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**Towards a modal shift: A critical examination of  
fare-free public transport in Luxembourg**

Master thesis

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Date:	January 26, 2024

## **Acknowledgements**

I hereby present the thesis I authored as part of the Master's programme in Spatial Planning at Utrecht University.

I would like to thank all those who have contributed to the completion of this thesis.

First and foremost, I am grateful to my supervisor, Jochen Monstadt, for his guidance and feedback throughout this thesis.

My sincere gratitude also goes to the participants of my interviews who shared their time and perspectives with me, enriching the depth of this study.

My friends and family deserve gratitude for their relentless encouragement and understanding during the ups and downs of my academic journey.

A particular note of appreciation is reserved for my girlfriend Dania. Her unwavering support has been the cornerstone of my resilience, and her presence has been a constant source of strength and inspiration.

This work is dedicated to all the people mentioned here and to all those who have contributed to this milestone in different ways. Thank you for being part of this important chapter in my academic and personal growth.

## **Abstract**

The following study examines the introduction of fare-free public transport in Luxembourg, which attracted worldwide attention. The central objective is to analyse the extent to which fare-free public transport can contribute to a modal shift from motorised private transport to public transport. It is examined whether the Luxembourg context offers a suitable environment for this purpose, taking into account both favourable conditions and persistent obstacles. The findings, drawn from qualitative research, particularly expert interviews, unveil a nuanced landscape. While promising aspects signal readiness for change, spatial deficits, cultural reliance on cars, and insufficient supporting measures that restrict the car present obstacles. The multifaceted nature of these challenges and their intricate interplay suggest that achieving a substantial modal shift may face substantial hurdles. In essence, while fare-free public transport does not prove to be a miracle cure, it does, however, offer additional benefits that can make it a meaningful component of a holistic approach to achieving more sustainable mobility.

## **Table of contents**

<b>Acknowledgements .....</b>	<b>2</b>
<b>Abstract.....</b>	<b>3</b>
<b>List of figures.....</b>	<b>6</b>
<b>I) Introduction .....</b>	<b>7</b>
<b>II) Literature review .....</b>	<b>10</b>
<b>II.1) Advances and concerns in private transport .....</b>	<b>10</b>
<b>II.2) Current discourses in transport planning.....</b>	<b>12</b>
<b>II.3) Sustainable development &amp; sustainable mobility .....</b>	<b>13</b>
<b>II.4) Mobility transitions .....</b>	<b>15</b>
<b>II.5) Transport policy instruments.....</b>	<b>16</b>
II.5.1) Regulatory instruments .....	16
II.5.2) Spatial planning instruments.....	17
II.5.3) Informational instruments .....	18
II.5.4) Economic instruments.....	19
<b>II.6) Fare-free public transport .....</b>	<b>20</b>
<b>II.7) Factors affecting public transportation ridership .....</b>	<b>23</b>
II.7.1) Population composition .....	23
II.7.2) Public transport network.....	24
II.7.3) Settlement and population density .....	26
II.7.4) Spatial structure .....	26
II.7.5) Public policy .....	27
<b>II.8) Conceptual framework .....</b>	<b>28</b>
<b>III) Methodology .....</b>	<b>33</b>
<b>III.1) Research design: Case study approach.....</b>	<b>33</b>
<b>III.2) Data collection .....</b>	<b>35</b>
III.2.1) Expert interviews.....	35
III.2.2) Document analysis.....	37
<b>III.3) Data analysis.....</b>	<b>37</b>
<b>III.4) Limitations.....</b>	<b>38</b>
<b>III.5) Ethical considerations.....</b>	<b>38</b>
<b>IV) Findings.....</b>	<b>39</b>
<b>IV.1) Luxembourg - An introduction.....</b>	<b>39</b>
<b>IV.2) Variable 1 – Settlement and population density .....</b>	<b>40</b>
<b>IV.3) Variable 2 – Spatial structure .....</b>	<b>44</b>
IV.3.1) Luxembourg’s unparalleled growth .....	44
IV.3.2) Population growth, employment expansion and cross-border commuting .....	45
IV.3.3) Challenges in the spatial layout.....	47
IV.3.4) Luxembourg’s housing crisis .....	49
IV.3.5) Luxembourg’s growth policy .....	51



<b>IV.4) Variable 3 – Population composition .....</b>	<b>52</b>
<b>IV.5) Variable 4 – Mobility context.....</b>	<b>56</b>
<b>IV.6) Variable 5 – Public transport network.....</b>	<b>59</b>
IV.6.1) Public transport services.....	59
IV.6.2) Quality of public transport services.....	61
<b>IV.7) Variable 6 – Public policy.....</b>	<b>66</b>
IV.7.1) National Mobility Plan .....	66
IV.7.2) Experts’ additions to the National Mobility Plan.....	68
IV.7.3) Experts’ assessment of the National Mobility Plan.....	69
IV.7.4) Master Programme for Spatial Planning .....	71
IV.7.5) Luxembourg’s governance system: A barrier? .....	72
<b>IV.8) Fare-free public transport in Luxembourg .....</b>	<b>77</b>
IV.8.1) Key aspects of FFPT in Luxembourg.....	77
IV.8.2) Criticism of the implementation.....	78
IV.8.3) Impact of the FFPT policy.....	83
<b>V) Discussion .....</b>	<b>85</b>
<b>V.1) Arguments in favour of a potential modal shift.....</b>	<b>85</b>
<b>V.2) Arguments against a significant modal shift.....</b>	<b>87</b>
<b>V.3) Research questions.....</b>	<b>89</b>
<b>VI) Conclusion.....</b>	<b>97</b>
<b>VII) References.....</b>	<b>100</b>

## **List of figures**

Figure 1: Conceptual framework .....	29
Figure 2: Overview of the interview participants .....	36
Figure 3: Population by municipality in 2023 .....	41
Figure 4: Population density by municipality in 2023 .....	42
Figure 5: Development of socio-economic indicators (1980-2015) .....	45
Figure 6: Density of employees in Luxembourg in 2017 .....	46
Figure 7: Motorisation level of selected EU countries .....	52
Figure 8: Modal split in 2017.....	53
Figure 9: Development of employment within the municipality of residence .....	56
Figure 10: Cross-border commuter flows in 2017 .....	57
Figure 11: Degree of saturation of the road network in 2009.....	58
Figure 12: Railway network.....	59
Figure 13: Bus network.....	60
Figure 14: Average values of the level of satisfaction with public transport .....	61
Figure 15: Planning system of Luxembourg.....	74
Figure 16: Intention to use public transport in the near future .....	81
Figure 17: Top 3 reasons to increase bus use in the near future .....	82
Figure 18: Top 3 reasons to increase train use in the near future .....	82

## **I) Introduction**

The pressure on the Earth is growing. The CO<sub>2</sub> concentration in the atmosphere has increased considerably since the beginning of industrialisation, most notably in the past three decades. The Earth's mean temperature has risen by more than 1°C compared to pre-industrial levels, and the ten warmest years by deviation from the global average have been measured in the past 16 years (as of 2020) (Statista, 2023). According to an EIA forecast, global energy-related CO<sub>2</sub> emissions will be around 43.1 billion tonnes in 2050, which would increase emissions by about 22%, exacerbating the current situation (Statista, 2022).

The existing mobility and transport system significantly contributes to this (Mattioli et al., 2020). The fossil fuel-based transport system is considered unsustainable for numerous reasons, as it is associated with countless negative ecological, economic, and social side effects. If one considers above all the primary negative environmental consequences of car traffic, such as noise pollution, increasing energy and land consumption, as well as emissions of air pollutants and climate-damaging greenhouse gases, it becomes clear that a fundamental transformation towards resource-efficient, environmentally, and socially compatible mobility is indispensable. Consequently, mobility in general and cars in particular face the most significant challenge in their history. At the same time, the entire field is characterised by a high level of dynamism and innovation. On the one hand, the sector is facing far-reaching technological upheavals such as digitalisation, electric mobility, and autonomous driving; on the other hand, the business models of the mobility industry are changing. Especially in urban regions, various forms of use such as car and bike sharing and, thus, mobility services are coming to the fore as new business fields. In addition, global developments will significantly determine future framework conditions of mobility and transport. Global trends such as demographic change, increasing environmental awareness, growing social inequality, urbanisation, as well as globalisation and liberalisation, are having an increasing impact on politics, the economy and society and will influence the way people travel in the future.

Worsening climate change and resource scarcity have increasingly become the focus of public discussion in recent years. Above all, the ecological impacts of transport, particularly its contribution to climate change, are increasingly being critically questioned by society and politics. There is widespread agreement that a fundamental transformation of the mobility and transport system is necessary to counteract the described problems and to meet the requirements of the Paris Climate Agreement adopted in 2015. Thus, policymakers around the world are increasingly trying to make mobility more sustainable. One of the transport policy

instruments that has recently attracted the attention of policymakers as a measure to reduce environmental problems and traffic congestion, and that is increasingly being proposed in several cities and countries, is the fare-free public transport (FFPT) policy.

When the Grand Duchy of Luxembourg announced its plans to introduce fare-free public transport nationwide from March 2020, the initiative was widely praised and made headlines around the world. In recent years, it has become increasingly clear that Luxembourg also needs to break new ground to eliminate its transport sector problems. The number of people, jobs and cross-border commuters continues to rise; Luxembourg has the highest level of motorisation in Europe and suffers increasingly from traffic congestion, especially around the capital city. Despite the worldwide praise that Luxembourg has received in 2020, it must at the same time be critically questioned to what extent this policy change can contribute to reducing the country's major transport problems. It is precisely at this point that the present thesis aims to build upon.

The central objective of the study is, therefore, to analyse to what extent the introduction of fare-free public transport in Luxembourg can contribute to a modal shift from motorised private transport to public transportation. To assess the effectiveness of this policy instrument in achieving more sustainable mobility, the potential and, thus, the possibilities and limits of this measure in the specific context of Luxembourg are investigated. For this purpose, various framework conditions and factors that contribute to the success or failure of this measure are examined.

Four research questions have emerged from the preceding objectives, the first being the central question of the thesis and the last three being sub-questions.

- To what extent can the introduction of fare-free public transport in Luxembourg contribute to a modal shift from motorised private transport to public transport?
  - What are the potentials and limitations of fare-free public transport?
  - To what extent is fare-free public transport effectively complemented by other policy instruments to facilitate the modal shift?
  - Which policy recommendations can be derived from the analysis of the specific case of Luxembourg?

It is important to note that the subsequent analysis does not include a quantitative comparison of modal shift due to fare-free public transport. As explained in the methodology section, such a comparison is not feasible. Therefore, the focus is on examining the specific context of Luxembourg in order to approach an answer to the question of the extent to which a significant modal shift is even possible in this particular context. The aim is therefore to find out whether Luxembourg offers a suitable environment in which this policy can be effective in the sense of a modal shift. In addition, the first sub-question aims to examine the opportunities and challenges associated with the fare-free public transport policy in Luxembourg. This includes a discussion of its potential beyond the impact on modal split. The second sub-question deals with the interaction of fare-free public transport with other policy instruments in achieving a modal shift. Finally, the third sub-question aims to formulate policy recommendations for Luxembourg.

The basis for the empirical analysis and the discussion of the research questions is the preceding literature review in the second chapter, which provides an overview of relevant literature on the topic and ends with a conceptual framework. The following third chapter explains the methodological approach of the thesis, describing the type of research that was conducted and the methods used to collect and analyse the data. The fourth and main chapter is the empirical part, in which the findings are presented and subsequently discussed and interpreted in the fifth chapter to answer the research questions. The thesis concludes in the sixth chapter with a summary of the results and a final assessment.

## **II) Literature review**

As the introduction notes, transport is a fundamental aspect of modern society, providing mobility and connections for people and goods. However, the dominance of private transport and unsustainable transport practices has led to numerous negative consequences. This is where the following literature review sets in. After restating these problems, the field of transportation planning is presented, how it has evolved historically, and what issues and discourses shape its current state. Arguably, the most crucial discourse is that of a transportation shift towards a more sustainable form. The paradigm of sustainable mobility is presented, as is the question of how such sustainability transitions occur, along with the role of transport policy instruments in promoting sustainability. Additionally, the literature review delves into the concept of fare-free public transport (FFPT), the central theme of the paper, discussing its implications and controversies. Further factors influencing the use of public transport are then discussed, as it becomes clear that the financial aspect is by no means the only factor that plays a role in whether people use public transport. It is precisely this part of the literature review that forms the basis for the conceptual framework with which the chapter ultimately ends.

### **II.1) Advances and concerns in private transport**

Over the past 50 years, private transport has rapidly increased with numerous positive consequences regarding convenience, speed and freedom. Especially in industrialised countries, private transport has significantly grown during the past few decades. Compared to other modes of transport, the use of the private car, in particular, has expanded considerably, accounting for a majority of the increase in passenger kilometres, whilst the mode share of public transport has remained relatively unchanged or even decreased marginally in most industrialised nations (Millard-Ball & Schipper, 2011). More than 80% of all journeys in industrialised countries and a steadily growing share in emerging countries are made by car (Marletto et al., 2016). From a sociotechnical perspective, the transport sector can thus be characterised as a sociotechnical automobility regime (Nykvist & Whitmarsh, 2008; Geels et al., 2012). This automobility regime is composed of different closely interconnected components and subsystems that, due to their interaction, generate and reproduce the supremacy of the automobile (Urry, 2004; Nykvist & Whitmarsh, 2008; Arnold et al., 2018; Fraedrich, 2018; Mattioli et al., 2020; Ruhrort, 2020). These individual components are interconnected and work together “as a positive feedback loop that is self-reinforcing” (Laa et

al., 2021, p.512). The automobile has a significant social status and is considered one of the fundamental objects of individual consumption, embodying speed, accessibility, freedom, progress and autonomy (Urry, 2004; Nykvist & Whitmarsh, 2008; Arnold et al., 2018; Fraedrich, 2018). Especially in the western world, the automobile is more than just a means of transport; it is deeply embedded in society as a “technological artefact” (Fraedrich, 2018, p.55). In addition, the car is associated with influential industries, has an essential economic significance and has long been closely associated with growth and participation (Moradi & Vagnoni, 2018; Canitez, 2019; Ruhrort, 2020). Arnold et al. (2018) refer to the mobility regime as a “powerful complex that is technically and socially linked not only to a variety of other industries but also to infrastructures, urban planning and other offerings and services” (p.14).

The automobile can be regarded as one of the most significant inventions of the modern era. Its achievements are numerous; it has revolutionised manufacturing, reshaped urban and suburban life and transformed transportation by making long-distance travel and commuting easier and faster, connecting people and communities like never before. In consideration of current problems, however, the car seems to have possibly already passed its peak and is increasingly being questioned (Gifford & Steg, 2007). While there are widespread improvements in some issues, such as local air pollution and road safety, there are only modest indications of progress in others, such as CO<sub>2</sub> emissions and fuel consumption. In fact, the transport sector is one of the main sectors responsible for CO<sub>2</sub> emissions into the atmosphere over the last decade. Based on various studies, Tongwane et al. (2015) reported that transport is responsible for almost a quarter of global energy-related greenhouse gas (GHG) emissions, with road vehicles accounting for about three-quarters of these emissions in 2004. In 2008, global GHG emissions linked to the transport sector constituted 23% of total emissions from the energy sector, the highest growth of any sector (IEA, 2012). In the EU, transport-related CO<sub>2</sub> emissions increased by 25% in 2007 compared to 1990, accounting for 23% of CO<sub>2</sub> emissions (EC, 2010). Road transport is the most significant contributor to total transport emissions, accounting for 76% of all transport-related greenhouse gas emissions in the EU in 2021 (EEA, 2023).

Recent studies thus show that reducing car use represents one of the most significant potentials for minimising per capita emissions (Wynes et al., 2018; Ivanova et al., 2020). At the same time, there are more than 1,5 billion motor vehicles today, and this number is predicted to exceed 2,5 billion by 2030 (Grujic et al., 2019; Carlier, 2021). Total CO<sub>2</sub> emissions from automobiles are thus expected to keep rising unless this dominant mobility system can be dismantled (Sperling & Gordon, 2009).

## II.2) Current discourses in transport planning

The field that addresses these issues is transport planning, which involves the systematic assessment, design and implementation of strategies to improve the movement of people and goods within and between cities, regions, and countries (Rodrigue, 2020).

Traditionally, transport planning has been a rather technocratic, isolated and siloed discipline, primarily concerned with enhancing the performance of the transport system (Heeres et al., 2012). Transport policies focused primarily on meeting increasing transport demand through infrastructure development and were limited in scope, usually focusing solely on a single mode of transport. Particularly in western industrialised countries, transport planning has been addressing travel demand as a result of urban population expansion, significant rise in car ownership and a shift to suburban areas. Over time, however, there has been an increasing recognition of the relationship and interactions between different modes of transport, and later between the transport system and land use, taking into account the multi-scalar nature of transport services and mobility patterns (Banister, 2002; Arts et al., 2014; Arts et al., 2016). This fundamental paradigm shift towards more integrated transport planning came about through the basic realisation that the classic technical and engineering transport planning paradigms of supply planning and efficiency improvement do not contribute to making transportation more sustainable but, on the contrary, further reinforce the status quo of car-centred planning (Goodwin, 1999; Huang, 2003; Schwedes, 2018; Schwedes et al., 2018).

Some current discourses have emerged from this more integrated and holistic people-centred transport planning approach. A prominent discourse and dimension of transport research pertains to digitalisation and technological advancements. Integrating technology in vehicles and transport systems is increasingly changing the way people move, e.g. through autonomous driving or the networking of transport systems. Mobility research is concerned with evaluating these developments and their impact on aspects such as road safety, the environment and



efficiency. Simultaneously, there is a trend towards new mobility services and new offers and forms of mobility. In this context, it is often referred to as smart mobility, encompassing the utilisation of real-time data to optimise transport networks and promoting the use of shared mobility services (Marsden & Reardon, 2018).

Increasing urbanisation and the associated challenges represent another key discourse, focussing on the strategic planning of transport systems and infrastructure to meet the growing demand for mobility in urban areas. Mobility research is also concerned with improving the integration of different modes, promoting sustainable urban development, reducing traffic congestion in cities, and designing public spaces that promote active mobility (Finck et al., 2021).

Societal considerations, such as accessibility and equity, are also becoming increasingly important. The aim is to ensure that all members of society have access to safe, affordable and convenient transport in order to improve social inclusion. This includes improving public transport services in underserved areas and providing accessible infrastructure for marginalised population groups, thus reducing transport-related social exclusion (Rodrigue, 2020; Litman, 2023).

Arguably, the most pivotal discourse is on sustainability and the environmental compatibility of transportation. Given the climate crisis and the need to reduce greenhouse gas emissions, the sustainability of mobility is a central topic in current mobility research and planning. Since sustainability is such a ubiquitous and partly ambiguous term, the following section addresses what exactly is meant by sustainability and specifically sustainable mobility (Gather et al., 2008).

### II.3) Sustainable development & sustainable mobility

The word “sustainability” is frequently used in various contexts nowadays and can be considered a word in vogue. The concept of sustainable development was first introduced in the Brundtland Report (also known as the Our Common Future Report), published in 1987 by the United Nations World Commission on Environment and Development. The commission aimed to develop adequate recommendations for action to initiate the process of sustainable development. In the context of the Brundtland Report, sustainable development is understood as a development that meets the needs of current generations without compromising the ability of future generations to meet their own needs (Pufé, 2017). Initially centred on environmental

and ecological considerations, the sustainability discourse has evolved to encompass economic and social dimensions, commonly referred to as the “three-pillar model” or the three dimensions of sustainability, which can also be applied to the mobility sector (Gillis et al., 2015; Kropp, 2018).

Sustainable mobility, within the environmental pillar, describes the commitment to address the ecological impact of transportation. The main objectives include reducing energy demand and minimising negative environmental impacts. This necessitates the promotion of ecologically friendly modes of transportation and strategies to reduce congestion, air pollution, noise and visual disturbances (Gather et al., 2008; Campos et al., 2009; de Dios Ortúzar, 2019). As advocated by Banister (2008), sustainable mobility calls for a paradigm shift, emphasising steps to decrease the necessity for travel, encourage modal shifts to sustainable modes and enhance the overall efficiency of transportation systems.

In the realm of the social pillar, sustainable mobility aims to prioritise the needs of individuals (Gillis et al., 2015). The focus is on ensuring that transportation systems provide safe, reliable, and comfortable mobility for all members of society. The core principle is social equity, ensuring that transportation does not become a barrier but rather a facilitator of equal opportunity. By promoting accessibility and inclusivity, the social pillar aims for a transportation system that enhances the overall quality of life for different population groups (Gather et al., 2008; Campos et al., 2009; de Dios Ortúzar, 2019).

The economic pillar of sustainable mobility outlines the pursuit of increased prosperity through transportation systems. This involves contributing to economic growth by creating new businesses and maintaining thriving economies (Gather et al., 2008; Gillis et al., 2015). In essence, sustainable mobility within the economic pillar focuses on transportation systems that are not only financially viable but also contribute to the economy. Consequently, the attributes of sustainable mobility form an interplay of the different dimensions of sustainable development, which aim to create an equal interaction between people, the environment and profit (Campos et al., 2009).

#### II.4) Mobility transitions

The shift to sustainable mobility, also referred to as a transition, can be described as a long-term, structural and systemic change within a societal regime (Grin et al., 2011). The socio-technical regime encompasses dominant system configurations such as technologies, infrastructures, cultures, politics, practices, regulations, and rules that uphold the existing system and reproduce the status quo (Geels, 2002; Loorbach et al., 2021). The regime thus represents the existing framework that encompasses all prevailing techno-economic, political, cultural, as well as actor, market, use and behaviour constellations (Merten et al., 2018). While regimes provide stability, they also engender path dependencies and lock-ins, often reinforcing and stabilising unsustainable policies, institutions, infrastructures and practices, often hindering necessary fundamental, systemic transitions towards sustainability (Geels, 2011; Loorbach et al., 2015). Regimes are thus dynamically stable over longer periods of time, but historically, they repeatedly go through phases of shock-like, abrupt and non-linear system changes, known as transitions (Loorbach et al., 2017).

Transitions involve a variety of changes at different levels. The multi-level perspective conceptualises socio-technical transitions as profound, structural, co-evolutionary processes that take place on three levels (Rotmans et al., 2001). In addition to the central meso level already described, that of the regime, there is a second level, that of the niches, where radical innovations emerge. They serve as protected spaces for the new to develop independently from the existing regime (Bauknecht et al., 2015). Niche innovations include technical, economic, social, political, and institutional aspects, encompassing new lifestyles, markets, practices, cultural elements, as well as patterns of use and behaviour that deviate from the regime (Loorbach, 2007; Nykvist & Whitmarsh, 2008; Köhler et al., 2017; Wittmayer & Hölscher, 2017; Haselsteiner, 2020).

The third level, the landscape, forms the exogenous context, describing the overarching environment in which change processes occur (Loorbach, 2004). It describes the structural context in which the individual regimes are embedded (Bauknecht et al., 2015). Landscape-level processes typically unfold gradually over decades and encompass environmental changes such as climate change, long-term social developments, and megatrends such as demographic changes, socio-cultural shifts, changes in political ideologies and fundamental economic changes (Van Driel & Schot, 2005; Geels et al., 2012).

The term transition thus describes structural shifts from an existing to a new socio-technical system, shaped by numerous incremental changes over the long term (Köhler et al., 2017). The multi-level perspective posits that transitions are non-linear processes resulting from the interplay of several developments on the three described levels (Loorbach, 2004; Loorbach & Rotmans, 2010; Geels et al., 2012). Accordingly, mobility transitions are also complex processes that are influenced by numerous interacting factors. Overcoming the enormous obstacles involved in sustainable mobility transitions therefore requires a comprehensive strategy.

In this context, transport policy instruments prove to be a means of contributing to a shift towards more sustainable transport systems. These instruments have the potential to influence mobility transitions as they play a crucial role in stimulating emerging technologies and practices in niches, destabilising the established car-centric regime, or influencing the overall landscape (Kanger et al., 2020; Paulsson & Sørensen, 2020; Griffiths et al., 2021). The subsequent section explores various types of transport policy instruments essential for steering towards more sustainable mobility.

## II.5) Transport policy instruments

Several policy instruments, including regulatory, spatial planning, informational and economic instruments, can be implemented to promote sustainable mobility at various levels, including national, regional and local.

### II.5.1) Regulatory instruments

Regulatory transport policy instruments include a range of measures and regulations that can be applied to address various aspects of transportation, namely environmental impact, safety and efficiency. These regulatory measures include environmental standards and the setting of norms aimed at reducing emissions and promoting more environmentally friendly technologies, such as electric vehicles and fuel-efficient engines (Griffiths et al., 2021). In addition, access restrictions are increasingly being imposed to limit the impact of internal combustion engine vehicles on the environment. These restrictions can take the form of bans on certain vehicles, limiting access to certain areas or at certain times. A more drastic approach is to ban the use of combustion engine vehicles or to plan phaseouts in order to accelerate the transition to more sustainable technologies or modes of transport (Plötz et al., 2019).

Another central type of measure is changes to road traffic regulations, such as lowering speed limits. The aim of such measures is to reduce congestion, fuel consumption and emissions while simultaneously improving road safety. An additional benefit is that it encourages the use of more environmentally friendly modes of transport, such as walking, cycling and public transport, which become comparatively more attractive (Institute for Transport Studies, 2009).

### II.5.2) Spatial planning instruments

People relocate from one place to another to satisfy certain basic human needs and to engage in activities such as work, education, recreation, and social activities (Becker, 2016). The locations of these activities and the prevailing land use patterns dictate the available options regarding the proximity of destinations to one's residence. Individuals select their destinations and, consequently, plan their journeys based on the options at hand. Therefore, an important issue related to land use policies is the potential to reduce transport demand (van Wee & Handy, 2014).

Within land use measures, land use planning and zoning regulations are effective tools for guiding urban and rural development. They determine land use and permissible densities, with the possibility of promoting mixed-use, transit-oriented development and pedestrian-friendly neighbourhoods. All these factors can be steered in a way that promotes more sustainable mobility (Rodrigue, 2020).

Other types of spatial measures are those concerning the infrastructure and the built environment, with distinctions between those enhancing walking and cycling and those improving public transport. Initiatives like park-and-ride facilities exemplify strategies that facilitate the use of public transport by allowing private vehicle users to park their car on the outskirts of cities and continue their journey using public transportation. These facilities, often linked to various modes of public transport and often accompanied by attractive pricing schemes, effectively mitigate urban congestion and reduce environmental impacts by diverting traffic away from city centres (Parkhurst, 2000; Meek et al., 2008; Institute for Transport Studies, 2009; Santos et al., 2010b).

Part of spatial measures is also the planning of transport corridors, such as dedicated bus lanes or cycle paths, to help optimise transport networks and promote more efficient land use patterns. Bus lanes or bus-only sections, for instance, allow buses to avoid congestion and maintain more reliable travel times. To further position buses as more competitive alternatives,

they can be given priority through various measures, such as traffic light priority (May & Still, 2000; Mundy et al., 2017). Similarly, unlike traditional cycle lanes, cycle routes provide dedicated, separated pathways for cyclists, physically segregating them from motorised traffic. This approach improves safety and accessibility for cyclists, encouraging more people to choose cycling as a preferred mode of transportation. In general, improvements in cycle infrastructure contribute to environmental benefits, improved public health, increased accessibility, and social inclusion (Hunt & Abraham, 2007; Pucher & Buehler, 2008; Institute for Transport Studies, 2009; Krizek et al., 2009).

In addition, improvements in the quality of pedestrian infrastructure can influence the walking experience and, thus, the decision to walk. To make walking more attractive, well-maintained sidewalks, cleanliness, and amenities such as flower beds, trees, benches, and safe crossings are crucial. Additionally, improvements like shorter waiting times, weather protection, and proper lighting contribute to pedestrian safety and comfort (Moudon & Lee, 2003; Institute for Transport Studies, 2009; Santos et al., 2010b).

Furthermore, infrastructural changes such as traffic calming measures serve as physical restrictions for car traffic. Speed bumps, chicanes and pinch points encourage drivers to operate more cautiously and consequently reduce the negative environmental and safety impacts associated with cars (May & Still, 2000; Gonzalo-Orden, 2016).

### II.5.3) Informational instruments

Informational measures within transport policy instruments encompass various strategies to increase public awareness, particularly among car users, of the sustainability effects of their travel behaviour and to inform them of available alternatives (May & Still, 2000; Kuss & Nicholas, 2022).

In addition to awareness-raising campaigns, informational campaigns can provide information on infrastructure improvements such as the expansion of bike lanes, pedestrian-friendly streets, and improved public transit. Moreover, travel behaviour can be influenced by providing information on multimodal trip planning, carpooling or the availability of sharing services (Kuss & Nicholas, 2022).

An alternative approach to convey information is through real-time passenger information systems at public transport stations that provide passengers with up-to-date departure information. The main benefit for passengers is that these systems reduce the uncertainty often associated with waiting for public transport (Institute for Transport Studies, 2009). Although real-time passenger information systems alone may not necessarily lead to an increase in public transport ridership, they are often part of larger initiatives aimed at improving the quality of public transport (May & Still, 2000).

#### II.5.4) Economic instruments

Economic instruments primarily include financial incentives and disincentives. Financial disincentives encompass charges such as parking fees, road tolls, taxes on car ownership and fuel taxes, all designed to reduce the attractiveness of using private cars by increasing their overall cost. Vehicle taxes, for example, are the most apparent direct charge on private cars. A distinction is made between taxes imposed on vehicle purchases and recurring license fees tied to vehicle ownership (Chia et al., 2001; Santos et al., 2010a). Purchase taxes can be based on fuel consumption per kilometre, environmental impact, fuel type, engine power, vehicle weight or sales price (Santos et al., 2010a; OECD, 2022). In addition to property taxes, taxes related to the usage of vehicles constitute another vital policy measure that affects supply and demand while addressing the externalities associated with road transport. Notably, fuel taxes serve as a cost-effective and efficient revenue-raising tool with the potential to reduce emissions (Santos et al., 2010a; OECD, 2022).

Whereas negative pricing refers to policies that impose financial costs or penalties for certain behaviours, positive pricing refers to policies that provide financial incentives for desired behaviours, such as using public transportation or more environmentally friendly modes of transport. One approach within this category involves tax differentials or subsidies on the purchase of fuel-efficient or electric vehicles (Santos et al., 2010a).

Additionally, there are incentives intended to encourage the use of public transport use, such as reduced fares or, central to the present thesis, the outright abolition of fares (Štraub & Jaroš, 2019). Given the central focus of this thesis on the concept of fare-free public transport, the following chapter will provide a comprehensive exploration of this transformative concept, delving into its implications and potential in shaping a sustainable mobility landscape.

## II.6) Fare-free public transport

The policy of abolishing fares in public transport, referred to in the following as fare-free public transport, abbreviated FFPT, is increasingly being applied in cities and municipalities but, at the same time, remains highly controversial.

Before delving into three different perspectives on the abolition of fares, a brief attempt is made to approach the term conceptually, as the idea of fare-free public transport is anything but uniform, manifesting in various forms, serving different purposes, and being interpreted differently in different locations. Besides full FFPT policies, such as exists in Luxembourg, there exist other partial policies. Kębłowski (2020) distinguishes between temporary, temporally limited, spatially-limited and socially-limited FFPT. Temporary FFPT refers to the temporary elimination of fares, often for a limited trial period. Temporally-limited FFPT involves not charging fares during specific time periods. Spatially-limited FFPT applies to particular sections of the public transport network or specific modes of transport. Lastly, socially-limited FFPT caters to specific user groups, which often include children, young people, students, disabled individuals, older people, or pensioners.

In the following, based on Kębłowski (2020), the controversy surrounding this policy will be argued from three perspectives, aligning the three pillars of sustainability, i.e. the economic, ecological and social aspects of the FFPT scheme are briefly discussed.

From an economic perspective, the abolition of fares often faces criticism due to its perceived adverse effects on the financial health of public transport networks, as it reduces revenues while increasing costs for additional maintenance, safety and higher passenger numbers (Storchmann, 2003; Fearnley, 2013). Accordingly, FFPT can be seen as a policy that drains essential resources from public transport (CERTU, 2010). From this perspective, abolishing fares is economically viable, primarily in smaller public transport networks characterised by low ticket revenue shares, limited demand, and lower passenger volumes (Duhamel, 2004; Fearnley, 2013). For instance, in analysing several FFPT cases, Volinski (2012) shows that eliminating fares in smaller networks can significantly reduce costs, often surpassing the revenue generated from fares.

In the field of economic science, FFPT is also criticised for questioning the logic of the transport market, as public transport is expected to function as a self-financing or profit-oriented system. Moreover, a free service would create the illusion that there are services that do not incur costs (CERTU, 2010). Many also see FFPT as removing basic financial incentives



for public transport operators and worry that it will lead to a symbolic devaluation of the transport service (Duhamel, 2004). In addition, it is argued specifically from the field of transport engineering that FFPT creates unproductive and unnecessary mobility that does not result from actual mobility needs (Baum, 1973; Duhamel, 2004). This is argued on the basis that fares are a demand management mechanism that controls passenger behaviour (Cats et al., 2014).

According to Volinski (2012), there is clear evidence that the abolition of fares is very likely to lead to an increase in passenger numbers. This, in turn, could lead to network overcrowding problems, reduced reliability and punctuality (Storchmann, 2003). However, according to Kębłowski (2020), “with the exception of three discontinued programmes in the US (Austin, TX; Denver, CO; Mercer County, NJ) there is no strong evidence that in any of the existing or discontinued cases fare abolition affected public transport network capacity and reliability in a significant and negative way” (p.2814). On the contrary, Volinski (2012) shows that in some public transport networks, the absence of ticket validation even leads to a reduction in time lost at stops.

The second perspective on FFPT revolves around its social implications, contending that the abolition of fares would enhance public transport accessibility for everyone (Hodge et al., 1994; Cordier, 2007). Consequently, FFPT directly addresses issues of social exclusion, inequality, and transport poverty by improving accessibility, specifically for marginalised residents (Schein, 2011; Larrabure, 2016). Cats et al. (2016) show that the abolition of fares in Tallinn led to higher levels of public transport use among various underprivileged groups, including the unemployed (+32%), the poor (+26%), young people (+21%) and the elderly (+19%). Other studies noted similar findings (Volinski, 2012; Briche et al., 2017; Kębłowski, 2018). Thus, FFPT can be seen as a means of promoting a socially equitable transport system, primarily benefiting those who cannot afford a car and rely on public transport (Brie, 2012).

In addition, FFPT leads to public transport no longer being seen as a product but rather as a common good, similar to other public services, including health care, schools, libraries, as well as infrastructure in general (parks, roads, pavements, bike lanes, etc.) (Schein, 2011; Larrabure, 2016; Kębłowski, 2020). In this sense, FFPT reduces the emphasis of the market-oriented focus on profitability and demand management (Cosse, 2010).

Another perspective on FFPT revolves around its potential ability to contribute to environmentally friendly transport (Baum, 1973; Cervero, 1990; Thøgersen & Møller, 2008; Cats et al., 2016). However, some studies conducted show “that an increase of public transport usage among car drivers correlates less strongly with a reduction or abolition of public transport prices than with increase of gas prices, restriction of parking and road usage, or increase of public transport quality in terms of its speed, frequency and coverage” (Kębłowski, 2020, p.2815). Similarly, Storchmann (2003) argues in his study that new passengers attracted by FFPT are mostly cyclists and pedestrians rather than car drivers. Consequently, many agree that reducing fares may be an inappropriate tool to reduce car use and external costs from a sustainable transport perspective (Fearnley, 2013). At the same time, however, there are FFPT schemes where the abolition of fares resulted in a modal shift from cars to public transport, thus reducing car use, although only to a limited degree and in parallel with a modal shift from walking and cycling. Cats et al. (2016) show that in Tallinn (Estonia), FFPT contributed to a modest 3% shift from car to public transport but also led to a more significant 5% shift from walking and cycling. In Hasselt (Belgium), FFPT has increased the number of passengers tenfold. 63% of these journeys were made by former bus drivers, 16% by car drivers, 12% by former cyclists and 9% by former pedestrians (van Goeverden et al., 2006). This suggests that the impact of FFPT on modal split is not uniform and varies depending on the context.

In principle, measures such as the abolition of fares are unlikely to significantly affect car dominance unless additional measures are taken to actively discourage car use (Schuppan et al., 2014; Maciejewska et al., 2023). While fare-free public transport policies have been identified as a means to increase public transport ridership without significantly reducing car usage in most cases, car-restrictive policies hold the potential to be effective in both (Volinski, 2012; Zhang et al., 2019; Maciejewska et al., 2023; Štraub et al., 2023).

Generally, a scientific consensus emerges from the literature that fares alone are by far not the only crucial determinant of people’s decision to use public transport. While fare structures undeniably shape passenger behaviour, an individual’s decision to use public transportation is influenced by a set of holistic criteria, of which fare affordability is only one small dimension. Numerous studies and empirical investigations have shown that public transport ridership is influenced by a complex interplay of factors spanning a broad spectrum, ranging from the quality of public transport services to local conditions.

## II.7) Factors affecting public transportation ridership

In the following, five pivotal factors are presented that, beyond the price of public transport, play a role in determining whether and how frequently individuals use public transport. This exploration forms the basis for the conceptual framework, which will subsequently be applied to the case study of Luxembourg to analyse the potential and effectiveness of fare-free public transport in Luxembourg.

### II.7.1) Population composition

Socio-demographic characteristics have a significant impact on whether and how often people use public transport. These include various attributes such as age, gender, driving license status, educational background, and employment status (Li et al., 2015; Miletić et al., 2017; Senikidou et al., 2022). In general, younger and older age groups are more likely to use public transport, while middle-aged groups tend to rely more on private cars (Ding et al., 2017; Coogan et al., 2018; Ha et al., 2020). Studies also indicate that women generally use public transport more often compared to men (Buehler, 2011; Ng & Acker, 2018).

Moreover, there is a correlation between education level and public transport use, with those with post-secondary or higher levels of education more likely to use public transportation than those with lower levels of education (Rachele et al., 2015). Additionally, an analysis of US census data has revealed that apart from women, minority groups, immigrants, and non-vehicle owners, households with incomes below \$30,000 are most likely to opt for public transport. This study also showed that households earning more than \$70,000 were more inclined to utilise public transit, indicating a preference for this mode of transportation, while lower-income households are more likely to be captive riders, depending on public transportation (TCRP, 2004).

When analysing the factors influencing public transport ridership, it is therefore essential to consider the economic status of the population, characterised by employment levels, income, consumption patterns and private car ownership. Car ownership, in particular, is considered to be an influential factor in the use of public transport. Various studies demonstrate that high car ownership in households is generally associated with lower use of public transport (Balcombe et al., 2004; Paulley et al., 2006; Chng et al., 2016; Oakil et al., 2016; Chakrabarti & Joh, 2019). Additionally, there is a direct correlation between car ownership and income. As income rises, people tend to prefer cars over public transport for reasons of financial independence and

perceived convenience and accessibility (Taylor et al., 2009; Chen et al., 2010; Van et al., 2014; Lee et al., 2015).

The category of population composition also includes people's attitudes, perceptions, and lifestyles. Habits and past experiences influence mode choice, with individuals showing an inclination toward preferring specific modes due to familiarity, convenience, or personal preference. People used to driving cars may find it difficult to shift to public transport, even if it offers potential benefits (Heinen, 2016). Awareness, particularly about environmental impacts, also influences mode preference, with environmentally conscious individuals often favouring ecologically friendly transport options (Sovacool et al., 2018). However, passengers' intention to use public transport does not only depend on intrinsic factors but is also influenced by exogenous factors such as the quality of public transport, which leads to the second factor examined more closely in the following (Friman & Felleeson, 2009; Eboli & Mazzulla, 2011; Mouwen, 2015).

#### II.7.2) Public transport network

Passengers who opt for public transportation have certain expectations and aspire to conclude their journeys within a safe, comfortable, and trustworthy environment. As passengers complete their trip using public transit, they gain first-hand experience. This experience is then compared to their initial travel expectations, ultimately shaping their satisfaction or dissatisfaction with the journey. Consequently, this evaluation process directly influences their future mode choice (Román et al., 2014; van Lierop et al., 2017). Previous literature research has identified several quality attributes that contribute to user satisfaction and are decisive in determining whether individuals will choose public transport again.

Customer satisfaction is notably influenced by three key quality attributes: frequency, safety and reliability (Brechan, 2017; dell'Olio et al., 2018). Additionally, factors such as information provision, staff behaviour, vehicle cleanliness and comfort are also mentioned as significant contributors to customer loyalty and satisfaction (van Lierop et al., 2017).

Frequency encompasses not only the frequency intervals, reducing waiting times, but also the overall travel time, i.e. the duration a trip takes in comparison to other means of transport. In principle, public transport is most suitable for trips characterised by regular, predictable trip patterns that are temporally and spatially concentrated. For this reason, commuter trips have the highest share of transit trips, followed by school trips. Public transport generally faces

challenges in facilitating leisure trips as they often lack confinement to specific areas in a city or particular time frames, requiring flexibility not readily provided by transportation services outside densely populated urban zones (USEPA, 2013). The travel time, therefore, depends on the nature of the trip itself, as well as factors such as accessibility and coverage. A general observation about travel time is its significant influence on the competitiveness of public transport. Research indicates that once the travel time by public transport exceeds 1.25 times that of driving, public transport becomes less attractive, leading users to exhibit a notably lower preference for its utilisation beyond this threshold (Collins & Chambers, 2005; Guan et al., 2020; Ha et al., 2020).

The most commonly used measure of reliability in public transport is punctuality, with research suggesting that delays significantly affect passenger satisfaction (Monsuur et al., 2017). When delays are more likely, people are less inclined to choose public transport (Jiang et al., 2014; Zhou et al., 2017). The importance of punctuality becomes even more pronounced when public transport services operate at low frequencies (Jackson et al., 2012). Additionally, effective communication of information regarding service interruptions is highly valued by passengers (Kroes et al., 2007; Gris  & El-Geneidy, 2017).

Comfort is another quality factor that relates to both the station environment and ride comfort. Onboard facilities, in particular, exert a substantial influence on perceived service quality. Thus, complementary services such as onboard Wi-Fi can significantly influence mode choice in favour of public transport (Mahmoud et al., 2016; Hansson et al., 2019). Crowding is also a crucial factor to consider, particularly in areas with higher population density, as it significantly affects the perceived total travel time within the vehicle (Hirsch et al., 2017; Sahu et al., 2018).

Accessibility stands as another critical quality factor, defined as the ease with which people can access public transport services (Ding et al., 2017; Litman, 2023). It involves various elements, including access to public transport stops, duration of journeys and access to destinations via public transport modes (Saghapour et al., 2016). The accessibility of a stop can be defined in different ways, encompassing “the physical distance to the stop, the ease of access to the stop (ramps, elevators, etc.), and the infrastructure available at the stop (shelter, bike or car parking etc.)” (Rasca & Saeed, 2022, p.251).

The degree of accessibility by public transport and the proximity to the destination are not only interconnected to the features of the public transport network itself but also to exogenous and spatial aspects such as land use and the size of the area, leading to the next factor, namely the density (Rasca & Saeed, 2022).

### II.7.3) Settlement and population density

More densely populated areas generally see higher transit shares as they typically offer a more diverse range of public transportation options, encompassing trains, buses, and occasionally new complementary mobility services, such as sharing options. Conversely, less densely populated areas often have a small public transport network and a correspondingly limited range of options (Chen et al., 2008; Buehler, 2011; Wang & Zhou, 2017). The positive correlation between density and transit use is also based on the indirect effects of density. In denser areas, transit is often within walking distance, parking for cars is limited, and car ownership tends to decline, collectively fostering a higher adoption of public transport. These factors often have a more direct impact on mode share than land use density itself, as they create a more concentrated pool of potential customers. Furthermore, beyond residential density, the density of employment in an area also contributes to transit use. This leads to another factor extending beyond density, namely the diversity and mix of land use, which also correlates positively with transit use (TCRP, 2003).

### II.7.4) Spatial structure

Increased density and mix are usually associated with reduced average travel distances for all transportation modes, generally resulting in shorter commutes. This correlation arises from the tendency for the number of potential destinations in a given geographical area to rise with increased density and mixture, thereby minimising distances and decreasing the requirement for travel (Kenworthy & Laube, 1996; Institute for Transport Studies, 2009; Rodrigue, 2020).

Numerous studies conclude that decentralised places of residence and work are difficult to serve with conventional public transport, as local transport performs most effectively when large numbers of people travel to and from concentrated hubs (Taylor & Fink, 2013). In this context, the term transit-oriented development (TOD) is often used to describe a planning approach that aims to create dense, walkable, mixed-use communities around public transport hubs. Linked to this is the multimodal approach, advocating for a shift to a multimodal transport

system that includes a mix of transport modes such as walking, cycling, public transport and car sharing to reduce reliance on single-occupancy vehicles (Baran et al., 2008; Joh et al., 2008; Chatman, 2009; Cervero, 2012; van Lierop et al., 2016).

The transit-oriented approach also involves a specific built environment with distinctive design elements. It consists of a high-quality, pedestrian-friendly environment that integrates streetscaping. The transit centre is strategically located at the heart of a destination, featuring a compact, diverse, mixed-use development. Alongside the provision of bicycle parking near public transport services, readily accessible and affordable parking or park-and-ride facilities at hubs are intended to incentivise car drivers to transition to public transport modes for a portion of their journey (Institute for Transport Studies, 2009; Hamer, 2010; Hanssen et al., 2016).

In general, land use and the built environment typically do not directly impact the use of public transportation. Nevertheless, they can create an environment that favours its use.

#### II.7.5) Public policy

Another essential category of factors, discussed in more detail in chapter II.5, pertains to public policy, encompassing aspects such as fuel price, parking costs, car use restrictions and public transportation subsidies.

Several factors can impact car ownership and usage, with one of them being the availability of parking facilities (Zhang et al., 2022). McCahill et al. (2016) found that an “increase in parking provision from 0.1 to 0.5 parking space per person was associated with an increase in automobile mode share of roughly 30 percentage points” (p.159). Christiansen et al. (2017) proposed that restricted access to parking stands out as the most effective strategy for reducing car usage during commutes. Both Christiansen et al. (2017) and O’Fallon et al. (2004), therefore, conclude that implementing charges for workplace parking can encourage commuters to shift from cars to public transportation.

Similarly, according to Taylor and Fink (2013), the availability of parking spaces and their pricing are the most significant factors influencing the relative utility of using cars in terms of land use and urban design. They cite various studies that underscore the substantial impact of parking availability on the usage of automobiles for transportation. For instance, in a study conducted by Bianco et al. (1998), the relationship between parking strategies and local transportation ridership was explored. This investigation encompassed a range of approaches,

“including increasing the cost of parking, changing parking regulations, cashing out employer-provided parking, and implementing transportation demand management programs” (Taylor & Fink, 2013, p.20). The study’s findings point to the conclusion that levying taxes on parking spaces is the most effective method for shifting the mode of transportation towards transit (Bianco et al., 1998). Additional research has corroborated these findings, demonstrating that strategies aimed at increasing parking costs are more successful in promoting transit ridership than strategies focused on enhancing the quality of public transport (Shoup, 2005; Mukhija & Shoup, 2006; Tyrinopoulos & Antoniou, 2013).

According to Taylor and Fink (2013), many comprehensive models of transit ridership also incorporate fuel prices, assuming that these encourage people to use public transport (Maghelal, 2011). Thus, both Haire and Machemehl (2007) and Chen et al. (2010) find that fuel prices are an important determinant of public transport use.

In summary, public policy encompasses all measures and regulations that increase the overall attractiveness of public transport. Essentially, the success of public transport lies in its integration within a comprehensive strategy comprising supportive regulations and measures (Zhang et al., 2022).

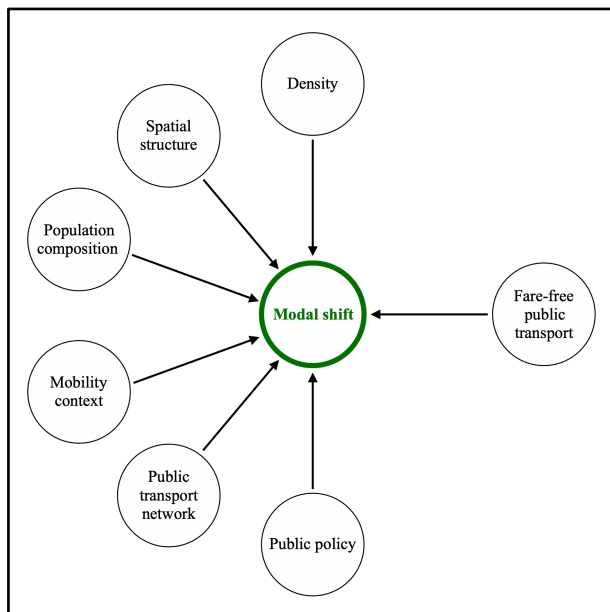
## II.8) Conceptual framework

This chapter presents a conceptual framework specifically developed to investigate the potential and effectiveness of fare-free public transport within the unique context of Luxembourg. Accordingly, central to this conceptual framework is the research question, which aims to determine the extent to which the introduction of fare-free public transport in Luxembourg can contribute to a modal shift from motorised private transport to public transport.

The literature review has shown that the potential of public transport, and thus of fare-free public transport, to achieve a significant modal shift from cars to public transport depends not only on its intrinsic characteristics, such as the price, but is additionally influenced by a range of other variables that form a complex interplay. Five variables were identified in the last chapter, and an additional one will be introduced in the conceptual framework below.



These variables, i.e. the factors that influence the modal split and thus affect fare-free public transport, together form the basis of the conceptual framework. They are presented below before finally being applied to the case study of Luxembourg in the empirical part. The conceptual framework thus provides a holistic view and serves as an analytical tool that guides the empirical analysis and ensures that all relevant factors are addressed coherently and comprehensively. The following figure summarises the variables, serving as a visual illustration of the conceptual framework.



*Figure 1: Conceptual framework*

### 1) Settlement and population density

The settlement structure, consisting of the settlement and population density, influences the demand for transport services, as shown in the previous chapter. In areas with a higher population density, the public transport network tends to be better developed and offers a more attractive alternative to the car. In contrast, in areas with a lower population density, public transport is less likely to be a serious alternative. An understanding of the settlement and population density thus helps to assess the potential impact of fare-free public transport (Hodge et al., 1994; Balcombe et al., 2004; Cats et al., 2014; Mattson, 2020).

- ➔ The potential of fare-free public transport to encourage more people to shift to public transport is greater in areas with a higher population density and urban concentration.

## 2) Spatial structure

Different spatial structures provide a different basis for public transport. Therefore, it is essential to gain an understanding of the current spatial structure, as well as urban and spatial development patterns and emerging spatial trends, as these have an impact on transportation patterns and mobility needs. The literature review has shown that a spatial structure that follows the principles of transit-oriented development supports public transport and, consequently, the introduction of fare-free public transport. The structure of cities and regions plays a central role in influencing commuting behaviour and expectations of transport systems. In essence, examining this variable allows to determine how fare-free public transportation fits into the unique spatial landscape (Hodge et al., 1994; Perone, 2002).

- ➔ The success of implementing fare-free public transport in a region is positively influenced by its alignment with existing urban and spatial development patterns. Regions whose spatial structure is in line with the principles of transit-oriented development are more likely to experience higher acceptance of FFPT and a shift to public transport.

## 3) Population composition

In principle, different population groups have different mobility needs, and some are more inclined than others to use public transportation. In the following, however, the focus is on broader trends rather than delving into individual transportation choices. Instead, overall societal and economic factors and private car ownership are considered.

- ➔ Convincing individuals to shift to public transportation is more challenging in a population heavily reliant on automobiles or facing significant car dependency for various reasons. Moreover, if the economic prosperity of the population ensures that people are not dependent on the availability of fare-free public transport, persuading them to shift from cars to public transport becomes even more difficult.

#### 4) Mobility context

Understanding the mobility context is crucial for evaluating the potential of fare-free public transport. This includes a comprehension of existing mobility patterns and challenges, including traffic congestion and road saturation, as well as other mobility-related problems. These factors are closely related to the car usage patterns outlined in the last variable (Balcombe et al., 2004; Kębłowski, 2019).

- ➔ The success of implementing fare-free public transport in a region is positively influenced by the compatibility of public transport with the existing mobility context. Complex mobility flows that are difficult to bundle with public transport and foster car reliance thus pose a challenge for a significant modal shift. However, when car use leads to highly congested road networks and increased travel times, the incentive to shift to public transport increases.

#### 5) Public transport network

It has been shown that the price is not the only factor contributing to the quality of public transport, but that various other factors contribute to people perceiving public transport as attractive. A well-developed, well-connected, accessible and efficient public transport system forms the basis for the adoption of fare-free public transport (Perone, 2002; Balcombe et al., 2004; Fearnley, 2013; UITP, 2020).

- ➔ High-quality public transport networks contribute significantly to the potential of fare-free public transport. Regions that prioritise and invest in this area are more likely to see higher acceptance rates for fare-free public transport and encourage more people to shift to public transport. In essence, examining this variable allows to determine to what extent the existing network serves as a basis for fare-free public transport.

## 6) Public policy

The literature has demonstrated that public policy, which includes various policy instruments, is another key factor influencing mode choice and, thus, the efficiency of fare-free public transport. FFPT should be integrated into broader transportation and sustainability policies to ensure that it aligns with overarching objectives. Above all, there should be supporting strategies and transport policy measures that promote public transport and restrict car use in order to contribute to a modal shift. This variable thus describes the policy environment with the associated planning system and governance structures, which play an important role in shaping spatial and transport policy (Balcombe et al., 2004; Fearnley, 2013; UITP, 2020).

- ➔ A supportive policy environment with a well-coordinated spatial planning system and effective governance structures that effectively integrates fare-free public transport into broader supportive policies and regulations influences the successful implementation of fare-free public transport.

### **III) Methodology**

The following section outlines the methodology employed to investigate the extent to which the introduction of fare-free public transport in Luxembourg can contribute to a modal shift from motorised private transport to public transport.

#### **III.1) Research design: Case study approach**

The study is based on a case study approach, which primarily involves expert interviews and document analysis. A case study approach is a research method that involves an in-depth investigation and analysis of a specific phenomenon in a particular context. It aims to gain a detailed understanding of the complexities and nuances of the chosen case by examining multiple data sources and exploring diverse perspectives. In the context of the present thesis on the fare-free public transport policy in Luxembourg, the application of a case study approach offers several advantages.

Firstly, the case study approach enables the examination of the fare-free public transport policy within its unique socio-political, economic and geographical context. To analyse the potential of this measure in the specific context of Luxembourg, it requires precisely this profound understanding of the context and the intricacies involved. In this way, the multiple aspects that contribute to the effectiveness of the policy can be captured.

Secondly, the case study approach enables a holistic analysis of the fare-free public transport policy by considering multiple data sources. Expert interviews with academics, practitioners, and policymakers provide insights into the policy's rationale, its implementation, challenges, and the perceived impacts. Document analysis allows for a review of official reports, policy documents and relevant publications to gain a comprehensive understanding of the context of the policy and its alignment with broader strategies. Supplementary statistical data complements the qualitative data by providing a quantitative perspective.

The use of Luxembourg as a case study is particularly relevant as Luxembourg is considered the first country worldwide to have introduced this pioneering initiative throughout the whole country. This therefore represents a unique opportunity to study the potential and effectiveness of such a policy. Moreover, Luxembourg's unique context adds an additional layer of relevance. The country's exceptionally high level of motorisation and the significant number of cross-border commuters residing in neighbouring countries such as France, Belgium and Germany while working in Luxembourg create a complex and distinctive mobility landscape.

This situation introduces specific challenges and considerations for policy making, making the study particularly pertinent. Added to this is Luxembourg's rapid development. Its gross domestic product has almost quadrupled since 2000 and almost twenty-fold in the last 40 years. Over the same period, the population has nearly doubled. As will be illustrated in the next chapter, these developments have a considerable impact on the spatial structure and, thus, also on the mobility of the country. At the same time, this situation presents an intriguing case for exploring the potential of fare-free public transport.

Additionally, the findings of this study can have broader implications beyond the country. As the global interest in fare-free public transport rises, insights into Luxembourg's experiences, challenges, and outcomes can contribute valuable perspectives to discussions and decision-making in other regions considering similar policies.

As noted in the introduction, the following analysis does not include a quantitative comparison of the situation before and after the introduction of fare-free public transport. This is due to the lack of sufficient quantitative data to allow this. In addition, a comparison of public transport figures would not be an adequate method, as an increase in the figures could not be guaranteed to be due solely to this policy. Above all, as will become clearer later, an increase in numbers does not necessarily mean that these are former car drivers. The focus of the study is, therefore, on the specific context of Luxembourg in order to approach an answer to the question of the extent to which a significant modal shift is possible in this particular context. The aim is to find out whether Luxembourg offers a suitable environment in which this policy can actually contribute to a significant modal shift from motorised private transport to public transport. Due to the lack of available statistics for quantitative analysis and the scarcity of literature on the subject, it was decided to primarily use expert interviews as a data basis. As the potential of this policy has not yet been studied in a whole country, let alone in Luxembourg, this study attempts to fill this empirical gap, which constitutes a lack of comprehension of the effectiveness of this specific policy in the unique situation and case of Luxembourg.

## III.2) Data collection

### III.2.1) Expert interviews

Expert interviews stand as the primary method of data collection, aiming to capture diverse perspectives from various stakeholders possessing distinct expertise in the realm of fare-free public transport. The participants were selected based on their experience and knowledge in transport studies, fare-free public transport, or the Luxembourgish context. The sample includes academics, practitioners and policymakers who have either been directly involved in the design and implementation of this policy or have dealt with this issue extensively in the past or present.

The interviewees include two researchers from the Department of Geography and Spatial Planning at the University of Luxembourg, renowned for their research on fare-free public transport in Luxembourg. They were complemented by the head of MobiLab, a transport research group at the University of Luxembourg known for its interdisciplinary approach combining engineering, computer science, humanities and economics. In addition, two researchers from the Luxembourg Institute for Socio-Economic Research (LISER) were interviewed, actively engaged in the project “From Low fares to no fares”, in which they analyse the economic, operational, socio-spatial and political dynamics of fare-free public transport.

These five researchers were joined by practitioners and policymakers from the Ministry of Mobility and Public Works, including the Director of the Public Transport Administration, responsible for managing and supervising public transport services in Luxembourg, representing the five public transport operators. Additionally, a government advisor responsible for mobility planning at the Ministry of Transport and co-author of the National Mobility Plan was interviewed. The Deputy Prime Minister and Minister for Mobility and Public Works, under whose leadership FFPT was introduced, also participated in an interview. The list of interviewees who work for a Luxembourg ministry is completed by a representative from the Ministry of Energy and Spatial Planning, working in the National Affairs Department. The final interviewee represents an environmental protection organisation, Mouvement Écologique, providing an alternative perspective that contributes to a multi-layered approach.

The interviews were conducted using the semi-structured interview method. A prepared guideline, which had different focal points depending on the interviewee, specified the course of the conversations but was handled flexibly rather than in the sense of a standardised scheme. The absence of a rigid structure allowed for adoption to the respective interview situation, enabling spontaneous follow-up questions and immediate deepening of statements when necessary. While the sequence of questions in most interviews closely mirrored the variables, the specific emphasis varied depending on the interview and the participants' expertise. Figure 2 provides an overview of the interview participants, providing additional details on each person and their respective interview.

No	hereafter referred to as	Employment	Expertise	Date	Interview form	Duration	Language
1	Researcher 1	Research scientist, University of Luxembourg, Department of Geography and Spatial Planning	Urban governance, policy, small states, dilemmas with urbanisation and growth pressure	30.06.2023	online (MS Teams)	34:29	English
2	Researcher 2	Professor, University of Luxembourg, Department of Geography and Spatial Planning	Cities and regions, economic networks and flows, metropolitan governance, policy and planning	12.07.2023	in person	1:10:01	German
3	NGO employee	Mouvement Écologique	Climate change, biodiversity loss, sustainable development, mobility	12.07.2023	in person	43:06	Lux.
4	Ministry employee 1	Ministry of Mobility and Public Works, Department of Mobility and Transport	Director of the Public Transport Administration	11.08.2023	in person	47:59	Lux.
5	Ministry employee 2	Ministry of Mobility and Public Works, Department of Mobility and Transport	Mobility planning, government advisor, co-author of the National Mobility Plan	16.08.2023	in person	1:01:31	Lux.
6	Transport Minister	Politician, government member	Deputy Prime Minister and Minister for Mobility and Public Works	04.09.2023	in person	41:14	Lux.
7	Researcher 3	PhD researcher, Luxembourg Institute of Socio-Economic Research, Urban Development and Mobility Department	Fare-free public transport, fare policy transitions, public transport, mobility policies, transport workers, policing of public space	04.10.2023	online (MS Teams)	47:46	English
8	Researcher 4	Research scientist, Luxembourg Institute of Socio-Economic Research, Urban Development and Mobility Department	Transport geography, spatial planning, public transport, interaction between lifestyles/well-being/built environment and travel behaviour	10.10.2023	online (MS Teams)	56:40	English
9	Researcher 5	Head of the MobiLab Transport Research Group & associate professor, University of Luxembourg	Transport policy and mobility analysis, traffic flow theory and control, intelligent transport systems, network modelling, travel demand estimation	18.10.2023	online (MS Teams)	54:40	English
10	Ministry employee 3	Ministry of Energy and Spatial Planning, National Affairs Division	Head of division, regulatory plans, landscape sector plan	30.10.2023	in person	1:25:25	Lux.

Figure 2: Overview of the interview participants



### III.2.2) Document analysis

The document analysis serves as a supplement to the qualitative data collected through expert interviews and describes the systematic process of reviewing and evaluating documents. While interviews capture different experiences and perspectives, document analysis provides more depth and context to the study. Document analysis is an essential element in understanding Luxembourg's fare-free public transport policy and is, therefore, a crucial component of this research methodology. It involves a systematic examination of official reports, policy documents and relevant (academic) publications, offering a rich source of historical and contextual information. This contextual understanding is essential for interpreting policy implementation and assessing its potential. In particular, the most recent National Mobility Plan and the Master Programme for Spatial Planning provide valuable information on the background and the political context and help to understand the extent to which FFPT is effectively embedded in wider supporting policies and regulations.

### III.3) Data analysis

After agreement with the interviewees, the interviews were recorded by phone as audio files, then automatically transcribed with the help of the programme Descript and subsequently checked again. The transcription of the interviews formed the basis for the subsequent qualitative content analysis. Initially, the transcribed text was first reduced to its essential content. In a second step, the transcription underwent coding, where individual text fragments of the transcribed interview were assigned to so-called codes, indicating the main topic of each fragment. After coding, a thorough analysis was conducted to identify patterns, themes, or relationships within the coded data.

Matching codes were connected to form a superordinate category. Coding and category formation served to structure the interview text, facilitating the generation of core statements for analysis and comparison. In this case, the six variables of the conceptual framework represented the superordinate categories in which the transcripts were structured, supplemented by a seventh category of content centred around the FFPT policy and its inherent impact. These were then categorised into individual subject areas for further refinement and comprehensive structuring.

#### III.4) Limitations

The study attempts to consider a diverse set of variables to assess the potential impact of FFPT on modal split. Nevertheless, it is essential to acknowledge the inherent complexity of mobility decisions. i.e. that the spectrum of influences on mobility decisions is vast and multifaceted. Specific individual reasons for choosing or not choosing public transport may exist that are not encompassed within the variables considered in this study. In addition, it is essential to note that the FFPT policy was introduced shortly before the outbreak of the global COVID-19 pandemic in March 2020. The aftermath of the pandemic is not to be neglected and, in part, impacts travel patterns to this day. Therefore, it must be borne in mind that the pandemic has possibly had a significant impact on the policy of fare-free public transport in Luxembourg.

It is thus essential to recognise that this study is an approximation of reality, attempting to paint a general picture by identifying overarching trends within the complex landscape of mobility decisions and modal split. The inherent complexity of individual behaviour, the multitude of influencing factors, and the dynamic nature of the transportation ecosystem contribute to the study's broader exploratory nature.

In addition, even though care was taken to cover as many different perspectives as possible in the expert interviews, it is essential to acknowledge that the inherent subjectivity of the selection process may still result in a partial representation of the diverse landscape of expertise and viewpoints within the studied domain.

#### III.5) Ethical considerations

In adherence with the General Data Protection Regulation and ethical research principles, explicit informed consent was obtained from all interviewees. Participants were fully informed about the research's purpose, the nature of their involvement, and the use of their data. Confidentiality and privacy measures were strictly adhered to, safeguarding participants' identities and sensitive personal information. The interviews were based on voluntary participation, free from coercion or undue influence, with the possibility to withdraw at any given time. Research quality was further ensured by guaranteeing that the data collection and analysis methods were appropriate and valid, and that the data was not manipulated or altered in any manner to present a different narrative.

## **IV) Findings**

The specifically developed conceptual framework will be applied to the Luxembourg case study in the following. Before applying the individual variables, Luxembourg is briefly introduced.

### **IV.1) Luxembourg - An introduction**

Luxembourg, officially known as the Grand Duchy of Luxembourg, stands as one of the smallest countries in Europe, with a population of 645,000 inhabitants (as of 2022) and covering an area of 2,586 square kilometres. Located in the heart of Western Europe, Luxembourg shares borders with Belgium, France and Germany. Its culture, people, and languages are closely linked with its neighbouring countries. As such, Luxembourg is considered a point of contact between the Germanic and Romance language communities; thus, three languages are conventionally used: Luxembourgish, German and French. The Grand Duchy's languages reflect its shared "interests and close historical relations with its neighbours. In the 20th century, Luxembourg became a founding member of several international economic organisations, including the European Economic Community and the European Union" (Biel et al., 2023).

Luxembourg's initial prosperity was due to its iron and steel industry, which accounted for up to 80% of the total export value in the 1960s. Since the end of the 20th century, however, the country's economic strength has been based primarily on its engagement in international banking and financial services and, more recently, on information technology and e-commerce. Luxembourg is also an important location for the European Union, hosting institutions such as the European Court of Justice, the European Investment Bank and several EU administrative offices, thus hosting around 20% of the workforce employed in administrative institutions across the European Union. Despite its relatively small size, Luxembourg thus holds significant political and economic importance in Europe (Chilla & Schulz, 2011; Caruso et al., 2015; Biel et al., 2023).

Luxembourg stands out for its exceptionally high percentage of foreign residents. Almost half of the population is of foreign origin, mainly from Portugal, France, Italy, Belgium and Germany (Biel et al., 2023). The initial wave of immigration occurred during a period when the country was still relatively poor and rural. The iron and steel industry established in the south attracted workers from abroad, first Germans from neighbouring regions who were

mainly recruited as skilled workers, then Italian migrant workers who took over the low-paid positions. This development continued after the Second World War; in 1948, the Luxembourg government concluded the first recruitment agreement with Italy, and in 1970, it concluded agreements with Portugal and Yugoslavia. Parallel to immigration into the lower segments of the labour market, a different form of labour migration gained momentum from the late 1980s onwards – the arrival of highly qualified individuals seeking employment in European institutions and the emerging financial sector (Hesse, 2013; Kühn, 2015).

The financial sector became the engine of economic growth, compensating for job losses resulting from the decline of heavy industry. Foreigners arriving for employment opportunities in the financial sector and European institutions primarily originated and still originate from the three neighbouring countries. However, a significant portion of this workforce, known as cross-border commuters, still resides outside Luxembourg and contributes to the cross-border labour market, encompassing regions like Lorraine (France), Wallonia (Belgium), Saarland, Rhineland-Palatinate (Germany) and Luxembourg. Accordingly, around 200,000 cross-border commuters commute daily to the Grand Duchy, accounting for 46% of the country's labour force, with around half originating from France and a quarter each from Belgium and Germany (Hesse, 2013; Kühn, 2015; Statec, 2022).

#### IV.2) Variable 1 – Settlement and population density

As diverse as the languages and the people of the country are the topography and the settlement structure and patterns of Luxembourg. The northern part of Luxembourg, known as the Oesling, covers parts of the Ardennes and forms a plateau with an average altitude of 450 metres. This forested highland is sparsely populated; apart from a few exceptions, most people live in small villages. The southern part of Luxembourg, known as Bon Pays or Gutland, has a more varied topography and is a much more urbanised and industrialised region that is far more densely populated than the rural Oesling. It includes the capital city of Luxembourg, known as Luxembourg City, as well as smaller medium-sized industrial towns in the south, such as Esch-sur-Alzette, the traditional centre of the iron and steel industry. A large part of the country's economic life is concentrated in this southern part (Randelhoff, 2019; Biel et al., 2023).

Despite a high degree of urbanisation, Luxembourg’s settlement structure is very dispersed, as the population is highly unevenly distributed across the country, as shown in figure 3, which indicates the number of inhabitants per municipality in 2023. Luxembourg City stands out as the most populated municipality, housing 132,780 residents, representing approximately 20% of the country’s total population. The following most populous municipalities are also located in the southern and southwestern regions and the outskirts of the capital. These include Esch-sur-Alzette (36,625), Differdange (29,536), Dudelange (21,953), Pétange (20,563), Sanem (18,333), Hesperange (16,433), Bettembourg (11,422), Schiffflange (11,363), and Käerjeng (11,015). The top ten most populous municipalities are thus all located within the agglomeration of Luxembourg City and the former mining area in the south and southwest (Statec, 2023c; Urmersbach, 2023). Accordingly, a quarter of the population is distributed among the capital agglomeration, another quarter among the seven following largest municipalities and half among the remaining 90 municipalities with less than 10,000 inhabitants each (Schmitz et al., 2022).

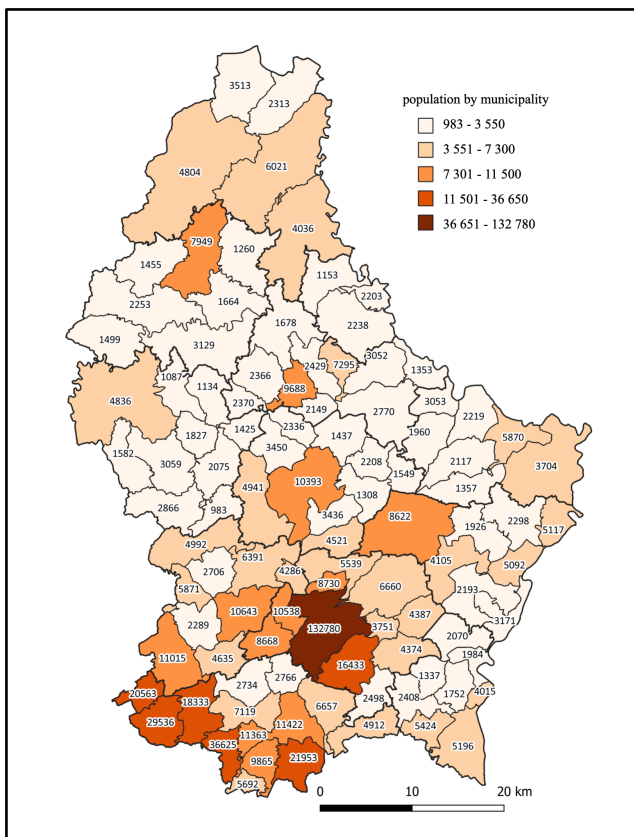


Figure 3: Population by municipality in 2023 (based on Statec, 2023a)

Figure 4 shows that the north-south difference in the spatial distribution of Luxembourg’s population becomes even more apparent when looking at the population density of the individual municipalities (Statec, 2023b). The population density varies significantly between municipalities, ranging from 36.5 inhabitants per km<sup>2</sup> in Kiischpelt to 2,517 inhabitants per km<sup>2</sup> in Esch-sur-Alzette (Statec, 2023c).

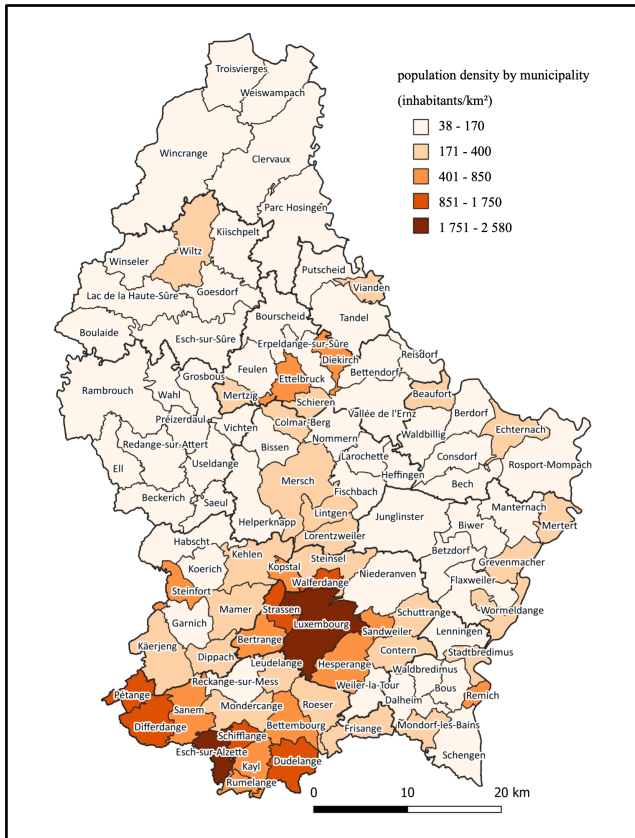


Figure 4: Population density by municipality in 2023 (based on Statec, 2023b)

The conclusions drawn from the literature review, which indicate a positive correlation between the effectiveness of public transportation and a higher settlement and population density, as well as urban concentration, are similarly applicable to Luxembourg, as confirmed by experts. The two interviewees from the Ministry of Transport highlight the challenging situation in the rural northern regions of the country, posing a hurdle for mobility planning (interview, ministry employee 1, 2023; interview, ministry employee 2, 2023). The described dispersion complicates the provision of efficient public transport services that can adequately cater to all residents, particularly in rural or less densely populated areas. “Public transport thrives on bundling supply. In the north, it is difficult to have a critical mass” (interview, ministry employee 2, 2023). He argues that the spatial structure does not allow quick travel for

everyone from their village to the nearest urban centre. Consequently, the bus network focuses on transporting people to the main axes and from there to the next, more urban areas, using another second means of transportation. Researcher 2 (interview, 2023) even describes the north of the country as left behind, and researcher 1 (interview, 2023) notes that there are no substantial connections from the north, apart from the train line to the capital, stating, *“it is not connected to Brussels or Germany in any meaningful way. It just leads to an abyss”*.

The dispersed settlement structure in the rural areas of Luxembourg, particularly in the Oesling region, presents a significant hurdle for establishing efficient and sustainable public transport systems, resulting in diminished connectivity between various parts of the country (interview, researcher 4, 2023). One of the major issues associated with this situation is the growing reliance on cars in these areas, primarily due to the limited availability of public transportation, which curtails residents' mobility options and makes the car a considerably more convenient choice (interview, Transport Minister, 2023; interview, ministry employee 2, 2023; interview, researcher 5, 2023). Researcher 5 (interview, 2023) explains that, given the current demand in rural areas, providing a service that can compete with the car, especially in terms of frequency, is not feasible. According to him, public transport in rural areas cannot match the door-to-door convenience offered by cars. He emphasises the need for region-specific solutions, acknowledging that the car may be the best option in some areas. *“It might be that the car is the best and even sometimes the most sustainable mode. It is a simple calculation: a normal bus, or even an electric bus, consumes more energy per passenger than a car if that bus is not used by at least eight people. So, if we introduce many buses and each will run with just the driver, we are just consuming more energy”* (interview, researcher 5, 2023).

To comprehend the origins of this spatial scenario, the upcoming chapter will provide a more detailed clarification of the factors that have shaped the current configuration of the settlement structure, shedding light on the intricacies and underlying reasons behind its specific structure.

### IV.3) Variable 2 – Spatial structure

In the following, the prevailing patterns of urban and spatial development, along with problems related to the spatial configuration in Luxembourg, are unveiled. This serves as a basis for the subsequent analysis to determine the extent to which the spatial context supports public transport in general and the FFPT policy in particular.

#### IV.3.1) Luxembourg's unparalleled growth

Luxembourg, along with its capital, Luxembourg City, have recently experienced a remarkable and rapid economic and demographic development. For the size of the country and its capital, the prosperity, the growth dynamics, and the international linkages are almost unparalleled (interview, Transport Minister, 2023; interview, ministry employee 1, 2023; interview, ministry employee 2, 2023). As outlined in the introductory chapter, Luxembourg is a global financial hub, hosts important European institutions and consequently attracts a large international workforce (Hesse, 2016; interview, researcher 1, 2023). Luxembourg thus represents a successful example of economic diversification, transitioning from iron-making industries to European institutions and ultimately to a prominent position in the global financial market (Hesse, 2013; SIP, 2022; Luxembourg Public, 2022).

While this accelerated economic and city-regional development has increased the country's financial capacities, it has also brought with it certain challenges that place high demands on planning solutions (Affolderbach & Carr, 2014; Hesse, 2016). This is reminiscent of earlier experiences “from rapidly industrialising regions, where planning institutions tried to catch up with the dynamics and consequences of rapid growth” (Hesse, 2016, p.7). This phenomenon is referred to as flawed urbanisation and refers to the discrepancy between the supply of infrastructure and its integration into urban areas, and the development pressure and the growing demand for space and transportation capacity (Hesse, 2016). Researcher 2 (interview, 2023) further elaborates, stating, “*in my opinion, Luxembourg is a unique case, of which there are not many others, at least not in Europe. Size, international orientation and sovereignty niche are the factors that have made Luxembourg very strong, that Luxembourg has cleverly exploited, and this has then manifested itself in spatial development, in the rapid growth of inhabitants, social product, building areas, infrastructures and the corresponding pressure, which at times was so strong in the 1990s, in the 2000s and 2010s that it was no longer possible to keep up with building*”.



Figure 5 shows the development of some socio-economic indicators from 1980 to 2015, illustrating Luxembourg's growth.

	1980	1990	2000	2010	2015
Population (Luxembourg)	364 900	384 400	439 000	511 800	563 000
Population (Luxembourg City)	78 912	75 833	76 688	93 865	111 300
Employees	137 000	170 400	244 900	341 900	380 800
Employees at banks, insurance companies, financial service providers	7 600	16 335	26 539	40 414	44 400
Gross domestic product (in billion US\$, adjusted for inflation)	5,9	12,7	20,3	55,1	56,5
Cross-border commuters	13 400	33 700	87 400	150 000	170 200
Share of settlement area (%)	no data	7,7	12,0	13,7	14,1
Registered cars	128 610	183 405	263 475	331 513	372 827

*Figure 5: Development of socio-economic indicators (1980-2015) (based on Chilla & Schulz, 2018)*

#### IV.3.2) Population growth, employment expansion and cross-border commuting

Luxembourg's distinctive population growth poses challenges for the country's spatial development, particularly with regard to settlement development and mobility. The following developments illustrate this: Between 1980 and 2021, the total population of Luxembourg nearly doubled from 364,900 inhabitants to 634,700 inhabitants, reflecting an average annual increase of almost 6,800 people and a 74% rise within 40 years (EC, 2011; Statec, 2021). Notably, Luxembourg is the only EU member state whose municipalities have consistently gained population for 40 years, regardless of whether they are central and urban or peripheral and rural (Becker & Hesse, 2021; Schmitz et al., 2022). Long-term projections predict a potential total population ranging from 996,000 to 1,162,000 inhabitants by 2060, assuming sustained positive economic development (Statec, 2017).

Luxembourg's rapid economic growth further led to an equally rapid expansion of the labour market. The number of employees in Luxembourg rose from 244,900 in 2000 to 474,300 in 2020, which corresponds to an increase of almost 80% (Statec, 2021). To meet this high demand for labour, a substantial influx of foreign workers became necessary (SIP, 2022). Consequently, Luxembourg has the most extensive daily cross-border traffic flows in Europe (OECD, 2008). Currently, 46% of all employees are cross-border commuters, representing a six-fold increase since 1990 (Statec, 2021; Schmitz et al., 2022; Schockmel et al., 2022). As economic growth is expected to continue, a significant portion of newly created jobs will continue to be filled by foreign workers in the future (Statec, 2017).

As a result of this high number of cross-border commuters, the country's daily population is considerably larger than the resident population (Hesse, 2013). In the capital, in particular, the daily workforce significantly exceeds the number of registered residents (Becker & Hesse, 2010; Hesse, 2016). This phenomenon is further accentuated by Luxembourg's historical development, concentrating a significant portion of activities in and around the capital (interview, ministry employee 1, 2023; interview, researcher 4, 2023). Accordingly, a large proportion of jobs are located in and around the capital, as can be seen in figure 6, which shows the employment density for each municipality. Chapter IV.5 delves deeper into the implications related to this situation in the realm of mobility.

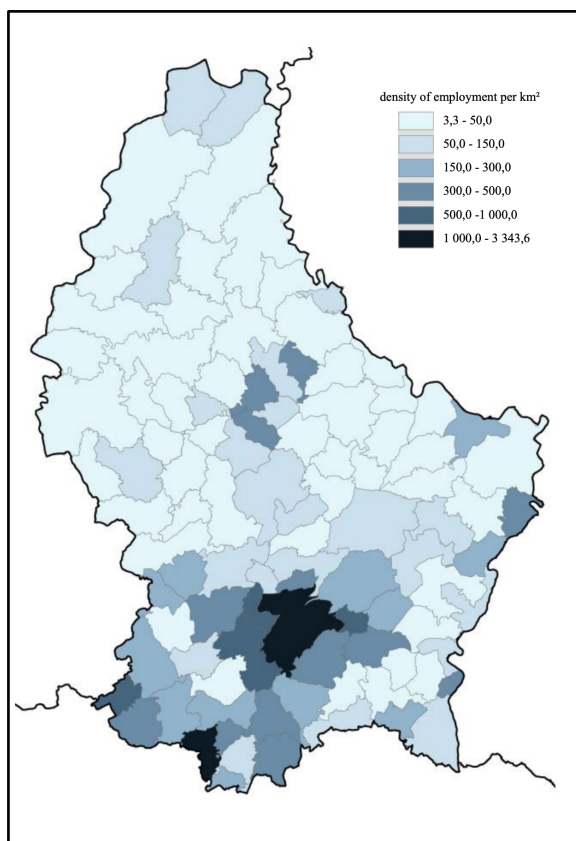


Figure 6: Density of employees in Luxembourg in 2017 (based on Lambotte et al., 2021)

### IV.3.3) Challenges in the spatial layout

Researcher 5 (interview, 2023) highlights a significant issue with the current spatial structure, emphasising a pronounced imbalance in the distribution of jobs, residential areas, and residents. He notes that Luxembourg's historical development as a monocentric country has favoured the concentration of activities in a single point, namely Luxembourg City, while residences are dispersed in peripheral areas. *“Everything, including public transport, is very radial. This also increases the total number of kilometres travelled, given the fact that we have very few circular and peripheral lines. The fact that it has been constructed this way makes it very difficult to create direct connections between peripheral areas”* (interview, researcher 5, 2023). Researcher 3 (interview, 2023) similarly describes Luxembourg's spatial structure: *“Luxembourg is still organised as a very simple centre-periphery model with Luxembourg City as the main centre and the rest of the country, the neighbouring suburbs and the provinces of the neighbouring countries depending on it. You have a lot of dormitory villages, and then all the activities in one place. This is not a modal that works well with public transport. You have a lot of buses that go from Luxembourg City to these villages, but it takes a long time”*. Hence, Luxembourg's spatial configuration diverges from the principle of transit-oriented development (TOD) outlined in the literature. TODs are typically defined by a network where numerous stops serve as both the origin and destination. However, this principle is not realised in Luxembourg due to the evident spatial disparities.

Additionally, there are specific deficits related to population density that may not be conducive to supporting public transportation. While this issue has been touched upon in the preceding chapter, discussing variations in density levels across the country, ministry employee 1 (interview, 2023) also points out this challenge in the immediate vicinity of the capital city as well as beyond its borders. *“It is difficult to organise public transport in such a way that many people can be transported in a short space of time. In the immediate vicinity of Luxembourg City, there is little settlement area where people live close to each other. This also applies to the neighbouring countries from where many commute; parts of the Grand Est, the Eifel region, the Trier area, Saarland, East Belgium and parts of Wallonia are, to a large extent, not densely populated but consist of scattered small villages”* (interview, ministry employee 1, 2023).

Concerning density within urban centres and villages, ministry employee 2 (interview, 2023) observes an inhibition among municipalities to build densely. In his opinion, there are only a few examples of successful high-density development in Luxembourg. He also emphasises the reluctance to construct taller buildings. *“In Luxembourg City, we have the problem that*

*anything taller than 5/6 storeys is very quickly criticised, so that compromises are often sought that are a shame from an urbanistic point of view”* (interview, ministry employee 2, 2023). There is, therefore, a significant rejection of residential structures that are perceived as too tall and too dense, resulting in the loss of considerable public space. *“If an investor is supposed to build a certain number of square metres and is only given a limited height, then the buildings are often built too wide, leaving less public space that could be used for cycle paths or public transport”* (interview, ministry employee 2, 2023). According to him, this tendency also leads to even more dispersed settlements, a sentiment echoed by ministry employee 1 (interview, 2023) pointing out a few examples. *“In rural areas, there are instances where new residential developments are established at a distance from the existing village, and these are then, of course, more difficult to integrate into the public transport network”*.

The spatial challenges are compounded by a lack of mixed-use developments. In response to the country’s economic growth and the associated demand for office space, the country’s building and planning policies have favoured large-scale urban construction projects, such as the Kirchberg plateau, which has been used to settle European institutions, banks, and firms since the 1960s (Hesse, 2013; Hesse, 2016). According to Hesse (2013), the Kirchberg is symbolic of the hegemonic planning policy in the country. Other recent large-scale development projects hosting service sector businesses and public facilities include the Esch-Belval service and science city, the recently developed Cloche d’Or service hub, and many other municipal, regional and national activity zones, primarily developed in non-integrated, rural locations (Schmitz et al., 2022). While more recent projects show some moderation in the division between the work and residential functions, it is still very extreme at the Kirchberg, according to researcher 2. *“The ratio in this neighbourhood is one to ten. When the new housing projects on Kirchberg are completed in ten to fifteen years, the ratio will change from 12,000 to 60,000, i.e. one to five, which is still insane in the dimensions of urban planning. Normally, in a grown city with a population of 100,000, you might have 40,000 jobs, and there are already extreme cities like Frankfurt, which currently has 700,000 inhabitants and 700,000 jobs. Yet in Luxembourg, where it is even more extreme, offices and companies are still being relocated at all costs”* (interview, researcher 2, 2023).

#### IV.3.4) Luxembourg's housing crisis

Luxembourg's growth model and the extensive preference given to office space over residential space by property markets and land-use planning have led to a dysfunctional housing market (Chilla & Schulz, 2011; Hesse, 2016). Accordingly, there is a pronounced scarcity in the housing and real estate market associated with above-average prices for buying or renting, even when measured against the significantly higher income level. Both rents and real estate prices in the respective size classes are about twice as high as in comparable locations in neighbouring countries (Becker & Hesse, 2010). Real estate prices in economic centres and nearby areas have reached top European levels, creating challenges for the middle class in acquiring property (Schmitz et al., 2022). The limited annual increase in housing stock is influenced not only by the stockpiling of building land reserves by property owners but also indicative of the influential position held by developers and a thriving construction industry (Hesse, 2013).

Researcher 4 (interview, 2023) outlines how this problem extends to transport. *“Many of the jobs are in the service sector, which are mainly in Luxembourg City and the south. But if you live in the north where it is more affordable, it means you have to commute for a long distance, for a long time, you need to change (the transport mode) a few times and that discourages people from using public transport to commute to work [...]. Our biggest issue is the fact that housing is so expensive, especially in Luxembourg City. If you want to live close to your amenities, you have to pay for it, and if you are not able to afford this, you have to move further away or even consider moving across the border, where it is much cheaper. This scenario results in extensive commuting, where public transport lacks the flexibility provided by a car. So, you push people to the car because of the housing conditions”* (interview, researcher 4, 2023). Indeed, Luxembourgish citizens are increasingly migrating to neighbouring countries for more affordable housing, contributing to growing cross-border interdependencies. The substantial number of cross-border commuters is also due to the economic advantage for many citizens from Germany, France, and Belgium, for whom it is more cost-effective to work in Luxembourg while residing in their home countries and commuting daily (Affolderbach, 2013; Schulz, 2013; Hesse, 2016; interview, NGO employee, 2023; interview, ministry employee 2, 2023). *“It is cheaper to live in Trier (Germany), buy a house there and own several cars than to live somewhere in Luxembourg City closer to where you work”* (interview, researcher 1, 2023). Researcher 3 (interview, 2023) is equally critical of this development. *“The problem of Luxembourg is this policy of laissez-faire, of the market. Therefore, it is crucial to implement*

*measures such as regulating the landmark, managing the housing market, controlling prices, and encouraging workers to reside within Luxembourg. When more and more people live outside the borders, the trips get longer, and that puts all the system in difficulty”* (interview, researcher 3, 2023).

In this context, ministry employee 1 (interview, 2023) recognises a systemic problem. In his opinion, Luxembourg’s firm adherence to liberal values is the primary reason for the extensive creation of office spaces. *“Economically, it is unfortunately more interesting to realise office space than residential space”* (interview, ministry employee 1, 2023). Researcher 2 (interview, 2023) shares this perspective, asserting that a fundamental change is necessary. *“Something would have to change, but there is no political culture and no political will for this because we have this liberal DNA with which we approach these things, which is also what has made Luxembourg successful [...]. The way things are handled in Luxembourg has a tendency for things to take on a life of their own very quickly, for example for investment interests to prevail, for offices to take over again and for housing to end up in price areas that are simply not healthy”* (interview, researcher 2, 2023). Ministry employee 2 (interview, 2023) also underscores the need for a significant focus on increasing public ownership of land. However, this is currently lacking, as the state only owns larger contiguous areas on the Kirchberg. Potentially developable land is predominantly privately owned, with ownership being highly concentrated. In Luxembourg, an average of 100 individuals own building land worth almost 30 million euros each, and five local developers own land with an average value of 500 million euros (Paccoud, 2023). Ministry employee 1 (interview, 2023) also emphasises the significance of having more land under public control in order to prevent the undue influence of economic interests. This approach, as suggested by ministry employees 1 and 2, would address two critical issues highlighted in this chapter: ensuring a more balanced mix of functions and providing more affordable housing, thereby enabling people to reside closer to their workplaces, leading to less traffic.

#### IV.3.5) Luxembourg's growth policy

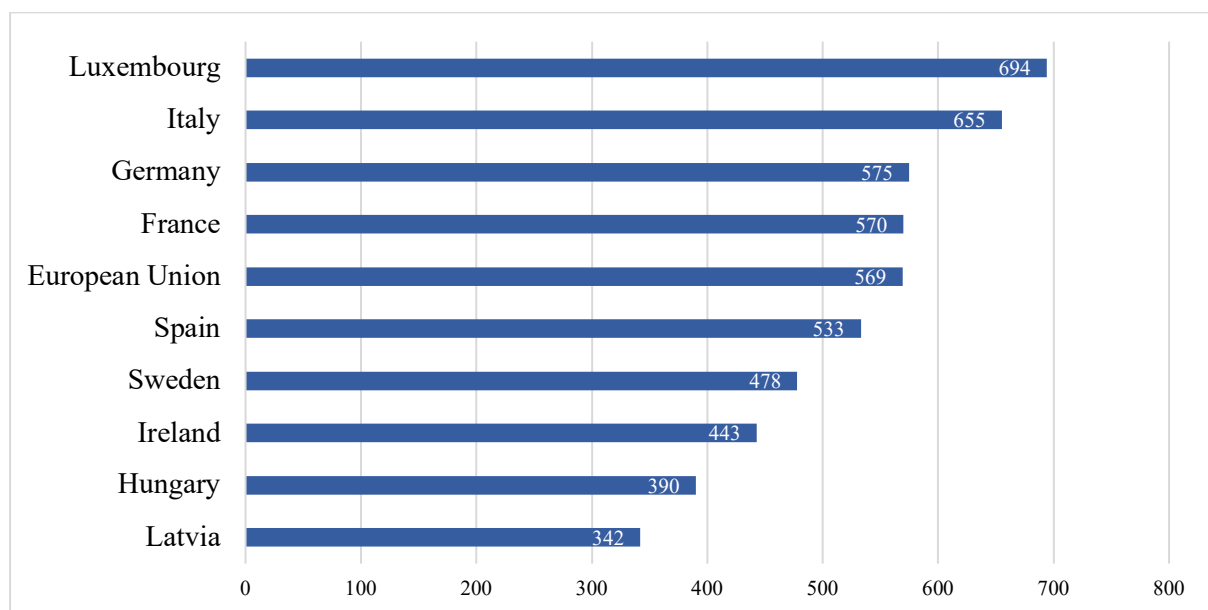
In summary, Luxembourg's actively pursued and encouraged growth, driven by political aspirations, brings forth a set of challenges affecting spatial structures, housing conditions, and, consequently, transportation dynamics. At the same time, this growth is seldom subject to thorough scrutiny, as explained by researcher 2 (interview, 2023), who highlights that the international orientation of the economy, while partly homegrown, is now accepted as an external framework without much questioning. *“Basically, they try to acquire what they can, and the financial sector is the sacred cow in this respect. And as long as that is the case, those responsible for the infrastructure have to absorb more and more. This development has made the small territory very strong economically, but it is exerting incredible pressure on the infrastructure and the construction areas, and that is a situation that you do not have in neighbouring countries; you have it more in the Gulf States, i.e. urban areas that have been developed from the desert within 20 years, only under different political conditions. Within 40 years, the population in Luxembourg has doubled, the social product has increased sevenfold, and if you want to organise this in a democratic context, then you have tension everywhere”* (interview, researcher 2, 2023). Researcher 1 (interview, 2023) shares a similar perspective. *“Luxembourg definitely has a policy of growth; they carry on this idea of 4% growth per year [...]. It is about developing economic stability in a small country that could otherwise perhaps be a bit unstable”* (interview, researcher 1, 2023).

On the part of the Ministry of Transport, the two experts agree that this rapid development has outpaced solutions to arising problems (interview, ministry employee 1, 2023; interview, ministry employee 2, 2023). The Minister of Transport agrees, noting at the same time that a slowdown in growth would also have several other consequences that would have to be considered. *“If you ask yourself the question of growth, you also have to ask yourself the question of financing the pension system or the social security system, which is currently very generous. These are financed by the growth we have at the moment”* (interview, Transport Minister, 2023).

#### IV.4) Variable 3 – Population composition

The demographic and economic development of recent decades has also had a major impact on the inhabitants, who have been catapulted from a predominantly agrarian society to one with the highest per capita gross domestic product worldwide. It is crucial to note, however, that this figure is inflated by contributions from cross-border commuters. These constitute about half of all employees in Luxembourg and contribute to the gross national product but are not included in the per capita calculation. Nevertheless, Luxembourg stands out in terms of prosperity within the European Union, reflected in the highest average annual gross and net income (Becker & Hesse, 2021).

According to the experts, this situation also reflects on car ownership and car dependency (interview, researcher 1, 2023; interview, researcher 3, 2023; interview, ministry employee 1, 2023; interview, NGO employee, 2023; interview, ministry employee 2, 2023). Consequently, Luxembourg exhibits the highest level of motorisation as of 2019, surpassing the EU average with 694 passenger cars per 1,000 inhabitants compared to 569 in the EU (figure 7) (Brandt, 2021).



*Figure 7: Motorisation level of selected EU countries (based on Brandt, 2021)*



Additionally, the number of registered vehicles continues to increase from year to year (visible in figure 5). As per data from the National Statistics Institute, the Grand Duchy saw an increase in registered vehicles from 411,443 in 2010 to 520,322 in 2021, marking a growth of 26.46% over the span of 11 years (Statec, 2021). These statistics may also be distorted by the unique situation of cross-border commuters. As noted by ministry employee 2 (interview, 2023), many cross-border commuters either lease their vehicles in Luxembourg or are provided with company cars that leave the country after work, resulting in vehicles being registered in Luxembourg but predominantly used abroad. Despite potential adjustments to the statistics, he concedes that Luxembourg would still stand out prominently in terms of vehicle ownership compared to other European nations.

The predominance of private cars in Luxembourg is also reflected in the fact that although 51% of all distances travelled by residents are shorter than 5 km, one-third of distances under 1 km and two-thirds of distances between 1 and 5 km are travelled by car (MDDI, 2018a). This car dominance is further emphasised by a 2017 survey conducted by the Ministry of Mobility and Public Works, targeting residents and cross-border commuters to provide a representative picture of mobility behaviour in Luxembourg. The survey reveals a clear dominance of cars in the modal split for work trips, leisure activities, and other private journeys beyond leisure activities, including shopping, transporting third parties, and visits (figure 8) (MDDI, 2017).

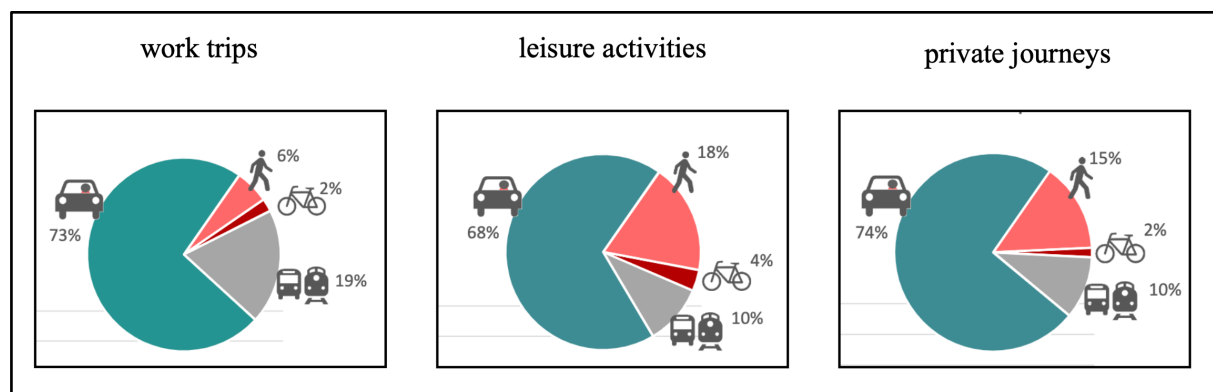


Figure 8: Modal split in 2017 (based on MDDI, 2017)

Nevertheless, the elevated level of car ownership and use is not unique to Luxembourg; it reflects a broader trend observed in other European and Western nations, driven by various developments (interview, ministry employee 2, 2023). The spread of the car as a consumer good was favoured by the structural changes of the 1960s and 1970s, when the standard of living, which was decisive for the development of motorisation, rose. Over the years, the car has acquired a significant social status and has become deeply embedded in society (Urry, 2004; Nykvist & Whitmarsh, 2008; Arnold et al., 2018; Fraedrich, 2018). This cultural phenomenon is also evident in Luxembourg (interview, researcher 1, 2023; interview, researcher 3, 2023). Researcher 4 (interview, 2023), an expert in travel behaviour, emphasises that *“transport decisions are often linked to or influenced by people’s attitudes, preferences, and lifestyle, i.e. subjective influences. And indeed, there is some impact of general culture, where you live, where you were brought up, and in Luxembourg the car is indeed dominating”*.

The prevalence of car dominance in Luxembourg is not solely attributable to its symbolic representation of prosperity but is rooted partly in the spatial orientation of the last century. Similar to other Central and Western European nations, Luxembourg’s investments during the 1960s, 70s, 80s, and 90s primarily favoured one mode of transportation – the car (interview, researcher 3, 2023; interview, researcher 2, 2023; interview, ministry employee 1, 2023; interview, ministry employee 2, 2023). The significant growth of the car industry and its associated lobbies during this period led countries to prioritise the expansion of car infrastructure over public transport (interview, researcher 3, 2023). *“In Luxembourg, this car mentality has been fostered for decades through infrastructure development, so it is not surprising that people behave accordingly”* (interview, Transport Minister, 2023). In the second half of the 20th century, the rail network shrank. Simultaneously, the car and its infrastructure were included in the planning directives for rapidly growing urban centres in various urban development initiatives. Notably, the abundant and systematic provision of parking spaces in areas such as the Kirchberg European Quarter and the city centre of the capital, along with the tendency towards greenfield developments, serve as compelling indicators of spaces where car accessibility was prioritised (interview, researcher 3, 2023; interview, ministry employee 1, 2023). It was only 10-15 years ago, according to ministry employee 2 (interview, 2023), that attempts were made to reverse this trend by prioritising investment in public transport infrastructure over road construction.

Researcher 5 (interview, 2023) draws parallels with countries like the Netherlands or Denmark, which were comparable to Luxembourg in the second half of the 20th century regarding car utilisation rates. However, in his view, their early and substantial investments in alternative transportation modes set them apart from Luxembourg. In contrast, Luxembourg continues to actively promote car ownership through various measures. *“There is still the old habit of using the car as an attractive means of transport. There are all these measures related to very convenient car leasing, for example, or companies that even have some tax advantage by offering company cars”* (interview, researcher 5, 2023). He also believes that the subsidy programme designed to promote electric vehicles, which he supports in principle, is geared towards encouraging people not to get rid of their cars but to replace them with cleaner ones. *“It is not a solution for an effective modal shift, but it is actually an encouragement to simply buy another car”* (interview, researcher 5, 2023). Researcher 4 (interview, 2023) also criticises the absence of measures to make car driving less appealing and thus to motivate people to switch. *“There is no debate about congestion charging, insurance or tax increases. We always talk about push and pull factors to move people from one mode to another. There is currently a big pull towards public transport, but no push away from the car. You need this combination to make it work because it is such a strong habit to use your car [...]. When you need to go somewhere, it is logical that the first reaction will be to take the car, even though you could easily bike or walk. It is just that you have easy access to the car, it is so convenient”* (interview, researcher 4, 2023).

The lack of significant push factors away from car usage is evident in Luxembourg, where, despite its higher relative prosperity, various car-related aspects remain relatively inexpensive. *“What do we have here? We have one of the highest per capita incomes, high salaries and cheap fuel prices. What can you expect? These are, of course, inhibiting factors”* (interview, researcher 2, 2023). The expenses associated with car ownership and obtaining a driving license are low by European standards. Additionally, state-regulated fuel prices have consistently been much lower than those in other Western European countries. The proximity to neighbouring countries and international interconnections have led to significant fuel tourism, benefitting Luxembourg through additional tax revenue from non-residents. As a result, per capita fuel consumption in Luxembourg is currently about four times higher than the EU average. The country hosts around 240 petrol stations in its relatively small area, with residents from Germany, Belgium, and France taking advantage of this situation, contributing to increased traffic volumes (interview, researcher 2, 2023).

#### IV.5) Variable 4 – Mobility context

The recent developments in Luxembourg, as outlined in chapter IV.3, involving population growth and the expansion of cross-border workers surpassing 200,000, constitute an exceptionally distinctive situation. Complementing this is the country's monocentric layout, characterised by a strong polarisation in and around Luxembourg City, as well as secondarily in the former mining region in the south of the country. In the capital alone, 38.2% of jobs are concentrated. The immediate surrounding area is also affected by a high job density, as are various polarities in the south-west of the country, including Esch-sur-Alzette, which is the country's second-largest employment centre with more than 31,000 jobs, equivalent to 6.8% of the country's total employment (2017) (Lambotte et al., 2021; interview, researcher 2, 2023).

This trend has resulted in an increasing distance between places of residence and workplaces, as shown in figure 9, which illustrates the diminishing number of residents working in their municipality of residence, generating more commuting. According to Eurostat, Luxembourg had the second longest commute in the European Union in 2019, with an average commute time of 29 minutes (Eurostat, 2020).

Year	People working in their commune of residence	People working outside their commune of residence	Percentage of people working in their commune of residence (%)
1960	53 000	32 756	62
1971	55 000	51 166	52
1981	54 800	76 294	42
1991	50 000	93 275	35
2001	52 600	135 360	28
2017	55 500	160 317	26

*Figure 9: Development of employment within the municipality of residence (based on Deconville & Feltgen, 2023)*

The high concentration of jobs in the southern part of the country results in substantial traffic flows and notable congestion, particularly during peak hours. Additionally, one-third of all private journeys are made to the capital, and more than half of cross-border journeys have Luxembourg City or the southern region as their destination (Randelhoff, 2019; Pilz, 2021). Figure 10 illustrates the commuter flows of cross-border workers to Luxembourg in 2017, underscoring the pronounced concentration of flows toward the southern part of the country.

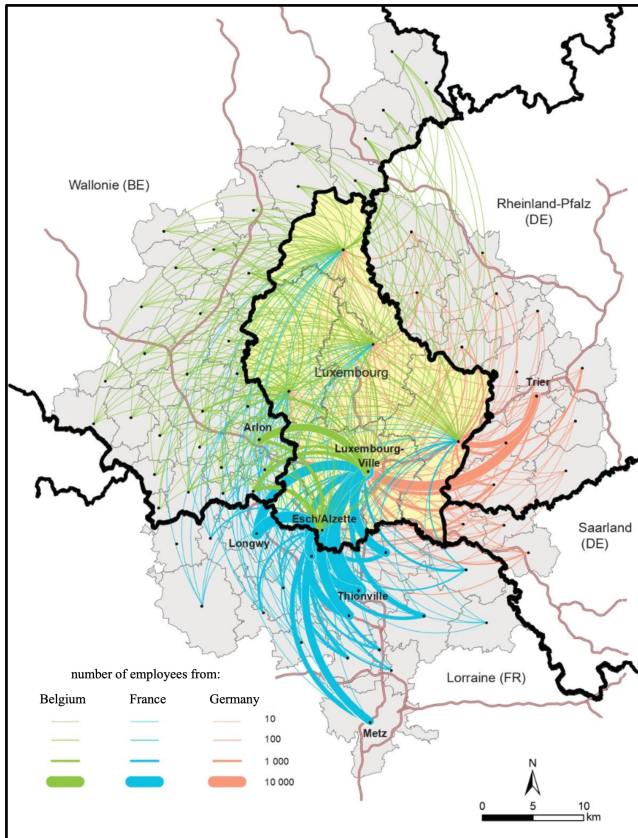


Figure 10: Cross-border commuter flows in 2017 (based on MDDI, 2018b)

Inner-city traffic in Luxembourg City accounts for more than 21% of total motorised traffic, while cross-border traffic accounts for more than 31%. This is partly attributable to the fact that 61% of the 200,000 cross-border commuters opt for personal vehicles for their daily commute (Pilz, 2021; MMTP, 2022). Moreover, car usage in Luxembourg demonstrates significant inefficiency, with a car occupancy rate of 1.16 individuals per car for residents and 1.22 individuals per car for cross-border commuters. Consequently, around 250,000 empty car seats enter the greater Luxembourg City area every morning (MDDI, 2018a).

Researcher 5 (interview, 2023) considers it extremely difficult to reverse this problematic situation, especially concerning cross-border transport, which accounts for half of all traffic during peak times. In particular, he underscores the difficulty in promoting a mode shift and strengthening public transport in the context of cross-border transport. *“Cross-border travel is much more difficult in terms of public transport, as part of the journey has to be organised by other countries, which have much less interest in facilitating and investing in public transport for people that end up finishing their journey in another country”*. At the same time, he shows that it is precisely these journeys that have the most significant impact in terms of traffic

congestion. “On average, a car travelling within Luxembourg covers less than half the kilometres of a car coming from outside, which means that a cross-border vehicle uses twice as much of the road resources as a non-cross-border vehicle” (interview, researcher 5, 2023).

Despite the historical emphasis on road construction in mobility planning, the current situation poses a significant challenge. Figure 11 shows the degree of saturation of the road network in 2009, demonstrating that the current volume of vehicles greatly exceeds the capacity of Luxembourg’s road network. To underscore the congestion situation, Beisel and Völklein (2020) emphasise that the average speed of car commuters in Germany is 50 kilometres per hour, whereas in Luxembourg, it is only 22 kilometres per hour. If this trend continues, as growth projections suggest, an increasing number of cars will contend for the same limited space in the small country, leading to a further escalation of traffic congestion (interview, researcher 2, 2023; interview, ministry employee 1, 2023).

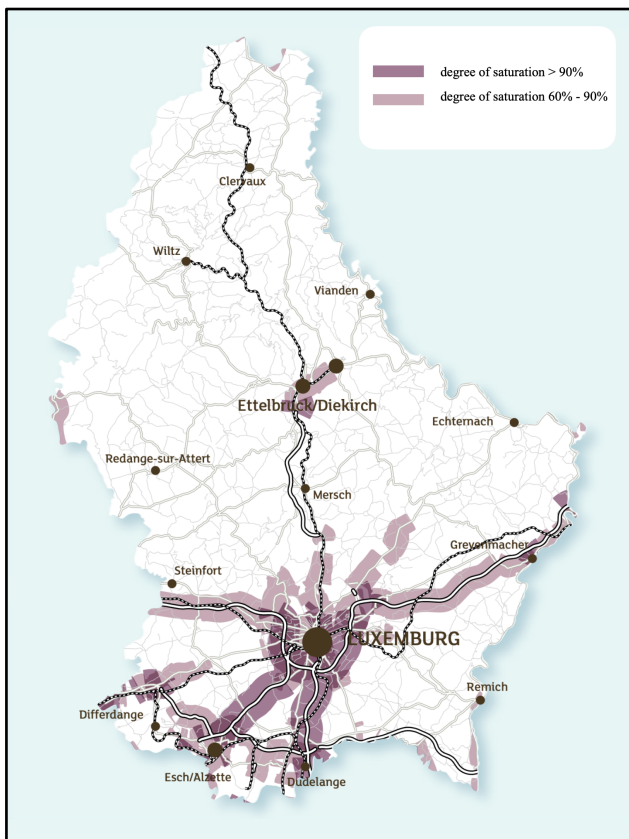


Figure 11: Degree of saturation of the road network in 2009 (based on MDDI, 2012)

#### IV.6) Variable 5 – Public transport network

Before delving into the experts’ assessments of the quality of public transport in Luxembourg and presenting some figures, an overview of the services and organisation of public transport is provided to facilitate better understanding.

##### IV.6.1) Public transport services

Luxembourg’s public transport comprises both international and national rail services, provided by the Luxembourg state railway CFL (RE, RB), the French state railway SNCF (TGV, RER), and the Belgian state railway SNCB (IC). The railway network is arranged in a radial pattern around the central station of Luxembourg City, the country’s largest railway station. The entire rail network spans a length of 275 km and consists of 6 national lines (figure 12) (Randelhoff, 2019; Mobiliteit, 2023).

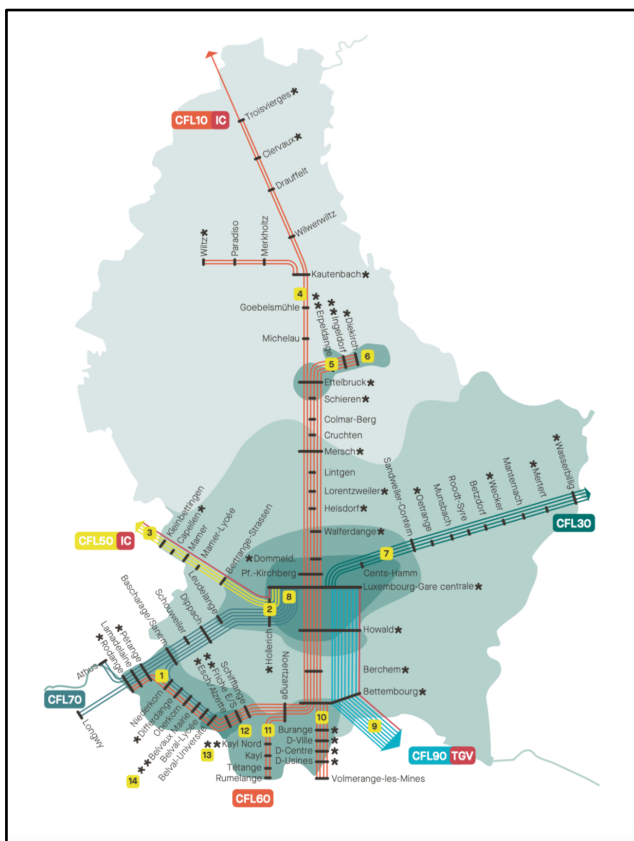


Figure 12: Railway network (MMTP, 2022)

Regional bus services are mainly coordinated and commissioned by RGTR (Régime Général des Transports Routiers). In addition to the RGTR, inter-municipal bus transportation in the southern region is managed by TICE (Syndicat des tramways intercommunaux du canton d'Esch) and bus transport within the capital is overseen by AVL (Autobus de la Ville de Luxembourg) (figure 13) (Randelhoff, 2019; Luxembourg Public, 2023).

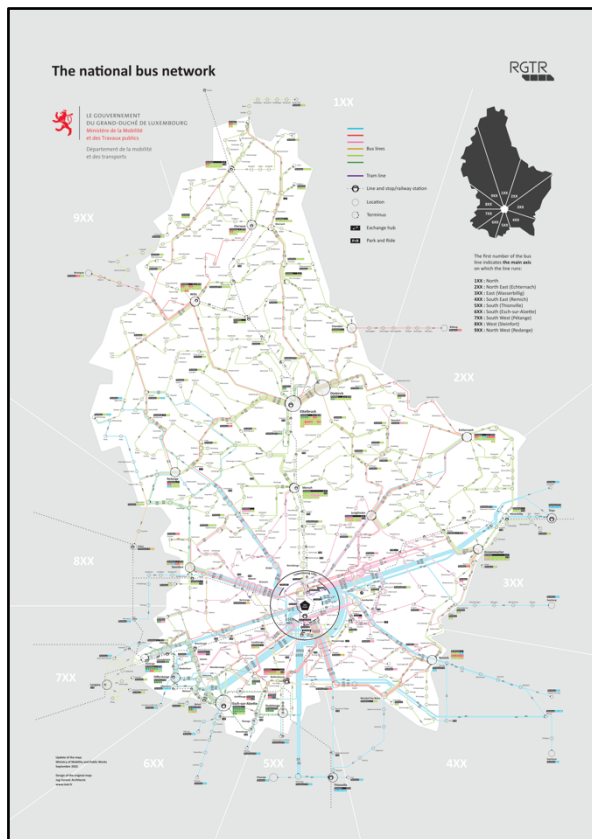


Figure 13: Bus network (Mobiliteit, 2023)

Since December 2017, Luxembourg City features a tram system and the Pfaffenthal-Kirchberg funicular railway, enhancing connectivity between the Kirchberg business and banking district and national rail network. The tramway, currently consisting of one line, aims to relieve congestion in the capital. Initially launched on Kirchberg, the line was extended to the Grand Duchess Charlotte Bridge, later to Place de l'Étoile, the Old and Upper Town and, in 2020, further to Luxembourg Central Station. Currently, construction is extending the tram to the Cloche d'Or service district in the south and Luxembourg Airport in the north. By 2024, the tram is expected to reach its final form, connecting the airport with the national stadium (Randelhoff, 2019; Luxtram, 2021). Accordingly, Luxembourg is served by five national public transport operators: CFL (train), LUXTRAM (tram), AVL, TICE and RGTR (bus).



#### IV.6.2) Quality of public transport services

To assess the satisfaction with public transport services, reference is made below to the data of an online survey on the use and satisfaction with public transport in Luxembourg. Conducted by the Luxembourg Institute for Socio-Economic Research (LISER) in collaboration with the University of Luxembourg and the Vrije Universiteit Brussel, the survey targeted residents and cross-border commuters aged 16 and above, with responses from 1964 people. Three-quarters of the respondents were residents, and the remaining quarter were cross-border commuters from Belgium, France, and Germany. The survey, carried out in February 2020, shortly before the introduction of fare-free public transport, sought opinions from both public transport users and non-users. Notably, it did not examine the possible effects of having fare-free public transport in the near future (Maciejewska et al., 2023; interview, researcher 4, 2023). Satisfaction was measured based on several specific characteristics of public transport services such as supply, accessibility, comfort, availability of information, pricing and safety. Respondents were asked to indicate their satisfaction with various attributes of bus and rail transport on a scale ranging from very dissatisfied (-3) to very satisfied (+3) (Maciejewska et al., 2023). The items relating to the service attributes are listed in figure 14.

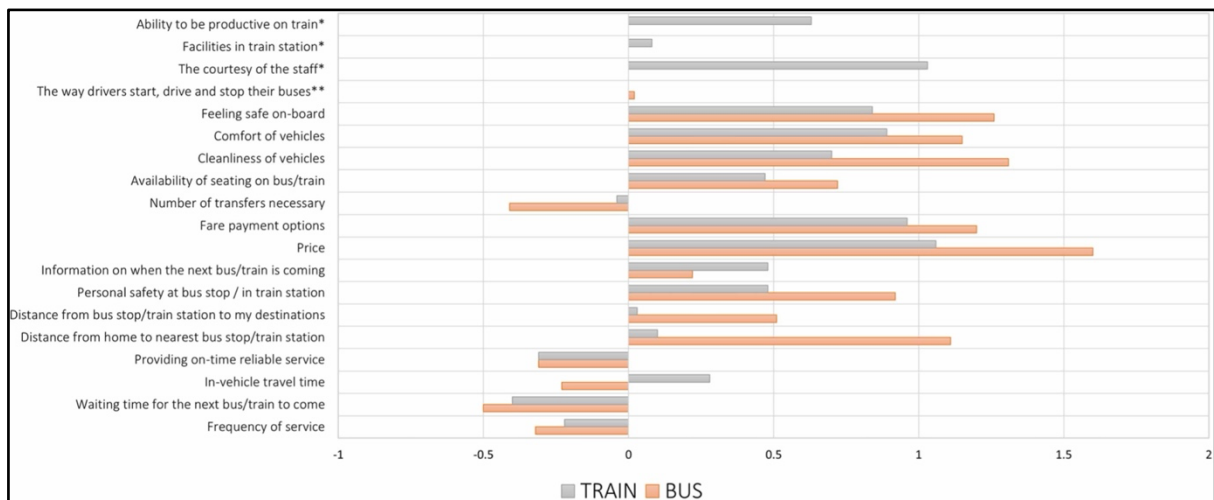


Figure 14: Average values of the level of satisfaction with public transport (Maciejewska et al., 2023)

The survey shows that respondents are satisfied with the majority of the attributes. As negative aspects of the bus, respondents mentioned reliability, long waiting times, in-vehicle travel time combined with low frequencies and the need to transfer between different services. Regarding the train, although in-vehicle travel time is rated quite positively, users are dissatisfied with waiting times, frequency, and reliability.

These observations largely coincide with the experts' observations from the interviews. Researcher 4 (interview, 2023), who was involved in this survey, confirms and adds: *"People were not satisfied with the frequency of the service, with the fact that there are many delays and cancellations, that the travel time is not guaranteed, that the waiting time is too high and that the service is not always reliable. In an open question at the end of the survey, several cross-border commuters in particular complained about overcrowding, especially at peak times on trains"* (interview, researcher 4, 2023). She generally states that the responses of residents and cross-border commuters differ significantly. Cross-border commuters are generally more dissatisfied with public transport, which she attributes to the longer commutes, where the likelihood of train cancellations, delays or interruptions is higher.

Researcher 3 (interview, 2023) confirms the aforementioned problem with transferring. *"One of the biggest problems is the transfer from one vehicle to another. There are many places where there is no synchronisation or where the frequency is insufficient to be effective"*. He notes the importance of direct connections and refers to studies that underpin their importance. *"Several studies show that the time spent on public transport is fine for passengers as long as the vehicle advances, but the time spent at a stop waiting for a connection is perceived as much worse"* (interview, researcher 3, 2023).

Ministry employee 1 (interview, 2023), who is responsible for the organisation of public transport, also acknowledges certain deficits. He emphasises the need for enhanced coordination between buses and trains and points out the prevailing issue of punctuality. At the same time, he accentuates that the offer is comparatively adequate in rural areas. *"We have a better offer than Switzerland in rural areas, even though they are very well organised. We do not have the situation other countries have, where there is only one bus per day in rural areas. We actually have a decent basic offer. We have comfortable vehicles and a modern infrastructure. Interestingly, international perceptions often acknowledge our high-performance public transport, a sentiment not always reflected domestically"* (interview, ministry employee 1, 2023). According to him and ministry employee 2, there is now increased monitoring to facilitate more effective responses. More data is being gathered, and the digital mobility observatory was recently established for this specific purpose (interview, ministry employee 2, 2023; interview, researcher 5, 2023).

According to ministry employee 2 and the Transport Minister, progress is clearly noticeable. *“We are catching up on the backlog of 80 years. Improvements are often associated with short-term deterioration. If you start working on the rails, building them, or modernising them, you will experience even more delays in the short term, but it will pay off in the long term. We have started to turn the tide, but it may take a few years before this has an effect”* (interview, ministry employee 2, 2023). *“The process of catching up requires time. Currently, there is significant momentum, evident in the rapid construction of new stations and train lines, including the extensive renovation of the main station in the capital, resulting in a 35% increase in capacity. However, the biggest leap in quality will be seen between 2026 and 2028. Most of the current construction work in the railway sector will be completed by then, with further station extensions and renovations as well as the extension of the tram line being finished”* (interview, Transport Minister, 2023).

The experts from the field of research also assess the trend of recent years as positive. Many see the reorganisation of the bus network as positive, as this will impact accessibility (interview, researcher 2, 2023; interview, researcher 4, 2023; interview, researcher 5, 2023). The NGO employee (interview, 2023) also believes that the new bus reform has increased the density of the bus network and expanded the range of bus options. Overall, bus usage has not only rebounded from the effects of COVID-19 but has also seen an increase in the number of users compared to the pre-COVID period (interview, Transport Minister, 2023).

The investments made in recent years are also seen as positive, including the introduction of the tram in 2017. *“The tram is one example of an investment that, in the end, has some positive effects in being an attractive mode of transport. It has given the possibility to restyle the city centre. Hamilius Square was a very unattractive area of Luxembourg City [...]. Now it is an active and attractive area which is growing very well”* (interview, researcher 5, 2023). Regarding passenger numbers, the Transport Minister (interview, 2023) notes that since its introduction in 2017, the tram has reached a record high of over 100,000 passengers per day. This increase is partly due to the expansion of the tram line in recent years (interview, researcher 4, 2023).

Researcher 1 (interview, 2023) and researcher 4 (interview, 2023) also consider the investments in infrastructure, such as railway stations, to be positive. Even though researcher 1 emphasises that many things are lagging behind, she recognises that a lot has been done in recent years. *“I would say it is behind, but it has changed a lot. The train stations have improved in terms of the architecture. The comfort has improved a lot in terms of new trains, Wi-Fi availability and platform signages. A lot has been built, so at this level, investments have been made, and new things are being built, but I would argue it could have been this way 15 years ago. It is still in need of more investment”* (interview, researcher 1, 2023). Researcher 4 (interview, 2023) describes it similarly, noting substantial improvements in the modernisation of train stations. She highlights the construction of increased park-and-ride facilities at stations, emphasising their crucial role, especially in border regions, as incentives to encourage cross-border commuters to shift to public transportation. *“Hopefully, this will help to convince cross-border commuters not to commute to their workplace exclusively by car, but to switch to public transport, as there is now an improved availability of parking spaces at the stations”* (interview, researcher 4, 2023).

At the same time, researcher 4 (interview, 2023) emphasises that there is still a great need for transit-oriented development, i.e. creating vibrant, liveable mixed-use communities centred around train systems. *“Some railway stations are very attractive, but they still function purely as places of transport; there are no other services around them, except for Luxembourg City, where you have a bit of shopping that you can do. That is basically the only railway station that offers these services”*. As a counterexample, she cites the Netherlands, where many railway stations are becoming places, almost as new neighbourhoods, offering access to all kinds of shops and services (interview, researcher 4, 2023).

Another aspect related to the concept of transit-oriented development is the accessibility of stations by other means of transport. While the situation in Luxembourg City is reasonably satisfactory in terms of accessibility by bicycle, the situation on the national territory is unsatisfactory, according to researcher 4. *“What is missing is a good cycling network for functional trips. There is a small network, but it is more for recreation, leisure, and sports [...]. In urban areas, the cycling lanes are not easily visible. They often look nice, architecture-wise, but the material is often the same as that of sidewalks”* (interview, researcher 4, 2023). Related to this, the NGO employee (interview, 2023) identifies shortcomings in the accessibility of railway stations. He notes that some lifts are not adequately spacious to accommodate bicycles and that there is a recurring issue with trains having only one carriage designated for bicycle

transport. *“These are all points that contribute to making multimodal transportation more complicated”* (interview, NGO employee, 2023). Another problem researcher 5 sees in this context is the incomplete priority network for public transportation. *“We do have a few bus lanes, but most of these bus lanes are only small segments on busy secondary roads. The problem is that these bus lanes end at intersections where queues are mixed with cars. Thus, all the gain made on these small segments is jeopardised and lost by the fact that you do not provide so-called high-level service bus lines, where corridors are all exclusive from A to B where there is transit priority at intersections”* (interview, researcher 5, 2023).

In terms of the equipment at the individual stops, there are also some differences between individual locations. According to researcher 5 (interview, 2023), the spread of real-time information at bus stops has generally improved. However, this situation is not uniform across all areas. The NGO employee (interview, 2023) states that many stops still lack screens with digital information and researcher 4 (interview, 2023) specifies: *“There are nicely designed bus stops, but other stops consist of just a pole and a bus timetable on paper, and that is it. There are no shelters to protect from the weather, wait for the bus or sit on a bench. So, you see changes here and there, but it is not uniform across the country”*.

#### IV.7) Variable 6 – Public policy

Several improvements mentioned in the preceding section are integral components of a more comprehensive strategy outlined in the last two mobility plans, the one from 2018 and the most recent one, the National Mobility Plan 2035, which will be looked at in more detail below. In addition, the new vision for the country's territorial development and the Luxembourgish planning system will be discussed. This exploration aims to establish a foundation for analysing how fare-free public transport aligns with the Luxembourgish policy environment.

##### IV.7.1) National Mobility Plan

The National Mobility Plan 2035 (PNM 2035) is the successor to Modu 2.0, which was publicly presented in 2018. In contrast to the Modu 2.0 concept, which serves as “the guide to the paradigm shift” or the “theory”, the PNM 2035 is a concrete roadmap that is intended to be more practical (interview, ministry employee 2, 2023). The starting point of the PNM 2035 is a projected economic growth of 3%, which would increase people's mobility demand by 40% by 2035. The aim is to manage this increase with fewer cars compared to 2017, as it is clear that Luxembourg cannot absorb 40% more road traffic. This results in three major challenges that are to be tackled through a multimodal transport network. The first challenge involves the better organisation of transport around the capital, which constitutes almost 50% of all trips. Secondly, mobility in the three major urban areas (the capital, the south, and the “Nordstad”) is also to be reorganised, emphasising alternatives to cars, including bicycles, buses, trams and walking. Thirdly, in rural areas, where the car will continue to play a significant role, more emphasis will be placed on the location of large projects, such as industrial zones, national institutions, and major housing projects. Construction will shift away from greenfield sites to locations with well-established connections to public transportation, whose offerings will be expanded (MMTP, 2022).

In concrete terms, the National Mobility Plan aims to turn the diverse transport networks into an integrated multimodal system that seamlessly integrates roads, railways, cycling paths and pedestrian routes. The plan envisions the establishment of numerous mobility hubs, i.e. multimodal stations that facilitate efficient connections. Accordingly, the 200-page brochure presents 14 measures for a more efficient railway network. These measures include the creation of a new focal point in Diekirch, part of the Nordstad, and the development of a new railway track triangle in Differdange, facilitating a more direct link between the southern part of the

country and the capital. This improved connection between Differdange, the third largest city and the capital, is expected to reduce travel time by 15 to 20 minutes. Additionally, the Hollerich station, located in a suburb of Luxembourg City, will be relocated and developed into a fourth multimodal transport hub in the capital. This hub aims to enhance connectivity for residents in the southern region, providing faster access to the capital and better connections to the tram and, thus, to frequently visited locations in the capital (MMTP, 2022).

The tram network, presently limited to specific areas of the capital and featuring a single line, is to be massively expanded by adding four more lines, enhancing multimodality at key transfer hubs. Added to this is the expansion to the south with the fast tram connecting the capital with the country's second-largest city, Esch-sur-Alzette (MMTP, 2022).

Another crucial aspect of the mobility plan involves alleviating traffic congestion by separating buses from general traffic. The proposed solution is the establishment of dedicated bus corridors with exceptionally high frequencies. These corridors will be primarily implemented in the three major agglomerations: the capital, around Esch-sur-Alzette, and between villages in the Nordstad region. Overall, the goal is to significantly increase public transport capacities by 2035 (MMTP, 2022).

Regarding the road network, a new classification of roads is intended to lead to a paradigm shift, striving to rebalance the various modes of transport, emphasising a more multimodal approach. Through traffic in town centres is to be prevented as far as possible; to this end, main axes that run through town centres are to be given bypasses. The future emphasis in town centres should be on people, achieved through a functional classification of the road network, which entails defining the intended use of each road. For instance, residential streets should no longer serve as shortcuts for through traffic, which involves considerable traffic calming measures. While driving will still be permissible, it should be less appealing on these local streets compared to main roads. This approach aims to allocate more space for buses, bicycles, and pedestrians (MMTP, 2022).

For the capital alone, the mobility plan envisages 34 measures that will benefit car traffic. These initiatives encompass enhanced cross-connections that will significantly reduce traffic in urban areas. Concurrently, public transport will experience enhancements through 16 targeted projects in and around the capital city. High priority is given to buses and carpooling on motorways, entailing the addition of dedicated lanes. So-called carpooling lanes on motorways

are intended as reserved lanes for vehicles carrying a minimum of three occupants (MMTP, 2022; interview, ministry employee 2, 2023).

The mobility plan also includes substantial improvements to pedestrian pathways, such as affording pedestrians increased priority at crossroads, exemplified by continuous sidewalks at junctions. The objective is also to create a comprehensive nationwide network of cycling paths, ensuring cyclists' accessibility throughout the country. A key component of this initiative involves the creation of four new express cycling routes. In addition, cyclists will also be allocated dedicated spaces, separated not only from car traffic but also from pedestrians (MMTP, 2022).

In essence, the PNM 2035 pursues a strategy in which the different modes of transport are designed to complement each other rather than operate in isolation and exclude each other. For instance, integrating the train network with the tram and road is emphasised to create numerous hubs and transfer points to facilitate seamless transitions between different infrastructures. As part of this initiative, the plan envisages the construction of 13 additional park-and-ride car parks in the coming years, serving as catchment car parks to keep car traffic out of urban areas (MMTP, 2022).

#### IV.7.2) Experts' additions to the National Mobility Plan

Ministry employee 2 (interview, 2023), co-author of the plan, states that in recent years and, especially with the PNM, a trend reversal has been initiated and states that two-thirds of the budget is invested in public transport and only one-third in roads. The Transport Minister (interview, 2023) adds that Luxembourg is the European benchmark in terms of per capita investment in rail, investing around 500 euros per capita in the expansion of railways.

At the same time, both the interviewee in charge of mobility planning and the one responsible for public transport planning acknowledge that while the PNM has laid the foundation, there is still a considerable journey ahead. For instance, ministry employee 2 (interview, 2023) emphasises that there is significant potential for enhancing bicycle traffic. Despite some improvements in recent years and further planned measures, the bicycle remains relatively underutilised in the overall mobility landscape, except in central areas of the capital. Compared to similar regions, the share of cycling and walking remains relatively limited. Ministry employee 1 (interview, 2023) also points out that the full potential of soft mobility, especially as a last-mile solution, is yet to be realised.



In addition to the PNM 2035, a new national car park strategy has recently been published. Ministry employee 2 (interview, 2023) notes that the current space allocation for longitudinal car parking takes up too much space in urban areas, which could be more effectively used for alternative modes of transport. Park-and-rides are intended to give people an alternative and provide an interface to public transport. *“As vehicles transition from rural to urban areas, every driver entering the main axes into the city centre should sense the availability of alternatives for parking their cars. These alternatives should make it easy to reach the city centre by public transport”* (interview, ministry employee 2, 2023).

Regarding public transportation, ministry employee 1 (interview, 2023) supplements the PNM by stating that the goal is to convert the entire bus fleet to electric by 2030. Currently, half of the bus fleet operates on electric power. The expansion of the train network is also progressing positively, even though the lines frequently used by cross-border commuters pose a challenge. *“Managing crowding and delays during peak hours, particularly in the two-hour morning and evening windows, is a significant challenge”* (ministry employee 2, interview, 2023). At the same time, he is optimistic that there will be sufficient capacity reserves once the ongoing expansions and enhancements have been completed. In addition, developments such as increased flexibility in working hours and the spread of remote working are helping to reduce overload at peak times (interview, ministry employee 2, 2023).

#### IV.7.3) Experts’ assessment of the National Mobility Plan

Among the experts interviewed who were not actively involved in the development of the PNM 2035, i.e. the researchers and the environmental NGO, there is a broad consensus that the plan is heading in the right direction. Researcher 2 (interview, 2023) notes that the state railway company CFL was in a dire state when the new government of Liberals, Social Democrats and Greens, along with Transport Minister Bausch, assumed office in 2013. Since then, however, he has seen improvements and believes that there has been a concerted effort to develop a clear strategy. Researcher 5 agrees: *“What I really appreciate about this government is that they have been putting a lot of effort into creating a vision and policy documents that have some coherence. They started creating this vision of sustainable mobility, of creating a target to reduce car transport. I believe that these documents provide a very solid base for concentrating the investments on the right decisions and the right things [...]. They are putting a lot of transportation science behind their decisions. Something that was much less evident in the past.*

*Most of the time, interventions were more responsive to specific requests rather than having a systemic view”* (interview, researcher 5, 2023). In other words, he describes how the logic of catching up has evolved into a logic of anticipation. Researcher 3 (interview, 2023) also takes a positive view of the investments made in recent years and expresses optimism about future progress. In this context, the NGO employee (interview, 2023) speaks of a paradigm shift, noting that the focus of mobility planning has shifted from the car to a greater emphasis on public transport.

Researcher 2 (interview, 2023), however, criticises the programme for primarily detailing construction plans without clear target corridors for traffic volumes or emissions. This criticism extends to the mobility plan for the capital, which also lacks concrete figures regarding upper limits. Nevertheless, he acknowledges the change of direction in the area of infrastructure but describes it as a corrective measure to address the consequences of past decisions. *“It is not apparent that they are now getting to the heart of the matter. In planning theory, such an approach would probably be referred to as modelling through”* (interview, researcher 2, 2023).

One point of criticism shared by the experts from the field of research and the person in charge of the Mouvement Écologique is that fundamental car restrictions are neglected in mobility planning in general and specifically in the PNM 2035. The NGO employee (interview, 2023) is of the opinion that the car is still given too much priority and that everything is organised around the car. He criticises the continued investment in car infrastructure and notes that even if the modal split targets were achieved, car dependency would decrease in relative terms, but the absolute number of cars would continue to increase due to population growth. On the part of the LISER, both experts argue similarly, as already briefly mentioned in chapter IV.4. Researcher 4 (interview, 2023) lacks measures to incentivise a shift away from using cars. In particular, there are no financial disincentives to discourage driving, no tolls and no increases in insurance or taxes. Researcher 3 (interview, 2023) agrees that taxes on car use and fuel should be increased and emphasises that both are among the lowest in Luxembourg compared to other countries. In terms of space, he claims that the car is still given much priority. *“The government is still extending or adding lanes to motorways”*. He cites studies indicating that the availability of parking spaces at the destination significantly encourages people to continue using their car. In this context, he identifies considerable potential for reform. Researcher 5 (interview, 2023) agrees and states that several different measures are necessary to change the mobility landscape in the long term. In his opinion, in addition to incentives, such as fare-free public transport, disincentives are needed to discourage people from owning a car.

Notably, the interviews with the minister and the responsible mobility planner show distinct differences in their views on this matter. Both share the perspective that the focus should be on promoting public transport rather than pursuing an anti-car policy. They believe that by providing high-quality public transport and effective alternatives, individuals will voluntarily choose to renounce their cars (interview, Transport Minister, 2023; interview, ministry employee 2, 2023). *“I cannot ask people to shift to a system that does not work. So, it is about creating a system in which, of course, the car also has its place. It should not be about arguing against something, such as the car, but about showing people the advantages of other modes of transport; a positive vision is crucial. There is this saying about the carrot and the stick, but the stick does not work very well. You do not get people to change their minds that way; it only leads to backlash and polarising discussions”* (interview, Transport Minister, 2023).

#### IV.7.4) Master Programme for Spatial Planning

At the spatial planning level, which, as extensively discussed in various sections of this paper, is directly related to mobility, a new document has recently been published, addressing some of the spatial challenges outlined in chapter IV.3 and, more specifically, in chapter IV.3.3. The so-called Master Programme for Spatial Planning (Programme directeur d'aménagement du territoire – PDAT) is one of Luxembourg's main planning policy instruments, providing a framework for the country's territorial development (MEA, 2023).

The new Master Programme for Spatial Planning, the PDAT 2035, adopted in June 2023, sets out the strategy for spatial development up to 2050 and pursues three main objectives:

- the reduction of land consumption
- the strengthening of cross-border consultation
- the concentration of development on the most suitable locations

The third objective, essential for mobility, describes that the three agglomerations, Luxembourg City, the southern region and the Nordstad, are to be developed further in a reasonable manner (interview, Transport Minister, 2023; interview, ministry employee 2, 2023; MEA, 2023). The PDAT envisages that the country should develop primarily in these three urban areas and selected smaller central locations in terms of population and activities. Thus, each region is to have a central location that offers all necessary services. In addition, the functions of living, working, education and leisure are to be brought closer together. These two approaches are intended to improve the accessibility of the essential functions of daily life and,

at the same time, reduce the need for mobility. The aim is a decentralised concentration, which is intended to take pressure off the capital city and lead from the monocentric spatial structure to a polycentric configuration. In terms of transport, this means that traffic flows can be distributed more evenly across the entire national territory (interview, ministry employee 3, 2023; MEA, 2023).

Specifically, the paper also presents some ideas to improve mixed-use and multifunctional construction. In addition to developing mobility hubs in new neighbourhoods and residential areas, efforts are made to create hubs in existing neighbourhoods that bring together services, leisure facilities and means of transport (MEA, 2023).

Although efforts to advance these three poles have been ongoing for years, it is worth noting that while the central conurbation and the southern region are indeed experiencing dynamic development, the Nordstad is falling behind in this regard. *“They try to realise this polycentric land use pattern, but it is still very much dominated by Luxembourg City and a bit in the south. They are now trying to develop the Nordstad, but I do not think it is already working as it should in reality”* (interview, researcher 4, 2023). Both ministry employee 1 (interview, 2023) and ministry employee 2 (interview, 2023) also note that the two agglomerations of the centre and the south have already developed in recent years, while the Nordstad is still in its infancy, as are the public transport connections between these three agglomerations. Researcher 2 (interview, 2023) concurs with this perspective, asserting that the dynamically developing areas need to be stronger and better connected. Researcher 3 (interview, 2023) underscores that the strategy of delocalising jobs away from the capital has not yet shown significant effectiveness and that it will take a considerable amount of time before noticeable results can be observed.

#### IV.7.5) Luxembourg’s governance system: A barrier?

The interviews highlighted that, despite the widespread praise for the positive direction of development supported by both programmes, the key point is that neither of these programmes, PNM nor PDAT, carry legal obligations; they only serve as guiding frameworks. Another limitation frequently discussed in the interviews is that Luxembourg’s municipalities possess planning autonomy and are thus not compelled to implement these plans. Before delving into the specific challenges of this system, a brief overview of the planning system is provided to enhance understanding.

### Excursus: Luxembourg's planning system

Luxembourg's planning system is still relatively young compared to other European nations. Until the end of the 1990s, the spatial planning system was neither legally nor institutionally sufficiently equipped to navigate the aforementioned dynamic developments or to address undesirable spatial developments. It was only the introduction of the Spatial Planning Act of 1999 that led to a paradigm shift (Becker & Hesse, 2021). Another distinctive characteristic is the two-tier administrative system, in which 100 municipalities are endowed with traditionally strong autonomy, positioned directly below the state institutions (Chilla & Schulz, 2018). Figure 15 shows the structure of the planning system explained below, including the individual instruments.

At the national level, it is primarily the Ministry of Energy and Spatial Planning that holds strategic competencies, mainly through the Master Programme for Spatial Planning (PDAT) and the Integrated Traffic and Territorial Development Concept (IVL). These two instruments are primarily used to coordinate diverse sectoral policies in accordance with the 1999 Spatial Planning Act and to define development objectives for future spatial organisation. However, both instruments lack a binding nature, serving only as guiding principles. Additionally, there exist the binding primary sectoral plans for the areas of mobility, housing, economic activity and the environment, created to elaborate on the content of the PDAT. A third essential instrument is the land-use plans (POS), where the ministry specifies land-use plans for the municipal level. This exceptional interference in municipal autonomy is limited to cases of particular importance, such as the Luxembourg Airport (Affolderbach & Carr, 2014; Chilla & Schulz, 2018; Becker & Hesse, 2021).

The second level of planning is that of the municipalities, which are responsible for land-use management at the local level. The 100 municipalities, some of which are extremely small, have a long history of having significant formal competencies in spatial planning under the supervision of the Ministry of the Interior. Municipal planning sovereignty unfolds mainly in the municipal land-use plans (PAG), the municipal zoning plans (PAP) and the accompanying master plans (SD). While the PAGs set the general direction of development, the PAPs contain smaller-scale details (Affolderbach & Carr, 2014; Chilla & Schulz, 2018; Becker & Hesse, 2021). In summary, while the national level sets the general political objectives and directions of spatial planning, the urban planning competencies largely lie with the municipalities.

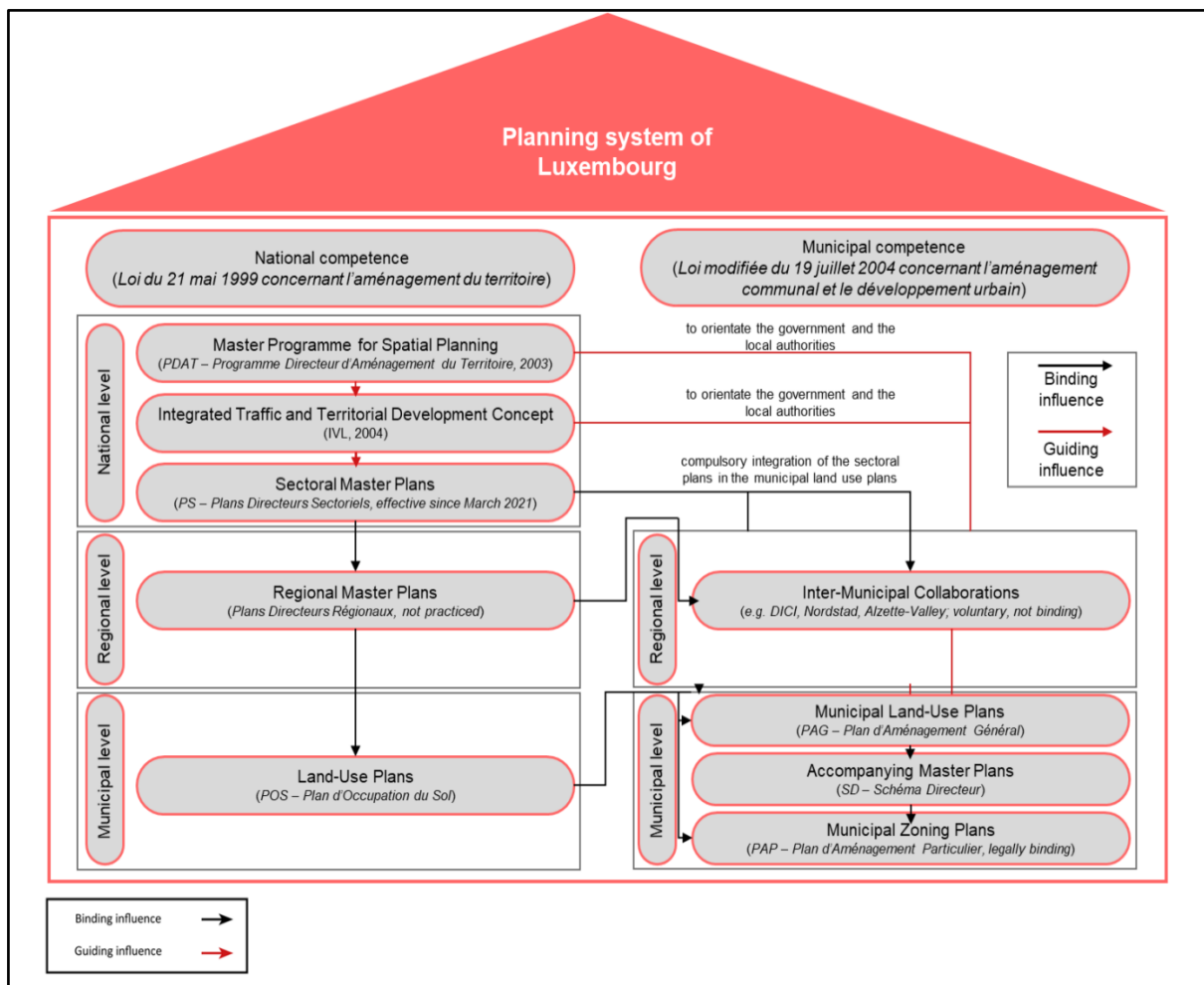


Figure 15: Planning system of Luxembourg (Becker & Hesse, 2021)

Similar to researcher 1 (interview, 2023), ministry employee 2 (interview, 2023) acknowledges the advantages of the current system, citing its reactivity and short distances. However, he critically assesses the power wielded by municipalities. The existence of numerous small municipalities results in correspondingly small municipal structures, posing a contradiction to their designated responsibilities. As a result, most municipalities lack professionals like urbanists, planners, or architects, leading to the necessity of commissioning planning offices for plan development (interview, researcher 2, 2023; interview, ministry employee 3, 2023). Thus, the elaboration of the PAGs and PAPs does not necessarily have to be a task of the municipality but can be handed over to a planning consultancy or a private investor. Becker and Hesse (2021) see this liberal approach as problematic in some cases. “It can be problematic when the various powers between private and public interests are unequally distributed, and the vested interest of development and profit maximisation cannot be entirely limited through

the planning process” (Becker & Hesse, 2021). Researcher 2 (interview, 2023) also emphasises that without the ten largest municipalities, 90 municipalities with fewer than 8,000 inhabitants remain. He contends that, in particular, these numerous smaller municipalities tend to be short-term and profit-oriented, characterised by highly personalised processes driven by individual calculations.

Ministry employee 1 (interview, 2023) points out the resulting complexity and challenges arising from the lack of unified direction in the country’s development. The autonomy of municipalities limits regional planning at the government level, hindering coordinated efforts. Ministry employee 1 (interview, 2023) and ministry employee 2 (interview, 2023) illustrate the practical consequences, particularly in the area of public transport, emphasising issues such as bus stops. Despite the state organisation and funding of public transport, the municipalities are responsible for access and infrastructure at bus stops, leading to significant differences in quality between the municipalities. Ministry employee 1 (interview, 2023) deems this situation problematic, emphasising the importance of user access to public transport. As the bus stop represents the first point of interaction with the transportation system, he finds it disconcerting that, as a public transport planner, he has no control over this crucial aspect.

Researcher 4 also notes the absence of a uniform system, advocating a more user-centred approach to enhance attractiveness. *“There should be a better way of thinking more in terms of what the user wants and how to make it attractive to them, rather than having one system in one place and another one in another place”* (interview, researcher 4, 2023). This lack of uniformity extends beyond bus stops and includes the configuration of roads, sidewalks, and bike lanes, making the overall experience inconsistent and perplexing. In this context, researcher 1 (interview, 2023) speaks of a fragmented territory in Luxembourg.

The Minister of Transport (interview, 2023) concurs, expressing that numerous challenges in the realm of mobility arise from municipal autonomy. Despite advocating for preserving municipal autonomy, citing its long tradition and deep roots, he emphasises the need for a new framework. *“We can develop the best ideas, the most impressive climate or mobility plans, but if they are not implemented at the municipal level, we cannot really do anything about it. One concrete example is the new guideline on traffic calming in towns and villages; we have finalised this guideline, but now it remains to be applied by the municipalities”* (interview, Transport Minister, 2023).

Ministry employee 3 (interview, 2023), an employee of the Ministry of Spatial Planning, describes the municipal autonomy in its current form as outdated and cites the example of the already mentioned Cloche d'Or district, located outside the city centre of the capital, which was transformed from a meadow into an office district in a short timeframe, primarily driven by the financial interests of the developer and the respective municipality. According to him, this development completely contradicts the principles of the PDAT, which advocates for deconcentrated concentration and greater mixed-use. He concludes that the municipal autonomy *“along with the right to private property, which is also deeply rooted in the constitution, are the main barriers to effective planning”* (interview, ministry employee 3, 2023).



#### IV.8) Fare-free public transport in Luxembourg

Following the application of the six variables from the conceptual framework, tailored to examine the potential and effectiveness of fare-free public transport within Luxembourg's distinctive context, this chapter addresses the implementation and effects of the fare-free public transport policy as such before addressing the research questions in the subsequent discussion section.

##### IV.8.1) Key aspects of FFPT in Luxembourg

Since March 1, 2020, public transportation by road and rail has been provided free of charge, without the need for a ticket. Free train travel is limited to the 2nd class and applies to and from a border point. Similarly, free travel applies on cross-border buses up to the last stop before the border (Legilux, 2020; interview, researcher 4, 2023).

For the past two decades, the concept of fare-free public transport has been a recurring topic in Luxembourg's political discussions and has been featured in various election programmes. After several parties included this idea in their 2018 election manifestos, the re-elected coalition government, comprised of Liberals, Social Democrats, and Greens, decided to incorporate this concept into their coalition agreement (interview, researcher 3, 2023; interview, ministry employee 1, 2023). However, for the Greens, who held the Ministry of Transport, it was crucial to avoid a short-term introduction. Their priority was to persist in refining the public transport offer and investing in the system before implementing it in 2020. Hence, they aimed to guarantee the highest possible quality at the time of implementation (interview, Transport Minister, 2023; interview, researcher 3, 2023; interview, ministry employee 2, 2023).

Transport Minister Bausch framed the introduction of FFPT as a significant social measure, describing it as the "social icing on the cake" of the overall strategy for a multimodal revolution. This metaphor emphasises that FFPT is just the icing on the cake and that the quality of public transport and the associated consistent and continuous investment to promote the attractiveness of public transport form the basis. Accordingly, it is an additional measure to enhance public transport's attractiveness and, simultaneously, a social measure, offering relief to low-income individuals and operating as a means of redistribution as it is financed by taxpayers (interview, Transport Minister, 2023).

The interviews revealed that the abolition of fares was not a substantial financial hurdle for Luxembourg, considering that, before the introduction, public transport revenue from ticket sales amounted to €41 million annually – about 8% of the total annual costs exceeding €500 million. The level of cost recovery through tickets was therefore very low, as public transport was already subsidised to over 90%, which distinguishes Luxembourg very strongly from larger countries where ticket sales contribute significantly more to the revenue (interview, Transport Minister, 2023; interview, ministry employee 1, 2023; interview, ministry employee 2, 2023).

The interviewees from the ministries expressed the realistic expectation that there would not be a substantial modal shift in the short term, recognising that the decisive factor of mode choice is rather the perceived quality (interview, Transport Minister, 2023; interview, ministry employee 1, 2023; interview, ministry employee 2, 2023). *“The most important factor for people to shift is not the price; it is the quality, the offer, the infrastructure, the multimodality, the system as such. You can only achieve a fundamental shift if you change the entire mobility system. The fare plays a role, but we know that it is not the most important aspect”* (interview, Transport Minister, 2023). The goal was rather to remove barriers, simplifying access to public transport. Not having to buy a ticket was seen as a convenience that could encourage people, especially in urban areas, to start using public transport naturally (interview, ministry employee 1, 2023; interview, ministry employee 2, 2023). The hope was that by providing free access, people would rethink their travel behaviour and that positive experiences during spontaneous leisure journeys might influence their long-term decisions (interview, Transport Minister, 2023; interview, ministry employee 2, 2023).

#### IV.8.2) Criticism of the implementation

In a 2020 publication by Carr and Hesse, the measure of fare-free public transport was heavily criticised in different respects, and some of these critiques were echoed in the interviews (Carr & Hesse, 2020). One of these aspects is the standalone nature of this measure. Researcher 3 (interview, 2023) believes that it is an isolated standalone measure that was added on top of other mobility policy measures and wonders about how it was introduced. *“Stakeholders, such as municipalities and NGOs, told me that they were not consulted about this policy. So, it was decided at the national level when the negotiations for the government programme took place. After that, it was applied, which is different from how it is usually done”*. Researcher 3

(interview, 2023) and researcher 2 (interview, 2023) are thus both of the opinion that it was a politically motivated measure and state that FFPT was a flagship measure of different election programmes that can be seen as a vote-winning strategy. *“When you look at the different parties’ discourses, they were all different. One was the sustainability discourse, saying that FFPT would attract users and foster a model shift from cars to public transport. Others presented it more as a social measure. So, there were different discourses and arguments; there was not really a structure; it was very vague”* (interview, researcher 4, 2023). Carr and Hesse (2020) state that the nature of decision-making was hasty and not thought through. *“There were no processes of reflexive governance such as research, vision, strategy-building, or monitoring, lacking a clear, balanced, or effective framework of analysis, intervention, and evaluation”* (p.3). They further note that implementing FFPT reflects patterns in the country’s governance practices, stating that Luxembourg tends to propose solutions without thoroughly examining political problems, favouring simplicity over addressing complex issues. *“Taking an actual closer look at problems would necessitate proposing measures that are either overly complex or that would defy vested interests (or both)”* (Carr & Hesse, 2020, p.3). They also criticise the fact that the aim of this measure was very imprecise, which they show by the fact that FFPT was presented very differently in the media. The Luxemburger Wort (2019), for instance, quoted the minister as saying that he did not expect an increase in passenger numbers but that it was more of a social measure. On the same day, the Frankfurter Allgemeine Zeitung (2019) confirmed a different narrative, namely that the government wanted to reduce traffic and traffic-related air pollution.

Thus, Carr and Hesse (2020) question whether this measure was a serious attempt to solve a socio-economic problem, arguing that if the aim was to relieve people financially, then the real social problem in Luxembourg, namely the exorbitant housing prices, should be addressed. *“Any savings on FFPT is far outweighed by exorbitant housing prices, which pose the real inequality issue in the country”* (p.2). They also question the sustainability argument, as they point out that the price is only one of many factors influencing mode choice, similar to what is highlighted in the literature review in the present paper. They point to de Grange et al. (2012), who, in a comparison of 41 cities, concluded that public transport only increases if car use is restricted in parallel. However, this is not being pursued, as described in chapters IV.4 and IV.7.3. Carr and Hesse (2020) state that questioning the car as a status symbol is a political taboo. *“Clearly, any policy measures that constrain the comfort of the four-wheel vehicle as the main means of transport are extraordinarily unpopular in Luxembourg. This also means*

that full-fledged transport policy packages are unlikely to come to fruition; as a consequence, this also means that FFPT in Luxembourg will likely remain an isolated measure, at least in the foreseeable future” (p.2).

Based on this reasoning, Carr and Hesse (2020) suggest that the measure could potentially be associated with nation branding. In fact, after the announcement, Luxembourg garnered global media attention. A nation that in many places was mostly known as a tax haven suddenly made headlines worldwide as the first country to adopt fare-free public transport for all modes throughout its entire territory (interview, researcher 1, 2023; interview, researcher 3, 2023). *“Transport minister Bausch used FFPT as an attraction point to promote Luxembourg as a kind of pioneer and as truly progressive country in terms of sustainable mobility”* (interview, researcher 3, 2023). In the interviews, ministry employee 2 (interview, 2023) and the Transport Minister (interview, 2023) responded that they never intended to engage in nation branding. They claimed that they were surprised by the media attention but did not deny that this was a positive side effect. They added that they used this opportunity to showcase this measure to the outside world.

Another aspect of criticism is that fare-free public transport provided a solution to a problem that, according to the academic experts, did not exist. Ministry employee 1 (interview, 2023) concurs, asserting that FFPT was not a genuine societal demand and did not emerge from any substantial prior debate. This is due to the fact that fares were already heavily subsidised before the policy change and were thus comparatively low by international standards. Compared to other surrounding countries, Luxembourg already provided the most favourable rates (interview, researcher 1, 2023; interview, researcher 3, 2023; interview, researcher 2, 2023; interview, ministry employee 2, 2023). In addition, various population groups were already able to travel for free before the implementation, such as children and students up to the age of 25, disabled people, along with certain individuals on social assistance. Moreover, some employers also provided their employees with reduced fares (interview, researcher 4, 2023; interview, ministry employee 2, 2023; interview, researcher 5, 2023). *“Fares were never considered an issue. There were probably people who would even have been willing to pay more for a system that worked”* (interview, researcher 1, 2023). Researcher 2 (interview, 2023) also believes that the chosen factor, the fare, was not particularly significant. Additionally, he points out that Luxembourg’s high income and wealth situation further diminishes the importance of this price difference.

Different surveys in Luxembourg confirm this impression that fares were not a decisive argument for using public transport (interview, ministry employee 1, 2023; interview, ministry employee 2, 2023). The survey mentioned in chapter IV.6.2, conducted shortly before the introduction of FFPT, even shows that the price was one of the attributes people were most satisfied with (interview, researcher 3, 2023; interview, researcher 4, 2023). This survey also included the question “Do you plan to use the bus/train in the coming months?” as can be seen in figure 16. The options were: “No”, “Yes, but less often than I do currently”, “Yes, more or less the same as I do currently” and “Yes, and more often than I do currently”. 13% (for bus) and 10% (for train) answered the question with “Yes, and more often than I do currently” (figure 16). In response to the follow-up question about the reason for this, only about half answered “because of free public transport” for the bus (figure 17) and far fewer for the train (figure 18) (Van Acker, 2023).

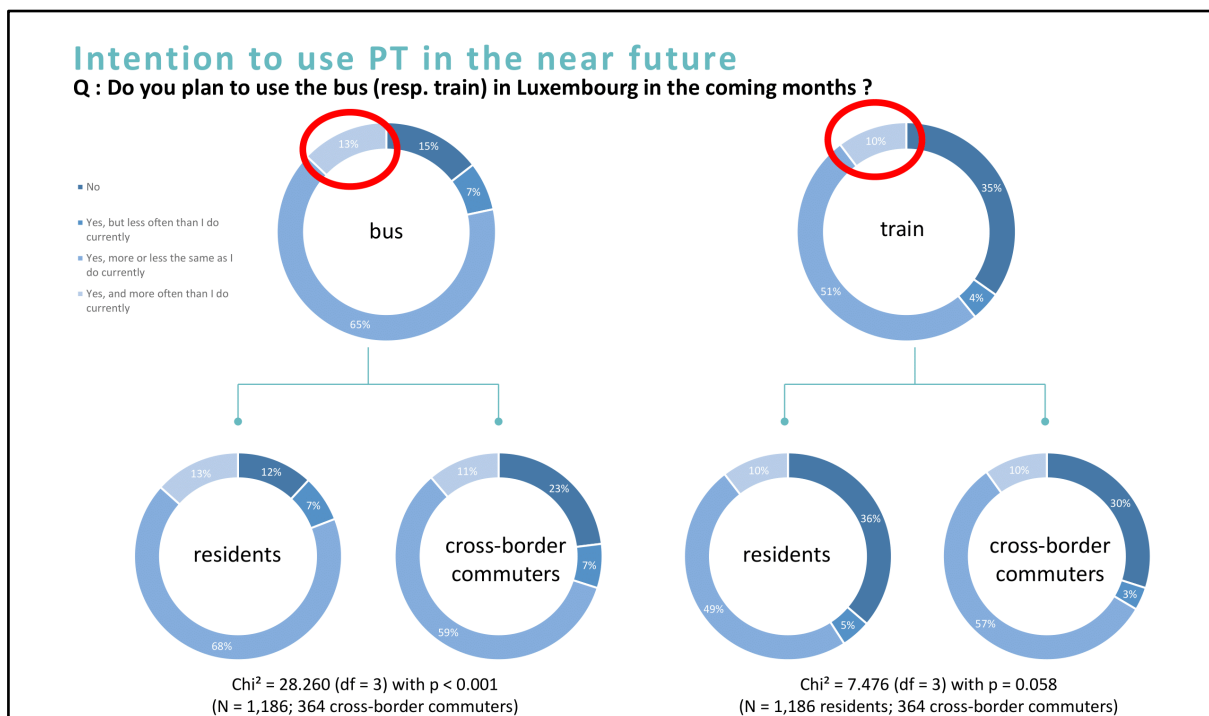


Figure 16: Intention to use public transport in the near future (Van Acker, 2023)

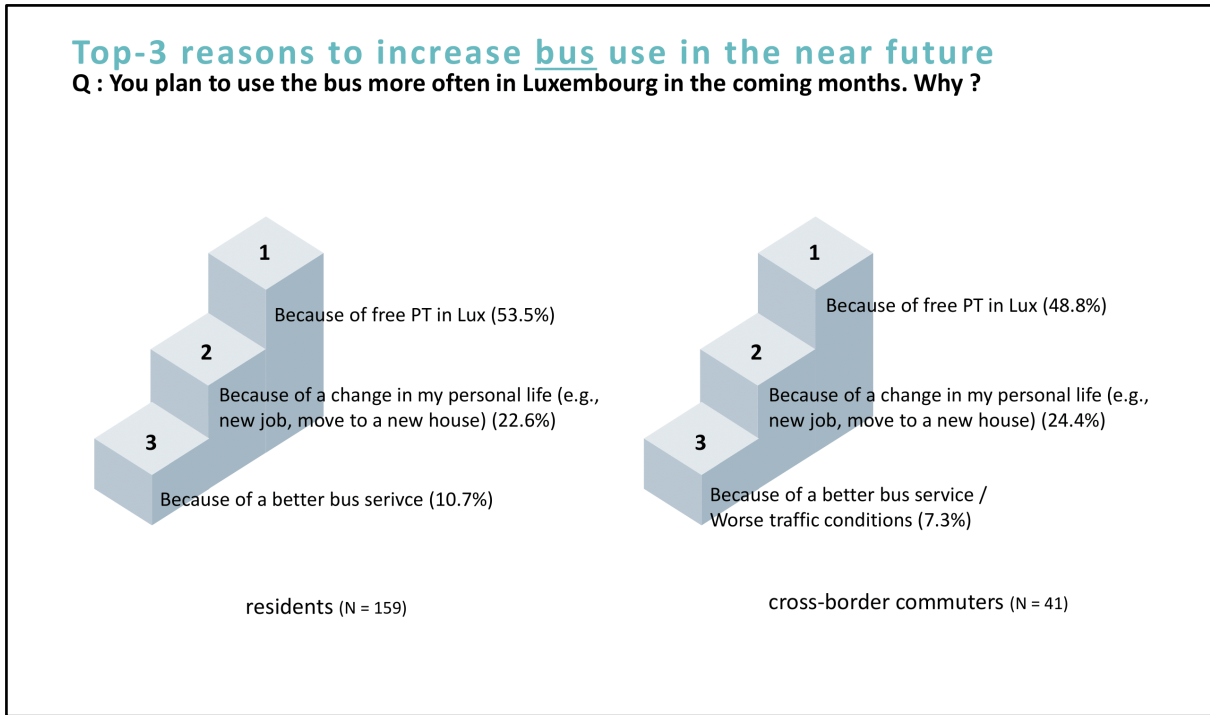


Figure 17: Top 3 reasons to increase bus use in the near future (Van Acker, 2023)

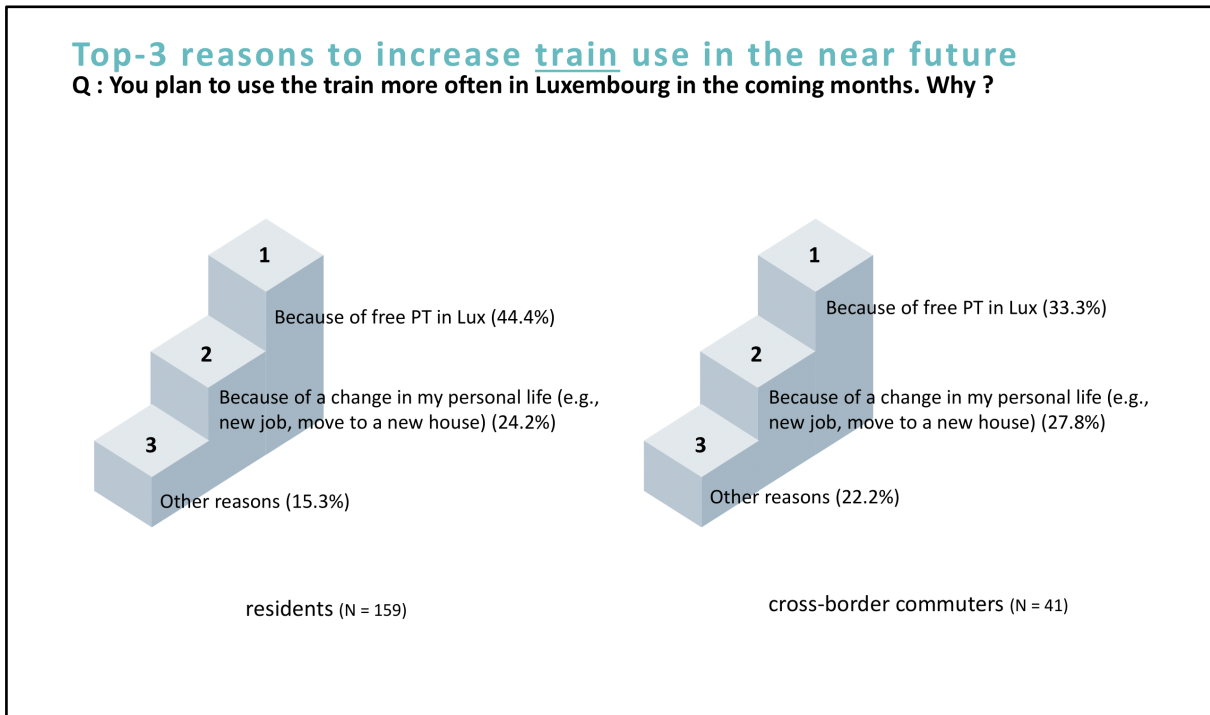


Figure 18: Top 3 reasons to increase train use in the near future (Van Acker, 2023)

#### IV.8.3) Impact of the FFPT policy

As previously mentioned in this paper, determining the precise impact of implementing fare-free public transport and whether individuals are shifting from cars to public transportation due to this initiative is not possible. What is certain, however, is that the number of users has increased compared to 2019 (interview, Transport Minister, 2023; interview, ministry employee 2, 2023). However, it is impossible to attribute this rise solely to a single measure, and it does not necessarily involve former car drivers. During the period from pre-implementation to the present, the onset of the COVID-19 pandemic occurred, efforts have been made to enhance the quality of public transport; as already noted, the entire bus network underwent revision, the tram line has been extended, and the growing population and workforce have also contributed to a rise in potential users (interview, ministry employee 2, 2023). While establishing a definitive cause-and-effect relationship is not feasible, insights gathered from the expert interviews provide some basis for drawing conclusions.

Examining the data, on the one hand, the tram users, recorded automatically through light barriers, and on the other hand, extrapolations from random samples for buses and trains, a clear shift in the daily curves is noticeable. According to ministry employee 2 (interview, 2023), comparing the periods before and after the introduction of FFPT shows that there is now a more balanced distribution of users throughout the day. Previously, there was a distinct peak in the morning and evening, indicating mainly commuters. Presently, there is a larger number of users between these peaks, resulting in a more even distribution pattern throughout the day. He attributes this change to FFPT and assumes that there are now more spontaneous leisure users than before.

The Transport Minister (interview, 2023) shares the view that the number of spontaneous journeys has increased. When inquired about his overall assessment of the impact, he responded that if he were to approximate the percentage increase in public transport usage attributable to fare-free public transport, he would attribute around 5% to the free service. He contends that more than 90% of the increase results from improved quality and service. Ministry employee 2 (interview, 2023) provides a comparable response, noting that FFPT might have initially contributed to a 10-15% upsurge. In his opinion, however, sustained acceptance and the acquisition of regular users hinge predominantly on providing a high-quality service. He also notes that the impact is more noticeable in urban areas, expressing scepticism that more people in rural areas would opt for the bus solely because it is free.

Researcher 5 (interview, 2023) and ministry employee 1 (interview, 2023) also contend that FFPT has an influence, especially for relatively short trips within 10 kilometres in urban settings. This is due to the fact that public transport is generally more competitive in urban areas, as it offers comparable travel times to the car. *“However, when longer distances are travelled, people unfortunately tend to value the gains and the flexibility that the car can offer in terms of travel time and spontaneity, especially in Luxembourg”* (interview, researcher 5, 2023).

Although the above indicates an increase in the use of public transport, this does not necessarily imply a corresponding rise in the number of people transitioning from cars to public transport. *“It cannot necessarily be said that FFPT attracts people who were car users before. In some cases, this is true, but the bottom line is that it mainly attracts active mode users, i.e. previous pedestrians and cyclists”* (interview, researcher 3, 2023). Ministry employee 1 (interview, 2023) agrees and assumes that people now take the tram for a few stops and no longer walk. Researcher 5’s simulation also supports this assumption: *“A negative aspect that we have observed is that, at least based on our simulations, the number of trips that are no longer made on foot or by bike has increased. There is, therefore, a non-negligible shift from active modes to public transport”* (interview, researcher 5, 2023).

Researcher 4 (interview, 2023) describes it similarly and explains that FFPT generates new public transport trips. *“Now that public transport is free, you get on when you see a bus coming and get off one or two stops later. So, it is not a car trip that you save; it is these short walking trips”*. She emphasises that solely considering passenger numbers is not expedient, as it does not account for the number of individuals transitioning from cars to public transport. *“When it comes to switching from cars to public transport, that change is often very small. This is really difficult to realise, and it is not visible at the moment [...]. The impact in that regard will potentially be very small”* (interview, researcher 4, 2023).



## **V) Discussion**

In this thesis, the different variables of the conceptual framework were applied to Luxembourg. These variables include settlement and population density, spatial structure, population composition, mobility context, public transport network and public policy. These variables describe the context of Luxembourg in which fare-free public transport was introduced and influence the potential of FFPT in contributing to a modal shift. After the application of the variables, the FFPT policy as such was examined in the last chapter of the empirical part.

In examining the empirical findings, two different perspectives on the potential of FFPT emerge. On the one hand, there are compelling arguments that FFPT can contribute to a reduction in reliance on private cars and thus encourage a modal shift. On the other hand, counterarguments suggest that achieving a significant modal shift is unlikely, given the unique unfavourable contextual factors in Luxembourg.

In the following, these two perspectives are addressed and contrasted sequentially. This serves as an overview of the key empirical findings, forming the basis for addressing the research questions. However, it is crucial to mention that the different arguments should not be considered equally weighted, as they are not equally decisive. The subsequent answers to the research questions will include an analysis of these arguments, clarifying the importance of the various aspects.

### **V.1) Arguments in favour of a potential modal shift**

**Traffic congestion:** The empirical part has shown that Luxembourg has to deal with persistent traffic congestion, especially at peak times around the capital, partly due to the spatial structure. Based on growth forecasts, it can be assumed that these problems will continue to worsen, making the private car increasingly inefficient. This situation could reduce the attractiveness of the private car, making public transport an increasingly attractive alternative. In particular, the introduction of fare-free public transport could help to make public transport a more attractive alternative in this scenario.

**Enhanced quality of public transport:** This is supported by the leap in the quality of public transport in recent years. Substantial investment in public transport infrastructure and services has significantly improved its quality. The improvement of the bus network, the construction of a tramway, the expansion of the railway network and other important investments, such as the modernisation of railway stations and the construction of park-and-ride facilities, have

made public transport a more attractive option. These improvements provide a solid foundation, contributing significantly to the potential of fare-free public transport.

**Public satisfaction with the network:** The empirical part has shown that the public's satisfaction with most aspects of public transport indicates a sound and appropriate system. This positive perception, as evidenced by the survey cited above and confirmed by experts, lays the foundation for increased acceptance and a potential shift to public transport. Even though the public transport network has shortcomings in some areas, there was broad consensus among the experts that Luxembourg has an adequate public transport system.

**Paradigm shift:** The leap in quality in recent years is primarily due to the fact that there has been a clear paradigm shift in spatial and transport planning. After decades of focussing on the car, there has been a trend reversal and, in relative terms, more and more investment has been made in public transport. This strategic shift in transport planning prioritises investment in public transport over infrastructure for the car. This reorientation underlines the commitment to promoting sustainable mobility solutions.

**Supporting policies:** The National Mobility Plan reaffirms this shift in perspective and outlines additional targeted enhancements for the coming years to increase the appeal of public transport. Essential problems are clearly identified, and concrete measures for implementation are proposed. Moreover, the Master Programme for Spatial Planning acknowledges significant shortcomings in Luxembourg's spatial configuration, contributing to car dependency and constraining the widespread adoption of public transportation. In this sense, there is a certain coherence between FFPT and other strategies.

**Barrier removal:** Fare-free public transport is not only seen as a direct incentive for modal shift but also as a means of removing (financial) barriers to improve access and quality of public transport services. At the same time, the introduction was not a substantial financial hurdle, as over 90% of the costs of public transport were already covered before the implementation. It was therefore a cost-effective method of improving the points of contact with public transport.

**Urban potential:** Especially in urban areas, FFPT has the potential to encourage the use of public transport. Figures from recent years show that the free service has attracted many spontaneous and occasional users, which may lead to more people reconsidering their mode choice if their experience is positive.

## V.2) Arguments against a significant modal shift

**Minor rural potential:** The potential of FFPT is far more significant in densely populated areas. However, it has been found that Luxembourg has a very dispersed structure. In rural areas, especially in the north of the country, there is currently no competitive offer of public transport compared to the private car. Geographical disparities in urbanisation and density thus raise doubts about the feasibility of a large-scale modal shift. It is unlikely that FFPT can help reduce the dominance of cars in these areas in the near future.

**Monocentric structure:** Not only is the dispersed settlement structure an example of a spatial structure that promotes the car and discourages public transport, but also the predominantly monocentric structure of Luxembourg. This spatial structure, which has been recognised as problematic but will still be very pronounced in the coming years, leads to long and complex commutes, especially as many workers come from abroad and most jobs are located in and around the capital. These are all factors that contribute to an increasing dependence on the car, as public transport can hardly offer effective and viable alternatives in this spatial structure.

**Divergence from transit-oriented development:** Luxembourg's spatial configuration does not align with the principles of transit-oriented development. Even in urban areas, there is a lack of dense mixed-use areas designed to combine transport functions with people, activities, buildings, and public spaces. In numerous locations, reaching employment and services by public transport remains challenging, limiting the efficacy of public transport as a convenient and competitive alternative. This distinctive spatial landscape poses challenges for fare-free public transport.

**Dysfunctional housing market:** The current housing market is making it increasingly difficult for many individuals to afford living close to amenities, particularly their place of work. Consequently, cross-border commuters choose to live outside the country, while a growing number of Luxembourgers relocate to rural areas or even abroad. This leads to further urban sprawl and increases the distance between living and working. This, in turn, leads to increased traffic, which perpetuates car dependency and jeopardises the prospect of a modal shift.

**Growth pressure:** The existing and expected growth in population, employment and the associated increase in cross-border commuters and economic activity are expected to amplify the existing traffic volume. Even if more people shift to public transport, the increase in demographic and economic factors will most likely contribute to an upswing in the absolute number of automobiles on the roads.

**Affluent and car-affine population:** The strong reliance on cars and the elevated and growing car ownership rates pose a significant barrier to a substantial shift to public transportation. Luxembourg's inclination towards the car is intertwined with its economic development and associated prosperity, as well as the fact that this mentality has been entrenched over decades due to the historical focus on developing car infrastructure. In addition, due to this economic situation, a large part of society is not dependent on the abolition of fares, and it is likely to have minimal impact on their travel behaviour.

**Lack of restrictive measures:** Despite the aforementioned shift in investment emphasis, there is a noticeable absence of policy measures to restrict car use. This absence, coupled with continued investment in car infrastructure and the fact that various car-related aspects remain relatively inexpensive, undermines the potential effectiveness of FFPT in promoting a modal shift.

**Concerns and ambiguity surrounding FFPT:** The empirical findings have shown that the FFPT policy is an isolated individual measure that has never been part of a long-term planned strategy and is not the result of reflexive governance but rather of political motives. The existence of unclear, ambiguous objectives and the experts' concerns about the policy's underlying rationale lead to uncertainty about its effectiveness in inducing a modal shift.

**Ineffective planning system:** The spatial planning system and the associated municipal autonomy pose a challenge when it comes to achieving coherence in mobility and regional planning and striving for a unified overarching objective. The system leads to considerable disparities in the quality of public transport between municipalities, creating an inconsistent and fragmented system that reduces the attractiveness of public transport. Despite the aforementioned positive direction of development supported by the National Mobility Plan and the Master Programme for Spatial Planning, municipalities are largely not obliged to implement these plans, leading to varying levels of commitment. As a result, some municipalities may lack the initiative to organise public transport in a manner conducive to the success of FFPT.

**A solution to a non-existent problem:** The literature has shown that the price is by no means the most important factor for using public transport. Furthermore, there was a broad consensus among the experts that this also applies to Luxembourg. In addition, public transport in Luxembourg was already comparatively affordable beforehand, especially considering the country's prosperity. Survey results showed a high level of satisfaction with the previous fare

structures. For this reason, FFPT was never a social debate or demand, which is also due to the fact that parts of the population were already able to travel for free before the implementation. As a result, for the majority, the shift to FFPT is unlikely to have a significant impact on their mode choice, as it does not represent a major additional incentive.

**Limited impact on car drivers:** While current data indicates a shift in usage and increased utilisation, this cannot be solely attributed to FFPT, as this increase may be due to a number of factors, including recent improvements in the quality of public transport. In addition, expert consensus suggests that the abolition of fares creates new public transport trips, e.g. former pedestrians and cyclists now using public transport for short journeys in urban areas. The shift is less noticeable among former car drivers.

### V.3) Research questions

Based on the findings section and the subsequent contrasting of individual key arguments, the following section attempts to answer the research questions.

**Main research question:** *To what extent can the introduction of fare-free public transport in Luxembourg contribute to a modal shift from motorised private transport to public transport?*

The examination of arguments both for and against a potential modal shift from motorised private transport to public transport following the introduction of fare-free public transport in Luxembourg reveals a multifaceted landscape. While there are promising aspects that could encourage a shift from motorised private transport to public transport, numerous challenges and contextual factors suggest that a significant shift may be unlikely. In the following, these different aspects are contrasted.

Several aspects provide a favourable backdrop for considering a transition. These factors include the country suffering from severe and persistent traffic congestion problems, which offers a promising opportunity for public transport. In recent years, many transport-related problems, such as deficits in the spatial configuration and quality of public transport, have been recognised. Subsequently, necessary strategic investments in public transport infrastructure have been initiated, with further plans in progress. This paradigm shift, this willingness to change, is clearly reflected in policy documents such as the National Mobility Plan and the Master Programme for Spatial Planning. At the same time, it was recognised that these documents serve as a mere orientation and are not necessarily required to be implemented. The

planning system and the municipal autonomy represent a significant barrier in this respect. In particular, the proposed spatial improvements largely exist only on paper and are still in a conceptual stage, remaining largely unimplemented in practice. Challenges such as spatial disparities, the prevailing monocentric structure, long commuting distances, the problem of unaffordable housing and the divergence from the principles of transit-oriented development collectively lead to public transport not being a competitive and viable alternative to the car in many places, especially in rural areas. Concerns are exacerbated by expected population growth, job expansion, and an increase in cross-border commuters, leading to increasing pressure in the mobility sector that could further undermine efforts to transition from private vehicles to public transit. Even with a higher number of individuals shifting to public transport, the overall number of cars is likely to increase in absolute terms.

Further complicating the situation is that the financial dimension of public transport is likely to hold little importance for the average Luxembourg resident. Given that the financial aspect of public transport was never a prominent issue, that the price was low to start with, and considering that the car-dependent society has been nurtured by the decades-long focus on expanding the car infrastructure, it can be inferred that the influence of this measure may be exceedingly limited. The user class for which FFPT represents a crucial incentive is relatively small. In view of the findings of the literature review, for a significant shift to occur, FFPT would need to be more strongly supported by car restrictive measures, such as financial disincentives. This is currently not the case. On the contrary, it was found that various car-related aspects remain relatively cost-effective.

In summary, the complex interplay of factors implies that it is unlikely that fare-free public transport in this context, under the conditions described, can significantly contribute to a modal shift from motorised private transport to public transport.

**Sub-question 1:** *What are the potentials and limitations of fare-free public transport?*

Fare-free public transport in Luxembourg demonstrates both potential benefits and inherent limitations in reshaping the mode choice between motorised private transport and public transit. In particular, the limitations of this policy became evident in the Luxembourg case study. The importance of the underlying contextual conditions for the implementation of this measure, i.e. the pre-existing situation, was emphasised. The contribution of this measure to the modal split can only be as high as the contextual factors allow. For instance, in the presence of inadequate

public transport, an unfavourable spatial structure for public transport, and a population with a firm reliance on private vehicles, fare-free public transport alone is insufficient to bring about fundamental and lasting changes to this situation.

With regard to the potential benefit of this measure, it can be noted that the present thesis has only focussed on one aspect of this policy, namely the modal shift. The main research question thus contains an implicit assumption that may not be consistent with the intended aim or strength of this policy. The idea that a considerable number of individuals may transition from using cars to public transport as a result of this measure may not be, or should not be, the primary intention and strength of this policy. The available literature also suggests that the actual benefits lie elsewhere. Therefore, it could be argued that fare-free public transport should not be seen as a policy capable of motivating individuals to shift from using cars. Rather, the potential strength of fare-free public transport lies in its ability to reduce financial barriers, improve accessibility, and contribute to a more equitable public transport system. This is particularly impactful for marginalised population groups facing economic constraints, therefore relying on public transport. This nuanced perspective highlights the multifaceted impact of FFPT and emphasises its potential to go beyond simply promoting a modal shift, becoming a catalyst for social inclusion.

In the long term, fare-free public transport could also have the transformative potential to alter the perception of public transport, positioning it as a common good, similar to free services such as public parks, i.e. essentially as a service provided to the public free of charge. As FFPT becomes ingrained in the fabric of daily life over an extended period, it could gradually redefine public transport as a fundamental service available to all, fostering a sense of common ownership and shared responsibility for a service that serves the entire population. Public transport would be seen as the baseline, the standard mode of transport, while alternatives such as the private car would be seen as supplementary options that could gradually be relegated to the status of excess or luxury. In essence, the long-term potential of FFPT extends beyond the impact on modal shift, making public transport an indispensable and universally accessible good.

**Sub-question 2:** *To what extent is fare-free public transport effectively complemented by other policy instruments to facilitate the modal shift?*

This thesis has shown that fare-free public transport can increase its impact in promoting more sustainable mobility if it is complemented by a comprehensive set of supportive measures. It was discussed that FFPT alone may be highly ineffective. Therefore, the success of modal shift depends on the synergies and coordination between FFPT and other policy measures. A nuanced perspective is essential to adequately address the extent to which this applies to Luxembourg.

The empirical findings indicate that the fare-free public transport policy stands as an independent, stand-alone measure within the broader spectrum of mobility policies. Unlike other measures, FFPT had not been intended or planned for years and, therefore, does not feature in any of the mobility plans. FFPT appears to have been superimposed on other mobility policies, which had their own rationales. Many experts, therefore, see FFPT more as a politically motivated election campaign or marketing tool, decided top down at the national level rather than a thoroughly planned policy. Consequently, there appears to be no evident or intentional relationship between FFPT and other policy instruments. Nevertheless, despite this apparent disconnection, the mobility plans and FFPT can serve both together and individually as measures to promote public transport.

Both the National Mobility Plan and the Master Programme for Spatial Planning show that fare-free public transport is complemented by other transport policy instruments and measures that contribute to a modal shift. These strategies incorporate different ideas discussed in the literature in chapter II.5 and focus on substantial investments to enhance the quality of public transport and on spatial restructuring to reduce the need for extensive car usage, thereby facilitating easier and better-served public transport journeys. As described in detail in chapter IV.7, the National Mobility Plan provides for a series of measures, such as the expansion of the tram and train system, the optimisation of the bus network and infrastructure, additional park-and-ride car parks and the improvement of cycle and pedestrian paths. The aim is to create a multimodal system in which the various modes of transport are seamlessly connected and complement each other in order to position public transport as a more attractive alternative to the car. As also described, the Master Programme for Spatial Planning envisages a series of spatial improvements that favour public transport and, thus, FFPT. It envisages loosening up the monocentric spatial structure, building in a more mixed-use, multifunctional and multimodal way, thus bringing the functions of living, working, education and leisure closer



together. The aim of these approaches is to improve the accessibility of the essential functions of daily life, reduce the need for mobility and thus promote transit-orientated development.

However, it is essential to mention that many of these measures have not yet been implemented, especially those of the Master Programme for Spatial Planning. In addition, when comparing these measures to the comprehensive overview of policy instruments outlined in the literature section, it becomes evident that there is a lack of concrete policies against car use in Luxembourg, as confirmed by various experts. This leads directly to the third sub-question, the policy recommendations.

**Sub-question 3:** *Which policy recommendations can be derived from the analysis of the specific case of Luxembourg?*

**Policy recommendation 1:** The first recommendation is an intensified policy restricting car use. This includes the consideration and implementation of measures that actively discourage and restrict the use of the private car. This approach recognises the need for more assertive strategies to shift the existing transportation paradigm. In Luxembourg, there is a significant amount of pull measures in favour of public transport, but there is a lack of push measures away from the car. Both the literature and the experts show that this combination is necessary to achieve a noticeable modal shift. Certainly, there have been notable developments in this domain in recent years, such as the reduction of available space for cars in urban zones and the prioritisation of public transport in various areas. However, there is a notable absence of proactive initiatives aimed at either diminishing the convenience of driving or increasing its associated costs. In particular, there are no financial disincentives, none of those described in chapters II.5.4 and II.7.5. Presently, there are no existing road tolls or congestion charges, and there are no indications of their implementation in the future. Similarly, there are no plans for substantial price increases in categories such as car parking fees or vehicle taxes. The Ministry's approach, as discussed in section IV.7.3, of not actively curbing car usage appears inconsistent with the main findings of the scientific literature. A reconsideration of this strategy might be necessary for achieving meaningful results in the realm of modal shift.

**Policy recommendation 2:** The literature review and the empirical analysis have clearly demonstrated that mobility is closely linked to various policy areas that go beyond mobility planning. Some of the experts expressed concerns that Luxembourg tends to think in silos, addressing problems in isolation. This study has highlighted significant deficits, particularly in land use and housing policy, which affect mobility and the success of public transport and, consequently, FFPT. While improvements in spatial planning are envisaged, as shown in IV.7.4 and discussed in the second sub-question, there appears to be no visible progress on the housing issue. This is problematic as it negatively impacts mobility for several reasons, preventing FFPT from achieving its full potential.

The expensive housing market forces individuals to seek more affordable housing options, often situated at a considerable distance from their workplaces, most of which are located in the capital. This leads to longer commuting distances, increasing reliance on private vehicles for daily travel. The dynamics of the housing market are also not in line with the principles of transit-oriented development, in which affordable housing is strategically located around public transport hubs. With many people living a considerable distance from transit options due to these housing constraints, the potential user base for public transport is reduced, impacting the anticipated modal shift.

The housing market scenario thus indirectly affects the success of public transport initiatives such as fare-free public transport. The housing issue is therefore not only a problem in itself but spills over into other policy areas and is closely linked to various problems identified in this paper. Therefore, the second policy recommendation is to consider various policy areas more collectively and make a more substantial effort to address the housing problem.

**Policy recommendation 3:** The third policy recommendation involves enhancing cooperation with neighbouring countries. While there is a certain degree of bilateral cooperation among policymakers in certain areas, the implementation of FFPT reveals limitations and a need for increased synergies.

The loss of revenue from ticket sales is covered by taxpayers, including cross-border commuters. At the same time, however, they can only partially benefit from FFPT, as they are still required to pay for the part of the journey that takes place within their own country. This is particularly irritating considering that cross-border car commuting accounts for a significant proportion of traffic. It should, therefore, be in Luxembourg's interest to allow cross-border commuters to travel completely free of charge too, in order to alleviate the traffic problems in Luxembourg.

This inequity does not only extend to cross-border workers; in general, low-income workers who are forced to live further away from their workplace do not strongly benefit from FFPT, as they often have to settle in rural areas, where public transport is often not a viable alternative to the car. Conversely, those with the financial means to afford more expensive housing in Luxembourg City experience greater advantages from fare-free public transport.

In addition, disparities exist between cross-border workers and residents in the number of days allowed to work from home, related to salary taxation and the social security system. This means that cross-border commuters are forced to make more frequent journeys to work, which tends to be counterproductive in terms of mobility.

To prevent such problems, further proactive efforts should be made to reach agreements with neighbouring countries and enhance bilateral cooperation. Currently, there is no systematic governing body overseeing mobility in the entire cross-border functional area of Luxembourg. Future mobility strategies thus need to be more effectively coordinated at the cross-border level. As Luxembourg is embedded in broader interconnected international flows, local and territorially limited sustainability policies that overlook the realities of increasing interdependence are unlikely to be effective. Attempts to address sustainability issues in Luxembourg, therefore, require a foresight that goes beyond national borders.

**Policy recommendation 4:** The fourth and final recommendation is to critically evaluate the Luxembourgish growth model. It is essential to question whether this type of growth remains viable and sustainable.

The Luxembourgish model, established over the last thirty years, relies heavily on attracting foreign capital and generating thousands of jobs annually, most of which are filled by immigrants or cross-border workers. While this economic dynamism has contributed to a relatively high level of prosperity for many in the country, the rapid and extensive growth also harbours potential long-term challenges and negative consequences for Luxembourg, its citizens, and the environment. Issues such as congestion and housing shortages are closely linked to Luxembourg's swift population increase and economic expansion. It could be argued that the social and environmental costs of this growth already outweigh the economic benefits. The objectives outlined in the National Mobility Plan, including reducing the share of car transport in the modal split from 66% to 48%, face challenges due to the ongoing growth, as discussed in section IV.3.2. Even if the PNM 2035 were to be implemented, despite existing political uncertainties, motorised private transport would continue to increase in absolute terms.

In Luxembourg, as in many other places, the subject of growth is being raised, if at all, by right-wing populists. Generally, however, this topic tends to be a political taboo that is rarely questioned, which is hardly surprising, given that it is precisely this growth that has been the cornerstone of Luxembourg's prosperity. In addition, this ongoing economic and demographic growth sustains the welfare state and fills the pension funds. Consequently, the economy is compelled to continue growing to uphold the welfare state. This dilemma presents a wicked problem; the necessity for growth has constrained Luxembourg. Hence, it is not surprising that none of the preceding governing parties has abandoned the proven path of unbridled growth.

There are no simple solutions to this complex issue, making it imprudent to propose simplistic recommendations. However, a first step would be to encourage more frequent discussions on this matter and to bring it more into the political spotlight. In the long term, efforts must be made to decouple the social system from growth as far as possible in order to make it more growth-independent. In conclusion, overcoming the lack of political imagination is essential to explore alternative models and address the multiple challenges associated with Luxembourg's growth-orientated trajectory.

## **VI) Conclusion**

The objective of this study was to analyse the extent to which the introduction of fare-free public transport in Luxembourg can contribute to a modal shift from motorised private transport to public transport. For this purpose, different contextual factors have been addressed that either function as barriers or facilitators for fare-free public transport in the sense of a modal shift. The effectiveness and potential, and thus the possibilities and limitations of this measure in the specific context of Luxembourg, were analysed.

Since it was already apparent in the literature review that the price alone is not decisive, a conceptual framework was developed to capture and analyse other essential variables in order to gain insights into various framework conditions and factors that contribute to the success or failure of this measure. The aim was to comprehend the Luxembourgish context in order to understand the circumstances under which FFPT is implemented. The findings revealed that the potential of FFPT to induce a significant modal shift in Luxembourg may be constrained due to a number of specific contextual factors that present a certain barrier, as outlined in the preceding chapter. Luxembourg thus proved not to be a suitable environment in which the introduction of fare-free public transport can significantly contribute to a modal shift from private motorised transport to public transport.

The study has shown that when considering an instrument like FFPT, it is essential to consider the preceding, i.e., the context in which it takes place and the historically specific situation it encounters. This realisation largely aligns with findings from the literature. To realise the full potential of FFPT, it should be complemented by additional measures, particularly those restricting car usage. In addition, the spatial structure needs to be conducive to public transport, the quality needs to be adequate, and the population should be willing to shift. Particularly in locations such as Luxembourg, the price is by no means the most important deciding factor; without other favourable factors, the price alone might not be sufficient to incentivise individuals to transition from private cars to public transport. In essence, the study highlights the interconnected nature of various factors and the need for a holistic approach when implementing policies such as FFPT in order to achieve meaningful changes in travel behaviour.

To summarise, FFPT should not be seen as a miracle cure but as one transport policy measure among many, which, depending on the context, is sometimes more and sometimes less successful in achieving modal split targets. FFPT is part of a solution, moving in a meaningful direction, but it is no more than one component. At the same time, more countries and cities should consider this measure. Especially in smaller countries or cities where ticket sales do not constitute a significant portion of revenue, where it makes little difference to the operator, as in the case of Luxembourg, this measure should be increasingly considered, as it is popular and easy to implement. While it may not result in substantial changes in modal preferences, it also does not cause any adverse effects.

The present study has only examined one dimension of this measure. As indicated in the literature section, this measure has another dimension in line with the three pillars of sustainability, namely the social dimension, i.e. the potential of FFPT to promote social objectives. Further inquiry is needed on this aspect. Recognising its diverse, multi-faceted impact on accessibility, affordability, and social equity can contribute to a more comprehensive and nuanced assessment of the policy's effectiveness. Consequently, future research should address broader dimensions, moving beyond the exclusive focus on modal shift and consider the holistic societal benefits of FFPT. To stay with the example of Luxembourg, it would be useful to investigate how fare-free public transport contributes to the well-being of marginalised communities, i.e. what impact this policy has on the mobility and social participation of individuals with lower incomes. How does it influence the daily lives of individuals facing financial constraints? What role does FFPT play in enhancing social inclusion and community cohesion? These inquiries could provide a more comprehensive understanding of this measure by revealing the complex dynamics of FFPT within specific socio-economic contexts.

Given the diversity of urban environments, there is also an urgent need for further case studies on fare-free public transport in different spatial contexts or regions beyond Luxembourg. Such studies can shed light on how the effectiveness of FFPT varies depending on local factors such as population density, existing transport infrastructure and cultural attitudes towards public transport. Through cross-city or cross-national comparative studies, researchers can recognise patterns and identify challenges and factors that contribute to the success of FFPT. These findings can inform policymakers and urban planners on tailoring FFPT initiatives to specific geographic and cultural contexts.

Lastly, additional research should be conducted on how spatial planning can be structured to enhance the effectiveness of public transport in order to optimise FFPT initiatives. Researchers should, for instance, further explore how infrastructure and urban layouts can be designed to facilitate the accessibility of FFPT. This includes exploring the impact of transit-oriented development, transit corridors, strategically placed stops, efficient linking of different transport modes and last-mile connectivity strategies. It is crucial to understand how spatial planning can either complement or hinder the effectiveness of FFPT through various available measures in order to identify barriers and opportunities within existing spatial planning frameworks.

In view of the challenges posed by motorised private transport and the urgent need to fundamentally shift the modal split towards more sustainable modes of transport, it can be concluded that the breakthrough from fossil-fuel-based automotive mobility to sustainable mobility requires a profound societal transformation towards sustainability that goes far beyond isolated measures, such as FFPT. The existing gap between the necessary steps for achieving climate and sustainability goals and the measures implemented in practice must be bridged. In this context, there is an urgent need to initiate a fundamental change of course and actively drive forward a comprehensive transport transition. The world is facing a climate emergency that is being exacerbated by the car-centred transport system. Therefore, necessary actions must be taken, not only on an individual level but also on a political, economic, and societal level. Bold decisions, innovative strategies, and extensive collaboration among all relevant stakeholders are essential. The time has come to collectively embark on a sustainable path and decisively reshape the future of mobility. This requires a fundamental paradigm shift that not only changes the way we travel but also the way we think about mobility, heralding an entirely new and indispensable culture of sustainable transportation.

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