL	15	21,4%	27	38,6%	28	40%	70	100%

Table 4 - Age

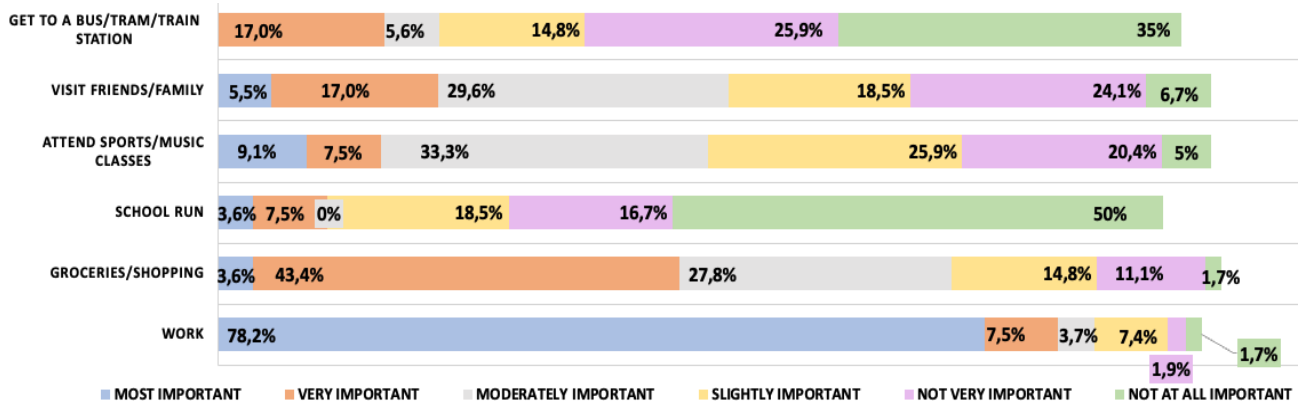
The age distribution of participants is detailed in Table 4. Among modal shifters, those aged 26-35 constitute the majority of frequent modal shifters, while most occasional modal shifters are between 36 and 45 years old. For non-modal shifters, the majority fall within the second oldest range, those aged between 46 and 64 years.

Gender	0		1					
	Non-modal shifters		Occasional modal shifters		Frequent modal shifters		Total	
	N	%	N	%	N	%	N	%
Female	7	10%	12	17,1%	13	19%	32	45,7%
Male	8	11,4%	14	20%	15	21,4%	37	53%
Gender neutral	-	-	1	1,4%	-	-	1	1,4%
TOTAL	15	21,4%	27	38,6%	28	40%	70	100%

Table 5 - Gender

In terms of gender distribution, the sample exhibited a slight gender imbalance, as shown in Table 5, with men comprising the majority.

4.2.3 Trip factors



Regarding trip purposes, as depicted in Chart 1, most modal shifters primarily used their bicycle to commute to work. Conversely, the utilisation of bicycles for trips to transport stations or school runs emerges as relatively less frequent among modal shifters. This observation suggests a restrained inclination towards using bicycles as part of multimodal or child transportation purposes.

Weekly Travel Distance	0		1					
	Non-modal shifters		Occasional modal shifters		Frequent modal shifters		Total	
	N	%	N	%	N	%	N	%
< 5 km	3	4,3%	-	-	-	-	3	4,3%
5 - 10 km	2	2,9%	1	1,4%	2	2,9%	5	7,1%
11 - 20 km	4	5,7%	4	5,7%	1	1,4%	9	12,9%
21 - 25 km	1	1,4%	6	8,6%	7	10%	14	20%
26 - 50 km	3	4,3%	6	8,6%	7	10%	16	22,9%
51 - 100 km	2	2,9%	8	11,4%	8	11,4%	18	25,7%
> 100 km	-	-	2	2,9%	3	4,3%	5	7,1%
TOTAL	15	21,4%	27	38,6%	28	40%	70	100%

Table 6 - Weekly Travel Distance

Table 6 encapsulates the prevailing weekly cycling travel distances. Modal shifters predominantly cover 51 to 100 km per week, with an average of 47,3 km[22] for all modal shifters. Occasional modal shifters average around 49,6 km, while frequent modal shifters cover approximately 53,9 km weekly. In contrast, non-modal shifters average around 24.8 km weekly. This data highlights a clear trend: modal shift becomes more evident as weekly travel distance increases.

4.2.4 Perceived feelings (Personal values) of modal shifters about cycling

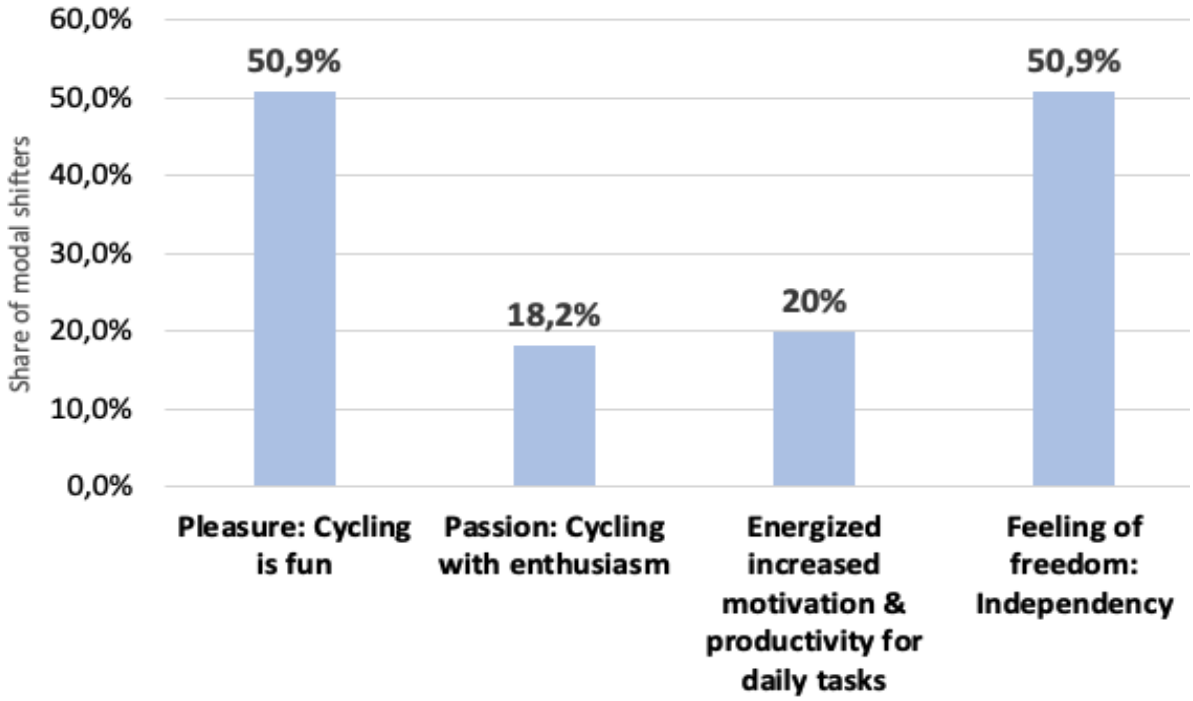


Chart 2 - Perceived feelings about cycling

This histogram indicates that personal values, like feelings of pleasure and freedom feelings, are prevalent among the modal shifters, suggesting that the enjoyment of bicycling and the sense of liberty derived from cycling are highly valued among the shifters. These sentiments are reinforced by the interviewees, who emphasised the sense of pleasure and freedom they

22 Average weekly km per modal shifter = Total km for modal shifters (2601 km)/ number of modal shifters (55) = 47.29 km/week

experienced while cycling for transportation, expressing that these personal values significantly influenced their decision to adopt the bicycle as their primary mode of transportation. For instance, interviewees *R3* and *R6* state:

"Personally, I find biking enjoyable and liberating." (R3)

"I always prefer to ride my bike because it's faster and brings me joy. [..]. Taking the bus is alright; I don't mind the crowdedness, but it's still more pleasant to be alone on a bicycle." (R6)

4.2.5 Perceived cycling barriers of modal shifters

Chart 3 - Perceived Safety Barriers

Among the surveyed modal shifters, a noteworthy 80%[23] acknowledged safety-related barriers to adopting cycling as a regular mode of transportation. Interestingly, only a fifth of respondents did not identify any perceived barriers[24]. Chief among the concerns expressed by the modal shifters is the discontinuity of bicycle routes and the lack of dedicated bike paths within Luxembourg City.

These concerns were reinforced through insights gathered from interviews, as highlighted by interviewees *R2* and *R4*:

"However, in other areas in Luxembourg City, it is a bit more picturesque because the cycling network has some gaps." (R2)

23 44/55 = 80%

24 This suggests that they either do not recognise significant barriers to cycling or have effectively adapted to such challenges. The most frequently cited challenges were safety-related structural barriers, particularly deficiencies in the cycling infrastructure.

"[...] there are still gaps, such as the absence of safe bike lanes when travelling from Bonnevoie to the City Center. Specifically, not before reaching the train station are [Gare district], I have access to a secure bike lane[25]" (R4)

Interestingly, certain interviewees have reported challenges in navigating from their residential neighbourhoods to primary cycling routes. Interviewee *R2* noted, *"In recent years, it has simply been neglected to complete the cycling network and to expand it in residential areas, and that has not happened. Just to note, there are neighbourhoods in the City that are poorly connected."* which underscores a perceived lack of cohesion between residential areas and the main cycling pathways in Luxembourg City.

Moreover, while survey participants did not prioritise bicycle parking challenges as significant, interviewees disclosed a notable apprehension regarding the absence of secure and accessible parking facilities, particularly within residential zones. For example, interviewee *R1*:

"In densely populated neighbourhoods like Gare or Bonnevoie, where many residents lack garages, the question arises: Where can I park my bike?" (R1)

In addition to the structural barriers perceived by respondents, another commonly mentioned obstacle relates to perceived risks within the traffic environment. These encompass a prevailing sense of inadequate recognition for cyclists among both drivers and pedestrians, along with a perceived prioritisation towards cars over bicycles. These sentiments align with statements provided by the interviewees, such as interviewee *R3*, who noted that:

"One of the main concerns is the attitude of car drivers towards cyclists. Cycling is not yet fully recognised as a legitimate mode of transportation, affecting cyclists' overall safety and acceptance on the roads." (R3)

Another perceived barrier brought to light through interviews but not directly addressed in this analysis revolves around the logistical difficulty of transporting sizeable and/or heavy items. Despite the prevalent use of bicycles for most journeys within Luxembourg City, several interviewees admitted to resorting to a car for such particular tasks. For example, interviewee *R6* explained, *"I tend to drive within my neighbourhood. But this choice is influenced by logistical reasons.",* highlighting an ongoing dependency on the car despite being a regular cyclist.

25 Secure bike lane = means separated cycle path

4.3 Inferential analysis: Exploratory regression analysis

To identify which and to what extent socio-demographic factors, trip characteristics and perceptual factors influence a modal shift from regular car use to cycling and to explore the potential associations between these variables, a multiple exploratory regression analysis was conducted. More specifically, a logistic regression model was conducted, as the dependent variable in this analysis is the modal car-bicycle shift, a binary variable indicating whether a shift from regular car use to cycling had occurred. The independent variables were a set of socio-demographic variables, trip characteristics variables and perceptual variables:

Socio-demographic Factors: (categorical variables)

- Age (Age)
- Gender (Male_Gender)
- Employment status (Employed)
- Car ownership (Car_ownership)
- Bicycle ownership (Bike_ownership)

Trip Factors:

- Weekly Travel distance (continuous variable – Travel_Distance)
- Type of bicycle used (categorical variable – Ebike_Type)

Perceptual Factors: (continuous variables)

- Attitudinal variables including perceptions of time efficiency in terms of punctuality and reliability, cost efficiency, convenience in terms of accessibility and practicality, health, and environmental awareness.
- Perceived values, including the personal value of *"Feeling free from traffic stress"* and societal values in terms of societal support towards cycling

Logistic regression — Number of obs = 70
LR chi2(14) = 28.69
Prob > chi2 = 0.0115
Log likelihood = -22.025079 — Pseudo R2 = 0.3944

Modal_Shift	Odds ratio	Std. err.	z	P>|z|	[95% conf.	interval]
Time_efficiency	5.587334	4.617206	2.08	0.037	1.106107	28.22359
Cost_efficiency	.4648087	.284552	-1.25	0.211	.1400154	1.543024
Convenience	1.349015	.7075453	0.57	0.568	.4825803	3.771062
Environmental_awareness	1.484945	.6054925	0.97	0.332	.6677735	3.302108
Health_awareness	.3970597	.2118816	-1.73	0.083	.1395186	1.130003
Personal_values	.4006567	.2427306	-1.51	0.131	.1222046	1.313583
Social_values	2.249839	1.06857	1.71	0.088	.8868899	5.707331
Gender_Male	1.590341	1.53945	0.48	0.632	.2385211	10.6036
Age	.9079813	.0397958	-2.20	0.028	.8332392	.9894279
Employed	1.448542	1.324066	0.41	0.685	.2414765	8.689351
Bike_ownership	.183821	.4660859	-0.67	0.504	.0012768	26.46382
Car_ownership	23.58111	40.28017	1.85	0.064	.8290502	670.7299
Travel_Distance	1.05696	.0233623	2.51	0.012	1.012148	1.103755
Ebike_Type	.4646835	.5063761	-0.70	0.482	.0549014	3.933063
_cons	2.414613	8.025316	0.27	0.791	.003579	1629.068

Note: _cons estimates baseline odds.

Table 7 - Multiple regression model[26]

4.3.1 Socio-demographic factors

Based on the multiple logistic regression model, among the socio-demographic variables analysed, only the variable (Age) is statistically significant at the 5% level ($p<0.05$), *ceteris paribus*[27]. This implies that for each additional year in age, the odds of an individual transitioning from regular car use to cycling (referred to as Modal_Shift) decrease by approximately 9,3%[28], *ceteris paribus*. This result suggests that the propensity to shift from regular car use to cycling diminishes as individuals age. This finding aligns with Table 5, highlighting that the most significant proportion of modal shifters falls within the [26 - 35] and [36 - 45] age groups. This can be attributed to the fact that individuals within this age range are employed and therefore require a daily mode of transportation to work, and that the physical ability to travel tends to decline as people grow older (De Witte et al., 2013).

Furthermore, based on the logistic model with the modal shift as the dependent variable and distinct age groups as independent variables (with the [36 - 45] as the reference group) (see Table 20), individuals within the [46 - 64] age bracket are significantly less prone to shift from regular car use to cycling in comparison to those in the [36 - 45] group. More specifically, the odds of an individual shifting from regular car use to cycling from the age group [46-64] years

26 The total number of observations are 70; LR chi2(13) is the goodness of fit test, with a value of 28.69 and a degree of freedom of 14 and its associated p-value is 0.0115 ($p<0.05$), which suggests that the model is a better fit than the null model; Pseudo R2 is the measure of fit suggesting that 39% of improvement in model likelihood over the null model; the odds ratios represents the multiplicative/relative change between the independent variable and the dependent variable.

27 Ceteris paribus = assuming all other factors hold constant

28 [(0,907-1)*100= -9,3%]

are predicted to be 90.9% less likely compared to a younger individual from the reference group [36-45] years, statistically significant at the 5% level, *ceteris paribus*.
Interestingly, when we juxtapose these statistical findings with insights from our interviews, a nuanced picture emerges. Among the six interviewees, three individuals adopted cycling as their primary mode of transportation during their relatively younger years, falling within the [18 - 38] age range. In contrast, the remaining three interviewees embraced regular cycling as a mode of transport at a later stage in life (see Table 9).

Age	**Quotations from the interviewees**	**Interview number**
Early Stage	*"In 1992, […], and moved to Luxembourg City, I really started to utilize my bicycle extensively, at least wherever it was possible."*	*R1*
Early Stage	*"Since 2013, I've been commuting to work on a bicycle every single day, […]. Yes, I've maintained this daily cycling routine since 2013."*	*R6*
Early Stage	*"Around the age of 18-19, I started fully embracing the bike as my primary mode of transportation."*	*R4*
Later Stage	*"It was when I acquired an electric bike. That's when I truly embraced cycling for all my journeys within Luxembourg City."*	*R3*
Later Stage	*"Following the introduction of the E-Bike."*	*R5*
Later Stage	*"I began using the bicycle sometime in the 2000s, around 2010 or 2011."*	*R2*

Table 8: Interview Quotations - Factor "Age"

4.3.2 Trip factors

Based on the multiple logistic regression model, among the trip characteristics variables examined, only (Travel_Distance) is statistically significant at the 5% level ($p<0.05$), *ceteris paribus*. This implies that for each additional kilometre cycled per week on average increases the odds of an individual shifting from regular car use to cycling by around 5,6%[29], *ceteris paribus*. This result suggests that the propensity for an individual to switch from regular car use to cycling increases the more frequently an individual cycles for transport on average per week, *ceteris paribus.* This aligns with the previously noted difference in weekly distances between non-modal and modal shifters. Moreover, insights from the interviews with public representatives further corroborated these findings. All the interviewees reported using the bicycle at least eight times a week, and five out of six stated that they commute by bicycle to work, essentially using the bicycle every day of the week. For example, Interviewee *R1 states:*

> *"I use it for everything. Whether it's going to work, engaging in sports, or getting around in Luxembourg City. I ride my bicycle everyday without a fail".*

29 [(1,056-1)*100= 5,6%]

4.3.3 Perceptions: Attitudes and Perceived Values

Among the examined attitudinal variables, only the perception of time efficiency[30] emerges as statistically significant at the 5% confidence level (p<0,05), *ceteris paribus*. This signifies that for each additional unit increase in the perceived time-related advantages[31] of using the bicycle, the odds of an individual shifting from regular car usage to cycling are approximatively 5,58 times higher, *ceteris paribus.* Essentially, this implies that individuals who perceive cycling as time-efficient in speed and predictability are significantly more inclined to shift from car usage to regular cycling. This observation is further reinforced by all six interviewed public representatives, each of whom cited reaching their destinations quickly and the reliability of travel time as their primary motivations for choosing bicycles as their primary mode of transport within Luxembourg City. For example, interviewee *R4* and *R5 state:*

> *"The main reason for choosing the bicycle as my primary mode of transportation was its efficiency compared to driving. This remains a clear and compelling argument. You move quickly, and you always arrive well." (R4)*

> *"Bicycles are much faster in the city compared to cars. You don't get stuck in traffic and can easily navigate through any route." (R5)*

Regarding perceived values, the logistic regression model assessed the influence of social values and the personal value of "Feeling free from traffic stress". The findings indicated that these factors did not significantly influence the decision to shift towards bicycles for transportation.

4.3.4 Intersections between perceptions, socio-demographics and trip factors

To test whether attitudes and perceived value vary significantly between genders in influencing a shift from car use towards regular cycling, a logistic regression model with multiple interaction terms was constructed (Table 21).The model reveals that the impacts of attitudes and perceived do not significantly differ between women and men, given that all interaction terms were not statistically significant, *ceteris paribus*. This means that gender not significantly alter the influence of attidudinal variables on the likelihood of a modal shift.

Furthermore, given the observed notable statistical significance of age and weekly travel distance in relation to the shift from regular car use to cycling, separate regressions were conducted for each age group. As a result, the effect of travel distance on the decision to shift towards regular cycling for transportation was found to vary across age groups. Specifically, within the age group of 46-64, the relationship is statistically significant at the 5% level (p<0.05), ceteris paribus. This suggests that each additional kilometre cycled on average per week increases the odds of an individual aged between 46 and 64 years shifting from regular car use to cycling by approximately 1.08 times, an 8% increase, *ceteris paribus*.

30 Time efficiency in terms of speed and predictability. It refers to an individual's perceived time-related advantages of using a bicycle, thus how swiftly and predictably one can reach a planned destination when cycling.

31 In terms of reliability and punctuality

```
-> age_group = 46-64

Iteration 0:   log likelihood = -14.883571
Iteration 1:   log likelihood = -10.112925
Iteration 2:   log likelihood = -9.8207905
Iteration 3:   log likelihood = -9.8153967
Iteration 4:   log likelihood = -9.8153884
Iteration 5:   log likelihood = -9.8153884

Logistic regression                                     Number of obs =     22
                                                        LR chi2(1)    =  10.14
                                                        Prob > chi2   = 0.0015
Log likelihood = -9.8153884                             Pseudo R2     = 0.3405
```

Modal_Shift	Odds ratio	Std. err.	z	P>|z|	[95% conf.	interval]
Travel_Distance	1.087257	.0418207	2.17	0.030	1.008303	1.172393
_cons	.0924399	.1132124	-1.94	0.052	.0083826	1.019383

Note: **_cons** estimates baseline odds.

Table 9: Regression model: Age_group

4.4 Discussion

The empirical findings shed light on the nature of the modal shift, revealing it to be more dynamic rather than binary[32]. Notably, even individuals classified as modal shifters still maintain a reliance on their cars. For example, occasional modal shifters, despite cycling at least four round-trip journeys per week, still use their cars at least twice a week. Similarly, most frequent modal shifters also still rely on their cars once a week. This phenomenon may arise from the perceived challenges when using bicycles for transport, compounded by the fact that most modal shifters possess both a bicycle and a car, facilitating a flexible shift between the two modes.
Nevertheless, it is crucial to acknowledge that the concept of modal shift is inherently linked to the criteria used to classify modal shifters (regular cyclists).

Drawing from the empirical results, a car-bicycle modal shift is less about completely replacing cars with bicycles but rather signifies a flexible interchange between the two modes, with a preference for cycling. Therefore, a shift towards cycling for transport does not imply a complete abandonment of cars but rather signifies a prioritisation of bicycles over cars. This illustrates that a modal shift is not immediately associated with a complete absence (decrease) of car use but rather a shift in preference where bicycles become the dominant mode of transportation while cars remain an alternative option for certain situations or conditions.
However, in contrast to the empirical findings, the literature review defines the ideal modal shift as a binary transition, ideally, a sustained and complete shift away from cars towards more sustainable modes like cycling (UNF-CCC, 2020).

Regarding the *socio-demographic factors*, both the qualitative and quantitative analyses reveal that age plays a significant role in influencing the modal shift, as hypothesised by the author. The most significant inclination to shift to regular bicycle use for transportation is observed among younger individuals, specifically those aged between 26-45 (Table 5). This trend can be rationalised by the natural decline in physical mobility that often accompanies ageing (De Witte et al., 2013). Additionally, within this age group, which constitutes the majority of modal

32 (Pagliarin, 2023)

shifters, bicycles are predominantly used for daily commuting to work. This empirical observation aligns with theoretical findings, such as those presented by Scheepers et al. (2013) and Pucher and Buehler (2008), which respectively suggest that age groups between 25-34 and 35-44 are more likely to use bicycles for transportation regularly and that a decline in cycling rates can be seen with age, particularly in countries with lower cycling levels.

Nevertheless, it is important to acknowledge that while the empirical results support the notion that younger individuals are more likely to undergo a modal shift, they also reveal that the 46-64 age group, although less prone to shift towards cycling for transport, is more likely to undertake a modal shift when engaged in longer weekly cycling distances. Furthermore, the interviews revealed a more nuanced dynamic between age and the transition from car use to regular cycling, as three participants initiated this modal shift later in life. These counter-narratives underscore that age exerts a strong influence but is not the sole determinant. Its interaction with weekly travel distance also plays a significant role. Nevertheless, the limited data values for each age group warrant caution in drawing definitive conclusions. Mindful of the study's limitations, these findings underscore the importance of targeting efforts beyond just younger demographics when promoting a modal shift.

In terms of *trip factors*, the empirical results reveal the significance of an increase in weekly travel distance in incentivising a modal shift. Notably, the transition towards more weekly frequent cycling aligns with longer weekly travel distances. Since the criterion for assessing the shift is based on weekly bicycle use frequency, this outcome can be elucidated by the association between higher weekly cycling frequency and greater overall weekly travel distance. A deeper dive into the data reveals that non-modal shifters generally report covering shorter weekly distances (see Table 7). Intriguingly, this empirical finding appears to contradict prevailing research findings, which suggest that increased trip distance is typically associated with reduced bicycle usage (Gatersleben & Appleton, 2007; Heinen et al., 2010). The empirical result suggests that in Luxembourg City, as aggregated weekly travel distances increase, there is a higher likelihood of a modal shift. This implies that while individual longer cycling distance might discourage people from choosing bicycles for transport, a consistent and frequent cycling pattern throughout the week, accumulating longer overall weekly distances, enhances the likelihood of a modal shift in the case of Luxembourg's capital.
Nevertheless, while these empirical findings underscore an apparent link between weekly cycling frequency and weekly travel distance and a lack of strong correlation with other factors in the model, it is plausible that unexplored variables within the model might additionally play a decisive role.
Overall, the empirical findings emphasise the significance of the frequency and intensity of cycling in fostering a modal shift. The decision to shift from cars to cycling for transport hinges on whether individuals incorporate cycling regularly and substantially into their weekly routines.

Regarding the conceptual framework, these empirical findings corroborate the notion that while adequate cycling infrastructure is essential, it does not, on its own, dictate an individual's decision to shift towards cycling. Particularly in the context of Luxembourg City, where there is still room for enhancing cycling infrastructure, individual-specific travel behaviour factors assume greater significance in shaping the modal shift decision. This empirical result aligns with the assertion made by Moudon et al. (2005) that cycling is primarily an individual choice rather than solely determined by the available built environment.

In terms of *perceptions*, the analysis underscores the importance of individual perceptions in the decision to shift towards cycling as a primary mode of transportation within Luxembourg City. This aligns with numerous studies that emphasise the significant influence of individual perceptions on the choice to use bicycles for transportation. In the context of Luxembourg City, perceived time efficiency in terms of speed and predictability emerges as a significant determinant driving this modal shift. This suggests that residents in the capital highly value travel options that are both timely and predictable. Consequently, the more individuals perceive cycling as a mode of transportation that offers speed and predictable travel times, the more likely they are to transition from cars to bicycles. This preference might be attributed to the city's prevalent traffic congestion, which often leads to travel time unpredictability and delays. These findings align with existing literature, as demonstrated by Fernandez-Heredia et al. (2014), whose study emphasised the importance of flexibility, defined as having no time or frequency limitations, for regular bicycle users. Furthermore, the fact that the majority of modal shifters indicated using bicycles daily for commuting to work aligns with the findings of Gatersleben and Appleton (2007), who suggested that cycling past stationary traffic is an indispensable motivating factor for those seeking timely arrivals at work.

Moreover, it is worth noting that while the factor of "*Feeling free from traffic stress*" may not have emerged as a primary determinant, as initially hypothesised, both the survey results and interview findings consistently underscore the prevalence of feelings of pleasure and freedom among modal shifters. The prominence of these sentiments, as evident in the descriptive statistics, coupled with their resonance in the narratives of interviewees, underscores their profound significance in the decision-making process, even though they were not subjected to inferential analysis. These findings align with Gatersleben and Appleton's research (2007), where enjoyment emerged as a significant motivation for cycling. This suggests that personal values related to the pleasure and freedom associated with cycling for transport appear to significantly influence the shift from car use to cycling for transportation purposes.
However, it is essential to acknowledge that the generalisability of these empirical findings is subject to debate, as perceptions related to time efficiency and feelings of pleasure and freedom are highly individual-specific and often shaped by context-specific backgrounds.

Concerning *perceived safety barriers*, both survey and interview results indicate two main perceived barriers among modal shifters: structural inadequacies and inconsiderate drivers toward cyclists. These findings highlight that Luxembourg City's existing cycling infrastructure is far from adequate, marked by the discontinuity of the cycling network, particularly between main routes and residential areas, coupled with a lack of dedicated cycle paths and parking facilities. The significance of these perceived barriers aligns with studies conducted by Pritchard et al. (2019) and Dill & Voros (2007), which emphasised the importance of establishing continuous cycling infrastructures along roads, as segments lacking cycling amenities can discourage cycling, especially for utilitarian purposes.

Furthermore, the prevalent disregard exhibited by motorists towards cyclists is a pressing concern. This phenomenon may help explain the relatively low number of regular cyclists and the limited use of bicycles for school runs in Luxembourg City. The findings mirror those of Gatersleben and Appleton (2007), who identified parental concerns in areas lacking safe, segregated cycle paths and where drivers exhibit inconsiderate behaviour. Similar patterns have been observed in regions like Poland, where the modal share of bicycles remains relatively low, as regular cyclists often perceive road safety negatively due to insufficient bicycle regulations and the discourteous behaviour of car drivers (Biernat et al., 2018). In light of these findings, it becomes apparent that enhancing Luxembourg City's cycling infrastructure is just

one piece of the puzzle. There is an equally pressing need to cultivate an inclusive road culture that recognises bicycles as a legitimate mode of transportation.

Chapter 5: Conclusion

In the face of rapid urbanisation, which is expected to increase by 10% by 2050 and with more than half of the global population residing in cities, European cities are grappling with escalating mobility challenges, particularly a heavy reliance on cars. Given that the transportation sector accounts for a substantial portion of GHG emissions, European policymakers have become increasingly concerned and committed to promoting environmentally sustainable modes of transportation (Schepers & Heinen, 2013).

The objective of this research has been to contribute to the existing body of knowledge on travel behaviour change, specifically focusing on the modal shift towards sustainable transportation as the preferred mode of transportation. The study employed Luxembourg City as a case study to investigate the underlying factors facilitating a shift away from motorised (private) automobiles and towards bicycles as a more sustainable mode of transportation. Despite a significant number of the capital's residents owning bicycles and a substantial portion of trips falling within a cyclable distance (less than 5 km), along with recent efforts to enhance cycling infrastructure, only a small fraction of the population cycles regularly. To this end, this study aimed to examine the extent to which individual-specific travel behaviour factors, such as perceptions, socio-demographics, trip factors, and their interactions, play a decisive role in fostering an active modal shift from car use towards regular cycling, beyond the necessity of adequate cycling infrastructure. By examining this modal shift in Luxembourg City, several key individual-specific travel behaviour factors emerged that significantly influence the decision-making process in undergoing such a shift.

First and foremost, this research illustrates that the car-bicycle modal shift is not binary but rather a dynamic shift between car use and bicycle use, with a preference for using the bicycle as their primary mode of transport. Notably, a significant proportion of these modal shifters possess both a car and a bicycle, affording them the flexibility to shift between the two modes of transportation based on their specific needs and circumstances, with a preference for using the bicycle. This fluidity underscores the dynamic nature of the shift and highlights the importance of considering individual choice and adaptability in transportation decisions.

Delving deeper into this dynamic shift, among the examined *socio-demographic factors*, age demographics play a pivotal role. The younger generation, specifically those aged between 26 and 45, are more inclined to adopt bicycles as their primary mode of transportation. However, while those residents of Luxembourg City aged between 46 and 64 are generally less prone to shift from car use to regular cycling, their likelihood to do so increases significantly when they engage in longer weekly cycling distances. This underscores that age alone may not be the sole determinant of a modal shift; rather, it is the interaction with an individual's travel characteristics, notably weekly travel distances, that influences the decision.

Concerning *trip factors*, the weekly travel distance plays a significant role in the modal shift. An increased frequency of weekly bicycle use aligns with longer overall weekly travel distances. This emphasises that the modal shift is closely linked with the weekly frequency of bicycle use and the overall distance travelled throughout the week. While previous research has primarily associated longer individual trip distances with reduced bicycle use, this study, within the context of modal shift, highlights the significance of consistency and cumulative distance across the week in driving this shift.

Furthermore, *individual perceptions* among Luxembourg City's modal shifters show a clear preference for speed and predictability in their travel choices. The perception that bicycles offer a reliable and fast travel mode emerges as a substantial driver of the modal shift. However, the decision to shift towards regular cycling for transport is not purely logistical; it also has an emotional aspect. The sensations of freedom and pleasure that cycling offers play a pivotal role in motivating the shift. Although these perceived advantages related to time and the feelings of freedom and pleasure serve as significant catalysts for modal shifters in Luxembourg City, there are still perceived safety challenges to overcome. Perceived gaps in the city's cycling infrastructure, along with motorists' inconsiderate attitudes toward cyclists, are significant perceived barriers, underscoring the need for not only improved cycling infrastructure but also greater societal recognition of cycling as a legitimate mode of transportation.

Regarding the conceptual framework, empirical findings from the case study on Luxembourg's capital affirm that while structural factors, such as adequate infrastructure, are necessary, they alone do not determine an individual's decision to shift toward cycling as the primary mode of transportation. In Luxembourg City, where there is room for improvement in cycling infrastructure, individual-specific factors, such as perceived time efficiency, feelings of pleasure and freedom offered by cycling, and increased weekly travel distances in association with age and bicycle use frequency, gain prominence in shaping the modal shift decision. This empirical result aligns with Moudon et al.'s (2005) assertion that cycling is more of an individual choice than solely dependent on the available built environment. However, contrary to the portrayal in the conceptual framework, empirical results reveal that an active modal shift is dynamic, oscillating between bicycle and car use, with a prioritisation of bicycles not necessarily leading to a complete abandonment or significant reduction of car use. Moreover, while this study does not conclusively demonstrate that increased bicycle use stimulates the development and enhancement of cycling infrastructure, it aligns with the contention of Pucher et al. (2010) that "substantial increases in bicycling require an integrated package of many complementary interventions".

By drawing insights from the case study, it becomes clear that the shift from car use to regular cycling is a nuanced and intricate process. The modal shift is not binary but rather a complex decision-making process influenced by various factors. Individual-specific factors, including socio-demographics, trip factors and perceptions, do not merely act in isolation; they also interact intricately with one another. This intricate web of influences emphasises the inherent complexity of the modal shift process. It is insufficient to examine them independently; one must delve into their interactions to gain insights into the forces propelling individuals towards cycling as their primary mode of transportation. This nuanced perspective illuminates the richness and depth of the decision-making process, underscoring the need for a holistic approach to comprehend and encourage the shift towards sustainable transportation modes.

Limitations

While this explorative study provided valuable insights into existing knowledge, it is essential to acknowledge its inherent limitations. Firstly, the research's geographic and demographic scope was confined to a specific subgroup, namely regular cyclists in Luxembourg City who had undergone an active modal shift. Additionally, data collection faced constraints due to time limitations and the occurrence of communal elections throughout the research process, resulting in a relatively modest sample size and a moderate number of interviewees. Therefore, the limited span of this study necessitates prudence in generalising its findings to other regions, even with similar structural and cultural facets.

Furthermore, the methodological limitations should be acknowledged. The central definitional delimitations of the study, notably that of "regular cyclist / modal shifter", defined as individuals undertaking at least four round trip journeys per week, could be seen as both beneficial and restrictive. While this criterion effectively identified a committed subset of regular cyclists, it inadvertently those individuals engaging in 2-3 weekly round trip journeys.[33] These individuals, though less frequent in their cycling habits, might have provided valuable insights into the motivations and barriers surrounding the car-bicycle modal shift. The selection of the four round trip journeys threshold, while theoretically sound in defining a modal shifter, could have potentially been reconsidered through the lens of a lower threshold to broaden the sample, consequently yielding diverse insights and varied results.

Moreover, the relatively modest sample size, despite the study's explorative nature, introduces its own set of challenges. Limited/smaller sample sizes can compromise the robustness of statistical inferences and obscure subtle interactions among variables. For example, when stratifying the age variable, the limited data per age group necessitates caution in providing solid statistics.

Additionally, the decision-making process for regular bicycle use, influenced by various individual-specific travel behaviour factors, is inherently complex and can vary significantly among individuals and across different locations. Given the focus on individual-specific factors in this research, the empirical findings are subject to the subjectivity and variability inherent in these factors.

Furthermore, the survey and interviews were conducted during favourable weather conditions in June and may reflect preferences and behaviours associated with cycling during such conditions. This temporal limitation could potentially constrain the generalizability of the findings to less favourable seasons, particularly the winter months.

Finally, the study's approach of interviewing public representatives who shifted from car use to regular cycling offers valuable insights but might, at the same time, inadvertently narrow the scope of perspectives. This approach might overlook diverse viewpoints from other key stakeholders, such as authorities from the Municipality of Luxembourg City and the Ministry of Transport and Public Works, who are responsible for the country's cycling infrastructure.

Further research recommendations

While this study serves as a significant milestone in the exploration of the car-bicycle modal shift, its limitations pave the way for specific and actionable recommendations for future research.

Future research could reconsider the definition of a "modal shifter", particularly the criterion of four round trips per week to encompass a broader spectrum of shifters to enhance the view of the modal shift landscape. A broader definition may allow for a more inclusive representation of modal shifters, ensuring that studies capture a wider array of experiences and behaviours, enhancing the generalizability of findings.

[33] Pagliarin (2023)

Additionally, in the case of Luxembourg City, a deeper examination of the personal feelings associated with cycling is recommended, given their potential variability among individuals' perspectives and preferences and the potential seasonal influences.

Finally, future research could include a comparative study to gain a more comprehensive perspective on the influence of individual-specific travel behaviour factors in driving a modal shift. These studies should involve cities similar to Luxembourg City but with more developed cycling infrastructures and higher cycling levels. A comparative approach can shed light on the extent to which individual-specific factors play a role in different urban settings. Such a study could offer valuable insights into the transferability of modal shift dynamics and help identify commonalities or differences across cities with varying cycling infrastructures.

Policy recommendations

Taking into account the limitations of this study, the empirical results reveal that both younger and older individuals are prone to undergo a modal shift, emphasising the need for inclusivity in promoting sustainable transportation like cycling.

Firstly, targeted outreach and incentives could, therefore, be tailored to different age groups to further encourage cycling for transportation among younger and older individuals alike. In addition to addressing perceived gaps in cycling infrastructure, addressing the issue of inconsiderate driver behaviour towards cyclists is crucial.

Secondly, more traffic calming zones could be implemented, and stricter penalties for violations could be devised as a means that could ultimately end up raising awareness about alternative transport modes, improving safety, and enhancing the perceived time efficiency and enjoyment associated with cycling.

Thirdly, to amplify the sensations of pleasure and freedom, organising vehicle-free days in different districts of Luxembourg City could encourage residents to explore cycling and other sustainable transport options. Finally, considering the dynamic nature of undergoing an active modal shift, mechanisms for regular monitoring and evaluation of cycling initiatives could be established to continuously assess policy effectiveness and adapt measures to be taken based on aggregated individual feedback and changing needs.

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Appendix 1: Operationalization table

Focus **Locus**	Modal car-bicycle shift Luxembourg City			
Concept / Variable	**Definition within the context of modal shift**	**Measurement(s) for modal shift / Indicator(s)**	**Description**	**Unit of measure**
Regular / Utilitarian cyclist / Modal shifter	Individuals who use cars not more than once a week and ride bicycles regularly, at least 8 times a week, and consider bicycles as their primary mode of transportation for utilitarian purposes, such as work, study, errands, and other daily travel needs (Rodriguez-Valencia, 2021)	Frequency of bicycle use for daily/utilitarian purposes	Identification of a regular / utilitarian cyclist (=modal shifter), namely a cyclist who switched from regular car use to cycling	Bicycle usage ≥ 8 times[34] per week month: Regular / Utilitarian cyclists / Modal shifters Bicycle usage < 8 times per week &: non-regular / non-utilitarian cyclist / Non-modal shifters
Level of regular bicycle use	Regular bicycle use refers to the weekly frequency of bicycle use	Frequency of bicycle use	Identification of how often the individual uses the bicycle per week	Less than 4 times (back & forth) per week 4 times (back & forth) a week More than 4 times (back and forth) a week
Level of weekly car use	Refers to the frequency of car use instead of the bicycle for transportation	Frequency of car use	Identification of how often the individual use the car	Several times per week Once per week Several times per month Once per month Several times per year Once per year

34 4 times back and forth, so 8 times per week. The author has chosen the threshold of 4 based on 2 reasons: (1) In Luxembourg, it is legally allowed to work remotely at least one day per week. (2) 4 days a week = average days of a week (7/4=3.5 ~4 days).

Concept	Dependent variable	Indicator(s)	Description	Unit of measure
Active modal shift / modal transition / modal switch / modal shift (= Transport mode shift)	The active modal shift refers to the transition from car use towards a more sustainable transportation mode, namely, the bicycle (UNFCCC, 2020). This shift depends on structural and individual specific factors that motivate and incentivize individuals to change their travel behavior and be persistent.	Frequency of bicycle and car use	Individual-specific characteristics refer to the individual perceptions and socio-demographic, and trip factors that influence travel mode decisions and by extension play a role in modal shift decisions (Faboya et al., 2020)	Identification of the most influential individual-specific factors, namely perceptual, socio-demographic and trip factors, of a regular cyclist which have induced a modal shift. 0 = non-modal shifter 1 = Modal shifter[35]

35 Modal shifters are divided into 2 sub-groups: (1) occasional modal shifters: those individuals who cycle at least 8 times per week and also use the car several times a week; (2) frequent modal shifters: those individuals who cycle at least 8 times per week and use the car not more than once a week

Concept	Independent variable	Indicator(s)	Description	Unit of measure
Perceptions	Attitudes	Perceived efficiency: In terms of time savings: Degree of predictability & speed (He & Thøgersen, 2017)	Perceived efficiency in terms of time refer to the perceived time-related savings / advantages whilst using the bicycle as mode of transportation regularly	Measured on a 5-point Likert scale: From strongly disagree to strongly agree
		Perceived efficiency: In terms of cost savings	Perceived efficiency in terms of costs refer to the perceived cost-related savings / advantages associated to the regular usage of the bicycle as mode of transportation	
		Perceived convenience In terms of practicality and accessibility Verma et al. (2016)	Perceived convenience refer to the cyclists perceived practicality, and accessibility of using the bicycle for transportation	Measured on a 5-point Likert scale: From strongly disagree to strongly agree
		Perceived awareness: In terms of environmental awareness Fernandez-Heredia et al. (2014)	Perceived environmental awareness in relation to cycling as a mode of transportation refers to the individual's recognition and concern of the environmental impacts	Measured by scale-points, level of influence up to 5 stars
		Perceived awareness: In terms of health awareness	Perceived health awareness in relation to cycling as a mode of transportation refers to the individual's recognition of the positive physical and mental effects	Measured by scale-points, level of influence up to 5 stars
	Perceived values	Perceived social values Heinen et al. (2010)	Identification of the values held by the society or a group of individuals, including relatives or friends, influencing the individuals' decision to regularly use the bicycle for transport	Measured on a 5-point Likert scale: From not all important to extremely important
		Perceived personal values (Gatersleben & Appleton, 2007 & Abrahamse et al., 2009)	Identification of the individual's values, the personal internal feelings towards cycling for transport	Measured by a limited, up to 3, choice selection: Pleasure Passion Energized Active Freedom Greater sense of environmental responsibility

Concept	Independent variable	Indicator(s)	Description	Unit of measure
	Perceived safety barriers	Perceived risks In terms of traffic environment (Blitz, 2021; Fernandez-Heredia et al., 2014)	Potential hazards or dangers, including the risks of falls or accidents, that regular cyclists perceive when interacting with other road users	Measured by a text entry question and interviews
		Perceived personal safety barriers (Hunt & Abraham, 2007 & Fernandez-Heredia et al., 2014)	Identification of regular cyclists' sense of safety and their perceptions of how to protect themselves while cycling. "I feel safe cycling on my regular route", "I feel safe cycling in my neighborhood", "I feel safe cycling in most cases due to my cycling experience", "I feel safer when wearing a helmet"	Measured on a 5-point Likert scale: From strongly disagree to strongly agree
		Perceived structural barriers (Blitz, 2021)	Perceived barriers in regards to the cycling infrastructure (cycle facilities)	Measured by interviews and by a text entry question
		Perceived natural environment barriers: In terms of climate (Heinen et al., 2010 ; Ferndandez-Heredia et al., 2014)	Identification of personal weather limitations or challenges such as rain, wind, snow, etc.	Measured by a text entry question and interviews
		Perceived natural environment barriers: In terms of topography (Heinen et al., 2010 ; Ferndandez-Heredia et al., 2014)	Identification of personal limitations or challenges posed by the physical landscape on the cycling trip	Measured by a text entry question and interviews
Socio-demographic factors (Heinen et al., 2010)	Gender		Identification of the age of the cyclists	Female Male Gender neutral
	Age		Identification of the age of the cyclists	18 - 25 years 26 - 35 years 36 - 65 years > 65 years

Concept	Independent variable	Indicator(s)	Description	Unit of measure
	Employment status		Identification of the employment	Student Employed Self-employed Retired
	Locality		Identification of the current living district of the cyclist	Measured by a drop-down list, listing the 24 districts of Luxembourg City
	Bicycle ownership		Identifying ownership of a bicycle	Yes No, but a subscription to a bicycle sharing system No, but share a bicycle with a relative or friend
	Car ownership		Identifying ownership of a passenger vehicle	Yes Yes, several cars No, share a car with people not being part of my household No
Trip factors (Fernandez-Heredia et al., 2014)	Distance of bicycle trips		Identification of the distances covered by the weekly bicycle trips	Less than 5 km 5 - 10 km 11 - 20 km 21 - 25 km 26 - 50 km 51 - 100 km More than 100 km
	Bicycle trip purposes		Identification for which purposes the bicycle for transport is used	For work For study For errands For shopping For leisure time (non-recreational)
	Bicycle point tip(s) (Ma et al., 2020)		Identification of single- or multiple-point bicycle trips Single point trip: The one-way trip includes no intermediate stop Multiple point trip: The one-way trip includes at least 1 intermediate stop	No intermediate stop / Zero stop 1 intermediate stop More than 1 intermediate stop
	Bicycle type		Identifying which type of bicycle, the individual uses on a regular basis	Conventional bicycle Electric bicycle Vél'Oh - public bicycle share scheme

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Appendix 3: Interview Questionnaire

Good morning / Good afternoon.
First, I would like to thank you for your willingness to participate in this interview.
As mentioned before, the purpose of this interview is to find out why and how residents of Luxembourg City have switched from cars to bicycles for their daily travels and which challenges they have encountered or/and still need to overcome regarding this modal transition.

Following standard practices in social research, I would like to record this interview to ensure that I will not miss out on any crucial information. I can ensure that any information you share will be treated anonymously and confidentially. It will only be used within the framework of my master thesis.
Please be aware that you can withdraw your consent at any point during the interview.
Before we begin with the question, do you have any questions?

1. Opening question:

1.1 By making reference to your experience, could you tell me when you began using the bicycle as your primary mode of transportation in Luxembourg City?

Prompts:

- Year when the transition took place?
- Since you have moved to Luxembourg City?
- Since your workplace is in Luxembourg City?
- Since the presence & expansion of the cycling infrastructure?

2. Open questions:

2.1 Based on your own/personal experiences, and if possible, by using examples or anecdotes, can you tell me which aspects have motivated your transition from using a car to choosing a bicycle as your primary mode of transport?

Prompts:

- Environmental concerns?
- Economic convenience? Cost-related reasons?
- Parking space concerns?
- Time savings?
- Presence & expansion of cycling infrastructure?
- Travel autonomy in terms of planning your travel?
- Health concerns?
- Travel flexibility, specifically to make planner or spontaneous intermediate stops?

2.2 Besides your personal motivations, could you tell me which aspects have facilitated your transition towards using the bicycle as your primary mode of transport?

Prompts:

- Expansion of the cycling infrastructure?
- Governmental subsidies for bicycle purchase?
- Cycling community support?
- The presence of the City's bike-sharing scheme, *Vel'OH*?
- Time savings?
- Economic efficiency?

2.2 By referring to your own experience and, whenever possible, by using concrete examples and anecdotes, can you tell me which aspects created some resistance in your transition from car to bicycle?

Prompts:

- Time savings?
- Parking space concerns?
- Presence of the cycling infrastructure?
- Safety concerns? Regarding yourself and/or the bicycle?
- Independency?
- Charging stations concerns?
- Weather concerns?

2.3 In your opinion, as a politician, what are the main driving forces that encourage Luxembourg City residents to choose cycling as their primary mode of transportation (over driving a car)?

Prompts:

- Environmental concerns?
- Economic convenience? Cost-related reasons?
- Parking space concerns?
- Time savings?
- Presence & expansion of cycling infrastructure?
- Independency?
- Health concerns?
- Lack of respect & attention from drivers?

2.4 From your perspective as a politician, which policy/ies or awareness measure(s) do you consider the most effective in promoting regular bicycle usage among residents of Luxembourg?

Prompts:

- Speed limitations (30km/h) within the residential districts?
- Elimination of car parking facilities within the city centre?
- Further expansion of the bicycle sharing system (Vél'OH)?
- Car-free day(s)?
- Campaigns?

3. Closed questions:

3.1 In which district of Luxembourg City do you live?

_____

3.2 Do you own a car?

- Yes
  If yes, under what circumstances do you typically use the car?
- No

3.3 How often do you use the bicycle per week, if the outward and return count as 1 time including an intermediate stop?
Please count as follows: Outward and return journey count as 1 (e.g., commuting to work and back), even if you do one or more intermediate stops (e.g. dropping kids to kindergarden/school)

- Less than 4 times a week
- 4 times a week
- More than 4 times a week

3.4 What type of bicycle do you prefer using on a regular basis?

- Conventional Bike
- E-Bike
- Cargo-Bike
- Vél'OH
- Other …

3.5 On a weekly basis, what are the main activities for which you find yourself using the bicycle the most, given that is your primary mode of transportation?

- To go to work
- To go shopping / do groceries
- To visit friends

- Leisure activities (e.g. go to sports, cycle in the countryside)
- Other ….

Concluding Remark/Question:

Thank you for your participation in this interview. Is there any additional aspect we should look into or give more attention to that may help me understand more about the transition from car to bicycle among residents in Luxembourg City?

In case you are interested, I can later share my thesis results with you.

Appendix 4: Interview quotations

Weekly Travel Distance	Quotations from the interviewees	Interview number
	"I use it for everything. Whether it's going to work, engaging in sports, or getting around in Luxembourg City. I ride my bicycle everyday without a fail"	*R1*
	"I use the bicycle every day. [..] I commute to work, attend meetings, and handle all my tasks by bicycle. It doesn't matter whether it's within the city of Luxembourg or its surrounding regions."	*R2*
	"My primary mode of transportation remains the bike, which I rely on daily for commuting to work and navigating through various destinations. I use the bike for everything."	*R4*
	"Every day, without fail. I use my bicycle for commuting to work and for all my local travels within Luxembourg City."	*R5*
	"I commute by bike every day within the city for work. During work hours in Luxembourg City, I also bike for appointments. Interestingly, even though I have access to a chauffeur and a car provided by my workplace."	*R6*

Table 10 - Quotations for Weekly Travel Distance

Attitudes : Time efficiency	Quotations from the interviewees	Interview number
In terms of time efficieny	*"It's a quicker mode of transport. The bicycle allows me to reach my destination from A to B swiftly. It offers another means of quick transportation without relying on a car."*	*R1*
In terms of time efficieny	*"For me, the bicycle is much more reliable in the city of Luxembourg when I need to travel from point A to point B, in regards to the time. It offers greater predictability. For me it is important that I arrive at my appointments on time, that I arrive where I want to be and at the time I want to."*	*R2*
In terms of time efficieny	*"The primary reason for me is the efficiency and speed that biking offers within the city."*	*R3*
In terms of time efficieny	*"The main reason for choosing the bicycle as my primary mode of transportation was its efficiency compared to driving. This remains a clear and compelling argument. You move quickly, and you always arrive well."*	*R4*
In terms of time efficieny	*"Bicycles are much faster in the city compared to cars. You don't get stuck in traffic and can easily navigate through any route."*	*R5*
In terms of time efficieny	*"The distance from my residence to my workplace is conveniently short, requiring only 10 to 12 minutes of travel time by bicycle. In contrast, if I were to commute by car, even though I have a parking space at work, it used to take me a minimum to 40 minutes to cover the few kilometers between my home and workplace. The fact that one is always faster. No matter where you go in the city, you are always quicker on a bike."*	*R6*

Table 11 – Quotations for Time Efficiency

Perceived personal values	Quotations from the interviewees	Interview number
In terms of feeling of freedom	"I don't have to wait for the bus or squeeze into a crowded one. I feel more independent compared to using the bus or getting stuck in car traffic. I get very impatient when I am stuck in a traffic jam by bus or car. With the bicycle, I experience a sense of freedom and autonomy."	*R1*
In terms of feeling of freedom	"Using the bicycle is generally better than using a car because with a car there's always an element of surprise."	*R2*
In terms of feeling of freedom	" It gives me a great sense of autonomy."	*R5*
In terms of feeling of freedom & pleasure	"Personally, I find biking enjoyable and liberating."	*R3*
In terms of feeling of freedom & pleasure	"I always prefer to ride my bike because it's faster and brings me joy." "Taking the bus is alright; I don't mind the crowdedness, but it's still more pleasant to be alone on a bicycle." (R6)	*R6*
In terms of feeling of pleasure	"It enables swift and efficient travel from one point to another while promoting physical well-being and enjoyment."	*R5*

Table 12 - Quotations for Feelings of Pleasure and Freedom

Convenience	Quotations from the interviewees	Interview number
In terms of accessibility and practicality	"I firmly believe that the bicycle stands out as the most appealing and suitable mode of transportation, especially for short distances, alongside walking. This holds true not only in urban areas but also in rural regions like small villages."	*R4*
In terms of accessibility and practicality	"One of the aspects that motivated me the most to use the bicycle as my main means of transportation is the convenience of always finding a parking spot right in front of my destination."	*R5*
In terms of accessibility and practicality	"In my opinion, the E-Bike has revolutionised cycling in the city of Luxembourg, making it accessible to a much larger audience than before."	*R5*
Accessibility	"It allows me to easily reach my destinations."	*R3*
Praciticality	"[…] a bicycle is versatile and can transport various items, reducing the need for a car"	*R1*

Table 13 - Quotations for Convenience

Perceived structural barriers	Quotations from the interviewees	Interview number
In terms of discontinuity	“One of the challenges I face is the absence of continuous bike lanes from home to my workplace.” (R6)	*R6*
In terms of discontinuity	"Absolutely. I think safety is the primary challenge, and to address it [safety], we need a well-connected cycling infrastructure."(R5)	*R5*
In terms of discontinuity	“However, in other areas in Luxembourg City, it is a bit more picturesque because the cycling network has some gaps.” (R2)	*R2*
In terms of non-segregated cycling routes	"From what I gather, many people desire completely separate cycling paths to feel safe when cycling in traffic."(R1)	*R1*
In terms of non-segregated cycling routes	"Apart from the infrastructure challenges, such as safe cycling paths, proper signage, and visibility." (R3)	*R3*

Table 14 - Quotations for Structural Barriers

Perceived Disconnection between main cycling network and residential areas	Quotations from the interviewees	Interview number
	“[...] there are still gaps, such as the absence of safe bike lanes when traveling from Bonnevoie to the City Center. Specifically, not before reaching the train station are [Gare district] , I have access to a secure bike lane” (R4)	R4
	“In recent years, it has simply been neglected to complete the cycling network and to expand it in residential areas, and that has not happened. Just to note there are neighborhoods in the City that are poorly connected.” (R2)	R2
	“Currently, neighborhoods like Neudorf and some northern areas are practically disconnected from the cycling network.” (R1)	R1

Table 15 - Quotations for disconnection between main cycling network and residential areas

Lack of Parking facilities	Quotations from the interviewees	Interview number

	"In Luxembourg City, particularly in older neighborhoods like Bonnevoie, many houses lack garages. As a result, people often have to store their bicycles in entrances, which is not very practical." (R4)	*R4*
	"Another aspect is secure bicycle parking. [...] Having easily accessible and safe parking areas for bicycles is important. For instance, in my office building, the bicycle parking is located at the -4 level, which is quite inconvenient."	*R2*
	"We also need to provide more secure and well-designed bike parking facilities." (R1)	*R1*

Table 16 - Quotations for Lack of parking facilities

Lack of recognition	Quotations from the interviewees	Interview number
	"One of the main concerns is the attitude of car drivers towards cyclists." (R3)	*R3*
	"Cyclists need to be careful themselves, especially because there is still a car-centric culture." (R2)	*R2*
	"One-way streets pose a particular concern, as many cars fail to recognize the bi-directional presence of cyclists and that cyclists also need some space to cycle." (R1)	*R1*

Table 17 – Quotations for Lack of recognition

Logisitic-related transport barriers	**Quotations from the interviewees**	**Interview number**
	"Well, sometimes a car is necessary, for big purchases. Obviously, that doesn't work with a bicycle."(R5)	*R5*
	"I use the car for purchasing larger items or when attending concerts in the southern part of the country."(R3)	*R3*
	"I tend to drive within my neighbourhood. But this choice is influenced by logistical reasons."(R6)	*R6*

Table 18 - Logistic-related Transport Barriers

Appendix 5: Codebook

Code	Groundedness	Creator
● **Barriers**	142	Camille Glas
● Climate barriers	15	Camille Glas
● Complex decision-making	11	Camille Glas
● Transport barriers	12	Camille Glas
● Personal safety	25	Camille Glas
● Structural barriers	50	Camille Glas
● Topographical barriers	6	Camille Glas
● Traffic environment	21	Camille Glas
● Transport mode competition	5	Camille Glas
● **Facilitators/Measures**	80	Camille Glas
● Behavioral measures	4	Camille Glas
● Personal / Emotional measures	10	Camille Glas
● Personal experience	4	Camille Glas
● Statutory Traffic measures	19	Camille Glas
● Structural	49	Camille Glas
● **Motivations**	99	Camille Glas
● Convenience	27	Camille Glas
● Cost efficiency	9	Camille Glas
● E-Bike (incl. Cargo-Bike)	4	Camille Glas
● Environmental awareness	11	Camille Glas
● Habit	1	Camille Glas
● Health awareness	4	Camille Glas
● Personal values	29	Camille Glas
● Social values	2	Camille Glas
● Time Efficiency	27	Camille Glas
● **Personal Characteristics**	50	Camille Glas
● Age	1	Camille Glas
● Car ownership	6	Camille Glas
● Car use	18	Camille Glas
● Gender	6	Camille Glas
● Level of experience	13	Camille Glas
● Locality	6	Camille Glas
● **Trip Characteristics**	46	Camille Glas
● Alternative transport mode use	4	Camille Glas
● Bicycle type	6	Camille Glas
● Travel Purpose & Bicycle use	36	Camille Glas

Appendix 6: Survey Questionnaire

From cars to bicycles: An assessment of how and why Luxembourg City inhabitants choose the bicycle over the car
I am a master student at the Erasmus University Rotterdam's Institute of Housing and Urban Development *Studies* (IHS) .
My research aims to analyze, how and why, residents of Luxembourg City regularly use their bicycle instead of a car for their everyday travels.
With this survey, I want to assess the personal motivations that have influenced residents of Luxembourg City to switch from cars to cycling as their primary mode of transportation, as well as the benefits and challenges associated with this transition.
This survey consists of 3 sections and takes approximatively 6 - 8 minutes.
Before taking part in this survey, you should know that all answers will be kept anonymous and confidential and will only be used for research purposes. No legal or financial risks are involved in your participation in this study.
Your participation is not compulsory, and you can cancel your participation in the survey at any time.
In case you have any further questions, please contact me via [redacted]@gmail.com.
Thank you in advance for your interest in participating and supporting my research.
By clicking on the arrow below, you confirm your participation and acknowledge that you are a Luxembourg City resident who has switched from regular car use to cycling.
De la voiture au vélo: Une étude visant à déterminer comment et pourquoi les résidents de la ville de Luxembourg choisissent le vélo plutôt que la voiture
Je suis étudiante à l'*Insitute of Housing and Urban Development Studies*, qui fait partie de l'Université Erasmus de Rotterdam. Mon mémoire vise à déterminer comment et pourquoi les résidents de la ville de Luxembourg ont choisi d'utiliser régulièrement le vélo plutôt que la voiture pour leurs déplacements quotidiens.
Par conséquent, avec cette enquête, je souhaite découvrir quelles motivations personnelles ont influencées les résidents de la ville de Luxembourg à passer de la voiture au vélo comme mode de transport principal, ainsi que les avantages et les défis associés à cette transition.
Cette enquête se compose de 3 sections et prend environ 6 à 8 minutes. Toutes les réponses resteront anonymes et confidentielles et ne seront utilisées qu'à des fins de recherche. Votre participation à cette étude ne comporte aucun risque juridique ou financier .
La participation n'est pas obligatoire et vous pouvez annuler l'enquête à tout moment.
Pour toute question supplémentaire, veuillez me contacter à l'adresse suivante: [redacted]@gmail.com.
Je vous remercie par avance de l'intérêt que vous portez à l'enquête et au soutien de mon mémoire. En cliquant sur la flèche ci-dessous, vous confirmez votre participation et confirmez que vous résidez dans la ville de Luxembourg et que vous êtes passé de la voiture au vélo pour vos déplacements quotidiens.
Vom Auto aufs Fahrrad: Eine Studie, die untersucht, wie und warum die Einwohner der Stadt Luxemburg das Fahrrad anstelle des Autos wählen
Vom Auto aufs Fahrrad: Eine Studie, die untersucht, wie und warum die Einwohner der Stadt Luxemburg das Fahrrad anstelle des Autos wählen
Ich bin Studentin am *Institute of Housing and Urban Development Studies* (IHS), das Teil der Erasmus Universität Rotterdam ist.
Meine Forschung zielt darauf ab, herauszufinden, wie und warum sich die Einwohner der Stadt Luxemburg dafür entschieden haben, für ihre täglichen Fahrten regelmäßig das Fahrrad anstelle des Autos zu benutzen.
Mit dieser Umfrage möchte ich die persönlichen Motivationsgründe ermitteln, die die

Einwohner der Stadt Luxemburg dazu veranlasst haben, vom Auto auf das Fahrrad als Hauptverkehrsmittel umzusteigen, sowie die Vorteile und Herausforderungen, die mit diesem Umstieg verbunden sind.

Diese Umfrage besteht aus 3 Teilen und dauert ungefähr 6 - 8 Minuten. Bevor Sie an dieser Umfrage teilnehmen, sollten Sie wissen, dass alle Antworten anonym und vertraulich behandelt werden und nur zu Forschungszwecken verwendet werden. Ihre Beteiligung an dieser Studie ist mit keinerlei rechtlichen oder finanziellen Risiken verbunden.
Ihre Teilnahme ist nicht verpflichtend, und Sie können die Umfrage jederzeit abbrechen.

Falls Sie weitere Fragen haben, kontaktieren Sie mich bitte unter [redacted]@gmail.com.
Ich danke Ihnen im Voraus für Ihr Interesse an der Teilnahme und die damit verbundene Unterstützung meiner Forschungsarbeit.

Durch das Anklicken des Pfeils unten, bestätigen Sie Ihre Teilnahme und dass Sie ein Einwohner der Stadt Luxemburg sind, der von der (fast) täglichen Nutzung des Autos auf das Fahrrad umgestiegen ist.
Vum Auto op de Vëlo: Eng Etude wéi a firwat d'Awunner vu der Staat Lëtzebuerg de Vëlo amplaz den Auto huelen
Ech sinn eng Masterstudentin op der Erasmus Universitéit Rotterdam. An menger Recherche geet et drëms eraus ze fannen, wéi a firwat, d'Awunner vu der Staat Lëtzebuerg reegelméisseg hire Vëlo amplaz den Auto fir déi alldeeglech Deplacementer benotzen. Dofir mat dëser Ëmfro well ech gären erausfannen, wéi eng perséinlech Grënn d'Awunner vun der Staat Lëtzebuerg dozou bruecht hunn, den Vëlo gréissten Deels am Alldag ze benotzen amplaz vum Auto,a wéi eng Virdeeler an Erausfuerderunge mat deem Wiessel verbonne sinn.

Dës Ëmfro besteet aus 3 Deeler a dauert ongeféier 6 - 8 Minutten. Ier Dir un dëser Ëmfro deelhëlt, sollt Dir wëssen datt all Äntwerte anonym a vertraulech gehale ginn an nëmme fir Fuerschungszwecker benotzt ginn. Et gi keng legal oder finanziell Risiken verbonne mat Ärer Participatioun un dëser Etude.
Är Participatioun ass net obligatoresch, an Dir kënnt Är Particpatioun un der Ëmfro zu all Moment annuléieren.

Wann Dir weider Froen hutt, da kontaktéiert mech w.e.g. iwwer [redacted]@gmail.com.
Merci am Viraus fir Är Participatioun an dobäi meng Fuerschungsaarbecht z'ënnerstëtzen.
Andeems Dir op de Feil hei drënner klickt, confirméiert Dir Är Participatioun a bestätegt datt Dir en Awunner vun der Stad Lëtzebuerg sidd, dee vum reguläre Auto fueren op de Vëlo gewiesselt ass.

Section 1: Car & bicycle ownership and your usage patterns
1ère Section: Vos modes d'utilisations
Teil 1: Auto- und Fahrradbesitz und Ihr Nutzungsverhalten
1ten Deel: Auto & Vëlo Besëtz an Är Benotzungs Eegenschaften

Q3 Do you own a car?
Yes (1)
Yes, I own several cars (2)
I share a car with people not being part of my household (3)
No (4)

Q3 Avez-vous une voiture?
Oui (1)
Oui, je possède plusieurs voitures (2)
Je partage une voiture avec des personnes ne faisant pas partie de mon ménage (3)
Non (4)

Q3 Besitzen Sie ein Auto?
Ja (1)
Ja, ich besitze mehrere Autos (2)
Ich teile ein Auto mit Personen, die nicht Teil meines Haushalts sind (3)
Nein (4)

Q3 Hutt dir en Auto?
Jo (1)
Jo, ech besetzen e puer Autoen (2)
Ech deelen en Auto mat Léit déi net Deel vu mengem Stot sinn (3)
Nee (4)

Q4 How often do use the car?

Use of the car	Once a week (1)	Several times a week (2)	Once a month (3)	Several times a month (4)	Once a year (5)	Several times a year (6)	Never (7)

Q4 À quelle fréquence utilisez-vous votre/la voiture?

L'utilisation de la voiture	Une fois par semaine (1)	Plusieurs fois par semaine (2)	Une fois par mois (3)	Plusieurs fois par mois (4)	Une fois par an (5)	Plusieur fois par an (6)	Jamais (7)

Q4 Wie häufig benutzen Sie das Auto?

Verwendung des Autos	Einmal pro Woche (1)	Mehrmals die Woche (2)	Einmal im Monat (3)	Mehrmals im Monat (4)	Einmal im Jahr (5)	Mehrmals im Jahr (6)	Nie (7)

Q4 Wéi oft benotzt Dir den Auto

De Gebrauch vum Auto	Eemol an der Woch (1)	E puer Mol an der Woch (2)	Eemol am Mount (3)	E puer Mol am Mount (4)	Eemol am Joer (5)	E puer Mol am Joer (6)	Nie (7)

Q5 Do you own a bicycle?
Yes (1)
No, but I have a subscription to a bicycle sharing system (vel'OH) (2)
No, I share a bicycle with a relative (friend or family member) (3)
No (4)

Q5 Possédez-vous un vélo?
Oui (1)
Non, je dispose d'ailleurs d'un abonnement auprès d'un système de vélo en libre-service (vel'OH) (2)
Non, je partage un vélo avec un de mes proches (ami ou membre de la famille) (3)
Non (4)

Q5 Besitzen Sie ein eigenes Fahrrad?
Ja (1)
Nein, aber ich bin Mitglied eines Fahrrad-Sharing-System (vel'OH) (2)
Nein, ich teile ein Fahrrad mit einem Angehörigen (Freund oder Familienmitglied) (3)
Nein (4)

Q5 Hutt Dir e Vëlo?
Jo (1)
Nee, mee ech hunn en Abonnement bei engem Vëlo-Sharing System (vel'OH) (2)
Nee, ech deelen e Vëlo mat engem Bekannten (Frënd oder Familljemember) (3)
Nee (4)

Skip To: End of Survey If Q5 = No

Display This Question:
If Q5 = Yes

Q6 Did you use the state's financial support to buy your bicycle?
Yes (1)
No, I did not use the financial state subsidies (2)
No, I was not aware of the financial aid regarding the purchase of a bicycle (3)

Q6 Avez-vous utilisé l'aide financière de l'État pour acheter votre vélo ?
Oui (1)
Non, je n'ai pas utilisé les aides financières de l'État (2)
Non, je n'étais pas au courant de cette aide financière pour l'achat d'un vélo (3)

Q6 Haben Sie für den Kauf Ihres Fahrrads die finanzielle Unterstützung des Staates in Anspruch genommen?
Ja (1)
Nein, ich habe die staatlichen Beihilfen nicht in Anspruch genommen (2)
Nein, ich war mir der finanziellen Beihilfe für den Kauf eines Fahrrads nicht bewusst (3)

Q6 Hutt Dir déi staatlech finanziell Hëllef benotzt fir Äre Vëlo ze kafen?
Jo (1)
Nee, ech hunn d'Staatshëllef net benotzt. (2)
Nee, ech war mir net bewosst, daat de Kaf vun engem Vëlo finanziell vum Staat ënnerstëtzt gëtt. (3)

Q7 How often per week do you use the bicycle? Please note: The outward & return counts as 1 time (including intermediate stop).

	Less than 4 times a week (1)	4 times a week (2)	More than 4 times a week (3)
Back & forth per week (1)			

Q7 Combien de fois par semaine utilisez-vous le vélo ? L'aller-retour compte pour 1 fois (y compris l'arrêt intermédiaire)

	Moins que 4 fois par semaine (1)	4 fois par semaine (2)	Plus que 4 fois par semaine (3)
L'aller et le retour par semaine (1)			

Q7 Wie oft in der Woche benutzen Sie das Fahrrad? Bitte beachten: Die Hin- und Rückfahrt zählt als 1 Mal (einschließlich Zwischenstopp).

	Weniger als 4 Mal die Woche (1)	4 Mal die Woche (2)	Mehr als 4 Mal die Woche (3)
Hin- und Rückfahrt pro Woche (1)			

Q7 Wéi dacks benotzt Dir de Vëlo pro Woch?
En Aller-Retour zielt als 1 Mol (inklusiv Zwëschenstopp)

	Manner wéi 4 Mol pro Woch (1)	4 Mol pro Woch (2)	Méi wéi 4 Mol pro Woch (3)
Aller-Retour pro Woch (1)			

Q8 Can you roughly estimate how many kilometres you cycle per week on average?
▼ Less than 5 km (1) ... More than 100 km (7)

Q8 Pouvez-vous approximativement estimer le nombre de kilomètres que vous parcourez en moyenne par semaine à vélo ?
▼ Moins que 5 km (1) ... Plus que 100 km (7)

Q8 Können Sie ungefähr abschätzen, wie viele Kilometer Sie im Durchschnitt pro Woche mit dem Fahrrad zurücklegen?
▼ Weniger als 5 km (1) ... Mehr als 100 km (7)

Q8 Wéivill Kilometer am Duerschnëtt fuert Dir pro Woch mam Vëlo?
▼ Manner wéi 5 km (1) ... Méi wéi 100 km (7)

Q9 On average, how many stops does your one-way bicycle trip include?
Please note: An uninterrupted bicycle ride is considered as no stop.

Example: From home to work = 0 stop **or** From home to kindergarden to work = 1 Stop
No stop / 0 stop (1)
1 Stop (2)
More than 1 stop (3)

Q9 En moyenne, combien d'arrêts comportent votre trajet (un aller ou retour simple) à vélo?
Un trajet à vélo sans interruption est considéré comme une absence d'arrêt.

Exemple : de la maison au travail = 0 arrêt **ou** de la maison à la crèche au travail = 1 arrêt
0 arrêt (1)
1 arrêt (2)
Plus que 1 arrêt (3)

Q9 Wie viele Stopps umfasst Ihre Einwegfahrt (Hin- oder Rückfahrt) mit dem Fahrrad im Durchschnitt?
Bitte beachten: Eine ununterbrochene Fahrradfahrt wird als kein Stopp betrachtet.

Beispiel: Von Zuhause zur Arbeit = Kein Stopp **oder** Von Zuhause zum Kindergarten und dann zur Arbeit = 1 Stopp
Kein Stopp / 0 Stopp (1)
1 Stopp (2)
Mehr als 1 Stopp (3)

Q9 Wéi vill Stoppen enthält Ären eesäitegen Vëlostrajet (den Aller oder Retour) am Duerchschnëtt?
En onënnerbrachenen Vëlostrajet gëtt als kee Stop ugesinn.
Beispill: Vun Doheem op d'Aarbecht = Kee Stopp **oder** Vun Doheem an d'Schoul an op d'Aarbecht = 1 Stopp
Kee Stopp (1)
1 Stopp (2)
Méi wéi 1 Stopp (3)

Q10 For which of the following activities do you use the bicycle the most?
Please rank the statements from most to least important (Click & drag the statement).
_____ To go to work (1)
_____ To go shopping / do groceries (2)
_____ To bring the children to kindergarden or school (3)
_____ To go to sports (4)

_____ To go visit friends / family (5)
_____ To get to a bus station / train station / tram station (6)
_____ Other: Please specify (7)

Q10 Parmi les activités suivantes, pour laquelle utilisez-vous le plus souvent le vélo?
Classez les affirmations de la plus importante à la moins importante (cliquez et faites glisser l'affirmation).
_____ Pour aller au travail (1)
_____ Pour faire des courses (2)
_____ Pour amener les enfants à la crèche ou à l'école (3)
_____ Pour aller au sport (4)
_____ Pour rendre visite à des amis/à la famille (5)
_____ Pour se rendre à une station de bus / tram / train (6)
_____ Autre : Veuillez préciser (7)

Q10 Für welche der folgenden Aktivitäten nutzen Sie das Fahrrad am häufigsten?
Bitte ordnen Sie die Aussagen in der Reihenfolge von "am wichtigsten" bis "am wenigsten wichtig" (klicken und ziehen Sie die Aussage).
_____ Um zur Arbeit zu fahren (1)
_____ Zum Einkaufen / Lebensmittel einkaufen (2)
_____ Um die Kinder in den Kindergarten oder die Schule zu bringen (3)
_____ Um zum Sport zu fahren (4)
_____ Um Freunde / Familie zu besuchen (5)
_____ Zu einem Bahnhof / einer Bushaltestelle / einer Straßenbahnhaltestelle zu gelangen (6)
_____ Sonstiges, bitte angeben: (7)

Q10 Fir wéi eng vun de folgenden Aktivitéiten benotzt Dir Äre Vëlo am meeschten?
Sortéiert w.e.g. d'Aussoen an der Reiefolleg vu Wichtegst bis am mannsten Wichteg (klickt an zitt d'Ausso).
_____ Fir op d'Aarbecht ze fueren (1)
_____ Fir akafen ze goen (2)
_____ Fir d'Kanner an d'Schoul oder Crèche ze bréngen (3)
_____ Fir an de Sport ze fueren (4)
_____ Fir Frënn / Famill ze besichen (5)
_____ Fir op e Busarrêt / Gare / Tramsstatioun ze fueren (6)
_____ Aner (spézifizéieren w.e.g.): (7)

Q11 What type of bicycle do you prefer using on a regular basis?
Conventional bike (City Bike, Mountain Bike, BMX, etc.) (1)
E-Bike (2)
VélOH - public bicycle share scheme (3)
Cargo Bike (4)
Other, please specify: (5) _____

Q11 Quel type de vélo préférez-vous utiliser régulièrement ?
Vélo traditionnel (City Bike, Mountain Bike, BMX, etc.) (1)
Vélo électrique (2)
VélOH - vélo en libre-service (3)
Vélo-cargo (4)
Autre, veuillez préciser : (5) _____

Q11 Welche Art von Fahrrad bevorzugen Sie, um regelmäßig zu fahren?
Konventionelles Fahrrad (City Bike, Mountain Bike, BMX, etc.) (1)
Elektrisches Fahrrad (2)
VélOH (3)
Cargo Fahrrad (4)
Sonstiges, bitte angeben: (5) _____

Q11 Wéi een Vëlo benotzt Dir léiwer fir reegelméisseg mam Vëlo ze fueren?
E traditionelle Vëlo (City Bike, Mountain Bike, BMX, etc.) (1)
En eletresche Vëlo (2)
VélOH (3)
E cargo Bike (4)
Aner (spézifizéieren w.e.g.): (5) _____

Q12 Section 2: Your personal motivations and perspectives for using the bicycle
Q12 2ème section: Vos perceptions et motivations personnelles pour utiliser le vélo au quotidien
Q12 Teil 2: Ihre persönlichen Beweggründe und Ansichten zur Nutzung des Fahrrads
Q12 2ten Deel: Är perséinlech Motivatioune fir de Vëlo ze benotzen

Q13 How do you feel when cycling?
Please note: Maximum 3 choices possible.
Pleasure: Cycling is fun (1)
Passion: Cycling with enthusiasm (2)
Energized: Increased motivation & productivity for daily tasks (3)
Active: Cycling keeps me physically & mentally fit (4)
Feeling of freedom: Independency (5)
Greater sense of environmental responsibility (6)

Q13 Comment vous vous sentez lorsque vous faites du vélo ?
3 choix au maximum sont possibles.
Plaisir : Le vélo, c'est amusant (1)
Passionné(e) : Faire du vélo avec enthousiasme (2)
Energétique: Augmentation de la motivation et de la productivité pour les tâches quotidiennes (3)
Actif/Active: Le vélo me permet de rester en forme physiquement et mentalement (4)
Sentiment de liberté : Indépendance (5)
Un plus grand sens de la responsabilité environnementale (6)

Q13 Wie fühlen Sie sich beim Fahrradfahren?
Bitte beachten: Maximal 3 Auswahlmöglichkeiten.
Freude: Radfahren macht Spaß (1)
Leidenschaft: Mit Begeisterung Fahrrad fahren (2)
Energisch: Gesteigerte Motivation und Produktivität bei alltäglichen Aufgaben (3)
Aktiv: Radfahren hällt mich körperlich und geistig (4)
Gefühl der Freiheit / Unabhängigkeit (5)
Größeres Verantwortungsbewusstsein für die Umwelt (6)

Q13 Wéi fillt Dir Iech beim Vëlo fueren?
Maximal 3 Choixen méigleg.
E Gefill vu Freed: Vëlo fueren mécht Spaass (1)
Et ass eng Passioun: Ech fueren Vëlo mat Begeeschterung (2)
Energesch: Ech hunn méi Motivatioun a sinn méi produktiv fir meng alldeeglech Aufgaben (3)
Aktiv: Vëlo fueren hält mech kierperlech & geeschteg fit (4)
E Gefill vu Fräiheet / Onofhängegkeet (5)
E gréissert Ëmweltbewosstsinn (6)

Q14 When choosing cycling as my main mode of transport, ...

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I feel like I can move around faster by bicycle (1)					
I feel like my travel time is more predictable by bicycle (2)					
I have no problems finding a place to park my bicycle (3)					
I feel like I have more time for other activities since I've been cycling regularly (4)					
I feel like my destination(s) are easier accessible by bicycle (5)					
I feel free from the traffic stress (6)					

Q14 Depuis que j'ai choisi le vélo comme principal mode de transport, ..

	Tout à fait en désaccord (1)	En désaccord (2)	Ni en désaccord ni en accord (3)	En accord (4)	Tout à fait en accord (5)
J'ai l'impression de pouvoir me déplacer plus rapidement à vélo (1)					
J'ai l'impression que mon temps de trajet est plus prévisible à vélo (2)					
Je n'ai pas de difficulté à trouver un endroit pour stationner mon vélo (3)					
J'ai l'impression d'avoir plus de temps pour d'autres activités depuis que je fais du vélo régulièrement. (4)					
J'ai l'impression que ma / mes destination(s) est / sont plus facilement accessible(s) à vélo (5)					
Je me sens libéré du stress de la circulation (6)					

Q14 Seitdem ich das Fahrrad als mein bevorzugtes Verkehrsmittel wähle, ...

	Stimme überhaupt nicht zu (1)	Stimme eher nicht zu (2)	Stimme nicht zu, weder noch, stimme zu (3)	Stimme eher zu (4)	Stimme absolut zu (5)
Habe ich das Gefühl, schneller voranzukommen. (1)					
Habe das Gefühl, dass meine Reisezeit besser vorhersehbar ist. (2)					
Kann ich problemlos einen Abstellplatz für mein Fahrrad finden. (3)					
Habe ich das Gefühl, mehr Zeit für andere Aktivitäten zu haben. (4)					
Habe ich das Gefühl, dass mein(e) Ziel(e) leichter zu erreichen sind. (5)					
Fühle ich mich frei vom Verkehrsstress. (6)					

Q14 Séit ech reegelméisseg mam Vëlo fueren, ...

	Staark net averstanen (1)	Net averstanen (2)	Weder net averstanen nach averstanen (3)	Averstanen (4)	Staark averstanen (5)
Hunn ech d'Gefill méi séier ronderëm ze kommen (1)					
Hunn ech d'Gefill dat meng Fuerzäit méi previsibel ass (2)					
Hu ech keng Probleemer eng Plaz ze fannen fir de Vëlo ofzestellen / ze parken (3)					

Hunn ech d'Gefill méi Zäit fir aner Aktivitéiten ze hunn (4)	
Hunn ech d'Gefill dass meng Destinatioun(en) méi einfach zougänglech sinn (5)	
Fillen ech mech fräi vum Verkéiersstress (6)	

Q15 How strongly has the health aspect of cycling influenced you to cycle regularly?

Level of influence (1)

Q15 Dans quelle mesure l'aspect santé du vélo vous a-t-il incité à faire du vélo régulièrement ?

Niveau d'influence (1)

Q15 Wie stark hat der gesundheitliche Aspekt des Radfahrens Sie dazu gebracht, regelmäßig Rad zu fahren?

Grad der Beeinflussung (1)

Q15 A wéi engem Moos huet de gesondheetleche Aspekt vum Vëlo Iech beaflosst fir reegelméisseg Vëlo ze fueren?

Afloss Niveau (1)

Q16 How strongly has the environmental impact of the car influenced you to use the bicycle on a regular basis?

Level of influence (1)

Q16 Dans quelle mesure l'impact environnemental de la voiture vous a-t-il incités à utiliser le vélo régulièrement?

Niveau d'influence (1)

Q16 Wie stark hat die ökologische Belastung des Autos Sie beeinflusst, regelmäßig das Fahrrad zu benutzen?

Grad der Beeinflussung (1)

Q16 A wéi engem Mooss huet den Ëmweltimpakt vum Auto Iech beaflosst de Vëlo regelméisseg ze benotzen?

Afloss Niveau (1)

Q17 How important is it for you that your relatives/friends have a positive attitude and acceptance towards cycling?
Not at all important (1)
Slightly important (2)
Moderately important (3)
Very important (4)

Extremely important (5)

Q17 À quel point est-il important pour vous que vos parents/amis aient une attitude positive envers le vélo?
Sans importance (1)
Peu important (2)
Modérément important (3)
Très important (4)
Extrêmement important (5)

Q17 Wie wichtig ist es für Sie, dass Ihre Verwandten / Freunde eine positive Einstellung und Akzeptanz gegenüber dem Radfahren haben?
Unwichtig (1)
Wenig wichtig (2)
Mäßig wichtig (3)
Sehr wichtig (4)
Extrem wichtig (5)

Q17 Wéi wichteg ass et fir Iech, datt Är Famill/Frënn eng positiv Astellung an Akzeptanz géigeniwwer dem Vëlo hunn?
Guer net wichteg (1)
E bësse wichteg (2)
Mëttelméisseg wichteg (3)
Ganz wichteg (4)
Extrem wichteg (5)

Q18 Which personal cost advantages encourage you to cycle regularly?

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I have reduced travel expenses (1)					
I have less parking fees (2)					
I can repair & maintain my bike myself (3)					
I have the impression that I go to the doctor less often (4)					

Q18 Quels sont les avantages économiques qui vous incitent à faire du vélo régulièrement ?

	Tout à fait en désaccord (1)	En désaccord (2)	Ni en désaccord ni en accord (3)	En accord (4)	Tout à fait en accord (5)
J'ai réduit mes frais de déplacement (1)					
J'ai moins de frais de parking (2)					
Je peux réparer et entretenir mon vélo moi-même (3)					
J'ai l'impression d'aller moins souvent chez le médecin (4)					

Q18 Welche persönlichen Kostenvorteile motivieren Sie dazu, regelmäßig mit dem Fahrrad zu fahren?

	Stimme überhaupt nicht zu (1)	Stimme eher nicht zu (2)	Stimme nicht zu, weder noch, stimme zu (3)	Stimme eher zu (4)	Stimme absolut zu (5)
Meine Fahrtkosten sind geringer (1)					
Ich habe weniger Parkgebühren (2)					
Ich kann mein Fahrrad selbst reparieren und instand halten (3)					
Ich habe das Gefühl seltener zum Arzt zu gehen (4)					

Q18 Wéi eng perséinlech Käschte Virdeeler encouragéieren Iech reegelméisseg mam Vëlo ze fueren?

	Staark net averstanen (1)	Net averstanen (2)	Weder net averstanen nach averstanen (3)	Averstanen (4)	Staark averstanen (5)
Ech hunn manner Transportkäschte (1)					
Ech hu manner Parking Käschten (2)					
Ech kann mäi Vëlo selwer reparéieren an ënnerhalen (3)					
Ech hunn d'Impressioun datt ech manner dacks bei den Dokter ginn (4)					

Q19 Which facilities are essential for you to use the bicycle on a regular basis?
Multiple choices are possible.
Parking facilities for the bicycle at work / school (1)
Provision of shower facilities at work / school (2)
None (3)

Q19 Quels sont les aménagements que vous jugez indispensables pour la pratique régulière du vélo?
Multiples réponses sont possibles.
Des facilités de stationnement pour les vélos sur le lieu de travail ou à l'école (1)
Mise à disposition de douches sur le lieu de travail ou à l'école (2)
Aucuns (3)

Q19 Welche Einrichtungen sind für die regelmäßige Nutzung des Fahrrads unerlässlich?
Mehrere Auswahlmöglichkeiten sind möglich.
Abstellmöglichkeiten für das Fahrrad am Arbeitsplatz / in der Schule (1)
Bereitstellung von Duschmöglichkeiten am Arbeitsplatz / in der Schule (2)
Keine (3)

Q19 Wéi eng Ariichtungen si wesentlech / fundamental fir dat Dir reegelméisseg de Vëlo benotzt?
Verschidde Choixe si méigleg.
Parkplazen fir de Vëlo op der Aarbecht / Schoul (1)

Dispositioun vun Duschen op der Aarbecht / Schoul (2)
Keng (3)

Q20 How do you perceive safety when cycling ?

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I feel safe cycling in my residential district / neighbourhood (1)					
I feel safe cycling on my regular route (2)					
I feel safe and confident cycling in most cases due to my cycling experience (3)					
I feel safe cycling a short distance trip (less than 5 km) (4)					
I feel safer when wearing a helmet whilst cycling (5)					
I feel safer wearing visible clothes whilst cycling (6)					
I feel safe cycling at night (7)					

Q20 Comment percevez-vous la sécurité à vélo ?

	Tout à fait en désaccord (1)	En désaccord (2)	Ni en désaccord ni en accord (3)	En accord (4)	Tout à fait en accord (5)
Je me sens en sécurité lorsque je me déplace à vélo dans mon quartier résidentiel (1)					
Je me sens en sécurité sur mon trajet habituel (2)					
Je me sens en sécurité la plupart des cas grâce à mon expérience du cyclisme. (3)					
Lorsque je fais du vélo sur une courte distance (< 5 km), je me sens en sécurité (4)					
À vélo, je me sens plus en sécurité en portant un casque (5)					
À vélo, je me sens plus en sécurité en portant des vêtements réfléchissants / à haute visibilité (6)					

Je me sens en sécurité à vélo le soir (7)	

Q20 Wie empfinden Sie die Sicherheit beim Radfahren?

	Stimme überhaupt nich zu (1)	Stimme eher nicht zu (2)	Stimme nicht zu, weder noch, stimme zu (3)	Stimme eher zu (4)	Stimme absolut zu (5)
Ich fühle mich sicher beim Radfahren in meinem Wohnviertel / meiner Nachbarschaft (1)					
Ich fühle mich mit dem Fahrrad auf meiner regulären Route sicher (2)					
Ich fühle mich aufgrund meiner Erfahrung mit dem Fahrrad in den meisten Fällen sicher und zuversichtlich (3)					
Auf kurzen Strecken (< 5km) fühle ich mit dem Fahrrad sicher (4)					
Mit einem Helm fühle ich mich beim Radfahren sicherer (5)					
Mit sichtbarer Kleidung fühle ich mich beim Radfahren sicherer (6)					
Ich fühle mich sicher in der Nacht Fahrrad zu fahren (7)					

Q20 Wéi empfënnt Dir Sécherheet beim Vëlo fueren?

	Staark net averstanen (1)	Avertanen (2)	Weder net averstanen nach averstanen (3)	Averstanen (4)	Staark averstanen (5)
Ech fille mech sécher mam Vëlo a mengem Wunnquartier ronderëm ze fueren (1)					
Ech fille mech sécher op menger regulärer Streck mam Vëlo (2)					
Duerch meng Vëlo Experienz, fille ech mech an de meeschte Fäll sécher an zouversiichtlech um Vëlo (3)					
Op enger kuerzer Streck (manner wéi 5 km) fille ech mech sécher (4)					
Mat engem Helm / Casque fille ech mech méi sécher (5)					
Ech fille mech méi sécher um Vëlo wann ech siichtbar Kleeder un hunn (6)					

Ech fille mech sécher owes mam Vëlo ze fueren (7)

Q21 If you are a parent, do you perceive your neighborhood to be safe enough for your children (6 - 11 years) to cycle to primary school?
Yes but only if accompanied by an adult (1)
Yes, an accompanying person is not necessary (2)
No, way too dangerous (3)
None of the above (4)

Q21 Si vous êtes un parent, trouvez-vous que votre quartier est suffisamment sûr pour que votre / vos enfant(s) (âgés de 6 à 11 ans) puissent se rendre à l'école à vélo ?
Oui, mais uniquement si accompagné d'un adulte (1)
Oui, une personne accompagnatrice n'est pas nécessaire (2)
Non, beaucoup trop dangereux (3)
Aucune de ces propositions (4)

Q21 Wenn Sie Eltern sind, glauben Sie, dass Ihre Nachbarschaft sicher genug ist, damit Ihre Kinder (im Alter von 6 bis 11 Jahren) mit dem Fahrrad zur Schule fahren können?
Ja, aber nur in Begleitung eines Erwachsenen (1)
Ja, eine Begleitperson ist nicht erforderlich (2)
Nein, viel zu gefährlich (3)
Keine Angabe (4)
Q21 Denkt Dir als Elterendeel, datt Ären Wunnquartier sécher genuch ass fir dat Är Kanner (6-11 Joer) mam Vëlo kennen an d'Schoul fueren?
Jo, awer nëmmen ënnert der Begleedung vun engem Erwuessenen (1)
Jo, eng Begleetpersoun ass net néideg (2)
Nee, vill ze geféierlech (3)
Trefft net op mech zou (4)

Q22 Where do you perceive your bicycle to be safer?
Multiple choices are possible.
Public bicycle lockers (mBox) (1)
Private bicycle lockers (2)
Public bicycle racks (3)
Indifferent (4)

Q22 Où croyez-vous que votre vélo est le plus en sécurité ?
Multiples réponses possibles.
Casiers publics pour vélos (mBox) (1)
Casiers privés pour vélos (2)
Supports / Racks publics pour vélos (3)
Indifférent (4)

Q22 Wo ist Ihr Fahrrad Ihrer Meinung nach sicherer?
Mehrere Auswahlmöglichkeiten sind möglich.
Öffentliche Fahrradboxen/Fahrradschließfächer (mBox) (1)
Private Fahrrad (2)
Öffentliche Fahrradständer (3)
Gleichgültig (4)

Q22 Wou mengt Dir ass Äre Vëlo méi sécher?
Verschidde Choixe si méigleg.
Ëffentlech Vëlo-Boxen (mBox) (1)
Privat Vëlo-Boxen / Schließfächer (2)
Ëffentlech Vëlo Stänner (3)
Keen Ënnerscheed (4)

Q23 Which of the following statements have been most important for you to regularly use the bicycle as a means of transport?
Please rank from most important to least important (Click & drag).
_____ To spend as little time as possible on daily transport (1)
_____ To avoid high monthly travel expenses (2)
_____ To incorporate regular physical activity (3)
_____ To reduce my Co2 emissions / To reduce my carbon footprint (4)

_____ To move / travel around in a safe travel environment (5)
_____ To enhance accessibility to my destination(s) (6)
_____ To belong to the cycling community (7)

Q23 Parmi les éléments suivants, lesquels ont été les plus importants pour que vous utilisiez régulièrement le vélo comme moyen de transport?
Classez les éléments suivants du plus important au moins important (cliquez et faites glisser)
_____ De consacrer le moins de temps possible aux déplacements journaliers (1)
_____ D'éviter des frais de déplacement mensuels élevés (2)
_____ De pratiquer régulièrement une activité physique (3)
_____ De réduire mes émissions de Co2 / Réduire mon empreinte carbone (4)
_____ De pouvoir se déplacer dans un environnement sécurisé (5)
_____ Pour faciliter l'accès à ma / mes destination(s) (6)
_____ L'appartenance à la communauté cycliste (7)

Q23 Welche der folgenden Aussagen waren für Sie am bedeutendsten, um das Fahrrad regelmäßig als Verkehrsmittel zu nutzen?
Bitte ordnen Sie die Aussagen in der Reihenfolge von "am wichtigsten" bis "am wenigsten wichtig" (klicken und ziehen Sie die Aussage)
_____ So wenig Zeit wie möglich für den täglichen Transport aufwenden (1)
_____ Vermeidung hoher monatlicher Fahrtkosten (2)
_____ Regelmäßig sportlich/physisch tätig zu sein (3)
_____ Reduzierung meiner Co2-Emissionen / Verringerung meines ökologischen Fußabdrucks (4)
_____ Fahren und Bewegen in einer sicheren Umgebung (5)
_____ Verbesserung der Erreichbarkeit / Zugänglichkeit meiner Zielorte (6)
_____ Zur Fahrradgemeinschaft gehören (7)

Q23 Wéi eng vun de folgenden Aussoe ware fir Iech am wichtegsten fir regelméisseg de Vëlo als Verkéiersmëttel ze benotzen?
Sortéiert w.e.g. d'Aussoen an der Reiefolleg vu Wichtegst bis am mannsten Wichteg (klickt an zitt d'Ausso).
_____ Sou wéineg Zäit wéi méiglech um / am alldeeglechen Transportmëttel verbréngen (1)
_____ D'vermeiden vun héijen Transportkäschten pro Mount (2)
_____ Regelméisseg physeg aktiv sinn (3)
_____ Meng Co2 Emissiounen ze reduzéieren (4)
_____ Sech an engem sécheren Ëmfeld ze beweegen / ronderëm ze fueren (5)
_____ Fir d'Erreechbarkeet vu menger(en) Destinatioun(en) ze verbesseren. (6)
_____ Zu der Vëloscommunautéit ze gehéieren (7)

Q24 Can you think of any obstacle(s) that make your cycling more challenging and that, if solved, could improve it?

Please write your answer below
_____

Q24 Pouvez-vous penser à un ou plusieurs défi(s) rendant votre trajet à vélo plus difficile et qui, une fois résolus, pourraient l'améliorer?
Veuillez rédiger votre réponse ci-dessous.
_____

Q24 Fällt Ihnen ein oder mehrere Hindernisse ein, die Ihr Radfahren erschweren und die, wenn sie beseitigt werden, es erleichtern könnten?
Bitte geben Sie Ihre Antwort unten ein.
_____

Q24 Wéi eng Obstaclen am Alldag sinn nach eng Erausfuerderung fir Iech als reguläre Cyclist?
Schreift w.e.g. Är Äntwert hei drënner.
_____

Q25 Section 3: Your personal information
Q25 3ème section: Vos données personnelles
Q25 Teil 3: Persönliche Informationen
Q25 3ten Deel: Är perséinlech Donnéeën

Q26 What is your age range?

▼ 18 - 25 years (1) ... ≥ 65 years (5)

Q26 Dans quelle tranche d'âge vous situez-vous?

▼ 18 - 25 ans (1) ... ≥ 65 ans (5)

Q26 Zu welcher der nachfolgenden Alterskategorien gehören Sie?
▼ 18 - 25 Jahre (1) ... 65 Jahre oder älter (5)
Q26 Zu wéi enger Altersgrupp gehéiert Dir?
▼ 18 - 25 Joer (1) ... ≥ 65 Joer (5)

Q27 What is your gender identity?

▼ Female (1) ... Prefer not to say (4)

Q27 Vous êtes?
▼ Une femme (1) ... Préfère ne pas le dire (4)

Q27 Bitte geben Sie Ihr Geschlecht an.
▼ Weiblich (1) ... Keine Angabe (4)

Q27 Sitt Dir?
▼ Eng Fra (1) ... Soen ech léiwer net (4)

Q28 What is your employment status?
▼ Student (1) ... None of the above (4)

Q28 Quel est votre statut professionnel ?
▼ Etudiant(e) (1) ... Aucune de ces réponses (4)

Q28 Welche der folgenden Kategorien beschreibt Ihren Beschäftigungsstatus?
▼ Studierende(r) (1) ... Keine Angabe (4)

Q28 Waat ass Är Berufssituatioun?
▼ Student (1) ... Keen vun den Ieweschten (4)

Q29 In which district of Luxembourg City do you live?
▼ Beggen (1) ... Weimerskirch (24)

Q29 Dans quel quartier de la ville de Luxembourg habitez-vous ?
▼ Beggen (1) ... Weimerskirch (24)

Q29 In welchem Stadtviertel der Stadt Luxemburg wohnen Sie?
▼ Beggen (1) ... Weimerskirch (24)

Q29 A wéi engem Quartier vun der Stad Lëtzebuerg wunnt Dir?
▼ Beggen (1) ... Weimerskirch (24)

Q30 Please let me know if you have any additional comment(s) regarding what ultimately motivated you to choose cycling as your regular mode of transportation.
_____

Q30 N'hésitez pas à me faire part de vos commentaires supplémentaires concernant ce qui vous motive à choisir le vélo comme mode de transport principal.
_____

Q30 Sollten Sie noch Anmerkungen dazu haben, was Sie letztendlich dazu bewogen hat, das Fahrrad als regelmäßiges Verkehrsmittel zu wählen, lassen Sie es mich bitte wissen.
_____

Q30 Wann Dir nach zousätzlech Bemierkungen hutt iwwer wat Iech beaflosst / motivéiert huet fir reegelméisseg de Vëlo amplaz vum Auto ze benotzen, kennt Dir déi gären hei hannerloossen.
_____

Appendix 7: Survey results – Socio-demographics

	0		1					
Employment Status	**Non-modal shifters**		**Occasional modal shifters**		**Frequent modal shifters**		**Total**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Student	3	4,3%	2	2,9%	1	1%	6	8,6%
Employed / Self-employed	9	12,9%	23	32,9%	22	31%	54	77,1%
Retired	2	2,9%	-	-	4	6%	6	8,6%
None of the above	1	1,4%	2	2,9%	1	1%	4	5,7%
TOTAL	**15**	**21,4%**	**27**	**38,6%**	**28**	**40%**	**70**	**100%**

Table 19 - Employment Status

	0		1					
Locality	**Non-modal shifters**		**Occasional modal shifters**		**Frequent modal shifters**		**Total**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Beggen	1	1,4%	2	2,9%	1	1,4%	4	5,7%
Belair	2	2,9%	3	4,3%	4	5,7%	9	12,9%
Bonnevoie Nord / Verlorenkost	-	-	1	1,4%	3	4,3%	4	5,7%
Bonnevoie Sud	1	1,4%	6	8,6%	3	4,3%	10	14,3%
Cents	1	1,4%	3	4,3%	-	-	4	5,7%
Cessange	1	1,4%	-	-	-	-	1	1,4%
Dommeldange	3	4,3%	-	-	3	4,3%	6	8,6%
Eich	1	1,4%	-	-	-	-	1	1,4%
Gare	-	-	-	-	1	1,4%	1	1,4%
Gasperich	-	-	1	1,4%	1	1,4%	2	2,9%
Hamm	1	1,4%	-	-	-	-	1	1,4%
Hollerich	-	-	1	1,4%	1	1,4%	2	2,9%
Kirchberg	-	-	1	1,4%	1	1,4%	2	2,9%
Limpertsberg	-	-	4	5,7%	3	4,3%	7	10,0%
Merl	2	2,9%	1	1,4%	3	4,3%	6	8,6%
Muhlenbach	-	-	2	2,9%	1	1,4%	3	4,3%
Rollingergrund	-	-	-	-	1	1,4%	1	1,4%
Ville Haute - City Center	1	1,4%	-	-	1	1,4%	2	2,9%
Weimerskirch	1	1,4%	-	-	-	-	1	1,4%
Not stated	-	-	2	2,9%	1	1,4%	3	4,3%
TOTAL	**15**	**21,4%**	**27**	**38,6%**	**28**	**40%**	**70**	**100%**

Table 20 - Locality

Appendix 8: Regression models

Logistic regression — Number of obs = 70; LR chi2(4) = 8.22; Prob > chi2 = 0.0839; Log likelihood = -32.261115; Pseudo R2 = 0.1130

Modal_Shift	Odds ratio	Std. err.	z	P>|z|	[95% conf.	interval]
age_group_num						
18-25	.3750003	.5598901	-0.66	0.511	.0200981	6.996951
26-35	.3541669	.4271576	-0.86	0.389	.0333105	3.765605
46-64	.0902778	.1009552	-2.15	0.032	.0100857	.808084
≥65	.1875001	.2902217	-1.08	0.279	.0090255	3.89522
_cons	15.99999	16.49241	2.69	0.007	2.121883	120.6474

Note: _cons estimates baseline odds.

Table 21 – Age_group Regression model

Logistic regression — Number of obs = 70; LR chi2(11) = 9.33; Prob > chi2 = 0.5915; Log likelihood = -31.705608; Pseudo R2 = 0.1283

Modal_Shift	Odds ratio	Std. err.	z	P>|z|	[95% conf.	interval]
Time_efficiency	3.202294	2.845349	1.31	0.190	.5612278	18.27188
1.Gender_Male	1.858508	7.102031	0.16	0.871	.0010385	3325.927
Gender_Male#c.Time_efficiency						
1	.6381162	.6646206	-0.43	0.666	.0828597	4.914239
Cost_efficiency	.4994867	.3541513	-0.98	0.328	.1244504	2.004711
Gender_Male#c.Cost_efficiency						
1	3.165664	2.684265	1.36	0.174	.600765	16.68111
Convenience	.8099627	.5398793	-0.32	0.752	.21933	2.991107
Gender_Male#c.Convenience						
1	.7821213	.7251681	-0.27	0.791	.1270738	4.813845
Health_awareness	.8003025	.3873262	-0.46	0.645	.3099518	2.066399
Gender_Male#c.Health_awareness						
1	.827699	.5859082	-0.27	0.789	.2066938	3.314496
Environmental_awareness	1.693176	.6429595	1.39	0.166	.8043973	3.563968
Gender_Male#c.Environmental_awareness						
1	.7150988	.4089472	-0.59	0.558	.233123	2.193547
_cons	.2795724	.837963	-0.43	0.671	.0007856	99.49527

Note: _cons estimates baseline odds.

Table 22 - Gender- Interacted Attitudes Regression modal

Appendix 9: Formatted Data

Modal_Shift	Time_efficiency	Cost_effi	Convenie	Environm	Health_aw	Personal	Social_val	Gender_M	Age	Employed	Bike_ownership	Car_ownership	Travel_Distance	Ebike_Typ
1	5	5	4	5	5	5	4	0	55	0	1	1	75,5	1
0	5	4	5	5	5	5	3	0	55	0	1	1	38	1
0	2,5	3	3	1	4	3	1	1	30,5	0	0	1	7,5	1
0	2,5	2	2	1	4	1	3	0	55	0	1	1	2,5	1
1	5	5	4	5	2	5	3	1	21,5	0	1	1	23	0
0	1,5	3	2	2	2	1	3	1	55	1	1	1	7,5	0
0	1	5	2	1	2	5	2	1	30,5	0	0	1	2,5	1
1	4,5	3	4	1	1	4	1	1	21,5	0	1	1	15,5	0
1	5	4	5	5	4	5	4	0	30,5	1	1	1	15,5	1
1	5	5	2	5	5	5	2	0	40,5	1	1	1	38	1
0	4,5	3	3	5	3	4	2	1	21,5	0	1	0	2,5	0
1	5	3	5	4	4	5	2	0	55	0	1	0	75,5	1
0	4	4	4	3	4	4	3	1	65	0	1	1	75,5	1
1	4,5	4	4	1	3	2	1	0	30,5	1	0	1	15,5	1
1	3	2	2	4	5	1	4	1	40,5	1	1	1	75,5	0
1	5	5	5	5	4	5	4	0	65	0	1	1	23	0
1	3,5	3	4	3	4	4	3	1	40,5	1	1	1	100	0
1	3	3	3	2	2	4	2	1	40,5	0	1	1	7,5	1
0	3,5	4	4	3	3	5	3	0	55	1	1	1	15,5	1
1	3	4	1	1	1	4	4	1	21,5	0	1	1	100	0
1	5	5	5	5	5	5	4	0	30,5	1	1	1	23	1
1	5	4	3	4	4	4	2	1	40,5	1	1	1	23	0
1	4,5	4	5	5	5	4	1	0	55	1	1	1	75,5	1
1	5	4	4	5	4	5	2	1	55	1	1	1	75,5	1
1	4	4	3	4	4	4	1	1	21,5	1	1	1	23	0
1	4,5	5	5	5	5	5	4	1	30,5	1	1	0	100	0
1	4	3	3	5	3	5	4	1	30,5	1	1	0	100	0
1	4	3	4	4	4	3	3	1	65	0	1	1	38	0
1	1	3	3	2	2	3	3	1	55	1	1	1	75,5	0
1	5	5	5	4	1	4	4	1	30,5	1	1	0	75,5	0
1	5	4	3	5	5	5	3	1	40,5	1	1	1	38	0
1	4	4	4	4	3	5	4	1	40,5	1	1	1	38	1
1	4,5	4	4	4	2	5	3	0	40,5	1	1	1	75,5	1
1	4,5	4	4	5	5	5	2	0	30,5	1	1	1	23	0
0	4,5	3	5	3	4	5	1	1	55	1	1	1	38	1
1	5	4	3	5	2	4	3	0	55	1	1	1	38	1
1	3,5	3	3	5	3	5	3	0	40,5	1	1	1	7,5	1
1	5	4	5	1	4	5	4	0	55	1	1	1	38	1
1	5	4	5	4	3	5	3	0	55	1	1	1	38	1
0	5	5	5	4	2	5	1	0	55	1	1	1	38	1
1	4,5	1	4	2	4	5	3	0	40,5	1	1	1	75,5	1
1	5	5	4	5	5	5	4	0	30,5	1	1	1	75,5	0
1	4	4	4	5	5	4	4	1	65	0	1	1	23	1
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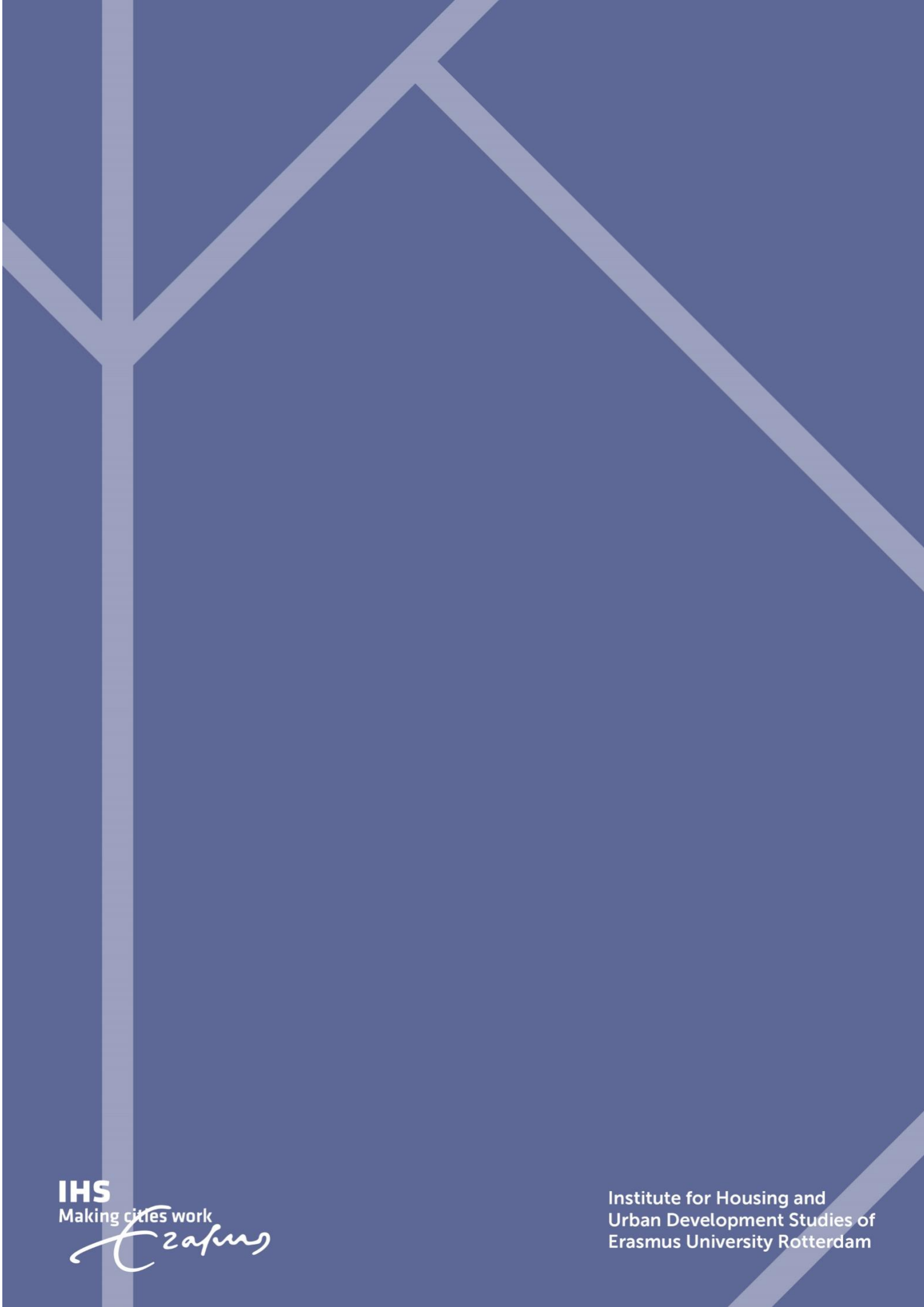
1	2,5	4	4	5	1	4	4	0	30,5	1	1	1	23	1
1	4,5	5	3	5	3	5	3	1	21,5	1	1	1	38	1
1	5	4	5	2	2	5	1	1	55	1	1	0	75,5	0
0	5	5	5	5	5	5	3	1	55	1	1	1	15,5	1
1	4	3	3	4	4	5	4	1	55	1	1	1	38	0
1	4	4	3	4	4	4	2	0	30,5	1	1	1	75,5	0
1	4,5	4	4	5	4	4	4	1	30,5	1	1	0	75,5	0
1	5	5	5	5	3	1	4	0	40,5	1	1	1	100	1
1	4,5	4	4	4	3	5	3	1	40,5	1	1	0	75,5	0
0	4,5	1	4	5	4	5	2	1	55	1	1	0	15,5	0
1	5	5	5	5	3	5	3	0	40,5	0	1	1	23	1
0	2,5	4	1	4	5	4	4	0	30,5	1	1	1	75,5	0
1	5	3	2	1	2	5	2	1	40,5	1	1	1	38	0
0	5	5	4	3	5	5	3	0	40,5	1	1	1	23	1
1	4	3	4	3	3	4	3	0	55	1	1	1	15,5	1
0	5	4	5	4	3	5	4	0	55	1	1	1	15,5	1
1	3,5	4	4	2	4	5	4	1	30,5	1	1	1	75,5	0
1	5	5	2	5	5	4	4	0	55	1	1	1	23	0
1	2	5	3	5	4	1	2	1	40,5	1	1	1	38	0
1	3,5	5	3	5	5	5	5	0	30,5	1	1	1	75,5	0
1	5	5	5	4	3	5	5	0	30,5	1	1	1	38	0
1	5	4	5	4	4	5	4	1	30,5	1	1	1	23	1
1	5	3	5	1	5	4	3	0	21,5	1	0	0	7,5	1
1	4	3	4	2	3	5	1	1	30,5	1	1	1	23	1
1	5	5	5	3	3	4	3	1	30,5	1	1	1	15,5	1
1	5	3	5	5	2	5	4	0	40,5	1	1	1	38	1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Making cities work
Erasmus
Institute for Housing and
Urban Development Studies of
Erasmus University Rotterdam