TRANSPORT CHALLENGES IN LATIN AMERICAN CITIES

Lessons learnt from policy experiences

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February 2019

IDB

Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library
Vassallo, José Manuel.
Transport challenges in Latin American cities: lessons learnt from policy experiences / José Manuel Vassallo, Paola Carolina Bueno.
p. cm. — (IDB Monograph ; 692)
Includes bibliographic references.
1. Transportation and state-Latin America. 2. Urban transportation policy-Latin America. 3. Local transit-Government policy-Latin America. I. Bueno, Paola Carolina. II. Inter-American Development Bank. Infrastructure and Energy Sector. III. Title. IV. Series.
IDB-MG-692

Key words: Public Transport, Urban Transport, Transport Policy
JEL Classifications: L91, R40, N76

This document is a product of the research program developed for the preparation of the Inter-American Development Bank 2020 flagship report: Infrastructure Services in Latin America. To know all the documents from the research program, see: www.iadb.org/infrastructureservices

CONTENTS

1. INTRODUCTION

Most cities of the Latin America and the Caribbean region (LAC) face similar problems, including low quality public transport supply, lack of planning, congestion, and both atmospheric and noise pollution. In addition, factors such as a strong population growth in recent decades, intense urbanization processes associated to urban sprawl are making the situation even more challenging. Meanwhile, roads operate in congested conditions, motorization rates continue increasing and externalities pose major problems.

As a response to these growing concerns, many governments are implementing actions aimed at encouraging the use of more sustainable transport modes and reducing transport dependence on the private car. The goal of these measures is to alleviate congestion, reduce air and noise and promote social equity. The implementation of Bus Rapid Transit (BRT) systems has been a remarkable cost-effective example to deal with these and other transport issues in most cities of the region. Other good examples of these continuous efforts comprise attempts to advance towards more integrated transport systems by, for instance, implementing single fare schemes, while making public transport affordable and accessible by means of transport benefits applicable to the most vulnerable people. Interesting practices in this later case are the so-called “Beneficios de Transporte para personas sisbenizadas” for people of the lowest socioeconomic levels in Bogota (Colombia), the preferential rates for students and the elderly in Santiago (Chile), and the Metro cable in Medellín (Colombia).

Despite the advances gained through the implementation of these and other policies in LAC, there is still a long way to go, especially in the promotion of seamless transport systems at the city level, the achievement of financial sustainability, as well as the improvement of urban air quality. In this respect, practical experiences have identified a number of best practices for overcoming or working around these challenges.

Apart from the introduction, the report is organized in five additional chapters. In Chapter 1, we explain the main trends and issues in megacities along with a descriptive characterization of urban mobility in LAC. On the basis of these major issues, the most important resulting transport challenges that LAC cities face nowadays are identified. Current and potential policies that may help tackle the challenges are then analysed and illustrated with specific examples of the successful implementation of these policies in some cities of the world. Three specific instruments or strategies worth to be studied in greater detail in the future 4 are finally defined.

Based on that framework, Chapters 2, 3 and 4 of the study focus on three specific strategies for addressing major transportation challenges, being of crucial importance for the case of LAC. Firstly, it offers an understanding of the benefits and barriers of fare and modal integration of transport services in urban areas, including aspects such as institutional, physical and network integration. Secondly, the report provides a look beyond the “transport subsidies from the demand-side”, by addressing the institutional processes, as well as the allocation and control mechanisms of public transport subsidies in urban areas from the supply-side. Finally, the study analyses the extent to which certain transport strategies contribute to the reduction of vehicle energy consumption and pollution emissions.

Existing experiences of transport instruments aimed at improving air quality, reducing transport inequalities and providing integrated and seamless transport services are analyzed through a series of selected examples. Particularly, the study focuses on three cities of developed and developing countries: London and Madrid in Europe, and Bogotá in Latin America. The first two cases represent interesting examples for LAC cities. The third case serves as a sample of what is being done now in the Latin American environment, despite there is considerable disparity across countries. The benchmarking exercise undertaken is aimed at evaluating the transport performance of the cities in relation to the described issues, as well as identifying best practices for policy development and improvement in rapidly expanding cities in LAC.

Finally, Chapter 5 of this report discusses and summarizes lessons applicable to LAC resulting from the policies and experiences analysed in previous chapters. Given the wide variety of cities in LAC, these recommendations may not be applicable to each individual city. However, these lessons should be taken in the context of good practice and may pave the path towards successful implementation of transport policies.

2. TRANSPORT POLICIES AND CHALLENGES IN LARGE CITIES

2.1 INTRODUCTION

LAC has experienced a strong population growth in recent decades. Associated with it, there has been an intense urbanization process encouraged by rural exodus, which has concentrated 80% of the population in cities. This trend will continue as forecasts point out that in the coming decades 90% of the population of the region will reside in cities. Urban population growth in Latin American and the Caribbean cities has usually been associated to urban sprawl.

Dealing successfully with city growth requires planning, and the balanced development of infrastructure facilities, public services and governance structures. Unfortunately, the right progress has not been achieved in many LAC cities due to financial, organizational and management problems. The rapid metropolitan development experienced by LAC cities in the last 15-20 years has occurred without due planning. As a consequence of that, a series of needs associated with this growth have not been conveniently met. Reports such as RED —see CAF, 2017— or PRO-INCLUSIÓN —see CAF, 2016— highlight the informality of the urban structure in many cities produced by inadequate land use management and planning.

In most LAC cities high income people reside in isolated residential areas. In some cases, these elitist districts show up in previously marginal areas giving rise to what is known as gentrification. This process causes that the original population is progressively displaced as a result of the higher cost of housing and the standard of living of the neighbourhood. Families with lower resources often live in informal settlements and marginal neighbourhoods that have been formed without any control, located both in the urban periphery and in more central areas. These settlements, often exposed to adverse weather and natural catastrophes, have a high population density, which lives in poor conditions with little access to basic services such as drinking water, sanitation or street lighting.

The great differences in income and quality of life among sectors of the population in LAC cities have greatly compromised social coexistence, giving rise to antisocial and violent behaviour. As the 2013 IDB report *Megacities and infrastructure in Latin America: what its people think* says insecurity and crime have become one of the region's main concerns. Every year the Mexican NGO Citizen Council for Public Security and Criminal Justice publishes the list of the 50 most violent cities in the world, almost completely covered by LAC cities (43 in 2016).

On the other hand, air pollution in LAC cities has greatly increased in recent decades due mainly to land transport, electric power generation and industrial production. In order to tackle this problem, some cities have begun to implement measures such as traffic restrictions to reduce emissions of pollutants. However, this is not a relatively widespread practice, especially in smaller cities, due to the economic and technical capacity it implies.

The rapid and disorganized growth of LAC cities has harmed the quality of urban mobility in the region. Urban sprawl along with income growth has prompted the rise of car ownership and enhanced its use thereby producing congestion and increasing pollution. Unfortunately, this trend has not been accompanied by actions aimed at facing the problem. Infrastructure supply has grown at a much slower pace than needed, and policies to make mobility more efficient and rational have been scarce.

In spite of the trend previously mentioned, public transport and walking are still very relevant in LAC because a large part of the population does not have the economic resources to purchase a

car. In this situation, the development of an adequate public transport system is crucial since it facilitates daily access to the resources and opportunities offered by the city to a massive amount of population at an affordable price. Moreover, public transport should contribute to correct the territorial and social segregation mentioned above.

Giving the relevance of transport to ensure sustainability and quality of life in LAC cities, the goal of this chapter is to shed light on the main challenges faced by urban mobility nowadays, and the policies to address those challenges. For the purpose of this chapter, urban mobility is understood as the capacity that people have to successfully get to the places where they develop their activities (work, leisure, social relationships, etc.), or receive the goods and services they require. The chapter will focus on all aspects of urban mobility (travellers and freight, private and public transport, etc.) even though special attention will be paid to public transport issues.

Apart from this introduction (Section 1), this chapter is organized in five additional sections as displayed in Figure 2.1. Section 2 characterizes urban mobility in LAC and provides a description of the main trends and issues in megacities. Section 3 builds on these major issues to identify the most important resulting transport challenges that LAC cities face nowadays. Current and potential policies that may help tackle these challenges are analysed in section 4. Finally, the fifth section provides examples of the successful implementation of these policies in some cities of the world and Section 6 defines specific policies worth to be studied in greater detail in the future.

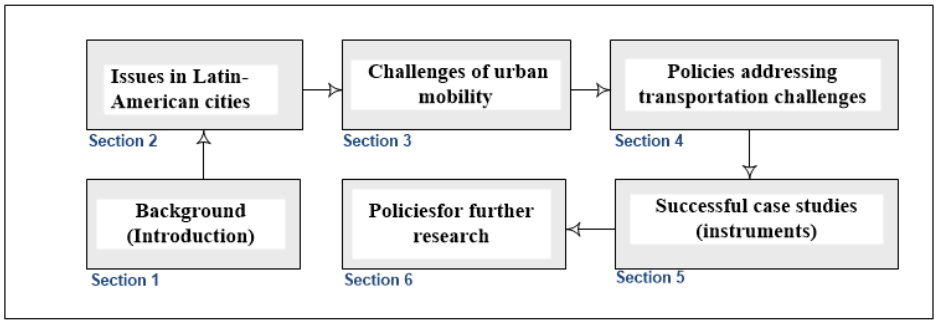

Figure 2.1. Sections of the chapter.

2.2 URBAN TRANSPORT IN LATIN-AMERICAN AND CARIBBEAN CITIES

LAC represents a special case with regards to the evolution of urban transportation. Although it has played a significant role in the development of LAC, most cities in this region face similar problems, including low quality public transport supply, lack of planning, congestion, and both atmospheric and noise pollution. In addition, public transportation still faces important challenges in terms of coverage and quality of the available infrastructure and services.

This section reviews the current transportation trends and issues in megacities. While many of these issues are general `symptoms´ of megacities, there are many others more closely related to transport. Although they have been studied in depth elsewhere (e.g ECLAC, 2012; Hidalgo & Huizenga, 2013; Jirón, 2013); an overview of these questions is crucial in framing the case studies presented throughout this chapter. Therefore, on the basis of these research works as well as other important correlative studies, Table 2.1 identifies the major issues that many large cities in the world face nowadays. It also presents a synthetized discussion of their applicability to the case of LAC.

Table 2.1 Issues in large cities and their applicability to the case of Latin-America

Trends / Issues	Explanation	Applicability to Latin-America
The population of the cities is increasing	The population of large cities is steadily growing and, as a consequence, managing mobility is becoming increasingly complex. The pace of the urbanization process entails great challenges in relation to the transport infrastructure and services.	Latin America has had a great population growth in the last decades, associated to an uncontrolled urbanization process. Between 1995 and 2009, the total population of the Region has increased by 20% in 15 years (CEEPAL, 2008). A result of the rapid pace in which Latin-American cities are growing is the limited response of formal transport means and the proliferation of disorganized transportation systems.
Urban sprawling and its consequences	House prices have encouraged people to move to the suburbs. Less dense cities are more difficult to be served by efficient transport systems. The sprawling effect favors the use of the private car which in turn will cause longer trips and greater congestion and emissions.	Latin America has experienced a fast motorization trend over the past decade so the problem of congestion has been accentuated. Road accidents and air pollution have also increased. In addition, the urban model requires long travel distances, especially to the poor. In the absence of adequate formal transport systems, private cars or informal transport means have become a solution to cover such trips.
Public transport systems do not provide fully coverage	Megacities are potentially lower density cities. The combination of rapid motorization and urban sprawl has hindered public transport coverage.	Though many cities in the Region are striving to expand their public transport systems, the provision of high-quality public transport services in Latin-America is far for being achieved. Limited mobility options tend to be particularly harmful to disadvantaged people.
High travel times deriving in economic and social costs	Housing location in the urban periphery and growing motorization rates result in increasing travel times. The time people spend caught up in traffic congestion has an impact on the global economy, as well as in the environment.	The costs of traffic congestion affect the economy and productivity of cities in Latin America and the Caribbean. Urban transport in large cities of the region consumes about 3.5% of regional GDP (ECLAC, 2000) in total. In addition to the lost economic efficiency, metropolitan areas in Latin American have experienced other negative consequences of traffic congestion (i.e. impacts among drivers and community life, environmental costs, noise pollution, among others).
Worrying air pollution levels	Urban air pollution is a major environmental problem in megacities, and transport represents one of their main causes. Despite current efforts (i.e. the increase of the transport systems´ efficiency or the deployment of low-emission alternative energy), the impact of transport on air quality still remains substantial.	Air quality continues to pose a significant issue in many cities of the Region. At least 100 million people in Latin America are exposed to levels of air pollution above those recommended by the World Health Organization (Cifuentes et al, 2005). The World Bank estimates health impacts due to emissions in countries such as Bolivia, Guatemala, Ecuador, Peru and El Salvador, representing up to 2% of the Gross domestic Product.
Traffic fatalities, a major cause of death	Due to the urbanization process and other particularities of large cities, traffic accidents constitute a significant issue to public safety. The total traffic crash deaths reached 1.25 million in 2013	Despite there are large variations among cities, safety in transport systems is another issue for the countries of the Region. 125,000 people die every year in Latin America as a result of traffic accidents. Some studies have estimated that the economic value of

Trends / Issues	Explanation	Applicability to Latin-America
	globally (Yuan et al, 2017). This problem is very challenging for large cities in developing countries.	externalities represents around 18% of the average income of the Latin American cities (Hidalgo & Huizenga, 2013). According to the Road Safety Observatory of Latin America (2016) , traffic accidents are the main cause of death among people between 15 and 44 years old.
Lack of institutional cooperation	Cities and governments have multiple institutions for constructing, maintaining and operating transport systems. As the cities become bigger, they have to face a more complex institutional structure, together with a wide range of relevant actors in transport policy and operations.	In many Latin American cities, the allocation of roles is not adequate for the management of urban infrastructure and services, mainly due to historical reasons. Furthermore, existing institutions would benefit from more recognition of technical knowledge, more participation from actors and technocratic leadership. Transport policies and projects require a suitable transport institutional framework to be effective. Furthermore, strategic planning —and the link between transport and urban planning— is weak or non-existent in many cities of LAC.

Source: Author´s elaboration

In addition to the problems arising from the fact of being a large city, most of LAC cities have other particularities which make the situation even more challenging. Firstly, despite there is considerable disparity across countries, the quality of the transport infrastructure in LAC can be considered particularly problematic. Although the region has made significant progress in recent years, its transport infrastructure has a historical backwardness. Calderon, Moral-Benito, & Servén (2011) found that infrastructure investment in Latin American and Caribe is currently around 2-2.5% of the GDP. However, this percentage is still lower than the recommended annual investment to meet the countries' competitiveness needs.

Secondly, administrative, fare and modal integration have not been a traditional common practice for transport authorities across the region. Despite recent efforts of many cities to implement integrated transport systems, an entirely integrated network that minimizes negative externalities and maximizes efficiency considering the different modes of transport at the city level is still far from being a reality in most LAC. Integrating transport services in all their dimensions (physical integration, network integration, fare integration and information integration) has proved to be an effective means of encouraging the use of public transport and reducing the reliance on car travel. For example, through integrated policies, Singapore and Hong Kong already have high modal shares in public transport (63% and 90% of all motorized trips, respectively). For further information, see Luk and Olszewski (2003).

On the other hand, it is worth noting that most collective transport systems in LAC are traditionally made up of private bus routes and are slow, congested, expensive, and incapable of responding to the challenges of urban expansion (Banick, 2009). In fact, one of the main problems of public transport highlighted by the inhabitants of these cities is the poor level of service, their low frequency, the insecurity during the trips and the long travel time associated to them —see CAF, 2016. This matter is particularly harmful for the poorest neighborhoods and informal settlements located in the urban periphery. As a response to this problem many cities have developed other types of collective passenger transport means such as the BRT systems.

Besides the lack of quality and social prestige of public transport modes, transport inequalities in the region also deserve comment. Growth in peripheral areas has been clearly related to spatial segregation, creating new structures of inequality and poverty. As shown by Guzman and Oviedo (2018), the spatial distribution of activities and the spatial distribution of population in the city of Bogotá may serve as a good example of this particularity. Furthermore, the costs of transport facilities and services in many LAC, often ignore pre-existing social inequalities. Despite the implementation of some public transport subsidies in LAC, specifically justified for disadvantaged people in terms of income, more research is necessary to improve the distributive impacts of current subsidies (see Serebrisky et al., 2009).

Public transport informality is one of the biggest challenges of the region and it has serious negatives consequences for productivity and quality of service (low performance vehicles, aggressive driving patterns and disorganized services). Although the region has made significant progress through the implementation of mass transit systems, most cities in LAC still depend on informal operators. Informal transport services also have costs, such as increased traffic congestion, air and noise pollution, and traffic accidents. For further information about the market, organizational and regulatory characteristics of the informal transport sector see Cervero (2000).

The informal transport sector is also a response to the inadequate and increasingly expensive public transport. As a response, local, regional and national governments have considered the introduction of free public transport. The opportunity of the fare-free public transport initiative has been tested or implemented in around 70 different cities over the world, including Tallinn in Estonia, Hasselt in Belgium and Chengdu in China (Zakowska et al., 2016).

2.3 CHALLENGES OF URBAN MOBILITY

The world is relentlessly becoming urbanized. Currently, more people live in urban areas than in rural areas. Given this fact, urban mobility challenges are getting more and more important for ensuring sustainability and quality of life. The aim of this section is to provide a comprehensive identification of the primary challenges (PC) of urban mobility. To that end, we first frame these challenges within the concept of livability.

Urban mobility and livability

The main goal of urban mobility is to ensure livability for citizens based on the concepts of quality of life and sustainability. Quality of life focuses on the right balance among the essential needs every individual requires to be happy: freedom, respect, safety, security, health, education, professional development, income, leisure, relationship with others, environmental quality, etc. Urban transport plays a key role to provide quality of life in the city since its primary goal is to contribute to get people, jobs and business opportunities closer to each other. However, in many cities, the systems have not been able to achieve the right balance among the key principles that ensure quality of life.

Another key concept for livability is sustainability, which intends to preserve quality of life over time. The concept of sustainability was defined by the Brundtland Commission as: “the development that meets the needs of the present without compromising the ability of future

generations to meet their own needs" (Brundtland World Commission on Environment and Development, 1987, p.1). Transportation has a key role to play in the city to provide access to work, education, leisure, social and cultural activities and facilitate the city to work. However, it might cause environmental, social and economic impacts according to the "three- legged stool" of sustainability proposed by Elkington (1998), which is now consensually applied in the academic literature and practice— see for example Dondero et al. (2013), European Commission (2009).

Besides integrating the balance among the "triple bottom line" aspects, transportation planning management should include a life cycle approach. Under this focus, the fact that impacts are spread over a long period of time should be measured. This latter point was addressed by the Brundtland Commission and other academic authors (Gilmour et al., 2011; Stamford & Azapagic, 2011).

Figure 2.2 sets the frame of the primary challenges of urban mobility identified in this section. These challenges should be understood in a two-dimensional way that integrates the major principles of quality of life (representing the vertical dimension in Fig 2), and the multiple dimensions of sustainable development (shown as the horizontal dimension in Fig 2).

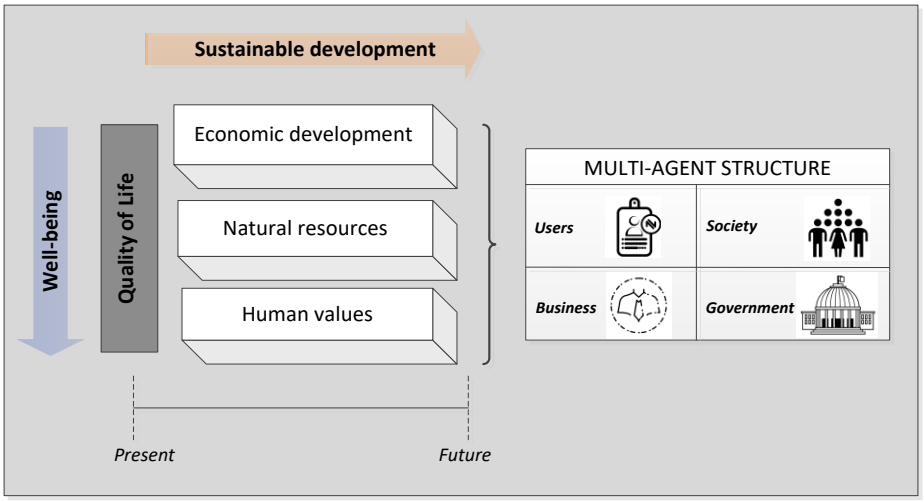

Figure 2.2. Two-dimensional theoretical framework for understanding transport challenges.
Source: Author´s elaboration

The transport´s role in sustaining economic growth and competitiveness is well acknowledged. For example, according to Eddington (2006), transport can deliver productivity benefits, and also contribute and drive economic growth at the micro level. In particular, this author claimed a key purpose for transport in supporting the productivity of the UK economy and its sustainable growth. However, though economic development is a precondition for wellbeing, it may also produce impacts —such as air and noise pollution or congestion— that may harm quality of life. Transport policy should intend to achieve the right balance across economic, social and environmental needs now and over the years.

Besides, it is worth mentioning that transportation impacts fall back on different stakeholders. In such a `multi-agent structure´, transport policies can contribute to a number of different government objectives, while directly impacting on the economy and the society in a number of

different ways. The following sub-section identifies the main urban transportation challenges, and describes the way they range over the agents of the society.

Identification of transportation challenges

Since the emergence of the concept of sustainability as an international priority in the 1980s and 1990s, there has been a growing interest in integrating the three sustainable development pillars in the definition of urban transportation goals and objectives. Therefore, there appears to be a general consensus on the need to achieve economic and social development and protect the environment through transport planning decisions. Currently, the proposed Sustainable Development Goals (SDGs) and the 2030 Agenda for Sustainable Development represent a framework for future transportation actions[1].

However, due to the fact that different countries and regions have different transport needs, a 'one-size-fits-all' approach to transport policy is complicated. Even though a widely accepted and standard list of urban mobility challenges is not fully agreed on the literature, the authors of this report have dig into important references and explored the opinion of experts in the field to point out a set of transportation challenges.

A descriptive overview of them, the main agent of the society on which the challenge falls back, and the sustainability dimension related to this question are summarized in table 2.2. Furthermore, the connection between the issues in large cities previously identified (see Table 1) and the challenges of urban transport is shown in the last column of Table 2.2. A complete description of each challenge can be found in the following paragraphs.

Governance

Governance is a key foundation for the planning, design, and implementation of transport policies. The way in which various transport institutions are structured and coordinated is crucial for supporting successful transport decisions. The processes, procedures, and regulations should be designed and implemented to support sustainable transport systems.

This fact has been widely recognized in the literature (World Bank and Imperial College London, 2017) and in the practice of cities like Madrid —through the creation of the Madrid Regional Transport Consortium (see Cristobal and Dionisio, 2007) or Bogotá —through the creation of Transmilenio for implementing the bus rapid transit system in the city (see Jirón, 2013). Therefore, establishing an effective governance framework is a task for building appropriate political and institutional conditions supporting successful mobility policies. Governance also includes the application of tools and policies to more rationally plan and regulate informal transport services.

Cost-efficiency and competitiveness

A competitive market is crucial for providing efficient public transport services. Giving adequate incentives or promoting a fair competition for the market (when competition in the market is not the most efficient option) will attract better companies which will offer more efficient

[1] 7 of the 17 Sustainable Development Goals include one or more targets that address transport, both in rural and urban contexts. For further information see UITP (2015).

services. Some case studies providing evidence on this fact can be found in Ardila (2008) and Paget-Seekins (2015).

The real urban challenge for decision makers in cities is to support and invest in sustainable and cost-efficient transport systems, but also to consider the market conditions of critical importance. When necessary, there is a need for strengthen the government supervision and intervention in order to guarantee healthy competitive conditions for ensuring efficient transport services.

Table 2.2. Urban transportation challenges

Challenge	Brief description	Mainly falling on	Sustainability component	Related to the following issues
Governance	Establishing effective governance frameworks for achieving successful and sustainable transport policies and projects.	Government	Economic Social	•Lack of institutional cooperation. •Low quality of the transport infrastructure. •Fare and modal integration have not been a traditional common practice. •Low quality in conventional collective transport systems. •Public transport informality.
Cost-efficiency and competitiveness	A competitive market for promoting efficient public transport services.	Businesses, Users	Economic	•Low quality of the transport infrastructure. •High travel times deriving in economic and social costs.
Funding and financing	Setting the means to obtain the economic resources necessary for covering investments and operation costs.	Businesses, Users, Government	Economic	•Lack of institutional cooperation •Low quality of the transport infrastructure
Travel reliability and fluency	To ensure non congested networks and systems and provide reliability to transport users.	Users, businesses and society	Economic Social	•The population of the cities is increasing. •Urban sprawling and its consequences. •Public transport systems do not provide fully coverage. •High travel times deriving in economic and social costs. •Worrying air pollution levels. •Low quality in conventional collective transport systems.
Decarbonisation, air quality and noise abatement	To reduce transport's contribution to carbon and air quality emissions and also to limit noise levels.	Society	Environmental Social	•The population of the cities is increasing. •Urban sprawling and its consequences. • High travel times deriving in economic and social costs. • Worrying air pollution levels.
Built environment	Transit and land use integration towards a more sustainable mobility pathway.	Society	Social Environmental	•The population of the cities is increasing. •Urban sprawling and its consequences.
Accessibility	People's ability to reach goods and services desired goods and activities.	Users, businesses and society	Economic Social	•The population of the cities is increasing. •Urban sprawling and its consequences.

Challenge	Brief description	Mainly falling on	Sustainability component	Related to the following issues
				•Public transport systems do not provide fully coverage. •Transport inequalities.
Social Justice	Closely related to the concept of fairness, it considers the distribution of costs and benefits of transport policies and developments.	Users, Society	Social	•Public transport systems do not provide fully coverage. •High travel times deriving in economic and social costs. •Transport inequalities.
Security and safety	Level of protection of staff and users and operational resilience in case of incidents.	Users, Society, Government	Social Economic	• Traffic fatalities, a major cause of death. •Low quality in conventional collective transport systems.
Comfort and information	Perceived quality of service in terms of comfortability, including factors such as information, convenience, ride comfort, customer care, etc.	Users	Social	•Fare and modal integration have not been a traditional common practice. •Low quality in conventional collective transport systems.
Seamless transport	To provide a continuous journey under integrated conditions in terms of fares, ticketing, physical services and infrastructure.	Users	Economic Social	•High travel times deriving in economic and social costs. •Fare and modal integration have not been a traditional common practice.
Resilience	System capacity to maintain or quickly recover its level of service after a disruption event.	Users	Economic Social	•Low quality of the transport infrastructure. •Low quality in conventional collective transport systems.

Source: Author´s elaboration

Travel reliability and fluency

The value of travel time savings refers to the benefits of faster travel that saves time (The Victoria Transport Policy institute, 2017). Implementing effective management measures for improving travel time may boost transit ridership and reduce personal vehicle use. However, it can also directly impact business costs. A short example may serve to illustrate this latter point: a 5% reduction in travel time for all business travel on the road network in Great Britain could generate cost savings to business in the region of £2.5 billion per annum, equivalent to some 0.2 per cent of GDP (Eddington, 2006).

As explained in section 2, most cities are now facing serious traffic congestion rates around its growing urban areas. It causes loss of efficiency for the movement of persons and goods, and increases the number of accidents, as well as fuel consumption and tailpipe pollutants. Traffic congestion negatively influences quality of life and economic productivity in metropolitan areas. Hence, a number of studies in the literature have dealt with the cost of traffic congestion in many different contexts —see for example Zancaran (2006) for New Zeland, McKinnon et al. (2009) for the UK.

In relation to transport services, reliability is the certainty of service aspects compared to the schedule as perceived by the user (Van Oort, 2011). It is one of the most important quality aspects of public transport, which is often evaluated in most benchmarking exercises. For instance, the International Bus Benchmarking Group (IBBG) facilitated by the Imperial College London, surveys found reliability and time as the main priorities for customer's satisfaction (Trompet et al., 2013).

As the literature shows, serious attention should be given to the service reliability in order to improve the level of service. Regularity and punctuality at the operational level might have a positive impact the users of public transport, but also to business and freight traffic. The efficiency of the transport system will benefit business, freight and commuter transport as a whole, with a direct contribution to GDP through investment, labor markets, among others.

Decarbonisation, air quality and noise abatement

There is an internationally growing call to improve the air quality of our cities. Meanwhile, the World Health Organization recognizes the great contribution of traffic to pollution levels in cities and their adverse effects on health —see Krzyżanowsk et al (2005). Particularly, The European Environmental Agency[2] pointed out that transport is responsible for more than half of all NOx emissions and contributes significantly (around 13 % or more) to the total emissions of other pollutants.

In this sense, transportation plays a major role in responding to the global challenge of climate change, as well as to other local impacts such as air quality. Despite the progress that has been made in reducing the emissions of many air pollutants from the transport, a future look suggests

[2] https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-air-pollutants-8/transport-emissions-of-air-pollutants-5

the need for continuous efforts to reduce transport's contribution to carbon and air quality emissions.

On the other hand, at the city level, traffic is also responsible for noise levels highly associated with a number of health effects. For example, scientists and health experts have estimated that around 20% of the European Union's population suffers from unacceptable noise levels (Nijland et al., 2003). In this sense, further efforts in the field of noise abatement are needed in order to considerably improve the `noise situation´, the human health and well-being of residential, recreational and nature areas.

Built environment

The mostly widely used definition of built environment can be found in Ewing and Cervero (2010). These authors established relationships between "the 6D´s", including density (population and jobs), diversity (land use mix and balance), design (neighbourhood and street design), access to destination (distance from downtown, accessibility to jobs), distance from public transport stops, and demand management measures (parking fees, congesting pricing, etc.).

Among the built environment variables, the link between land use and transport emerges as a major urban challenge. Land use planning should be consistent with transport strategies, working in tandem towards guaranteeing sustainable mobility patters in the city. Interesting examples of successful transit and land use integration can be found in Singapore, Copenhagen and Curitiba (for further information see Suzuki, Cervero and Iuchi, 2013).

Accessibility

Transit accessibility is a social indicator (Geurs and van Wee, 2004; Bocarejo and Oviedo; 2012) and a variable influencing transit ridership (Bueno, 2017). According to Litman (2017), accessibility refers to people's overall ability to reach services and activities, and therefore the time and money that people and businesses must devote to transportation.

In the field of public transport, there are many factors influencing accessibility, including people´s needs and abilities, the transport network and the land use patterns. As the level of accessibility has a great impact on people, businesses and communities, to provide accessible transport systems for all will be indispensable for reaching sustainable development goals and particularly for those related to education growth and employment and promotion of equal rights to economic resources.

Social Justice

In the field of transport, the concept of social justice results from the analysis of the distribution of the net benefits and the costs (derived from a transport policy intervention) among different members of the society. It is still seen as a complex issue due to its multidimensional definition. Litman (2012) provides a comprehensive summary of the key variables to consider in transportation equity analysis. Within these evaluation variables, transportation affordability arises as one important dimension, especially for disadvantages groups.

Affordability is generally defined in the literature as the ability to make necessary journey to access basic needs, such as work, school, health, shop, and other services (Venter, 2011)[3]. According to Litman (2014), it refers to the financial burden households bear in purchasing transportation services, particularly those required to access basic goods and activities (healthcare, shopping, school, work and social activities). Either way, this challenge is closely related to the transportation costs in a given city, as well as the land use patterns, and the available transportation options. Individual needs and abilities as well as household incomes should be also considered.

Improving transport affordability can significantly increase social equity, as well as contribute to support the economic success of countries and regions. All transport users will benefit from the consideration of affordability as an important planning objective.

Security and safety

Creating an environment for safe transport is essential for the society and highly valuable for travellers. In fact, operators place safety and security as their first priority. Besides direct social costs, these factors may have an impact on the economy. For example, in the UK road casualties cost the economy an estimated £2.5 billion or 0.22 per cent in lost GDP in 2004 (Eddington, 2006). For low-income and middle-income countries traffic injuries cost between 1% and 2% of their gross national product (World Health Organization, 2004).

In a general sense, there is widespread acknowledgement that additional efforts to enhance safety and security of transport systems are needed in the cities. A proper definition of major urban transportation challenges should include all those aspects that include fundamental principles of sustainable development.

Comfort and information to the user

A recent published research work, have defined `comfort in public transport´ as one of the most important determinants of public transport convenience (İmrea and Çelebi, 2017). As acknowledged by the authors of this study, a holistic definition of comfort in public transport should incorporate the crowd density in-vehicle as well as other factors such as air-conditioning in-vehicle, information and guidance to the user, cleaning in-vehicle, seat comfort, possibility of doing other activities, among others.

When the level of discomfort is higher than the passengers´ acceptance level, the public transport become less attractive to them. Hence, the perception of comfort in public transport networks is helpful to understand the passengers' choice of transport mode, and thus it constitutes an important transportation goal in urban mobility.

Seamless transport

To deliver more seamless transport services arises as an important urban transportation challenge. A seamless journey is closely related with the concept of integration, widely acknowledged in the literature (Potter, 2010; Givoni and Banister, 2010). Thus, we can hardly

[3] A comprehensive analysis on how to define affordability in the transport sector is provided by Serebrisky et al. (2009).

speak of a desirable future urban transport system if it does not embrace a proper integration for both transport fares, physical infrastructure and transport services.

In practice, an integrated and seamless transport will support the intermodal mobility in the city of tomorrow, encouraging the use of sustainable and soft modes. At the same time, it will give value to the time spent in intermodal facilities, making the travel experience much more pleasant.

Resilience

The concept of resilience offers a perspective on the transport system's capacity to maintain or quickly recover its function after a disruption or a disaster (Mattsson, and Jenelius, 2015). It has attracted an increasing attention in the transport literature. A compilation of these studies can be found in Reggiani et al. (2015).

Transport system resilience should be included in any future transport strategy since it is linked to the concept of `vulnerability´, which can result in reductions in the level of service. Resilience is an indispensable pillar of a sustainable transport system and is necessary to avoid the high economic costs caused by disruptions and to ensure a continuous usage of the facilities and services regardless of constraints upon the system.

2.4 POLICIES ADDRESSING TRANSPORTATION CHALLENGES

After reviewing the different challenges that cities are facing nowadays regarding urban mobility, we will shed some light on current and potential policies implemented or studied worldwide to give response to them. The approach used in this section focuses on the analysis of these policies, classified into dimensions. Specific strategies (hereinafter referred to as `instruments´) are also described within the different dimensions from which they can be analysed.

As abovementioned, a range of transport policies are currently applied to achieve specific objectives such as improving traffic safety, reducing transport congestion, optimizing vehicle energy consumption and pollution emissions, etc. Examples of these policies addressing some of the challenges previously mentioned include:

- Institutional reforms, implemented to overcome governance issues and ensure a more comprehensive planning processes.
- Policy strategies to encourage more efficient transportation, motivated by concerns over air pollution and transport energy consumption.
- Congestion-reduction strategies and policies aimed at improving travel time and reduce personal vehicle use, representing effective means to deal with congested networks and to provide reliability to transport users.
- Integration policies to ensure a seamless transport service from a system-wide perspective.

Because of the large number of policies available, a taxonomy exercise is carried out in this paper aimed at facilitating their right understanding. In that respect, we propose the following policy dimensions, which are common to different transport policies:

- Legal, governmental and regulatory policies.
- Land use and transport planning policies.

- Infrastructure and service improvement measures.
- Push and pull policies.
- Strategies based on digitalization and the use of new technologies.
- Policies for reducing mobility needs.

In order to face one or several challenges, specific instruments or strategies falling within the above-mentioned dimensions can be implemented. In the following paragraphs, a more detailed explanation of the specific instruments or strategies is provided.

Legal, governmental and regulatory policies

Governments are involved in the transport sector to `protect´ users and ensure the public interest. They usually do that by safeguarding quality, controlling the market, regulating informal services and setting safety standards. Examples of such actions include setting speed limits, regulating fares, intervening markets and rationalise and formalise illegal services. Nowadays, governments are exploring other ways of regulation, including value capture of real estate properties resulting from accessibility improvements caused by transportation networks.

In addition to the need and importance of an appropriate regulatory and legal framework, effective mechanisms of enforcement are key for improving the quality of urban mobility. For example, setting the right speed limits, together with appropriate enforcement measures (e.g. speed cameras) is expected to decrease accident rates. Table 2.3 shows some instruments falling within this category associated to the specific challenges they will address.

Table 2.3. Classification and examples of legal, governmental and regulatory policies

Policy Dimension	Potential Instruments	Definition	Challenge addressed
Institutional integration	Constituting a single transport authority	Development an urban mobility authority integrating all the institutions involved.	• Governance • Seamless transport • Social justice
Regulation	Setting value capture mechanisms	Fiscal or regulatory tools aimed at capturing real estate value growth caused by transport improvement.	• Governance • Funding and financing • Social justice
	Ensuring competitive tender of transport services	Legal provisions for guaranteeing the selection of the most efficient transport operator in natural monopolies.	• Cost-efficiency and competitiveness
Enforcement	Enforcing road safety	Strategies for ensuring the compliance of rules and standards in relation to road safety.	• Security and safety • Social justice

Source: Author´s elaboration

Institutional integration addresses urban transportation challenges in several ways. It ensures a comprehensive and unified transport strategy, and a greater efficiency in the use of resources due to greater synergies. Having an integrated transport system is a precondition to provide a seamless journey, wherein users are unaware of organizational and spatial boundaries. On the other hand, regulation instruments are essential for establishing a competitive and transparent framework so that projects and the operation of services are implemented in a more efficient

way. Finally, other intervention mechanisms can be implemented for improving citizen´s quality of life by promoting safety. For example, mechanisms for road safety enforcement are potentially able to contribute to improve driving behaviour and road safety outcomes, in terms of accidents and casualties.

Land use and transport planning policies

In response to the urban transportation challenges, several land use and planning policies can be implemented. These can be entirely related to planning or they can even be referred to urban interventions. Due to their implementation scale, this kind of policies adopted in developed and developing countries, have shown to have strategic impacts at the macro level. For instance, the design and implementation of a mobility plan provides the policy basis for transportation projects, programs and services in a city. In its turn, land use planning in cities also plays a significant role in identifying the strategic actions towards the promotion of sustainable development, including elements of land-use as well as strategic decisions and guidelines for social services, public space and mobility infrastructure. Table 2.4 presents a descriptive summary of some of the most relevant instrument examples in this dimension and the challenges that can be addressed through their implementation.

Table 2.4. Classification and examples of land use and planning policies

Policy Dimension	Potential Instruments	Definition	Challenge addressed
Urban interventions	Densification	Policies drawn up to limit urban sprawl in order to concentrate urban functions (compact city).	• Cost-efficiency and competitiveness •Social justice •Accessibility • Travel reliability and fluency.
	Land-use mix	Characteristic of the built environment referring to the setting up of varied and complementary land uses within a certain area.	• Built environment • Accessibility
Transport Planning	Mobility plans (city level) or companies mobility plans	Mobility plans are strategic policy tools aimed at satisfying the mobility needs of people and businesses in accordance to sustainable principles.	• Cost-efficiency and competitiveness • Travel reliability and fluency • Accessibility • Seamless transport
	Contingency plans	Plans or actions designed for failure situations (events, interruptions, incidents).	• Resiliency • Security and safety • Confort and information to user

Source: Author´s elaboration

Densification policies promote a more efficient use of services and resources thus shortening distances and reducing associated costs. Under these circumstances, more people may have access to high quality public services with good coverage and frequency. In its turn, the effectiveness of urban design and land use (increasing density, promoting a mix use) is essential to build more accessible cities.

Opportunities for improving transportation services can be identified by developing sustainable urban mobility plans aimed at addressing transport related problems in urban areas such as accessibility and quality of life and the efficiency and coordination of transportation services. Finally, other category of plans may be developed in order to ensure the transport system's capacity to maintain or recover its performance after a disruption —caused by weather conditions or a technical failure—, or an unexpected disaster. Contingency plans aims at guaranteeing a transport resilient system by ensuring a safe and secure urban environment and mobility.

Infrastructure and services improvement measures

Infrastructure is a pillar for operating efficient transportation systems. Supporting infrastructure investments, such as expanding the metro network or building modal interchanges, can enhance the experience of public transport users while reducing companies´ operating costs. This can also result in notable benefits for increasingly seamless public transport journeys, as well as improving accessibility and reducing transport costs.

Besides the physical infrastructure, the quality of service is also considered as a major determinant for public transport usage. It includes many factors of the day to day user´s experience such as comfort and safety within the vehicle, the system´s frequency, the level of crowding, the travel time, etc. An efficient, comfortable and reliable system is more able to encourage people to switch from driving alone to public transit.

To sum up, there are many successful examples of infrastructure and service improvements strongly contributing to solve urban transportation challenges. Table 2.5 shows some examples of these strategies involving positive impacts for users and for the society as a whole.

Table 2.5. Classification and examples of infrastructure and services improvement policies

Policy Dimension	Potential Instruments	Definition	Challenge addressed
Infrastructure improvements	Underground, interchanges, bus and cycle lanes.	Infrastructure investments to achieve cost-effective and sustainable solutions.	• Accessibility • Seamless transport • Fluency and travel reliability • Comfort and information to the user
Service improvements	Fare and mode integration	Range of measures to improve the efficiency and quality of transport services in order to boost transit ridership and reduce personal vehicle use.	• Cost-efficiency and competitiveness • Social Justice • Accessibility • Seamless transport • Comfort and information to the user

Source: Author´s elaboration

Special attention should be paid to the case of infrastructure and service integration, including several issues such as the coordination of services and a common fare scheme. Despite the complexity of the policy and the possible consequences on financial sustainability, it has shown to be highly effective in terms of promoting public transport use and shifting demand from the private car to public transportation. For example, the integrated fare approach in Madrid evidenced that fare and modal integration can be considered a success with respect to

promoting public transport usage as well as other transport challenges because: (i) it has increased the number of trips by frequent users and the likelihood of attracting new ones, (ii) it has shown to satisfactorily target the least wealthy people and fulfil vertical equity principles, and (iii) it has succeeded in ensuring a seamless integration of the transport system.

Push and Pull measures

Besides planning and governance policies, it is possible to implement other type of measures to encourage the use of public transport modes to increase efficiency and sustainability in daily mobility patterns. This group may include actions to discourage car use, as well as policies encouraging the use of public or alternative modes. The latter are often called pull measures—i.e. improving public transport, improving infrastructure for cycling and walking or increasing the level of public transport subsidies—while the former are generally referred to as push measures—i.e. restricting parking availability, taxation on cars and fuel, decreasing speed limits, implementing road pricing mechanisms.

Nowadays environmental sustainable strategies support these policies to struggle with climate change impacts, making them mainstream. In addition to the above-mentioned aspects, these policies may help protect the planet by cutting carbon emission. Table 2.6 summarizes some examples of these strategies.

Table 2.6. Classification and examples of push and pull policies

Policy Dimension	Potential Instruments	Definition	Challenge addressed
Pull measures	Public transport subsidies	Subsidy policies for public transport users, usually justified on social grounds.	• Social justice • Decarbonisation, air quality and noise levels • Fluency and travel reliability
	Benefits for employees	Option which employers provided to employees aimed at influencing their travel behavior, including benefits for driving, using public transportation, and walking or cycling.	• Fluency and travel reliability • Decarbonisation, air quality and noise levels
	Subsidies to renew the fleet	Incentives to replace diesel and older vehicles by cleaner vehicles.	• Decarbonisation, air quality and noise levels
	Walking, Pedestrianization, Cycling	Measures for encouraging the use of soft modes, thus increasing efficiency and sustainability.	•Decarbonisation, air quality and noise levels
Push measures	Pricing policies	Strategies encouraging users to pay for the external costs they produce (financial disincentives for auto use).	• Fluency and travel reliability • Decarbonisation, air quality and noise levels • Funding and financing
	Parking restriction policies	Policies restricting parking to discourage car travel (e.g high charges, no parking zones).	• Fluency and travel reliability • Decarbonisation, air quality and noise levels • Funding and financing

Policy Dimension	Potential Instruments	Definition	Challenge addressed
	Diesel powered vehicle restrictions	Restrictions of diesel-powered vehicles, usually justified on the grounds of air quality, modal shift, and public space.	• Decarbonisation, air quality and noise levels • Fluency and travel reliability

Source: Author´s elaboration

Public transport subsidies may be an effective means to make low-income people better off. The adoption of these policies has shown that they achieve social equity objectives while making public transport and soft modes more attractive to users. At the same time, users benefit programs have a great impact on commuter travel behaviour. As a consequence, implementing effective travel demand management measures may boost transit ridership and reduce personal vehicle use and the associated externalities (congestion, emissions, accidents).

Similarly, instruments reducing the use of the private car may contribute to address challenges related to efficiency and sustainability in daily mobility patterns. For example, the implementation of road-pricing mechanisms has proven to be an effective instrument for promoting efficient mobility, relieving congestion and improvement environmental metrics. Finally, other restrictions imposed by engine type have proven to reduce the number of polluting vehicles while accelerating the introduction of cleaner vehicles thereby giving rise to health benefits and a more attractive environment for people and businesses.

Digitalization and the use of new technologies

New technologies are changing paradigms in several sectors such as social relationships, financial markets, communications and mobility. Despite the numerous advantages for companies, people, and governments, and although the new opportunities which must be embraced for transport decision makers; emerging technologies also face important challenges. For instance, the capacity of governments to catching up and regulate new technology issues such as privacy and security. On the other hand, technological transformations will require a public policy approach based on incentives to encourage innovation in companies, the qualification of the workforce and the training of specialized resources. This group of policies can be classified into policies for digital infrastructure and policies for improving services through technology. Table 2.7 presents an overview of some of these instruments based on emerging technologies and provides a list of the transportation issues directly or indirectly tackled with them.

Table 2.7. Classification and examples of policies based on new technologies

Policy Dimension	Potential Instruments	Definition	Challenge addressed
Digital infra.	Internet of things and sensor deployment for Smart city platforms	Policies based on smart technologies for monitoring transport metrics and manage transport demand.	• Cost-efficiency and competitiveness • Fluency and travel reliability • Comfort and information • Security and safety • Resilient transport systems
	Deployment of intelligent	Technologies and applications that allow effective data exchange	• Cost-efficiency and competitiveness • Fluency and travel reliability

Policy Dimension	Potential Instruments	Definition	Challenge addressed
	transport systems (ITS)	between components and actors of the transport system (V2V and V2I).	• Decarbonisation, air quality and noise levels • Comfort and information to the user
Digital services	Promoting MaaS	Strategies offering flexible and personalized mobility solutions by adapting transport services to individual needs.	• Cost-efficiency and competitiveness • Accessibility • Decarbonisation, air quality and noise levels • Resilient transport systems • Seamless transport • Comfort and information to the user
	Smart ticketing	Using emerging technologies for mass transport ticketing (i.e Public transport ticketing with contactless smartcards or mobile phones).	• Seamless transport • Comfort and information • Travel reliability and fluency

Source: Author´s elaboration

The concept of mobility as a service (MaaS), frequently compared with the Netflix business model applied to urban transport relies on digital platforms that integrate planning, booking, and payment services across all transportation modes. While generating new business opportunities, its application ensures that mobility is managed more efficiently. As a result of this better use of existing capacity of roads and services, the modal split in favor of public transport may be redistributed, the effects of congestion may be mitigated, and the air quality can be improved. Lastly, other strategies such as the provision of smart ticketing options can improve customer experience by making the journey easier and more pleasant, while reducing queues for tickets and enabling high quality services for non-frequent users.

In addition to the importance of strategies for improving services, managing infrastructure in the right way is also crucial. This is supported by evidence where use of technologies for transportation demand management have provided many benefits, including: reduction of congestion, reduction of costs of maintaining and building new roads, savings for parking, savings for users and reductions in energy consumption and emissions. As a result of the real-time information users receive, they can make more informed decisions and thus change their route, travel mode or time of day to make a more convenient use of transport services. By the same token, policies encouraging the deployment of ITS services should have a macro impact on mobility in terms of safety, traffic fluidity, travel reliability, comfort, energy efficiency, pollution reduction, etc.

Measures for reducing mobility needs

Although to a lesser extent than the dimensions of policies previously mentioned, other strategies aimed at influencing mobility behavior in the long term are currently being considered by policy makers. Under this consideration, it is worth mentioning new forms of labor relationships such as teleworking, as well as a number of other similar measures for promoting learning and reduced shopping are being considered as sure means of influencing shorter travel distances and less frequent mobility needs.

As shown in Table 2.8, strategies for reducing mobility needs can be classified in three categories: schemes aimed at reducing work travel needs, strategies for influencing study trips, and measures generating less shopping trips while preserving the overall quality of life and the productivity in the city.

Table 2.8. Classification and examples of measures for reducing mobility needs

Policy Dimension	Potential Instruments	Definition	Challenge addressed
Strategies for reducing work travel	Teleworking	Flexible options provided to employees for working at a remote location or for adapting their starting and finishing times of work	• Travel reliability and fluency • Decarbonisation, air quality and noise levels
	Jobs-housing balance	Land use strategy for improving the proximity of jobs to housing and reducing work travel	• Travel reliability and fluency • Decarbonisation, air quality and noise levels • Built environment • Accessibility
Strategies for reducing study travel	Distance learning	Flexible options and scheduling provided for those students who are geographically distant	• Travel reliability and fluency • Decarbonisation, air quality and noise levels • Social justice
Strategies for reducing shopping travel	Electronic shopping	Strategies for encouraging consumers to engage in travel-less shopping	• Travel reliability and fluency • Decarbonisation, air quality and noise levels

Source: Author´s elaboration

Even though flexible-schedule strategies were not originally designed for responding to transport challenges, but to save office space and maintenance costs while keeping a high level of productivity, they have proven to have a great impact on mobility. Teleworking reduces trip generation, which reduces traffic congestion, energy consumption and pollution.

Similarly, promoting jobs-housing balance is also an important determinant for improving travel efficiency patterns while reducing household vehicle kilometers traveled. The role of land use is conducive to a more sustainable form of mobility. Likewise, enhancing the educational opportunities offered by distance learning or promoting the adoption of Internet shopping may reduce trip generation rates and possibly reduce private-mode choice, lowering energy consumption and pollution.

2.5 CASE STUDIES

Using the dimensions to group mobility policies described in section 4 of this chapter, an analysis was made of 16 policies already implemented in specific cities of the world that could contribute to address previously identified transportation challenges in LAC. Organized by dimension of mobility policy, the following boxes present an overview of the analysis findings in terms of the key characteristics and benefits associated with each of the case studies reviewed. Based on Tables 2.2 to 2.8, a comprehensive connection between issues-challenges-policies-dimensions-instruments can be found in Annex 1.

Examples of legal, governmental and regulatory instruments

Instrument: Constituting a single transport authority.

Case study: The Madrid Regional Transport Consortium in Madrid (Spain).

Brief description: Given the need to build an efficient management model for the transport system in the region, a new public authority called The Madrid Regional Transport Consortium (CRTM) was created in 1996. The CRTM is in charge of coordinating the services, networks and fares of all the different transport modes in the region. The national and regional government, together with municipalities as well as private and public companies collaborate closely in this common effort.

Results: The CRTM has been actively engaged in improving the quality of public transport, including the extension of the metro and urban bus service network, together with other significant improvements in the suburban rail system and other metropolitan services. Its more remarkable results lie in the development of an integrated fare scheme covering all modes of public transport in the region. As a consequence, the public transport patronage has significantly increased (Matas, 2004) and the public transport management has been internationally recognized as a `best practice´ approach. In addition, the subsidy policy associated with the travel pass in the city effectively targets economically disadvantaged people (Bueno, 2017).

Instrument: Setting value capture mechanisms.

Case study: Value capture for transportation finance in Colombia.

Brief description: Colombia has a long history in applying policy instruments to capture land rents originated by public decisions and investments. The `*contribución por valorización´* and more recently, a more progressive form of value capture called `*participación por plusvalías´* are value capture policies applied as an alternative source of revenue for major public infrastructure needs. With the latter instrument the government is able to recoup up to 50% of the unearned land value increments produced by public planning investments.

Results: The implementation of value capture policies in Colombia is broadly recognized as noteworthy for its continuity and for being determinant in infrastructure development (Smolka and Furtado, 2001). Besides being effective for providing substantial cash flows for capital intensive urban projects, value capture applications —under the umbrella of redistributing the increments in land value— have deal with some of the factors restricting that restrict access to land (Acosta, 2008).

Instrument: Enforcing road safety.

Case study: Safety enforcement measures implemented worldwide.

Brief description: Several road safety measures are continuously developed and implemented in different contexts, which indicates policy makers´ determination for reducing traffic accidents. Possible measures include roadside inspections, photo-radar programs and automated speed limit enforcement. Other regulation such as the so called “penalty point system” are becoming increasingly common in Europe and the US. It consists on assigning points to different kinds of traffic offenses and subsequently adding them to the driver´s license, integrated into the driver´s record. When a certain amount of points is achieved, the driver’s license will be suspended for a period of time. To recover the license, the driver has to attend a course and pass a new exam.

Results: While road safety enforcement strategies might be expensive to administer, their implementation in different contexts have reduced the number of traffic accidents and casualties, thus suggesting their effectiveness (an exhaustive recompilation of the effects of different safety enforcement measures can be found in Wong et al., 2004). In particular, an international review of works devoted to evaluating penalty point system effectiveness have shown that this strategy is associated with a reduction of 12% in accidents and 17% in those injured —see Elvik and Vaa (2006).

Examples of land use and planning policies

Instrument: Urban densification.

Case study: Densification policies in Singapore.

Brief description: Density seems to be a good determinant for a competitive and public transport friendly city. When evaluating the influence of urban spatial structure on vehicle usage it is concluded that low-density increases car dependency. Understanding these premises, Singapore has adopted high-density solutions to concentrate economic activities and infrastructure facilities. This spatial accumulation policy, together with other territorial transformations (such as dissemination, extension and contraction) has oriented urban development towards an efficient urban mobility system.

Results: The so-called "transit-oriented Constellation Plan" in Singapore was able to successfully incorporate a transit-oriented planning concept into the land use and transportation development. In addition, other strategies enhancing transport supply as well as additional transport demand management policies (controlling motorization, road pricing) complemented the plan. As a result, Singapore built an efficient and viable transport system providing a paradigmatic `best practice´ for other contexts. Further information about the Singapore experience can be found in Haque et al. (2013).

Instrument: Mobility plans at the city level.

Case study: Urban mobility plans throughout Europe.

Brief description: Comprehensive sustainable Urban Transport Plans (SUTPs) are being developed and implemented as planning tools in most European cities. SUTPs are long term strategies for the future development of transport and its associated mobility and infrastructure services. Under the guidance of the European Commission, these plans should encourage a shift towards more sustainable modes, while guaranteeing the basic mobility needs of all users balancing economic viability, social equity, and environmental quality.

Results: According to the European Urban Mobility Observatory, there are 542 cities in the European Union, Iceland, Norway and Switzerland, which have been involved in sustainable urban mobility plans activities and initiatives. Among these cities, the implementation of SUTPs has shown to be positively correlated with a higher share of public transport and a lower share of car traffic (www.civitas-initiative.org). As a consequence, SUTPs can be claimed to lead the implementation of successful sustainable transport measures. For a detailed description of the European experience with SUTPs the reader is referred to May (2015).

Examples of Infrastructure and service improvements

Instrument: Underground, interchanges, bus and cycle lanes.

Case study: Urban transport interchanges in Madrid (Spain).

Brief description: Interchanges are essential facilities for improving seamless mobility in metropolitan areas. Under this premise, the Madrid Regional Transport Authority developed the regional plan for public transport interchanges. Presently, different transport interchanges in the city act as access gateways to Madrid's public transport —suburban buses and suburban trains— hence optimizing accessibility to the mainly urban modes of transport (CRTM, 2013). A detailed description of the evolution of Madrid's transport interchanges can be found in Vassallo (2015).

Results: The city of Madrid has a recognized long tradition in promoting modal integration. The interchange terminals in Madrid represent a key policy for achieving this goal, while enhancing the user´s experience. Furthermore, they constitute a crucial determinant in people's transport-related choices. For instance, as a result of all integration efforts in Madrid, the number of annual trips i involving suburban buses has increased from 121 million in 1986 to 276 million in 2006. This increase can be explained by the Madrid Regional Transport Authority's policy regarding the improvement of the interurban network's infrastructures and service (The European Forum on Intermodal Passenger Travel, 2010).

Instrument: Underground, interchanges, bus and cycle lanes.

Case study: BR T´s in Latin-American cities.

Brief description: The Bus Rapid Transit (BRT) system is based on buses that provide fast urban mobility through the provision of segregated lanes (ITDP, 2010). These systems have been implemented in many Latin-American cities, including Curitiba, Bogotá, Cali, Lima, Quito, Santiago, Rio de Janeiro, among others. As many of these cases have shown, implementing a BRT constitutes an opportunity to encourage the use of public transport and to foster urban renovation, as well as to integrate population to the city (particularly the lower income people).

Results: In many cases, BRT´s succeeded in their efforts to change the mobility paradigm of the cities where they operate, while providing more affordable, comfortable and reliable transport means — see Ardila, 2004. Furthermore, some experiences have been quite successful; managing to reduce travel time and offer increased comfort and safety for passengers (Jiron, 2013). BRT systems have proven to be an effective solution for congested cities and are becoming more popular for reducing emissions and improving road safety (Banick, 2009).

Instrument: Fare and mode integration.

Case study: Fare and modal integration in Zaragoza (Spain)

Brief description: In 2010, the city of Zaragoza implemented the *`tarjeta ciudadana´*, a citizen card aimed at integrating identification and economic characteristics of citizens, with different services provided in the city (public transport, public sport centers, libraries, museums, bike sharing system, parking, among others). In the case of having to pay for the service, the smart card can be charged with a variable amount of money. It offers the flexibility to adapt fares of services to each citizen, approaching their socioeconomic circumstances.

Results: Zaragoza´s citizen card has become the essence of `belonging to the city´ and has facilitated the access to around 20 services within the city, including public bikes, bus, light-rail, parking, public libraries, swimming pools, theaters and city Wi-Fi. Adapted taxis for disabled people are a remarkable example of the implementation of social policies through this card. Its use has reduced the costs of this service by 33% to the users and has facilitated access to public transport services to disadvantaged people (Alocén et al., 2016).

Examples of push and pull policies

Instrument: Public transport subsidies.

Case stuyd: Subsidy policy in Madrid (Spain).

Brief description: Public transport in many European cities is highly subsidized. In this scenario, the city of Madrid can be considered a paradigmatic case study. Besides the typical single and multi-ride tickets for public transport, there is a considerable subsidy for frequent users (the travel pass). Under this scheme, established in 1987 and based on a monthly travel pass, users can make unlimited trips across the network. The user cost per trip is €0.47 with a regular travel pass, whereas a single ticket falls in the range between 1.5€ and 2€.

Results: Despite the consequences on financial sustainability derived from this highly subsidized public transport fare, the introduction of a travel pass can be considered a successful practice in order to make transport more affordable to disadvantaged groups. In Madrid, people in poorer neighbourhoods use travel passes much more often than do people in richer areas and thus obtain greater benefit from public subsidies —see Bueno et. al (2016). Furthermore, the introduction of this scheme has been effective for increasing the public transport patronage by more than 50% (Matas, 2004).

Instrument: Benefits for employees.

Case study: Commuter benefit program in New York and New Jersey (US).

Brief description: Subsidy policies can be oriented on the basis of different premises such as increasing the use of sustainable modes or addressing externalities. In this line, a number of benefits for riding transit or vanpooling have been offered to employees in the Region of New York and New Jersey. These mechanisms, often referred to as `commuter benefits´, include benefits for using public transportation (e.g., monthly passes, universal passes, or vouchers), benefits for driving (e.g., toll payments, subsidized parking), and walking or cycling (e.g., financial incentives for bicycling or walking, or secure bike parking).

Results: Commuter benefit programs are advantageous for transit authorities (since they increase transit ridership and reduce costs associated with cash handling and individual fare transactions), as well as for employers and employees (generally, both of them reduce their contribution on income taxes). In addition, as the case of New York and New Jersey evidenced, they constitute an effective policy to encourage the use of public transport modes, thus increasing efficiency and sustainability in daily mobility patterns—see Bueno et. al (2017).

Instrument: Diesel powered vehicle restrictions.

Case study: Restriction to high pollutant vehicles in London (UK).

Brief description: The United Kingdom has implemented a set of standards and technological solutions to address urban air pollution. These include the introduction of low emission areas, the application of urban pricing schemes and other monetary incentives to switch to cleaner vehicles. In this context, in 2008 London established a Low Emission Zones (LEZ) where the most polluting vehicles are restricted from entering. The scheme is applied to all types of vehicles regardless of their use (private or commercial), except for cars, motorcycles and small vans. It covers most of Greater London area and is in operation all the year 24 hours a day.

Results: Different studies have indicated that there is a statistically significant, but rather small reduction of NO2, NO, and NOx concentrations associated with the Low Emission Zone in London — see for example Vaughan et al. (2016) and Carslaw et al., 2002. Despite decreasing pollution trends as a consequence of this strategy, the level of emissions remains an important challenge for the city. On the other hand, the policy has had a substantial effect on the vehicle fleet composition, increasing the replacement rate for older vehicles (Ellison, et al., 2013).

Instrument: Pricing policies.

Case study: Road Pricing in Stockholm (Sweden).

Brief description: Road charging strategies have been a transportation policy advocated by economists for decades. They have been implemented in urban environments —such as Singapore (1975), Oslo (1990), London (2003), and Stockholm (2006)— as well as in metropolitan and interurban contexts worldwide. Among these examples, the case of Stockholm is of particular interest and it has attracted enormous attention in the literature. Consisting of a toll cordon around the inner city (30 km^2), it started in 2006 with an initial six-month trial followed by a referendum where the majority was in favor of making the system permanent. A complete description of the scheme can be found in Eliasson (2009).

Results: The implementation of road pricing mechanisms has proven to be effective instruments in achieving the objectives of congestion relief, environmental improvements and revenue generation to face public budget constraints (Cao et al., 2014). The Stockholm congestion charging has demonstrated improvements in travel time and great changes in public acceptability. In this respect, Börjesson et al. (2012) pointed out that the effects on the traffic system, as well as general environmental and political attitudes formed the basis of the strong public support.

Examples of strategies based on digitalization and the use of new technologies

Instrument: Promoting MaaS.

Case study: Mobility as a service (MaaS) in Helsinki.

Brief description: MaaS consists on digital platforms offering travelers door-to-door mobility services, integrating various modes of transport, fares and other information services. By adapting transport services to individual needs while generating new business opportunities, MaaS offers flexible and personalized mobility solutions. Some current applications are: (i) Bridj, the bus service on demand in Washington DC, which provides users efficient and flexible bus trips without fixed stops; and (ii) Whim, the application for Helsinki residents that allows them to plan and pay for the use of public and private transportation modes available in the city.

Results: Whim is a mobility as a service case study that shows the impact that technology can have in the operation and integration of infrastructure systems. Whim allows planning and paying for all public and private transport modes (train, taxi, bus, carshare or bikeshare). This system has facilitated a better integration between modes, while redistributing the modal split in favor of an increased percentage of public transport (74%, Vs 48%) and reducing the use of the private vehicle from 40% to 20% with the consequent favorable impacts on traffic flow and air quality.

Instrument: Smart ticketing.

Case study: Smart card ticketing in public transit implemented in different cities.

Brief description: The use of transit smart cards is now emerging as a feasible option for many transport operators. Public transport smart cards are now widely implemented all over the world with remarkable experiences in Europe (UK, France), America (Canada, USA, Chile), and Asia (Hong Kong, South Korea). By providing an alternative means for users to access and pay for transport services, the use of smart card enhance users´ experience (Ibrahim, 2003) while improving trip data quality and allowing to better understand travel behaviors (Bagchi and White, 2005).

Results: Besides the usefulness of the production of detailed data for transport planners, smart card automated fare collection systems facilitate a variety of pricing options for transit fares which may result in making public transit more attractive. In addition, smart-card technology can be used for implementing fare policies on the grounds of equity —see for example the case of Seul in Smart Card Alliance, (2009). A comprehensive review of advantages and disadvantages of Smart card marketing can be found in Pelletier et al., (2011).

Examples of policies for reducing mobility needs

Instrument: Teleworking.

Policy case example: Flexible work environment in Cisco.

Case study: With the advance of telecommunications, establishing new forms of employment has become increasingly common. A notable example in this regard is provided by Cisco, a company that has created a flexible work environment for increasing productivity while enhancing work-life balance. Cisco provides a number of options for developing a workable home office solution, including flexible working hours, remote working and virtual meetings.

Results: The case of Cisco has shown that teleworking can considerably reduce the cost of office and parking spaces. In addition, to facilitate employees working from home has led to lower costs of bandwidth and electricity (Cisco, 2013). A pilot implementation of a Cisco virtual office for 150 employees in India eliminated three hours commute time/week/employee and resulted in an increase in productivity per user/year equivalent to US$16,000. With an annual operational cost of US$624 per employee, the scheme has boosted productivity by approximately 15% per user (Cisco, 2008). Furthermore, flexibility in working days has shown to be determinant for employee satisfaction, which is closely related to loyalty and can be directly translated into higher efficiency for the company due to the extraordinary costs associated to job rotation.

Instrument: Jobs-housing balance.
Case study: Jobs-housing program at University of California, Los Angeles.
Brief description: It is becoming more common that employers, via transportation demand management (TDM) programs, encourage their employees to decrease their reliance on personal vehicles and to shift to public transport and soft modes. Within this dynamic, TDM measures offered by Universities represent a case of particular interest, including subsidized housing options near workplace. In this respect, the University of California in Los Angeles (UCLA) provide to its community (students and staff) a set of options to encourage the use of sustainable modes (e. g. subsidized transit pass, subsidized vanpool program, ridesharing support, among others). In addition, the UCLA´s TDM program promotes a number of options for promoting better jobs/housing balance, including housing options for faculty/postdoctoral employees and housing rental support.
Results: TDM programs are effective means of increasing transit ridership, reducing car dependence and related problems such as air pollution and traffic congestion. For the case of the University of California, Zhou (2012) pointed out that UCLA employees: (i) have a better jobs/housing balance than other groups of employees, (ii) are significantly less likely to drive alone to work and (iii) are more prompt to use alternative modes. In particular, the policy has been successful for improving housing options near campus, with a high percentage of employees living within short distances to worksite.

2.6 INSTRUMENTS FOR FURTHER RESEARCH

A wide approach to analyse different types of strategies for addressing major transportation challenges has been taken throughout this chapter. Relevant strategies and policies are too numerous to be fully addressed in this report. In order to limit the present study to a manageable scope, the present section is aimed at selecting only three specific instruments worth to be studied in greater detail in the future.

The three selected strategies come from a consensus of the authors of this paper made after a careful review of the scientific literature and practical reports. The working set of criteria for selecting key instruments include data availability and the importance for the case of LAC given the major issues that many LAC cities face nowadays (see section 2.2).

Firstly, additional efforts are needed to extend the analysis in order to understand the benefits and barriers of **fare and modal integration of transport services in urban areas**. Future contributions should attempt to explore in detail case studies on transport integration in cities of developed and developing countries, including aspects such as institutional, physical and network integration. Studying in detail this issue is particularly important for rapidly expanding cities in LAC where motorization rates continue increasing and externalities pose major problems. The challenge to be investigated in this future work is related to deliver seamless transport services.

Secondly, additional research should delve more deeply into the impact of **transport subsidies from the supply-side**. As the current literature has been focused on analyzing this matter from the demand-side (equity and distributional implications), additional studies could be developed in order to address the institutional processes, as well as the allocation and control mechanisms of public transport subsidies in urban areas.

Thirdly, the extent to which certain **transport strategies contribute to the reduction of vehicle energy consumption and pollution emissions** should be examined in greater detail. Future studies should explore the relationship between air quality problems and transport in Latin American cities. To analyze existing experiences of transport instruments aimed at improving air quality, reducing congestion or improving general travel times in some cities around the world, may represent an interesting approach to this research gap.

3. TRANSPORT INTEGRATION POLICIES IN LARGE CITIES

3.1 INTRODUCTION

In terms of public passenger transport, integration should be understood as all the necessary adaptations to ensure a seamless transport service from a system-wide perspective. The main objective of this policy is to improve the access to the service and its coverage. Integration also enhances the convenience of passengers for using all the different transportation modes and has proven to be an effective means for tackling transportation-related problems such as air pollution or traffic congestion.

In recent years, transport integration policies have received particular attention in different cities. Efforts aimed at implementing an `integrated public transport system´ have encouraged the use of more sustainable transport modes, providing an opportunity to reduce transport dependence on the private car. Addressing these issues is particularly important for rapidly expanding cities in LAC where motorization rates continue increasing and externalities pose major problems.

Given the importance and steady growth of integration policies worldwide, the goal of this chapter is to shed light on the benefits and barriers of implementing fare and modal integration of transport services in urban areas. This study is a response to one of the main challenges faced by urban mobility nowadays. In particular, the challenge thoroughly investigated is related to delivering seamless transport services. In this chapter, social, economic and environmental impacts resulting from the implementation of these policies will be analyzed through a series of selected examples.

Apart from this introduction, the chapter is divided into five additional sections. Section 2 analyses transport integration in the Latin-American context. Section 3 identifies the major benefits and costs resulting from the implementation of transport integration policies. Section 4 examines in detail case studies on fare and modal integration in some cities of developed and developing countries. Finally, in Sections 5 a cross-sectional analysis of the various cases previously described is conducted aimed at providing recommendations for the case of LAC.

3.2 BACKGROUND: TRANSPORT INTEGRATION IN LAC CITIES

In many cities of LAC, public transport systems are made up of bus routes, mostly run by private operators with little coordination. As a result, collective transport systems in the region are more focused on competing than cooperating thereby providing inefficient and dissociated networks with low quality of service. Private operators usually compete for passengers in the street (competition in the market), under informal economic rules (Hidalgo & Huizenga, 2013). Bus routes, often operated by medium size vans or small buses under dispersed ownership, are frequently characterized by the lack of regulation from public authorities.

More specifically, public transport riders in LAC have to face often difficult connection between private and public transport means, and across public transport routes in the city. This makes passengers' day-to-day experience inconvenient and uncomfortable since continuous journeys

under integrated conditions —in terms of fares, ticketing, physical services and infrastructure— are not ensured. In particular, users have to pay, usually on board, for transferring between modes; face complicated connection among routes; and endure limited availability of sources to obtain information to plan their journeys.

In addition, as many inhabitants of LAC cities are dependent transit riders, conventional public transportation in these cities depicts a non-existing customer care (i.e. interface for inquiries, physical assistance, information, etc.), and comfort (i.e. ambient conditions, furniture design, cleanness, overcrowding, etc.). This fact not only makes the journey less easy and pleasant, but also gives to the user a strong feeling of lack of protection, which reduces customer loyalty and increases the likelihood to leave the system for the so-called `choice riders´ (those who are not transit-dependent).

On a macro level, the fact that administrative, fare and modal integration have not been a traditional common practice for transport authorities across the region, results in less efficient and effective public transport systems. As the service becomes less attractive, the usage of cars tends to increase, particularly among riders with personal vehicle availability. It can therefore cause severe negative externalities such as congestion, air pollution, and accidents. An integrated and seamless transport will improve operating efficiency of the system and the convenience and comfort for existing users as well. By making transport seamless, transit ridership will increase since automobile travelers may shift to public transit or combine it more often with private transport means, which will in turn lead to less congestion, lower air and noise pollution and greater safety. A more detailed explanation of the benefits derived from a seamless service is presented in section 3.

Under this panorama, Bus Rapid Transit (BRT) systems[4] have emerged as a cost effective alternative to deal with these and other transport issues in most cities of the region. Over the past years, these bus-based mass transit systems have demonstrated to be an efficient solution to improve public transport in congested cities, as well as an opportunity for discouraging the use of less sustainable transport modes while fostering urban renovation[5]. In addition, the implementation of these high-capacity bus systems has opened the path to unify tariff collection and encourage public transport integration. However, the implementation of BRT systems in some cities has not been complemented by holistic changes in the institutional structures of transport planning at the city level. Institutional frameworks of BRT´s have been mostly limited to the creation of new management entities, with responsibility for the planning and control of the operation of the new systems (Errazuriz et al., 2017). In the absence of a common institutional framework citywide, an entirely integrated transport network is far to be feasible.

In summary, despite the advances gained through the implementation of BRT systems in LAC, there is still a long way to go, especially in the scope of integration of all transport modes within a city (interurban and urban buses, metro, rail, walking, cycling, car). Although BRTs and the development of complementary transportation policies to change the mobility paradigm have

[4] They are defined as “high-quality bus-based transit systems that deliver fast, comfortable, and cost-effective urban mobility through the provision of segregated right-of-way infrastructure, rapid and frequent operations, and excellence in marketing and customer service” (Wright and Hook 2007, 11).
[5] Other benefits derived from these experiences can be found in Ardila (2004), Banick (2009) and Jiron (2013).

succeeded in their efforts to advance towards more integrated transport systems, the evolution in most cities of the region is slow and limited.

3.3 BENEFITS AND COSTS OF TRANSPORT INTEGRATION

How is transport integration defined?

Multimodal planning refers to transportation and land use planning practices that consider diverse transportation options, typically including walking, cycling, public transport and automobile (Litman, 2017). In recent years, theory and practice regarding transportation planning has evolved towards a more multimodal perspective, aimed at taking advantage of the strengths of different existing transport modes.

On this base, recent innovative concepts for achieving transport integration have induced significant changes in the current transport practices. Such is the case of "Mobility as a Service" (MaaS), a new idea of conceiving mobility based on digital platforms aimed at improving the transportation network by bringing together multi-modal transportation options and offering travelers door-to-door mobility services. A critical review of this concept can be found in Jittrapirom et. al (2017).

There is a general consensus on the benefits of transport integration in urban areas. On the one hand, it is associated with greater patronage. On the other, it may favor the social inclusion of the most vulnerable citizens and improve accessibility and user experience due to a better level of service. Overall, integration has proved to be an effective means of encouraging the use of public transport and reducing the reliance on car use. Multimodal transport planning is often the most cost effective city-wide policy to improve the transportation system in a comprehensive way.

However, impacts of integrated transport approaches may vary across cases depending on the extent and nature of the integration strategy put into practice. The construction of intermodal exchange hubs in metropolitan areas to facilitate modal change, and the development of smart and integrated ticketing approaches are all examples of strategies at different levels supporting 'seamless' travel and integrated transport systems. Other governance measures for ensuring the integration of public transport services have been adopted at the city level, such as the implementation of a single transport authority coordinating all the modes and setting common fares. These governance approaches are crucial for facilitating the integration of the entire public transport network, fares and services (fare and multimodal integration).

In the experience of the authors of this report, and according to the literature (see Luk and Olszewski, 2001; Luk and Yang, 2001), measures for integrating transport services include the dimensions explained in Table 3.1 of this Chapter.

Table 3.1. Dimensions of transport integration

Dimension	Definition	Examples
Physical integration	It includes all the necessary physical adaptations —generally undertaking at stations, for providing access to an integrated and efficient transport system.	• Multimodal facilities. • Walkways to change mode. • Bikeways along BRT routes. • Taxi stands outside bus terminals. • Car-sharing stations located near railway/tram/bus stations.
Network integration	Network integration refers to the integration among existing transport networks in order to optimize the overall functionality and maximize coverage. It is similar to physical integration, but it is more closely related to the concept of organizing separate networks (e.g bus, rail or tram network) in concert with other networks.	• BRT platforms directly linked to interurban buses departure points. • Metro platforms adjacent to rail platforms. • Rail transport providing services to airports.
Fare integration	Integrating fare payments across all the transport modes to make the system easier to use while facilitating transfers.	• Single card issued by the public authority or EMV contactless for multiple transit services. • Fare approaches to make transfers cheaper to the user.
Information integration	To provide a standardized and integrated information system for customers, including static and dynamic sources of information.	• Multi-modal navigation tools (smartphone applications, websites). • Timetables, maps. • Real time information about the arrival of transport services.
Institutional integration	Constituting a single transport authority to coordinate services, networks and fares of all transport modes.	• A regional transport authority. • A multimodal planning agency.

Source: Author´s elaboration

In the following paragraphs, an explanation of the specific benefits of transport integration is provided. Such analysis is fairly complex because it may impact various stakeholders with single characteristics. For example, passengers would benefit from the improvement of access and coverage of the system, while transport operators would benefit from a consequent increase in transit ridership and fare revenues. The actual potential beneficial impacts of implementing a multi-modal integration can vary significantly, as indicated in Figure 3.1.

Benefits and costs of integrated-multimodal public transport

By increasing the transport system efficiency and improving the overall satisfaction with transit experience, integration policies provide multiple benefits, including those described in Figure 1. Although not every integration strategy achieves all of these benefits in every situation, this analysis shows a comprehensive taxonomy of the benefits that multi-modal integration may produce.

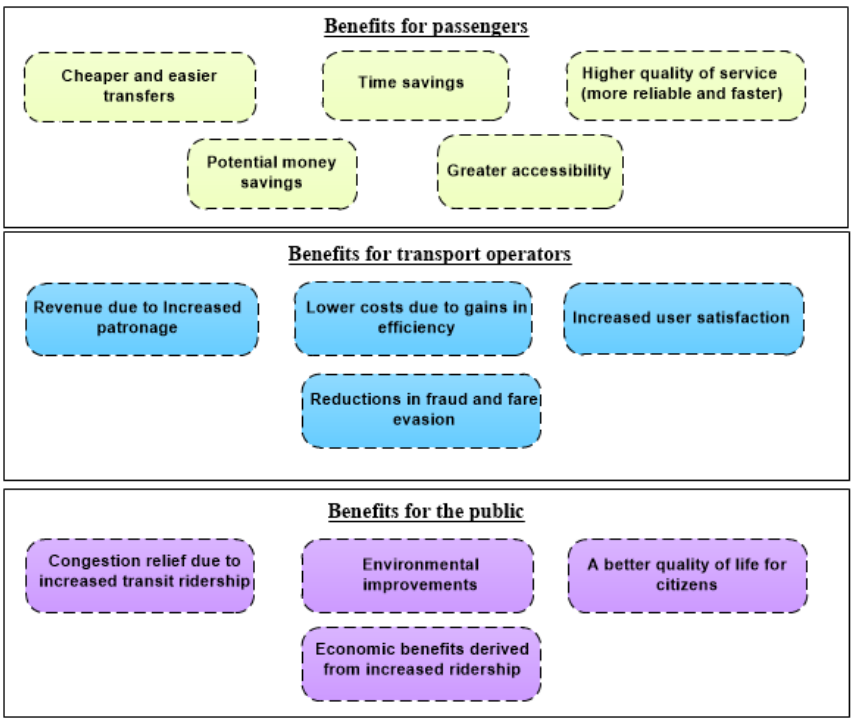

Figure 3.1. Typical benefits from multi-modal integration

Source: Author´s elaboration based on PADECO Co. Ltd (2000) and Booz & co. (2009).

According to a study commissioned by the Passenger Transport Executive Group (PTEG)[6], the most commonly reported benefit associated with the introduction of integrated fare systems is related to increasing transit ridership. Patronage growth caused by the advantages of transport integration falls in the range between 6% to 20% (Booz & co., 2009). On the other hand, due to a reduction in redundancies and maximization of synergies across different means of transport, other benefits for the public, as well as for passengers and transport operators have been derived —see Figure 3.1. For example, higher modal shares in public transport, increased passenger satisfaction, and fraud decrease. In this latter respect, there is evidence that fare integration policies have a positive effect on fare evasion (LT Planning Department, 1993).

Impacts previously listed in Figure 3.1 have been quantified in some urban areas where different integration strategies have been implemented. Some quantitative examples of these effects are displayed in Table 3.2. Studies supporting these results are shown in the *reference* column of the mentioned table. The year of introduction of the integration policy is shown in italics, below the case study name.

[6] The PTED was a federal body in the United Kingdom, consisting of local government bodies, responsible for public transport within large urban areas. In 2016 it became the Urban Transport Group.

Table 3.2. Examples of benefits derived from integration strategies

Benefit	Case study	Evidence	References
Increase transit ridership	Fare structure revisions and introduction of a travel card in **London, UK**. *(1983)*	Patronage increased by 10% in subway and 16% in buses.	White (2009) TCRP (2004)
	Travel card in **Madrid, Spain**. *(1986)*	Underground trips increased by nearly 15% and bus trips by more than 7%.	Matas (2004)
	Low cost 'environmental' travel cards in **Freiburg, Germany**. (1983)	50% increase in the amount of trips, 7.5% per year	Fitzroy and Smith (1998)
Revenue increases	Fare structure revisions and introduction of travel card in **London, UK**. *(1983)*	Bus revenues increase by 4% and underground revenues by 16%.	TCRP (2004)
	Fares simplification and introduction of multi-modal passes in the State of **Maryland, USA**. *(1996)*	Increases in revenues: 11.6% for Buses, 18.6% for the Metro and 13.2% increase for light rail.	Booz & co. (2009).
Shift ridership	Physical, network, fare, information and institutional measures for multimodal integration in **Singapore.**	Higher modal share for public transport (63% of all motorized trips).	Luk and Olszewski (2003).
	Physical, network, fare, information and institutional measures for multimodal integration in **Hong Kong**, **China.**	Higher modal share for public transport (90% of all motorized trips).	Luk and Olszewski (2003).
Increased user satisfaction	Fares simplification and introduction of multi-modal passes in the State of **Maryland, USA**. *(1996)*	Improved convenience of fare payment and reduction in travel costs resulted in a general higher passenger satisfaction with the service.	TCRP (2003)
Reductions in fraud	Fare structure revisions and introduction of travel card in **London, UK**. *(1983)*	A 7% decline in total revenue lost due to fare evasion control (1980 to 1992). The total revenue lost due to passenger fraud went down from 6% to 3%.	Booz & co. (2009).
Potential money savings for passengers (social benefits)	Travel card with fare discounts for frequent users, senior citizens and young people in **Madrid, Spain**. *(1986)*	The subsidy policy associated with the travel pass in the city can be considered progressive, since it effectively targets economically disadvantaged groups.	Bueno et. al (2016).

Source: Author´s elaboration based on Booz & co. (2009), Matas, A (2004) and Luk & Olszewski (2003). For a detailed description of these and other case studies the reader is referred to Booz & co. (2009) and TCRP (2004).

On the other hand, implementing integration measures may impose costs or issues such as:

- Construction and maintenance costs for physical and network integration such as multimodal facilities or pedestrian and cycling environment surrounding stations.
- Low public acceptability of the new integrated transport systems (cancelation of previous routes, the need for users to make additional transfers for certain origin-destination relationships, overcrowding levels at interchanges facilities, among others).

- Financial sustainability problems for transport authorities due to a lower coverage of transportation costs with user fares.

Financial sustainability problems are the most important issues derived from integration policies, since these policies (specially integrated fares) usually require subsidies[7]. An analysis of the related literature conducted by Matas (2004) concluded that the implementation of a non-uniform price scheme does not necessarily imply an increase in revenue coverage. An interesting example is the case of Madrid, where the implementation of the travel pass reduced the cost coverage of the public transport system, which has been decreasing steadily over the years, leading to growing public subsidies over time. A detailed explanation of this case study is provided in the following section 4.2.

3.4 INTERNATIONAL EXPERIENCE ON TRANSPORT INTEGRATION

This section examines in detail three case studies on fare and modal integration in cities of developed and developing countries: London and Madrid in Europe, and Bogotá in Latin America. For each case study, it is described how the different dimensions of transport integration, previously explained in Table 3.1, have been implemented. Moreover, this chapter provides a review of the impacts of the three types of integration policies in each city.

The case of London in the UK

Being one of the global metropolises across Europe, London has a population of 8.7 million inhabitants (2016) with an average density of 5,590 persons per square kilometer[8]. The public transport system consists of different modes including the subway[9], buses, a tram system, a light metro system, the overground (commuter rail) and other river services. The total number of trips made in the city averaged 26.7 million per day (Transport for London, 2016), 45% of the trips are made by public transport means, and 32% by private car. This fact reflects a well-established sustainability trend in daily mobility patterns. London is a city of particular relevance to understand the effects of integration policy strategies because of its size and the complex array of transport means interacting in the metropolitan area.

Ever since 2000, London has witnessed a 11% increase in the modal split of public transportation while the private transport mode share has been decreasing accordingly. This has been achieved through a range of cost effective strategies and vast improvements that are outlined in this section, including the creation of a regional transport authority and the implementation of integrated fares and ticketing.

Transport integration in London is the result of diverse processes, framed within the different dimensions of transport integration, and promoted over the last few decades. The paragraphs below highlight the key elements promoted by the city to foster transport integration.

[7] For example in the case of Europe, most integration strategies have been implemented simultaneously with subsidized fares for frequent users or the most needed (low-income riders, people looking for work, disabled customers, students, the elderly, etc.).
[8] Data from Eurostat and GLA.
[9] The Underground, commonly known as “the tube”

Institutional framework

The creation of a unified public transport authority in 2000, Transport for London (TfL), was a fundamental pillar to ensure seamless integration across various modes of transport in the Capital. As the primary executive agency for the Greater London Authority (GLA), TfL´s operational responsibilities include London Overground, London Underground, Buses, Docklands Light Railway (DLR), TfL Rail, London Trams, London River Services, London Dial-a-Ride, Victoria Coach Station, and the Santander Cycles.

TfL, chaired by the Mayor of London, also regulates taxis, runs the congestion charging scheme implemented in the city center, and operates all traffic signals. This constitutes a strategic factor to ensure a strong institutional capacity. According to Wilcox et al. (2014), the reasons behind the city´s efficient and high quality transport system rely on the governance model under which TfL operates, which is characterised by the following features:

- The management of the majority of public transport services, including bus services.
- The ability to raise local funds to reinvest in transport, such as the congestion charging scheme. For example, in 2011/2012 TfL reported a net income of £136 million from this scheme, which was spent in the transport sector.
- A governance structure that facilitates a robust institutional capacity and enables planning and investment at large scale.
- A transport strategy integrated with other policy instruments of different areas such as economy and health.

Infrastructure and operations

The success London has experienced in the last few years to substantially improving public transport integration is also caused by investment in various transport modes, along with limitations on the capacity of the road network[10]. London's transport system has seen a significant growth over time, with an annual expenditure of approximately £8.5 billion during 2015-2016 (two-thirds on capital projects). As an example of these continuous efforts, current planning envisages increasing the public transport supply by 70% between 2001 and 2051[11].

London has a dynamic approach to multi-modal improvements focused on ensuring an accessible and inclusive transport system[12]. At the time of the writing of this report, the city had 600 stations involving any type of multi-modal interchange. Moreover, there were 18 terminal stations known as `London station group[13] ´ served by the National Rail network. These railway stations were built in the mid-19th century around the edge of central London; and, in practice operate as intermodal interchange stations, making connections between urban modes and major national rail services.

Similarly, other forms of inter-modal interchanges such as Park and Ride lots have also been promoted to take advantage of transport networks in a more efficient way. Moreover, besides infrastructure investment to provide additional transport capacity, London has also upgraded

[10] Such as the creation of the London low emission zone, a scheme to encourage the most polluting heavy diesel vehicles driving in the city to become cleaner.

[11] All the data shown in this subsection comes from Transport for London, 2016.

[12] www.tfl.gov.uk

[13] Including London Bridge, Euston, King ´s Cross, Liverpool Street, Waterloo, Marylebone, St Pancras, Victoria and Paddington.

services by increasing the reliability of the different modes. Since 2000, the capacity of the system has increased its service by 29% (underground) and 35% (bus); while there have been also dramatic gains in reliability over the period: 47% and 46%, respectively.

Integrated payment

Apart from building a high-quality integrated system with different multimodal hubs and transfer stations, London has embraced fare integration as a key policy element which, in addition to increasing public transit ridership and transport operators' revenue, may prompt faster boarding and enhance customers' satisfaction.

In July 2003, the capital launched a contactless smart card called "oyster card" to allow seamless access and payment across different modes, including the possibility of paying for single journeys in the `pay as you go´ method (touch-in/touch-out). The Oyster card is one of the world's most popular transport smartcards allowing special kinds of travel passes for potentially vulnerable groups of people: a free travel pass available to older or disabled travelers, a pass to people aged 60 or over, a young people pass and other discounts for people receiving specific benefits.

Besides the Oyster, passengers can use different ways to pay for journeys, including contactless payments by conventional cards such as Mastercard and Visa, mobile phone or other devices. In particular, the rise of contactless payment (same fare than with an Oyster card) is making travel more convenient. Usage of smart cards has become very popular among users and only 1 per cent of payments are now made with cash (Hoscik, 2014).

In summary, passengers can travel by using contactless, Oyster to `pay as you go´ or they can also add a flat fee (travel card) to the Oyster card. A travel card is defined as a flat fee which gives passengers unlimited travel (1 day, 7 days, 1 month or 1 year). Except for the buses, fares are set in accordance with the London Fare Zones System which divides the city into concentric zones. As an example, a monthly travel card for the central zone 1 currently costs about US$173,5, while passengers pay US$3,2 for a single ticket (zone 1). Despite the price is mostly determined by the fare zones users want to travel, fares may vary depending on the direction of travel, time of day and day of the week. Transfers are allowed between the different modes without additional fees.

Information integration

Information has contributed a piece of puzzle to the big picture of transport integration in the city. Passengers use a variety of static, print, and real-time information sources to plan their journeys. Maps, TfL website, digital solutions and mobile information systems are examples of how customers consume information. Presently, nearly half of online Londoners (42%) use journey planning apps[14] and there has been an increasing use of social media for travel information (Transport for London, 2017).

[14] There are 600 apps approximately. The most used are Google Maps (63%), Apple Maps (31%), London Bus Live Countdown (22%) and Citymapper (22%).

London has a GPS enhanced automated vehicle location system (iBus) for improving bus fleet management and giving buses priority at traffic signals. Furthermore, live bus arrival information is available online, on smartphones and via SMS for all bus stops in the city. Additionally, passengers can use the automated service on Facebook Messenger (Facebook TravelBot) to find out services.

Real-time travel information is provided directly by TfL and through third party organizations in order to keep users informed and connected. TfL provide around 11,000 developers with access to over 50 real-time data feeds through their unified Application Programming Interface, covering multi-modal transport data for all the transport modes including the Tube, DLR, Bus, Rail, Overground, Coach, Rivers and others (Transport for London, 2017).

Impacts of transport integration

The impacts of transport integration for the case of London have been extensively studied. The most common reported benefit is associated with growing patronage. In this respect, Figure 3.2 shows the evolution of passenger demand in London and highlights the most important previously mentioned milestones which have shaped the development of an integrated transport system in the city.

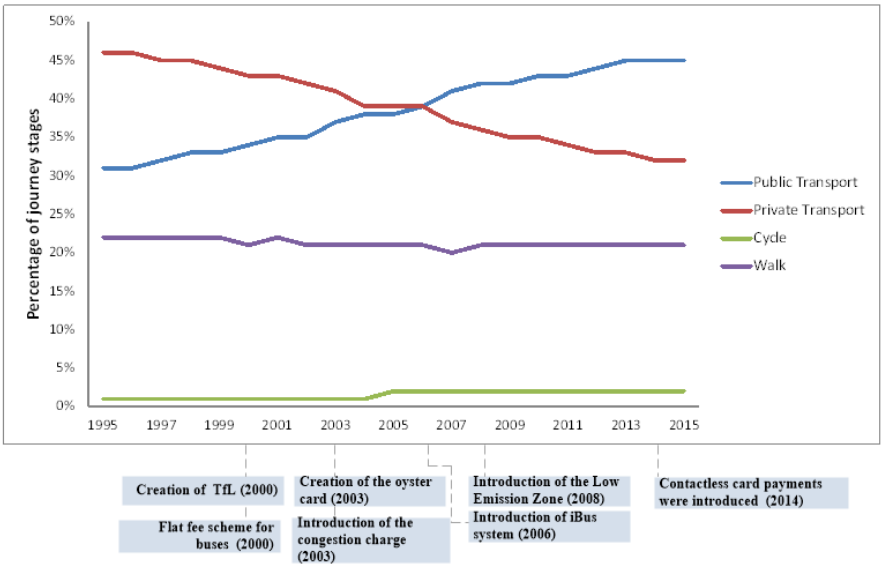

Figure 3.2. Evolution of passenger demand in London
Source: Author´s elaboration based on Transport for London, 2016

As can be seen in Figure 3.3, passenger demand has been steadily increasing since the creation of TfL and the corresponding upgrade programs for increasing the system´s capacity and reliability introduced after this period. Another important strategy associated with an increase in transit ridership was the introduction of a flat fee scheme for the buses in 2000. GMPTE (2009) reported that the 'simplification effect' was estimated to increase tube and bus patronage by 3-4% in the long run.

Other studies, such as the one conducted by White (2009), pointed out that fares reform was one of the major components of the ridership growth between 1999/2000 and 2005/2006. This author specifically suggested some of the following potential reasons for explaining the increase in passenger numbers:

- Lower real fares and higher aggregate service levels.
- More comprehensive coverage of service.
- Comprehensive passenger information.
- Ease of interchange (reducing the financial penalty imposed by interchange).
- Simplified fares.

On the latter point, the introduction of the Oyster card in 2003 also allowed to reduce the cost of revenue collection for the transport authority. According to TfL, ever since its implementation, there have been 26% more journeys, 12% more km operated, an increase of 7 points on Customer Satisfaction and a 54% improvement in reliability (Lost Customer Hours)[15]. After the implementation of this widely used card, cash fares on buses were eliminated in 2014, which will save £130 million to 2022/2023, to be reinvested in public transport.

Furthermore, the use of contactless to pay as you go in London has shown an array of positive impacts in customer perception, satisfaction and usage. Firstly, as can be seen in an example shown in the figure below, contactless payment with conventional cards is gaining momentum in contrast to the use of the Oyster private card. Since early 2016, the proportion of pay as you go journeys made using contactless has risen from 25 per cent to more than 50 per cent today (Transport for London, 2018). Secondly, fare evasion has been reduced and currently do not exceed 0.1%. Finally, passenger opinions have suggested satisfaction due to increased convenience of fare payment (complains less than 0.01%). Other impacts for the case of London can be found in *ATUC* & Visa (2018).

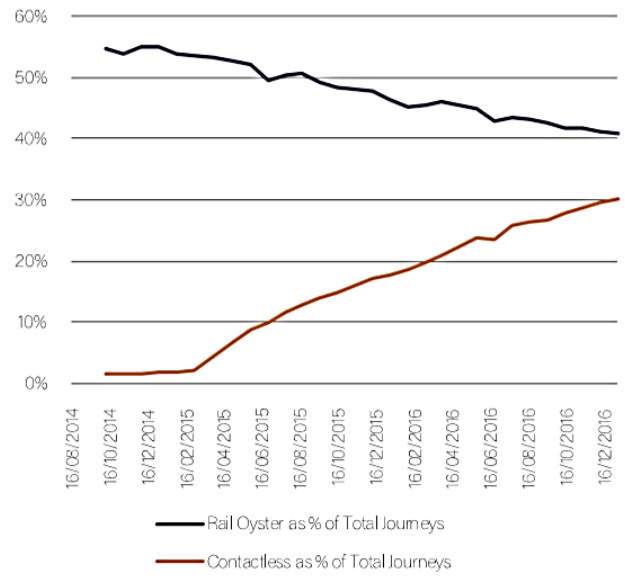

Figure 3.3. Example of EMV contactless usage in London
Source: ATUC & Visa (2018).

Other impacts such as the derived from the deployment of iBus have been quantified by Wong and Hounsell (2010). This study claimed tangible improvements to the operation of the London bus network, including a reduction in waiting times, can be found since TfL has been rolling out iBus.

[15] For further information see Transport for London, Travel in London Report 5, 2012.

The case of Madrid in Spain

More than 6 million inhabitants live in the Madrid metropolitan area. About 50% of the population lives in the city of Madrid, in an area of 607 km^2. The population density in the capital is 5,390 inhabitants per square kilometer[16]. The public transport system consists of four modes: two urban modes, underground rail system and urban buses; and two metropolitan modes, commuter rail and interurban buses. The last Transport Survey conducted in the city in 2004 revealed that "there are 6,670,000 motorized trips every working day—48% served by public transport and 52% by car" (Monzón and Guerrero, 2004).

The public transport patronage has grown from 950.5 million in 1986 to 1,385.7 million in 2015[17] and the system is widely recognized as one of the best practices in public transport integration, inspiring the implementation of different integration strategies across Spain. This has been achieved through a wide spectrum of policies ranging from the creation of an autonomous regional body (The Regional Transport Consortium) to large scale investments in public transport infrastructure. The purpose of this section is to explain the `package of policies´ addressed in the city of Madrid for guaranteeing the integration of the overall public transport system. The approach to be used for this case study will follow the dimensions of integration previously described in Table 3.1.

Institutional framework

The most significant policy for an integrated and high-quality public transport system in the city was the creation in 1986 of the Regional Transport Authority (CRTM) as a body owned by the Regional Government, and the municipalities of the Madrid Metropolitan area. The CRTM is in charge of:

- Planning the public transport infrastructure.
- Establishing the integrated fare across the system and acting as a clearance house for all model and lines.
- Planning and coordinating the operation of all transport modes: metro, light rail, urban buses in the city of Madrid (EMT), urban buses of other associated municipalities, and interurban buses.
- Creation of a global common image for the public transport system.

The CRTM was promoted with the aim of boosting public transport use and shifting demand away from the private car. Since then, the modal share of public transport rose by more than 50% (see section `impacts of transport integration). On this basis, it is possible to claim that the increase in public transport patronage in the city of Madrid can be directly associated to the building of the institutional framework. However, setting up the authority has embraced different strategies to support public transport integration, including the creation in 1987 of an integrated fare scheme for the whole transport network and the construction of a number of interchange terminals in the city. Some of these strategies are described in the following subsections.

[16] Data from INE, National Institute of Statistics.
[17] Data from The Madrid Regional Transport Consortium (Consorcio Regional de Transportes de Madrid).

Infrastructure and operations

In addition to the institutional reform, Madrid has promoted several infrastructure and service improvements as part of the strategy for encouraging transit ridership. The most remarkable improvements include:

- Different infrastructure extension plans (e.g. the metro extension plan 1995-1999, the metro extension plan 1999-2003 and the metro and light rail extension plan 2003-2007) to increase the length of the networks and make major improvements to the existing system (e.g. new interchange stations, extension of the length of station platforms, among others)
- The Public Transport Infrastructure Plan 2007-2011 to integrate the region's Metro and railway network, and the Suburban Rail Infrastructure Plan 2009-2015 to improve and reinforce the rail network for Madrid and the surrounding area.

Among the transit infrastructure programs, the Madrid transport interchanges plan represents a best practice for ensuring the system's optimal modal integration while achieving a seamless mobility between long and regional journeys. With a total investment of €435.6 million, 5 interchanges were strategically placed in the limits of city to facilitate the modal transfer of commuters coming from the suburbs in regional buses to both the subway and urban bus networks. The construction of intermodal exchange stations constitutes a key element of the process of increasing the supply of public transportation through investing in new infrastructure, and improving the physical connection among modes.

It is worth mentioning that, intermodal exchange stations were built by the private sector through PPPs with little public support, so that the concession approach has to be deemed a success also in financial terms. As shown by Vassallo et al. (2012), the intermodal exchange stations in Madrid has proven that it is possible to fund transport infrastructure in urban areas without public subsidies and at the same time, ensuring that the stakeholders involved (users, transport operators, infrastructure concessionaires, and the government) ultimately gain. A detailed description of the evolution of Madrid's transport interchanges can be found in Vassallo (2015).

Integrated payment

Ticketing has played a key role in the transport integration process of Madrid. In 1987, the CRTM implemented an integrated fare system based on a travel pass, a monthly flat fare with a considerable implicit subsidy suitable only for frequent users. This pass is valid for all public transport modes (e.g. buses, metro, suburban railways) inside a certain ring around the central area of the city. Therefore, travel pass holders can make unlimited trips inside the ring zone associated with that travel pass.

There are three types of monthly transit passes, including a standard travel pass and two specific categories of passes that address potentially vulnerable groups: a travel pass for young people (younger than 23 years old), and a travel pass for senior citizens (65 years and older). Currently, standard travel pass holders pay US$63,74 if they travel within the city, while young people paid US$23,35 and seniors US$14,36 for a regular monthly travel pass. The cost of a single ticket falls between US$1,75 and US$2,34.

The CRTM introduced in 2012, a contactless card to reinforce its integrated fare scheme. Travel passes, now integrated into a public transport card named as *`tarjeta de transporte público´*

became very popular among users. According to the CRTM, in 2017, 72.2% of all trips used this card. In 2018, existing options such as the typical single ticket and the multiride (10-trip) tickets for the current network were integrated into a single card (named as `*tarjeta multi´*). The implementation of this card has replaced conventional tickets thus contributing to the environment by eliminating 27 tons of paper per year.

Information integration

Committed to a continuous development of an integrated public transport system, the transport authority of Madrid has also implemented a number of strategies to enhance customer information on their mobility options. For example, real-time transit information on bus arrivals which can be obtained by means of SMS messages since 2006, and the installation of new shelters including information about the arrivals for the buses since 2009.

Apart from the real-time information on arrival times provided at the bus stops with the greatest demand and in all the metro and rail stations, passengers in Madrid mostly use a variety of static and print information sources to plan their journeys. Other major sources of information include the CRTM website and Google Maps. Since 2015, real-time travel information is provided directly by CRTM via an app called `*mi transporte´* for mobile devices. The app, partially financed with European funds, integrates data from 40 operators and allows users to obtain information about the nearest transit stop, the availability and accuracy of route, as well as real-time transit vehicle arrival information. At the time of the writing of this paper, other third party organizations such as Google Maps did not have access to this information and therefore they could only recommend the best route alternative on the basis of their own algorithms.

Impacts of transport integration

The transport integration strategy in Madrid can be considered a success in terms of promoting public transport usage because it has increased the number of trips made by frequent users and the likelihood of attracting new ones. As Figure 3.4 shows, ever since the creation of the public transport authority, the usage of public transport has risen by 45.8% despite the negative impact of the economic crisis in the last few years. According to Matas (2004), the introduction of an integrated fare system for the whole region was a key element for success in reversing the declining patronage trend of public transport in the city.

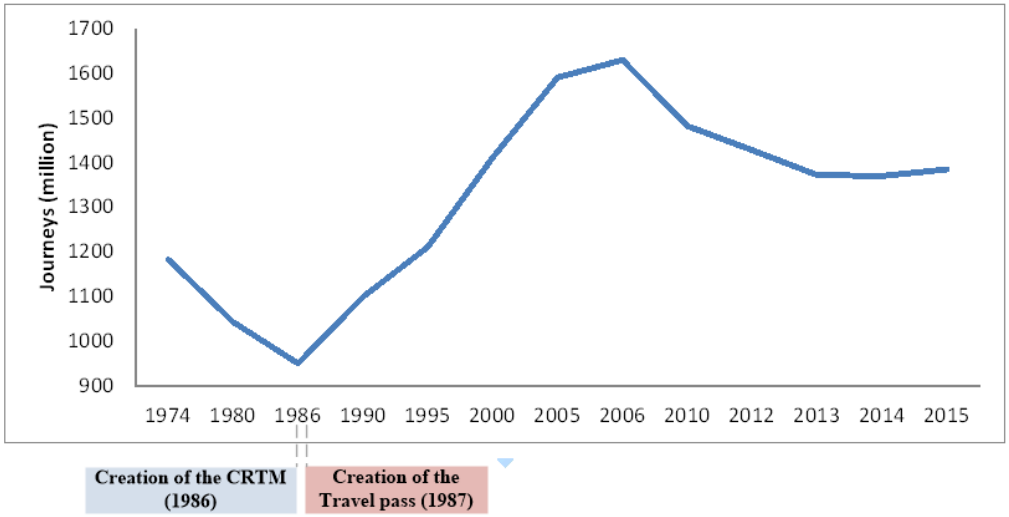

Figure 3.4 Evolution of public transport demand in Madrid

Source: CRTM, 2015.

Other benefits derived from the construction of intermodal interchange facilities have been discussed in the literature, including reduction in the buses' travel time and consequently in operation and environmental costs. Particularly, Di Ciommo et al. (2009) reported a reduction of 39% in the users' travel time and a bus patronage increase between 15% and 30%.

Before the implementation of the fare integration policy in Madrid, individual transport modes already received specific subsidies. However, the new integration policy implied the need for much greater subsidies, and the subsequent commitment of the regional and municipal governments to provide them. A more detailed analysis of this policy will be conducted in the following chapter.

Ever since the implementation of the travel pass, due to the economic boom of Madrid's economy till 2008, politicians in office were reluctant to raise public transport fares (specially the travel pass) for electoral reasons while at the same time they kept on investing to provide greater quality and accessibility to the users. This has been conducted at the expense of increasing public subsidies over time. This fact explains why the coverage ratio of the system went down till 2008 (see Figure 3.5).

With the arrival of the economic crisis in Spain in 2008, the EU obliged national and regional governments to cut down public expenditure, and subsidies to the public transportation system was not an exception. As a consequence of that, governments were forced to raise fares and curb costs (reducing frequency in some lines, closing exists at stations, etc.). This fact demonstrates how important is to keep the right balance between fares, subsidies and financial sustainability when fare integration is implemented.

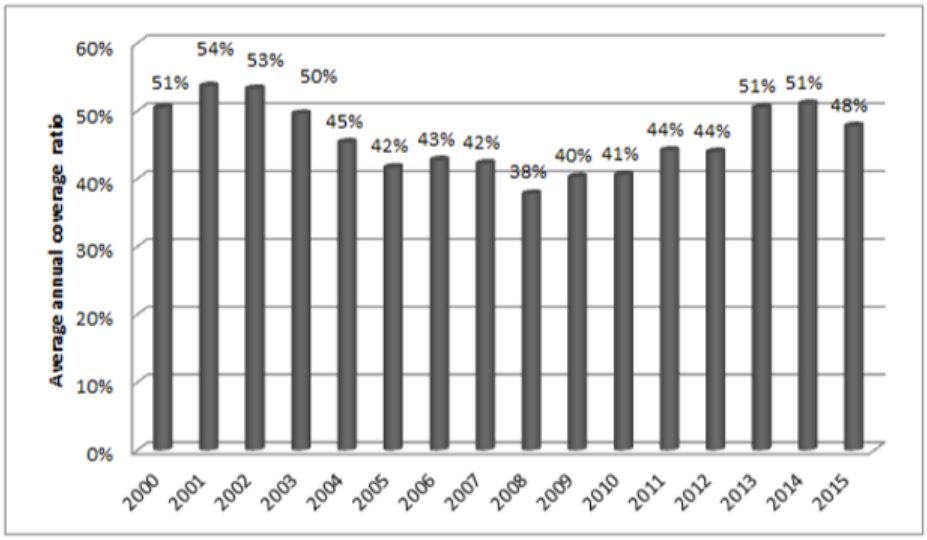

Figure 3.5. Evolution of the coverage ratio in Madrid
Source: Bueno (2017).

Unlike the case of London, the impacts of the different dimensions of transport integration in Madrid have not been extensively reported in the literature. Most of the results, published by the CRTM, have been devoted to the quantification of the effect on total patronage. However, it is worth mentioning the research conducted by Bueno et al. (2016) concluding that the public transport policy in the city is progressive with respect to income since it establishes a fair treatment between individuals with different income levels. However, more analysis is needed

to determine the impacts of the new cards available for users in Madrid and to quantify other effects from the different dimensions of the integration policy.

The case of Bogota in Colombia

Colombia´s capital has a population of 8.2 million inhabitants with an average density of 5,184 persons per square kilometer[18]. As a response to the challenges associated with public transport services and systems, Bogotá implemented an iconic bus-based mass transit service named `Transmilenio´. This experienced has been key to prove that Bus Rapid Transit (BRT) systems can provide a fast, comfortable, and cost-effective transport service, at a lower cost than a rail-based transit system (e.g. typically a BRT cost between 10 to 100 times less). An exhaustive analysis of the characteristics of the Transmilenio system can be found in Hidalgo et al (2013).

Following the successful best practices in Curitiba (1974) and in Bogotá (2000), bus rapid transit systems in the region have gained popularity. Up to now, 54 LAC cities (13 countries) have adopted bus-based transit systems. Most of them have adopted the `management competition´ model (Hook, 2005; Wright, 2011) under which the public authority maintains the planning and policy role, while an operating bidding process encourages competition for the market among bidders. The mass transit system in Bogotá operates under a public-private partnership mechanism in which the city administration is in charge of the infrastructure (construction and maintenance), while private operators provide the necessary buses and guarantee the services agreed upon the concession contracts.

After this experience, the Andean city decided to undertake a citywide reorganization of the public transport system thought an integrated approach. Under this new scheme named `SITP´ (*Sistema Integrado de Transporte Público*), the city was divided in thirteen zones awarded to a transport provider selected through a competitive bidding process. However, the implementation of a holistic integrated transport system in Bogotá is still in a very early stage, and has some crucial issues to overcome. The main objective of this section is to discuss the experience of Bogota regarding public transport integration. As previously done for the cases of London and Madrid, the approach to be used will be structured on the basis of the dimensions of transport integration set out in Section 3 (see Table 3.1).

Institutional framework

The implementation of BRT´s systems in LAC has fostered the development of new institutions in charge of the planning and management of the system´ transport services. These bodies, commonly set up outside existing public institutional frameworks, have represented a change of paradigm with respect to the provision of high-quality transport services. In this context, the success of Transmilenio in Bogotá can be largely explained by the institutional framework operationalized through the creation of Transmilenio S.A, a BRT authority in charge of the planning, management, and control of the service. A detailed explanation of the BRT authority´ administrative structure in Bogotá can be found in ITPD (2017).

On the other hand, it is worth mentioning that Transmilenio has been considered as a milestone for a citywide transport reform. Indeed, besides managing the BRT in the city (operated through

[18] Data from DANE (National Department of Statistics).

contracts by private concessionaires), Transmilenio S.A has been entrusted the organization and management of the new integrated transport system in the city[19] (SITP). The effectiveness of Transmilenio S.A in terms of the management of the integrated transport system cannot be yet assessed as the implementation of the SITP is still at an early stage. Anyway, the creation of this institutional structure has played a key role in the efficiency, the quality of service, and the cost of operation of the BRT system in the city. According to the experience of Bogota, a new administrative structure originated by the BRT system may overcome the lack of institutional and technical capacity associated to existing public transport departments.

Infrastructure and operation

In addition to the institutional framework, the implementation of a BRT system in the capital required strong political willingness coupled with significant public investments. In fact, Transmilenio System represented the largest investment in public transportation in the country in the last decade. At the time of the writing of this paper, Transmilenio had completed three (112,9 km) of the six phases (388 km) originally planned, achieving coverage of 26% of the public transport trips in the city (Hidalgo and King, 2014)[20]. Initially, the plan envisaged an investment amount of around USD 1,970 million in infrastructure and USD 960 million in buses and fare collection systems (Conpes, 2000). However, capital costs have been revised upwards from USD 7 million per kilometer to USD 18,6 million (first phase), 33 million (second phase), and 24,6 million (third phase) —see ITDP (2017). Cost overruns have occurred in a large extent due to land and property acquisition costs greater than expected to implement the project.

In order to facilitate a seamless integration i.e. transfers among trunk routes, between feeder and trunk routes, and between other modes, the system required the construction of different integration facilities. Presently, Transmilenio uses a combination of the following intermodal exchange options: 9 terminals (*portales*), placed at the end of the trunk routes where trunk-feeder interchange can take place, and (ii) 1,380 stations, including simple stations and intermediate interchange stations[21], which also allow passenger transfers from feeder buses.

On the other hand, the integrated system covers 1,180 km and is currently using a total of 7,157 standard zonal stations (*paraderos zonales*) where passengers can board: urban (blue buses, running within the city), complementary (orange buses, providing services from/to the surrounding areas), and special SITP buses (dark red buses, providing services from/to peripheral areas of the city). The cost of the transition from the existing system to SITP was estimated to be about USD 400 million (Cubillos Murcia, 2013). However, the city of Bogotá adopted a gradual implementation process for the SITP, and it has not been completed until now. Despite the complete operation of the system was projected for 2014, up to date, the progress in the implementation of the integrated system is still limited. For example, the system planned a total of 450 routes served by 10,550 buses, but presently the SITP serve 245 urban routes with a total

[19] In spite of the existence of a local public institution in charge of the urban public transport system *Secretaría de Movilidad*).

[20] It means that most of the public transport remained in traditional public transport, characterized by a poor level of service.

[21] Intermediate stations are situated at a few locations (7) to allow interchange with feeder buses. In contrast, simple stations are located approximately every 500 - 750 m.

fleet of 6,672 vehicles (Transmilenio, 2016). In this respect, Hidalgo and King (2014) identified the following major hindrances of the SITP in Bogotá:

- Infrastructure delays.
- Difficulties in removing existing bus routes and scrapping existing old vehicles.
- Lack of transparency in the financial conditions such as subsidies.
- Difficulties in integrating the legacy fare collection system with the new system, due to contractual barriers.

Integrated payment

Fare integration is another key factor for the successful implementation of the SITP in the city of Bogotá. Due to contractual issues, the new system started operation in 2013 without a complete integrated payment with the collection system of Transmilenio phase I and phase II. In November 2012 the payment was integrated for the Transmilenio system, but still could not be used for the SITP. On the other hand, the SITP implemented his own smart card called "*tu llave*", initially applied for Transmilenio phase III. It was not until 2015, after different gradual advances, when fare collection operators reached an agreement and a total integrated payment took place in the entire bus system.

Presently, a seamless payment across the SITP-Transmilenio bus services within the city is ensured. SITP passengers pay US$0.78 for a single ticket if they use Transmilenio (trunk services) and US$0.71 if they use urban, complementary or special SITP buses (zonal services). When a transfer from a zonal service to a trunk service takes place using the "tu llave" card, customers are required to pay an additional fee (US$0.07). While other transfers are free (among zonal services and from a trunk to a zonal service). There are two particular conditions applying: (i) only two transfers are allowed between the services, and (ii) the user has a maximum of 95 minutes to make the transfer.

Despite the fact that fare integration in the Bogota includes a multimodal fare with a penalty for changing from one mode to another, it has substantially improved value to users when travelling among the different routes in the city. However, there is still a long way to go to get full integration in Bogota. For example, there still exist remaining traditional bus services, carrying daily more than 1.5 million of passengers and operating in parallel and independent of the integrated system (see Semana, 2017).

Information integration

Given the complexity of the transport system in the city, different options are available for traveling easier. Transmilenio and zonal stations (*paraderos zonales*) are provided with static information about bus stops, routes and schedules. SITP buses by themselves reinforce this information by carrying a poster (*rutero/tablero de ruta*) showing the itinerary of the route. However, real-time information on arrival times is not provided at the bus stops/stations.

In addition to information on routes and connections provided at stations and terminals, staff is available to help customers and respond to passenger queries. An alternative to selecting routes is to use digital information to plan multimodal trips effectively. At the time of the writing of this paper, this information was available to the users through Google maps, TransMi App

(official application of Transmilenio S.A) and Moovit (a multimodal public transit journey planning service). Passengers using Moovit can make better decisions about how to reach their destinations, while rating the route service, the driver, the cleaning and the crowding level, among other characteristics.

Impacts of transport integration

Transmilenio demand has rapidly grown since it was first launched. As pointed out by Hidalgo et al (2013), it has increased from 14,000 passengers per day in December 2000 to 1.7 million in 2013. In 2016, the annual total number of passengers travelling by Transmilenio was about 690 million (see Figure 3.6 —*Troncal serie*). It has been regarded as the major achievement of Bogota´s transport system in the last 20 years. The success of Transmilenio represented a milestone in the transformation of the city in terms of mobility, public space, quality of life and citizen culture. On the other hand, passenger demand has been steadily increasing since the implementation of the SITP in 2013 (see Figure 3.6 —*Zonal serie*). This increase is associated to a decrease in the number of passengers using traditional buses, known as "Transporte público Colectivo or TPC" [22] (see Figure 3.6 —*TPC serie*).

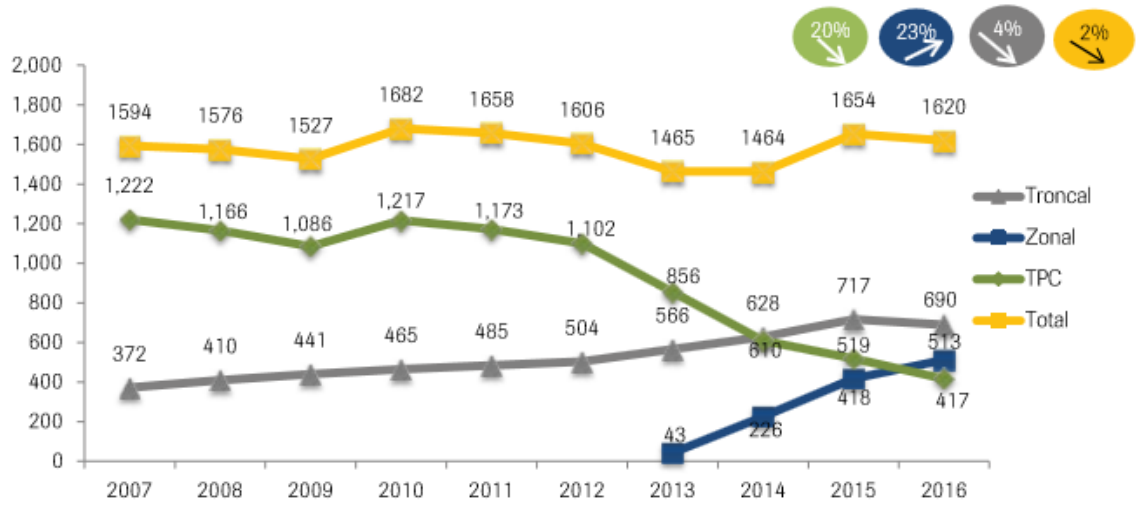

Figure 3.6. Evolution of public transport demand in Bogotá (in millions of passengers)
Source: Cámara de Comercio de Bogotá-Universidad de los Andes, 2017.

Unlike the cases of London and Madrid, the policy of transport integration in Bogota does not indicate substantial increases in patronage. This can be due to the fact that the majority of public transport users are captive-riders and that the integrated system has not been attractive enough to encourage the use of public transport modes in the city. In fact, the number of trips made by car increased by 17% from 2011 to 2015.

Nevertheless, unlike other large cities, in the last 10 years Bogotá has managed to maintain a share of public transport above 40%, while the percentage of trips by private vehicles remained below 24%. The evolution shown in Figure 3.6 can be considered the main impact of the

[22] Due to the scrapping process of existing old buses carried out after the implementation of the SITP.

Transmilenio-SITP: a relative stability in the public transport modal share. Cycling and walking are also very relevant in the city (25%) —see Cámara de Comercio de Bogotá-Universidad de los Andes (2017). Currently, the modal share of public transport represents 64% of all the trips in the city, private modes (car and motorcycle) around 16% and walking and biking around 13.5% (Bogotá cómo vamos, 2017). Another result of the approach developed in the city of Bogota is the implementation, for the first time to a large scale, of transport subsidies to the most needed people (low-income groups, disable and elderly people).

Despite the positive impacts of the public transport integration in the city, the process has been tremendously complex and there are still many unresolved problems, especially in relation to service and infrastructure management. Examples of such problems include delays in the expansion and improvement of existing BRT infrastructure, slow progress on the SITP implementation, and a persisting competition between traditional old buses (still representing a 9% of the total trips made in the city) and the integrated transport system of the city.

3.5 COMPARISONS ACROSS CASE STUDIES

After analyzing each city on an individual basis, the present section conducts a cross-city assessment of the fulfillment degree of the dimensions of public transport integration displayed in Table 3.1 of this Chapter.

Table 3.3 provides a qualitative comparison of the different case studies analyzed on the basis of the literature review described above. Each column describes to what extent the four dimensions previously explained are met by each city. In order to facilitate the interpretation of the analysis, we set an assessment "score" that follows these principles: "●" for a dimension which is covered by the integration policy of the city, "≈●" for a dimension which is covered but could benefit from some minor improvements, and "○" for a which is partially covered by the city integration policy and still needs some major improvements. The scoring comes from a consensus of the authors of this paper made after a careful review of the scientific literature and the state of practice. In any case, it does not constitute an absolute assignment, but serves as a point of reference for what is considered acceptable for the right integration of public transport systems.

As can be evidenced in Table 3.3, the case of London is a best practice in the field. Despite the complexity arising from the fact of being a megacity, London has managed the `basic dimensions´ that need to be accomplished for an integration policy to be successful. It was able to physically and structurally integrate all the transport networks and services within the city, to build a proper institutional structure, and to integrate fares to allow easy transfer across modes. In its turn, the case of the region of Madrid is also remarkable since most experts consider its policy for public transport integration to be also a best practice. For example, the system could benefit from an enhancement in the provision of real-time information provided to the user, or a simplification in the fare scheme since the options have grown large and require rationalizing.

Another main result coming out from Table 3.3 is that despite Bogotá has made enormous progress; it still requires structural changes to guarantee the success of the public transport integration policy. Although the approach applied in the Andean city has been notorious, it still does not address all the dimensions of transport integration in a thorough way (see Table 3.3).

In particular, integration should be understood from a city-wide perspective and a number of obstacles should be resolved: (i) service and infrastructure improvements, avoiding duplication of services, (ii) full completion of the SITP, and (iii) a more convenient fare integration, ideally through a common fare card allowing passengers to use any service in the city without having to buy a new ticket or purchase a different card. The system should also be aware of the risk of over-encumbering Transmilenio S.A. with more tasks and responsibilities than it can handle.

Table 3.3. key foundations of transport integration in London, Madrid and Bogotá

City/ Dimension	Physical and Network integration	Fare integration	Information integration	Institutional integration
London	● - A number of multimodal facilities and physical adaptations are provided by the system. - Transport networks (e.g. bus, rail or tram network) are organized to provide maximum integration.	● All the systems use the same fare media (Oyster card), which allows to travel on bus, Tube, tram, DLR, London Overground, TfL Rail, Emirates Air Line, River Bus services and most National Rail services in London.	● Customer Information is provided through static, print, and real-time information sources. Departure/arrival times, trip planning and special events travel are also available to the user.	● Constitution of an integrated transport authority (Transport for London) responsible for most aspects of London's transport system (coordination of services, transport network, fares, congestion charge).
Madrid	● - Transport interchanges and other facilities provide access to the system and facilitate the integration. - Existing transport networks are organized to share resources and maximize coverage.	● Integrated fare payments across various transport systems. Two smart cards available (*Tarjeta multi and tarjeta de transporte público)*, which allow traveling on metro, light rail, commuter rail and urban buses in the city.	≈● Public timetables and maps are provided at stops/stations. Real-time information is also provided at metro/rail stations and at the bus stops with the greatest demand. The system could benefit from advances in technology making information integration easier.	● Creation of a regional public authority (Consorcio de Transportes de Madrid) in charge of the coordination of the services, networks and fares of the different modes of transport operating in the region.
Bogotá	○ - The new SITP system integrates bus rapid transit corridors with a network of bus routes on arterials and feeder zones. However, the system does not provide full coverage in the city and future networks integrations are still necessary (i.e regional network, metro) - Service and infrastructure improvements are required. In addition, the implementation of the SITP has to be completed.	○ Passengers are allowed to travel among the different transport modes offered by the city at a discounted fare. Two smart cards available (*Tu llave* for the SITP, and *Tajerta cliente frecuente* for Transmilenio users). However, users may incur a penalty fare whenever transferring between systems.	○ Stations and terminals are provided with extensive information on routes, connections and tickets. Available digital information also helps customers plan their trips. However, more real time information is needed to ensure information integration at stops/stations.	≈● As a result of historical circumstances, a new transit authority was not created to run the SITP system. These responsibilities have been added to a preexisting institution already managing the BRT system in the city (Transmilenio S.A). There is a risk of over-encumbering this institution with more tasks and responsibilities than it can handle.

Source: Author´s elaboration

On this basis of the good practices previously identified, a set of guidelines is outlined in order to provide cities with a sound path for moving towards an integrated transport system. The following "roadmap" is suggested for Latin American governments that have not implemented yet any integrated policy:

1. Prepare to implement an integrated transport policy. A new integrated transport system does not create by itself. Planning guidance should be provided by central or local governments. A proper integration strategy should be based on good planning processes which clearly define the financial, institutional and physical viability of the integration policy. This requires comprehensive evaluation of the potential costs and benefits of integration.

2. Create the institutional conditions. Effective and transparent institutional arrangements play a vital role in supporting multi-modal transportation policies. Building an optimal institutional and legal structure is strongly recommended for achieving transport integration. As abovementioned, the creation of a single authority represents a best practice to manage integrated transport services.

3. Build the physical system. Physical infrastructure and network connections are key to ensuring seamless integration across various transport modes within a city. The so-called "hardware" of the transport system includes all the necessary physical structures and network connections for providing access to the system and maximizing coverage among metros, urban rail and buses services. Although the system´s design depends upon several factors such as cost, functional attributes and other context conditions, it should always be performed to allow maximum integration and achieve a high quality of service.

4. Embrace fare integration. Integration of fare payments constitutes a requirement for effective modal integration. It benefits transit operators (e.g. potentially increases in ridership, reduction of fare evasion), passengers (time savings, improvements in rider convenience, potential subsidies), and citizens (reduction of pollution and other economic benefits from using more sustainable modes, etc.). An integrated fare scheme also requires to evaluate the financial sustainability over time of the subsidies necessary to cover the costs of the system. These subsidies can be effective means to make low-income people better-off.

5. Enhance customer information, marketing and promotion of the integrated transport system. Providing comprehensive information to users, including people with special needs, is crucial for the successful implementation of a multi-modal system. Different sources should be properly designed to deliver convenient and reliable information to users on their mobility and accessibility options. Furthermore, building public acceptability is an important step for catalyzing new transport integration policies. The perceived sentiment of fairness towards integration strategies is expected to increase if the purpose and the benefits coming from this policy are clearly understood by the society.

4. SUBSIDY POLICIES TO PUBLIC URBAN TRANSPORT

4.1 INTRODUCTION

Urban public transport —also called transit— is an essential driver to promote sustainability in cities. However, the experience shows that encouraging people to switch from their private cars to transit is not an easy task. This issue is accentuated insofar as per capita income grows in many cities. Increasing the transit share reduces energy consumption, improves the environment, and alleviates congestion produced by cars. Public transport subsidies have been usually justified as effective means to encourage sustainable mobility from the economic, social and environmental point of view. Subsidies contribute to make mobility more efficient in urban areas by reducing transport costs and energy consumption, by internalizing externalities (such as congestion and pollution), and by providing greater accessibility to the poor.

Transport subsidy policies substantially vary from one country to another. In many Latin American cities, transport authorities are too much focused on covering public transport costs, and they give little importance to other environmental and social goals reached by subsidies. In contrast, for most European cities, subsidies are understood as a crucial mechanism for achieving a more sustainable mobility. As a consequence, in European cities fares cover on average just 50% of operating costs (Brueckner, 2005).

Subsidy policies face however important challenges. The first one is that governments have to make sure that they will be able to pay the subsidies committed for a long period of time regardless of the evolution of the economy or the political changes. The second one is that subsidies are sometimes used by governments for electoral reasons, by for instance increasing them to reduce public transport fares; rather than as a means of achieving economic, environmental and social goals. This problem has compromised financial sustainability in some cities.

To date, the scientific literature has been mainly focused on analyzing the impact of subsidies from the demand point of view. To that end, different quantitative and qualitative studies have been developed with the objective of evaluating the equity and distributional consequences of these subsidies. However, in addition to the importance of determining whether these policies meet their social objectives and promote social inclusion, analyzing subsidies from the supply side is also key aspect to assess.

On the basis of these considerations, the objective of this paper is to contribute to the literature by analyzing the institutional processes and mechanisms for the right allocation, control and supervision of public transport subsidies in cities. As far as the authors are concerned, this is among the first works exploring this issue from an overall perspective. Through a critical evaluation, this study provides recommendations to LAC regarding the institutional processes for setting, monitoring and auditing subsidies, to reach the right balance between the fulfilment of their economic, social and environmental goals, and the achievement of the reasonable financial sustainability over the years to guarantee that subsidies do not undermine the right balance across different public policies.

Apart from this introduction, the chapter proceeds as follows. Section 2 analyses the current situation of public transport subsidy policies in the Latin-American context. Section 3 identifies the main reasons found in the literature for the implementation of public transport subsidies. Section 4 characterizes the main challenges that public transport policies face nowadays. Section 5 examines in detail the provision of transit subsidies in three cities: London, Madrid and Bogotá. Finally, in Sections 6 a cross-sectional analysis of the various cases previously described is conducted aimed at providing recommendations for the case of Latin America.

4.2 BACKGROUND: PUBLIC TRANSPORT SUBSIDIES IN LAC CITIES

Reducing poverty as much as possible is one of the most challenging goals for policy makers in LAC. By recognizing the role of transport in promoting better access to basic needs such as health, employment and education, many cities in the region have introduced in a way or another public transport subsidies. These subsidies have been usually justified on social grounds, as a means of making public transport affordable and accessible for the well-being of people, particularly for the most vulnerable segments.

Demand-side subsidies such as discounts for the elderly, students, or other specific groups are commonly used in LAC cities. Supply side subsidies such as capital and operating costs subsidies directly channeled to transport providers, with the final objective of keeping fares low are also implemented in some cities. Some of the most remarkable examples of these subsidies are displayed in Table 4.1, along with a synthetized discussion of their main characteristics and supporting references (reference column of the table).

Table 4.1. Examples of subsidies to public transport in LAC

Type of subsidy	Case study	Explanation	References
Conditional cash-transfer programs	• *Chile Solidario* Program (Chile) • *Bolsa Familia* (Brazil) • *Familias en Acción* (Colombia) • *Asignación universal por hijo* (Argentina) • *Oportunidades* Program (México)	Social programs at the national level based on direct cash payments from the government to low-income households, intended to be spent on food and education. Potential beneficiaries of these instruments —people living in extreme poverty conditions— can qualify for other specific programs such as the pro-poor transport subsidy in Bogota (Colombia).	-Mehndiratta et al. (2014). -Serebrisky et. al (2009)
Pro-poor Transport subsidy	Transport benefits for people of the lowest socioeconomic level, called "*Beneficios de Transporte para personas sisbenizadas* in Bogota" (Colombia)	Discounted fares for low-income people living in Bogota (around 25%) to travel across the new integrated transport system in the city. These subsidies are established through a special smart card, by using the country´s poverty targeting system and database.	-Guzman and Oviedo (2018). -Rodriguez et. al (2015)

Type of subsidy	Case study	Explanation	References
Transport benefits	*Vale-Transporte* (Brazil)	Benefit created by the Government in 1985, whereby employers contribute to cover public transport commuting expenses of employees. Under this this scheme, employers retain 6% of their employee´s salary and complement the rest as a tax-deductible expense. If workers opt for this program, they receive transport vouchers for their home-to-work and return trips. Since its establishment, this mechanism has proven to be advantageous to transit authorities, as well as to employers and employees.	-Lima and Faria (1999).
Flat fee tariff structures	• *Billete Unico* in Sao Paulo and Rio de Janeiro (Brazil) • Flat fare tariff structures in Mexico	Integrated fare payments across various transport modes. Travel passes are flat fares suitable only for frequent users and implying implicit cross- subsidy.	-Neri (2011). -Flynn (2007).
Subsidized fares	•Preferential rates for students and the elderly in Santiago (Chile)	Transit passes targeted to the population with disadvantaged status (physical disability, elderly, unemployed, students).	-Gomez-Lobo (2009).
Free Feeder and social services	Metro cable in Medellín (Colombia)	Cable-car based transit systems have been designed to improve access to deprived areas in hilly zones. Operating as free feeders to the massive transport system, they have increased employment opportunities to residents of poorer neighborhoods.	-Bocarejo et al. (2014).
Policies for keeping low transit fares	Fuel Price Stabilization Fund in Chile	Policy mechanism that defines the percentage of increase in the prices of fuel, by establishing tax credits or taxes in order to avoid significant variations in final consumer prices. In practice, it has operated as a subsidy mechanism which has kept public transport fares lower.	-Márquez (2000). -Zapata et al.(2012).
Capital subsidies	Transmilenio in Bogotá	TransMilenio, one of the world´s most iconic bus rapid transport systems, could not have been implemented without the national government support. These grants supported up to 70% of the infrastructure capital costs of the system.	-Bocarejo and Tafur (2013). -Hidalgo (2004).
Operating subsidies	Operating subsidy for the buses in Argentina	Subsidies from the national government to help cover the costs of operating and improving bus services. The amount of subsidies depends on the number of passengers transported and the kilometers operated.	-ASAP (2014). -Serebrisky et. al (2009).

Source: Author´s elaboration

Overall, in the last few years, many countries in LAC region are following the worldwide trend towards subsidizing public transport. As shown in Table 4.1, transport subsidies are ubiquitous in some cities. Different kinds of subsidy schemes are currently applied, including subsidies aimed at

encouraging the use of public transport modes —thus increasing efficiency and sustainability in daily mobility patterns—, and those based on equity reasons, which are targeted directly to disadvantaged people to make urban transport more affordable for them.

One of the key questions is to what extend public transport subsidies are effective means to make low-income people better off. Current literature suggests that in most cases public transport subsidies are not that progressive (Gomez-Lobo, 2009)[23]. However, this conclusion should be analyzed with care, taking into consideration that in LAC there are still many informal services, mostly used by the less wealthy people, which do not qualify for subsidies while they offer low quality standards for users and the community. Under this panorama, the lowest-income people of developing cities are not receiving benefits from public transit subsidies. Finally, as pointed out by Serebrisky et al. (2009), there are structural limits to public transport subsidies due to the non-universal nature of accessibility for all segments of the population. Hence, besides the issue of targeting the right population, due to the multidimensional characteristics of poverty, the capability of transport policies to help lower income households is constrained.

The following section provides a knowledge base for the reasons behind the use of transport subsidies. An analysis of the recommendations from the literature about the main theoretical and policy-oriented explanations for the establishment of subsidies will be presented. In addition, a description of the main budgetary sources used to finance these supporting mechanisms will be reviewed.

4.3 LITERATURE REVIEW

Subsidies have been a transportation policy advocated by economists for many years. On this basis, an overview of existing reasons for subsidization of transport is provided throughout this section. From a practical point of view, we also provide a short overview of the main funding sources of transport subsidies, including government grants, cross-subsidies and other alternative sources.

What reasons justify transport subsidies?

Subsidization to urban transport has been extensively applied throughout the world. Some countries directly provide benefits for disadvantaged people or set fares for public transport systems below the break-even point, thereby requiring public subsidies to cover operating costs. Being a common practice in real-world policy planning, transit subsidies have been widely considered in the literature for decades —see for example Frankena (1973), Pucher et al. (1983) and Asensio et al. (2003), and remain one of the most debated topics for transportation planners and researchers.

Basically, the results of these studies and other relevant research pieces show that these policies may pursue the following major objectives:

- To promote a higher modal share for public transport.

[23] For further details on this matter, please see section 3.

- To reduce transport externalities directly associated to the use of the private vehicle, such as congestion, pollution and accidents.
- To make a more rational use of the existing public transport infrastructure.
- To guarantee access to affordable travel options for physically, economically and socially disadvantaged groups.

In this way, the main arguments that support the implementation of transit benefits can be broadly grouped into two main categories, including efficiency and social equity.

- The so-called `economic efficiency criterion´. According to a number of authors —see for example Gomez-Lobo (2009), Parry and Small (2009)— this argument is considered the main justification for the existence of public transport subsidies. The idea underlying behind this principle is that by providing subsidies, the society as a whole will be better off since subsidies will contribute to reduce congestion and other externalities associated to the use of the private vehicle. Furthermore, on the basis of this criterion, scale economies, pre-existing distortions in the economy and market imperfections constitute reasons for justifying transport subsidies. A detailed description on this idea can be found in Estupiñán et al. (2008).
- The so-called `social equity´ criterion, closely related to the concept of fairness has the objective of ensuring that all population groups receive a fair treatment with regard to their travel options. However, as Nuworsoo et al. (2009) observed, only a few authors have looked at equity aspects of transit fare policies per se. Equity considerations associated with the distributional incidence of subsidies have hardly ever been studied using rigorous approaches, as the common perception is that subsidies always have progressive distribution effects (Vassallo et al., 2009).

A detailed analysis on the application of these criteria (the economic efficiency criterion and the social equity´ criterion) to the Latin American context is provided by Estupiñán et al. (2008). In summary, the justification for transport subsidies depends on the local context where the policies are going to be implemented. However, the more developed the country, the less valid the social argument becomes for the subsidization of transport.

Main funding sources for transit subsidies

There are a significant number of studies intended to identify funding options for public transport systems. A comprehensive compilation and summary of this literature is provided by Ardila-Gomez and Ortegon-Sanchez (2016), and also by Litman (2013). The objective of this section is to explore, from the practical standpoint, different funding sources for transit subsidies. Figure 4.1 presents a summary of how transit is funded, and highlights where subsidies may come from (cross-subsidies from other users, taxpayers, etc.). In the following paragraphs, an explanation of the specific funding sources is provided.

From a broad perspective, a rider is subsidized when she/he pays for the use of public transport services a price lower than the operation cost (including the depreciation cost of the infrastructure) attributable to her/his trip. Assuming this definition, subsidies may come from different sources such as cross subsidies from users (from public or private means) that pay higher fares than their

costs, earmarked taxes allocated to finance public transport subsidies, the general budget, or other alternative revenue sources.

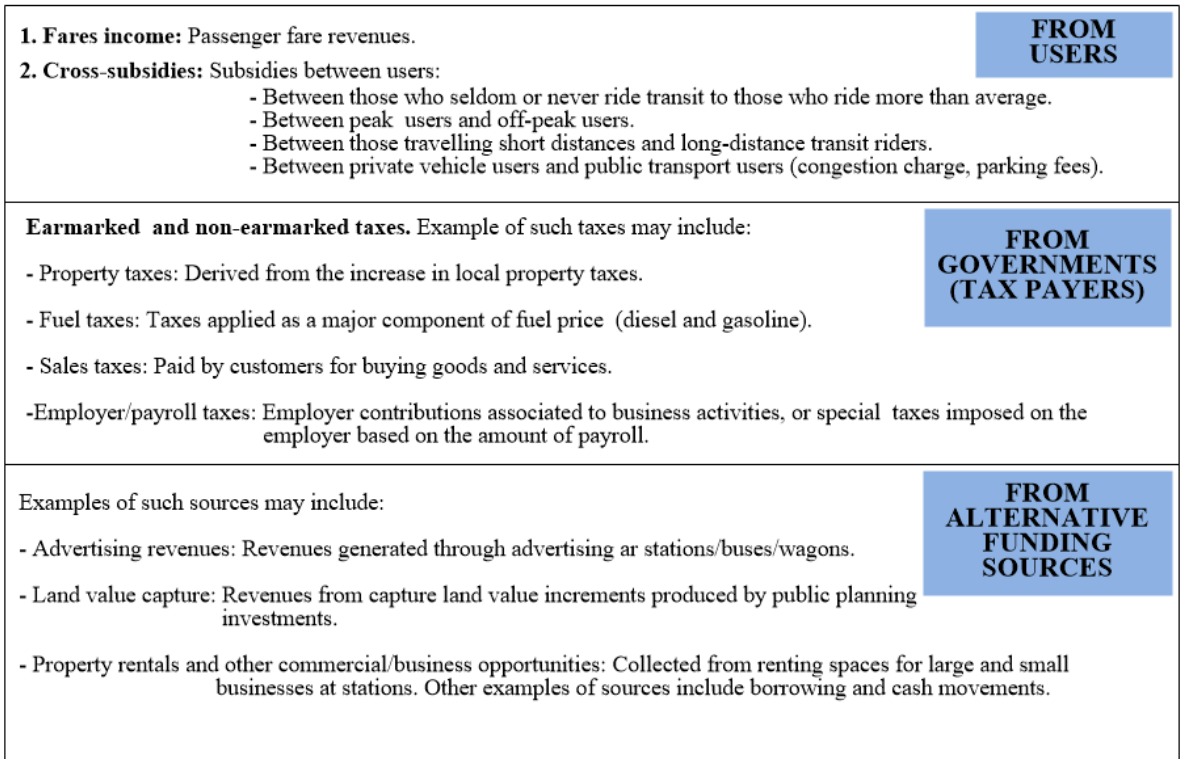

Figure 4.1 Typical funding sources for public transport
Source: Author´s elaboration.

According to this definition, Figure 4.1 shows different sources for funding transit costs. Traditionally, fares are the main source of income for local transport authorities. This includes cross-subsidies, where users paying more finance part of the travel cost of user paying less. These cross subsidies may also take place between peak and off-peak users, regular and non-regular users, etc. Cross subsidies may also come from private car users through for instance congestion charges. Transport authorities can also generate income from other sources such as advertising or shopping rents.

In most of the cases, however, the difference between fare revenues and transport costs should be covered with other sources, including grants from central and local governments. These grants are commonly based on earmarked taxes collected by the authorities, or budgetary items allocated from general taxation sources. Examples of sources allocated to finance public transport in some countries include property, fuel and other income and payroll taxes imposed on the employer based on the amount of payroll. Employer taxes to help finance local public transport infrastructure and services (such as the Versement Transport applied in France) can be included in this category.

A detailed analysis on these sources of funding for public transport can be found in Ubbels et al. (2001).

Besides the wide variety of schemes previously described to finance public transport subsidies, new forms of obtaining funds are being sought. Indeed, non-transportation specific revenue sources are currently being used by local transport agencies. Such is the case of advertisement, added value capture mechanisms, property rental, property sales and other commercial development opportunities such as 'click and collect' at transit stations.

No matter the funding sources employed to cover public transportation costs, it is crucial that transport authorities find the right balance between efficient and affordable prices and the financial sustainability of the system. As implementing transit subsidies often causes an impact on the financial resources of the system, city leaders should be able to explore alternative funding schemes. This situation is particularly important for cities of the Global South, commonly facing limited resources.

4.4 CHALLENGES OF SUBSIDY POLICIES FOR PUBLIC TRANSPORT

As it was previously shown, public transport subsidies, as long as they are correctly addressed and targeted, may be a powerful tool to improve welfare and quality of life in urban areas. However, practical experiences around the world demonstrate that providing subsidies is not such an easy goal for transport planners. This section makes an in-depth reflection about the main challenges that subsidy policies have to address to be fully effective.

Providing subsidies in the right way requires a good combination of two types of policies. The first policy (demand side) should focus on setting the right public transport fares and henceforth establishing subsidies according to economic, social and environmental objectives. The second policy (supply side) should ensure the necessary resources to subsidize the public transport systems. According to this classification, we look at the challenges from a triple perspective: challenges related to ensuring the necessary funding sources to provide the subsidies, challenges related to the setting of right fares and subsidies to public and private transport means, and challenges aimed at achieving the right coordination between supply and demand policies.

Ensuring funding sources to provide subsidies

Once assumed that subsidies are necessary, it is crucial to identify the right sources to guarantee that they will be available to cover the needs over a reasonable period of time. In order to address this issue, it is possible two identify two subgroups of challenges. The first one refers to setting the right means to capture all the resources directly associated to the value produced by public transportation or the charges applied to internalize the externalities of substitute modes. The challenges for governments, planners and transport authorities associated to this subgroup are the following:

- Ensuring that charges aimed at internalizing externalities from alternative transport modes (especially the private car) are allocated to fund the whole public transport system. For instance, if a road charging approach is implemented in a city, it would make sense to allocate those revenues to finance public transport subsidies.
- Earmarking to public transport funding a percentage of certain special taxes whose value has clear influence on the transport system or depend on it. There are taxes, such as vehicle

ownership taxes or fuel taxes, that play a key role to balance the use of different transport modes in the city. Similarly, property taxes, usually linked to the cadastral value of a property, are clearly influenced by public transport accessibility.

- Setting up measures to capture the external value produced by public transport as a means of raising resources to finance it. Public transport systems produce many positive externalities that are often difficult to capture. The construction of a new metro station provides accessibility thereby making the area around it more attractive for retail and commercial activities, and subsequently increasing real estate prices. Transport authorities should do their best to find means to capture the value created and allocate it to fund public transportation systems.

In many cases, however, the sources previously mentioned are not enough to ensure the necessary funds to cover all public transport costs. In this case subsidies should come from budget items approved by the Parliament. The second subgroup of challenges, related to these issues, are the following ones:

- Setting up the right framework to coordinate the contributions all the governments involved in providing subsidies to public transportation systems. Metropolitan areas usually go far beyond the scope of a single municipality. This is the reason why it is not rare to see different governments (national, regional and municipal) contributing in a way or another to finance the public transport system. A key challenge is therefore to set an intergovernmental framework aimed at, on the one hand, defining the contribution criteria of each government; and, on the other, ensure that the necessary resources will be available.
- Developing the right budgetary programming to ensure that the budget will be able to comply with its commitments in a reasonable time horizon. One of the greatest risks of committing budgetary resources for years is that they are submitted to the uncertainty of the economic cycle. If the economy is not doing well, the budget may experience cuts that will likely affect subsidy commitments. This risk is really difficult to mitigate, as the evolution of the economy is not always easy to foresee. However, governments should at least conduct medium-term programs to predict the near future and adopt with enough anticipation measures to adjust the economic balance of the public transport system.
- Promoting mechanisms to monitor public subsidies so as to ensure that they are being used in the right way, and do not discourage the efficiency of operators. It is well known that public policies have a lot of inertia. If monitoring mechanisms are not applied in the right way, governments and public authorities run the risk of losing efficiency in the use of public resources. To avoid this problem, it is crucial that they set the right processes to monitor the use of subsides. This monitoring process, beyond a mere audit of the accounts, should analyze the impact that they have in the efficiency and competitiveness of the system.

Setting the right fares for public and private transport means

As it was previously mentioned, most of the literature on subsidies has to do with the setting of optimal fares since subsides are calculated as the difference between revenues, mostly depending on fares, and transportation costs. The way taxes are set has a clear influence on the ultimate subsides necessary to reach the break-even point. Some of the challenges for planners and transport authorities related to this subject are pointed out below:

- Defining clear criteria to set public transport fares. One of the main problems of many metropolitan areas is that there are not clear guidelines to set public transport fares. Unfortunately, fares are often fixed according to political reasons having to do more with social perception rather than with objective economic, social and environmental criteria. Transport authorities should define guidelines to explain to the public the reasons behind public transport fares.
- Setting public transport fares and private car charges considering the positive and negative externalities generated. The use of public transport produces positive externalities that justify the use of subsidies from a rational point of view. Moreover, private cars produce negative externalities, such as pollution and congestion, that have to be internalized. Fares and charges are to be calculated and adapted according to that criterion.
- Using price discrimination to reach efficiency and targeting subsidies in the right way. Price discrimination is a useful tool to optimizing revenue and targeting subsides pro poor. Subsidized flat fares usually benefit less wealthy people who live in the outskirts of the city and do not have access to a car. Lower fares at off-peak hours will allow a more balanced use of the network, and will facilitate poorer people the option of paying less.

Achieving the right coordination between transportation costs, fares and funding contributions

One of the main problems of subsidy policies is the lack of the right coordination between the three pillars that ensure the economic balance of any public transport system: transportation costs, fares and subsidies. This coordination should safeguard a reasonable balance between the three aforementioned pillars over a long period of time. This balance requires avoiding unnecessary investments in times of economic bonanza, having enough flexibility to adapt fares and subsidies to the changing circumstances, and foreseeing in advance the availability of necessary resources. It would not make much sense to set very low public transport fares if there is not going to be available sources to subsidize the system in the future. Likewise, it is not reasonable to invest in a very expensive transport system when users are not willing to pay for it, and taxpayers cannot afford it.

Below we show the main challenges for governments, planners and transport authorities to achieve a good coordination among these measures:

- Having flexibility and adaptation capacity to deal with changing circumstances. Unlike private companies, transport authorities and governments are subjected to administrative rigidities hindering the necessary flexibility to adapt fares, and transport services to the changing habits and needs of the population.
- Setting the right mechanisms to avoid that certain decisions are ultimately taken just on the basis of electoral criteria. One of the main causes explaining the lack of financial sustainability of public transport systems is precisely the decision of some governments to keep or even reduce public transport fares for electoral reasons at the expense of incurring large deficits and indebtedness that will be ultimately paid by future generations.
- Anticipating the future. Financial sustainability requires of transport authorities and governments to anticipate the future because there are key parameters of the equation that may experience important changes over the years. For instance, in the last few years, public transport patronage in some cities of developed countries is dwindling due to the irruption of

new mobility forms such as car-sharing and ride hailing. Similarly, the amount of subsidies to be provided depends very much on the evolution of the economy.

- Adopting rational criteria at the time of conducting long-term investments that require large financial commitments over a long period of time. Sometimes transport authorities seem to be guided by fashion rather than rationality at the time of selecting the right transport investments. Materializing large capital investments without evaluating the viability of financing them is usually one of the main reasons explaining the lack of financial sustainability.
- Conducting ex-post evaluation of the financing programs of the transport systems in order to evaluate whether subsidies are being used in the right way in order to learn lessons applicable to future experiences.

4.5 INTERNATIONAL EXPERIENCE

This section analyzes, in the context of public transport subsidies, three case studies in cities of developed and developing countries: London and Madrid in Europe, and Bogotá in Latin America. To evaluate institutional processes for setting, monitoring and auditing subsidies for each case study, we developed a questionnaire with eight targeted questions. The questionnaires were distributed to the corresponding transport authorities in charge of managing subsidies: Transport for London for the London case study (TfL), the *Consorcio de Transportes de Madrid* (CRTM) for the case study of Madrid, and Transmilenio (TM) for the case of Bogota.

The eight questions addressed in the questionnaire are the following ones:

1. What is the level of coverage of public transport subsidies compared to the operating costs of the transport system?
2. Through which institutions are public transportation subsidies channeled, managed and controlled?
3. From which public sources do these subsidies come from?
4. Is there any procedure or criteria to determine the level of subsidies that each public administration grants to the public transport system?
5. What degree of coordination exists between the subsidies and the public transport fares?
6. Is the process of fixing public transport subsidies coordinated with the fiscal policy of the government regarding the control of public debt and deficit?
7. Are there mechanisms for auditing and controlling the subsidies addressed to urban public transport?
8. Is there a specific source of financing, apart from fares and subsidies, to finance urban public transport?

The results obtained from the questionnaires are presented in the next sub-sections. The findings aim to provide a standardized approach to analyze how public transport subsidies are managed and controlled in order to produce useful lessons for Latin American cities.

The case of London in the UK

A good example of an effective organization of public transport management is the case of London as a consequence of its clear governance framework and the management autonomy of its public transport authority. Since TfL came into existence in July 2000, this functional body has been

receiving grants from the central government (Department for Transport —DfT) and the local government (Greater London Authority —GLA). It also receives a Crossrail funding to build the infrastructure for the new Elizabeth line to be launched in December 2018.

As show in Figure 4.2 for the case of 2017/18, TfL's activities are funded from the following main sources:

- Passenger income: it is the largest single source representing 47% of the total income in 2017/2018. Fares help to cover the operating costs as well as transport services improvements.
- Other sources of cash, including the congestion charge to motor vehicles in central London, road network compliance charges and other commercial developments, such as advertising and property rental and development. Currently, it represents 11% of the total income.
- Grants received from the Department for Transport (central government) and the Greater London Authority (local government). In 2017/18, the total general grants received by TfL make up 23% of the authority income.
- Borrowing and cash movements. TfL has also the power to borrow (bonds, commercial paper, loans), under an authorized borrowing limit for external debt. In the studied year, it represents 17% of TfL´s income.

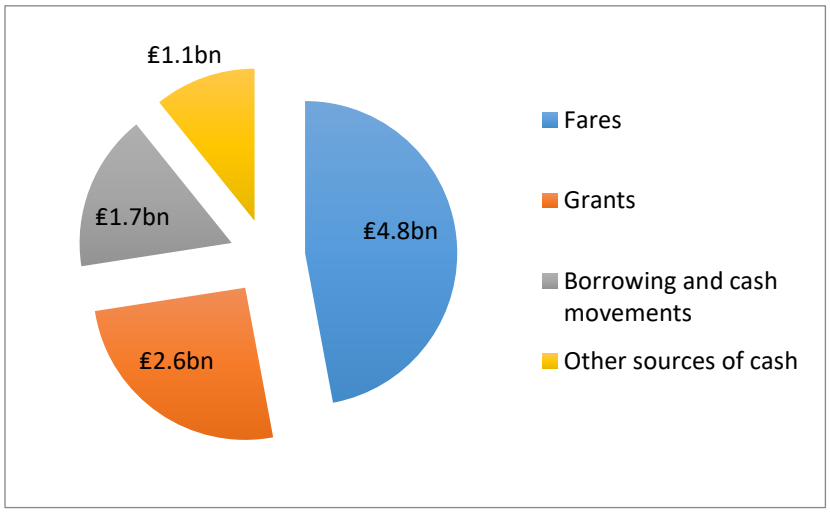

Figure 4.2 Breakdown TfL´s funding sources.
Source: TfL (https://tfl.gov.uk/corporate/about-tfl/how-we-work/how-we-are-funded).

Table 4.2 presents the evolution of the grants for public transport in the city for the period 2010-2018 in contrast to the gross income and the gross expenditure, which includes day to-day operating costs plus depreciation and amortization of some assets. Following the general trend, gross expenditure increased by 3.8 per cent from £7,234 million to £7,411 million, reflecting a steady growth in levels of activity. As abovementioned, it is also noticeable that revenue from users are the largest source of income for the transport authority. Over the years, it has covered an increasing share of the gross expenditure of the public transport system, thereby reducing the implicit subsidy. However, due to new investments required, yearly contributions from the government have been

higher than the hypothetical required contribution to cover the difference between gross income and expenditure (implicit subsidy).

Government grants however represent a significant source of income. Other sources of grants include specific capital grants for the Crossrail project and other projects[24] provided by Crossrail Ltd, a wholly-owned subsidiary of TfL. This additional grant (representing 2% of its income) is jointly sponsored by TfL and the DfT. As part of the Government´s strategy, it was announced that from 2019, TfL will receive no general grant funding to cover operation costs from the central Government. This represents a new financial challenge for TfL, which will have to face the loss of more than £700m for operating expenses.

Table 4.2. Evolution of the amount of subsidies for public transport Vs operating costs

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gross income[1] (£m)	3,595	3,884	4,181	4,495	4,790	5,039	5,289	5,399	5,382
Gross expenditure[2] (£m)	6,108	6,067	6,230	6,480	6,774	7,055	7,436	7,234	7,511
Implicit subsidy[3] (£m) (expenditure-income)	2,513	2,183	2,049	1,985	1,984	2,016	2,147	1,835	2,129
Grant income (£m)[4]	3,338	4,673	4,823	5,464	5,132	4,560	3,510	2,660	2,477
% expenditures covered by income	58,9	64,0	67,1	69,4	70,7	71,4	71,1	74,6	71,7
% expenditures covered by implicit subsidies	41,1	36,0	32,9	30,6	29,3	28,6	28,9	25,4	28,3

[1] It includes fares, revenues from the congestion charging, rents and other sources of income. The primary source of gross income comes from fares (around 80%).
[2] It includes operating costs, depreciation and amortization of assets.
[3] Calculated as the hypothetical required subsidy to cover the difference between income and expenditure. Distortions between actual and implicit subsidies are due to the funding of capital costs depreciated over the years.
[4] It represents the total of general and capital grants receivable by TfL, excluding specific Crossrail funding.
Source: Author´s elaboration based on TfL annual reports and statement of accounts, 2010-2018.

The next subsections describe three key elements of public transport subsidies management in the city of London, including the institutional framework for managing these subsidies, the degree of coordination between fares and subsidies, and the existing mechanisms for auditing and controlling them.

Institutional framework

As established in the Greater London Authority (GLA) Act 1999, transport grants are channeled and managed through the public transport authority of the city of London, Transport for London (TfL). Every year, the public body receives public contributions from the central and local government, through the following sources:

- The General Grant from the Department for Transport ('DfT'), a resource grant under Section 101 of the GLA Act 1999. It may be used to support transport activities including capital expenditure.

[24] Including the Northern Line Extension.

- An investment Grant from the Department for Transport ('DfT') aimed at supporting the delivery of the Investment Program.
- A share of Business Rate Retention[25] received from the Greater London Authority ('GLA'), classified also as resource grant from the local government funded through a proportion of local business rates.
- Other funding includes capital grants for specific purposes received from the DfT and the GLA, as mentioned before.

The main source of grant income for 2017/18 was the grant received from the Greater London Authority (GLA) by means of the Business Rate Retention. For the analyzed period, the total of general and capital grants receivable by TfL, excluding specific Crossrail funding, amounted to £2,477m (2016/17 £2,660m). The following table shows the contribution of each source and the total amount of grant income allocated to revenue and capital for the years 2017-2018.

Table 4.3. Grant income for the years 2017 and 2018 (£m)

Grant	**2017**	**2018**
Non ring-fenced resource grant from the DfT used to fund operations	311.2	255.1
Non ring-fenced Business Rates Retention from the GLA used to fund operations	854.3	1,036.5
Other revenue grant received	19.6	50.8
Council tax precept	6.0	6.0
Total grants allocated to revenue	1,191.1	1,348.4
Non ring-fenced resource grant from the DfT used to fund capital	163.2	-
Investment grant from the DfT used to fund capital	944.0	-
Non ring-fenced Business Rates Retention from the GLA used to fund capital	-	777.8
Community Infrastructure Levy used to fund capital expenditure	944.0	100.4
Other capital grants and contributions received	213.4	250.3
Total grants allocated to capital	1,468.9	1128.5
Total grants	2,660.0	2,476.9

Source: Author´s elaboration based on TfL Annual Report & Accounts, various years.

The "Transport for London Funding Agreement" establishes the amount of grants committed and provided by the Government through the spending review process. Presently, the TfL Funding agreement established in March 2017 sets out the principles over which this funding is being granted, and proposes a payment schedule. Regarding London's business rates, the agreement also sets up the high level principles between the Government and the GLA.

Coordination between subsidies and public transport fares

TfL fare decisions are taken by the Mayor based on a number of considerations including: (i) providing more affordable and accessible transport options; (ii) encourage more people to use public transport, and (iii) the coverage of the capital and operating costs of transport services.

[25] Business Rates are property taxes paid by occupants of non-domestic properties to authorities (district and unitary councils).

By a political decision, the fares of the Tube, DLR, Emirates Air Line, rail services, bus and tram, as well as fees on Santander Cycles remained constant from 2016. This customer benefit will remain in place until 2020. The price freeze is being covered through TfL's efficiencies programme, established in the Business Plan. This decision was taken based on the financial sustainability of the system. Annually, Business Plans ensure enough planned funding sources to meet planned expenditure and encourage a year-on-year reduction in operating costs.

However, as explained before, TfL currently faces the reduction of resources grants from the central government. Even with the loss of more than £700m in operating grant funding and the economic uncertainty caused by Brexit; the core financial objective of the public body is to achieve break-even on the cost of day-to-day operations by 2021/22.

Mechanisms for auditing and controlling transport subsidies

TfL is delivering ambitious plans to further improve its efficiency, so that it can make an appropriate contribution towards saving public expenditure and safeguarding the financial sustainability of the system as a whole. Furthermore, the diversification of the sources of income, and the reduction in the amount of public grants, provides it with greater autonomy and stability.

On the other hand, the financial statements of Transport for London are audited under the Local Audit and Accountability Act 2014. This includes the audit for expenditures and income, containing public contributions to TfL. As part of the income is received in the form of government grants, these contributions are reflected annually in both financial statements (TfL and the corresponding administration). Grant and borrowing support for TfL is determined after a consultation between the Mayor, TfL officials, and the corresponding contributing authority. This process takes into account, amongst other things, TfL's existing and anticipated spending commitments and potential revenue.

The case of Madrid in Spain

Providing urban public transport subsidies is a common practice in Spanish cities (see Asensio et al., 2003). Madrid, the capital of the country, represents an interesting case in this context since the adoption of the subsidy policy for travel passes has had a positive impact associated to increasing patronage[26], but hindered by the negative impact on the financial sustainability of the system.

Table 4.4. presents the evolution of the amount of subsidies for public transport in the city. From the aforementioned strategy, it can be concluded that, overall, larger grants have been required over the years to cover the operating costs and improving transport services (see the coverage ratio). The data shows that, for the period 2007-2015, the percentage of costs, excluding infrastructure amortization, covered by fares lies in the range between 40 and 54%.

Intuitively, these data can be explained by the fact that politicians have been reluctant to raise public transport fares in Madrid while at the same time have kept on investing to provide greater quality and accessibility to the users. This partly explains why the public transport system in the city

[26] For further information see the second report of these series.

is not self-sufficient with its operating costs, and its fare integration policy highly relies on grant funding from the central, regional and local government. In 2017, grants covered 63% of the system operating cost.

Table 4.4. Evolution of the amount of subsidies for public transport Vs operating costs

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016 *	2017 *
Annual operating costs (M€)	1,738	2,041	1,935	2,109	2,225	2,234	1,988	1,869	1,898	2,017	2,107
Fare income (M€)	740	586	786	855	978	1027	1005	1001	965	922	952
% costs covered by fares	42,6	28,7	40,6	40,5	44,0	46,0	50,5	53,6	50,8	47,2	43,8
Grant funding (M€)	1,045	1,259	1,149	1,262	1,247	1,307	983	983	1090	1,263	1,326
% costs covered by grants	60,1	61,7	59,4	59,8	56,0	58,5	49,4	52,6	57,4	62,6	62,9

Source: Author´s elaboration based on information provided by the Consorcio de Transportes de Madrid (CRTM).
**Data for 2016 and 2017 were calculated by the authors on the basis of a previous version of the 2016 and 2017 annual reports, not yet published.*

Figure 4.3 illustrates the financial impacts resulting from the aforementioned strategy, which has required more subsidies to cover the costs of operating and improving transport services over the years. Currently, revenues from users only cover 44% of the operating costs of the public transport system.

Despite the fact that transport services in Madrid requires significant and increasing financial support, the case in Madrid is considered a best practice in terms of promoting public transport usage. The experience gained by the *Consorcio de Transportes de Madrid* (CRTM) in managing and coordinating the transport system has become an attractive example for numerous transport authorities around the world.

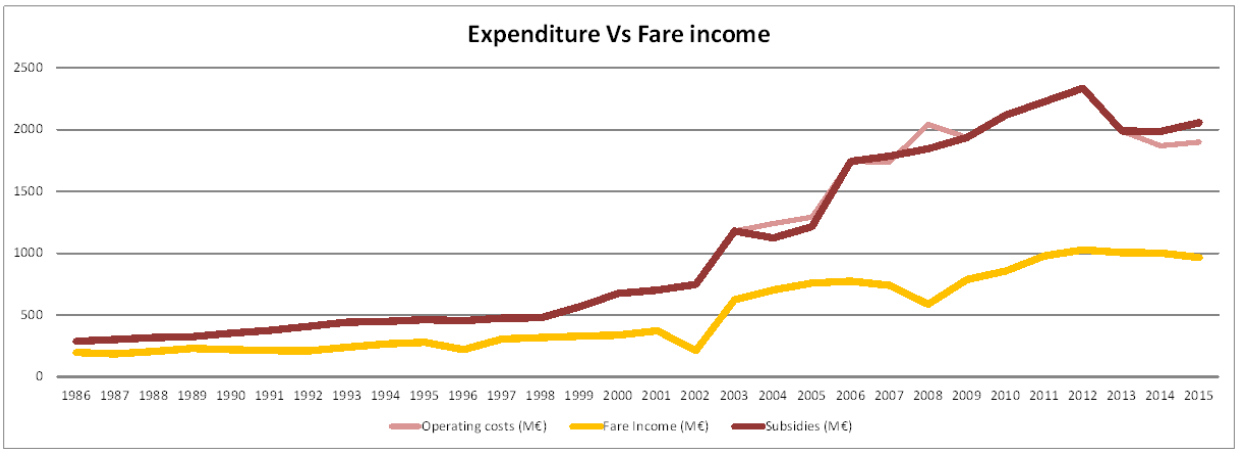

Figure 4.3. Financial impacts of public transport subsidies in Madrid. Evolution of the amount of subsidies vs. fare income.
Source: Author´s elaboration based on information provided by the CRTM.

The sections below describe the institutional framework for managing these subsidies, the degree of coordination between fares and subsidies, and the existing mechanisms for auditing and controlling them.

Institutional framework

Transport subsidies are channeled and managed through the public transport authority of the region of Madrid, the *Consorcio de Transportes de Madrid* (CRTM), established in 1985. The competences and functions of the CRTM include coordination and control, planning of infrastructures and services, setting a common fare structure, determining the characteristics and type of transport tickets and the economic compensation between the different modes of transport. This last duty includes the provision of subsidies to transport operators (subway, buses, commuter rail, among others), whose revenues are lower than their operation costs.

The difference between the economic commitments of the CRTM and the revenues collected from fares is covered by public contributions from different government levels. In year 2017, the value of these grants (1,326M€) represented the largest source of income (57% of the total income). The following figure shows the contribution of each administrative level including the Central government, the Regional government (Community of Madrid), the Madrid City Council, and the councils of other cities located in the region of Madrid. The Regional government is by far the most important contributor to the system.

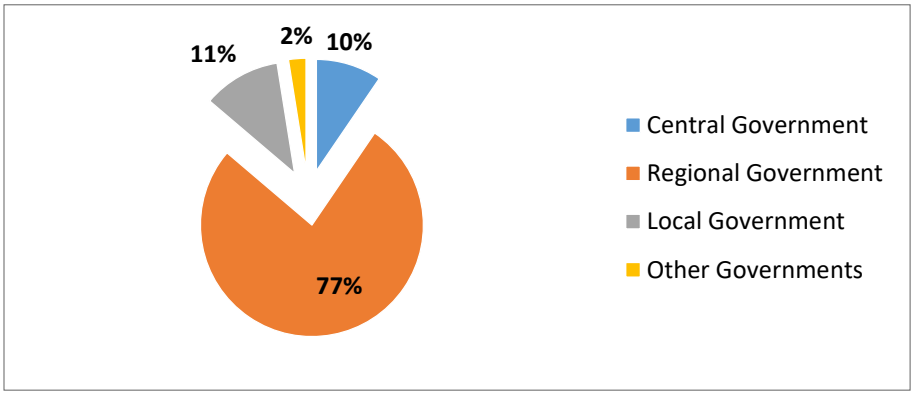

Figure 4.4. Grant funding to the CRTM

Source: Author´s elaboration based on information provided by the CRTM

The CRTM and the Central Government established an agreement under which grants are received to cover the financial needs of the system as a whole (nominative subsidy)[27]. Once such contribution is deducted from the total economic needs of the system, and the collection is assigned to the operators according to the usage of their services, the pending needs to be covered are distributed according to the following criteria shown in Figure 4.5.

[27] A detailed anaylisis of the evolution of these agreements since 1990 in Spain is provided by De Rus and Socorro (2006). This study also provides a description of about the allocation criteria for these grants.

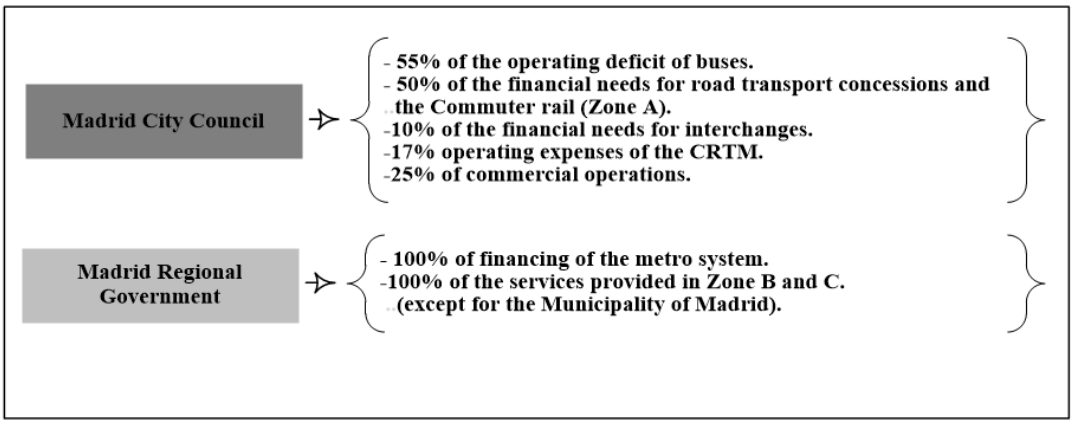

Figure 4.5. Distribution of agreed contributions to the CRTM in Madrid.
Source: Author´s elaboration based on information provided by the CRTM.

The level of contributions is determined by framework agreements between the CRTM and the governments. In particular, the CRTM has a `Framework contract´ with the Central Government regulating the financing of its transportation services. For its part, `Regulatory Agreements´ are established with the Regional Government and the Municipalities of the Madrid Region. Two agreements are also established with the Communities of Castilla-La Mancha and Castilla y León, for transport services between these regions. Those agreements establish the yearly subsidy commitments from different governments.

Coordination between subsidies and public transport fares

As mentioned before, the contractual relationship with the two largest public transport operators in the city (Metro de Madrid and the EMT, respectively) is governed by annual agreements based on the establishment of an `equilibrium tariff´ (the average price per user that covers the annual operation costs) in the case of Metro de Madrid, and a `commitment of production´ for the bus system (service supply). The CRTM is in charge of the establishment of the framework for the economic compensation to these operators, which depends on the demand or the number of kilometers travelled.

The CRTM collects the revenues coming from the integrated fares such as travel passes. In return, it compensates transport companies with the revenue corresponding to the `equilibrium tariff´ times the number of trips made with the integrated fare. This implies a hidden subsidy since the revenue collected from the integrated fares is always less than the `equilibrium tariff'. Each operator negotiates its `equilibrium tariff´ with the transport authority on a regular basis.

Subsidies are justified on the grounds that the cost of the transport system should not fall entirely on users, but also on other indirect beneficiaries (companies, private transport users, the society, etc.) through the contribution of the government. The level of coverage from public transport fares is not established ex-ante since it depends on the ultimate use of public transport services, but it is intended to fall in the range from 50 to 60%.

Mechanisms for auditing and controlling transport subsidies

As previously explained, each level of government contributes to the CRTM from its budget (City Council, Central government, Community of Madrid). Transfers between different administrations are reflected annually in both budgets (the CRTM and the corresponding administration). According to the Spanish Law, these budgets are audited and reviewed by the National Audit Office (*Tribunal de cuentas*).

The coordination between subsidies, deficit policy and the control of expenditure is implicitly established in the negotiation of the framework contracts and the regulatory agreements between the CRTM and the public governments providing subsides to the CRTM. The public administrations that contribute to the transport authority carry out internal administrative processes for expenditure control. However, there is no existing mechanism to guarantee the financial sustainability of the public transport system. As mentioned before, subsidies in Madrid have had a considerable impact on the system´s financial sustainability.

The case of Bogota in Colombia

Unlike the cases previously described, the reorganization of the public transport system through an integrated approach is a new practice in Colombia´s capital. It constitutes a remarkable case, being one of the transport systems in LAC developed under the premise of reaching financial sustainability. However, as detailed throughout the rest of this section, the transport authority should also rely on public contributions to cover the economic compensations of operators, while considering the needs and the payment capacity of the users.

The new transport integrated scheme of the city named `SITP´ (*Sistema Integrado de Transporte Público*), operating regular bus services and Transmilenio (the Bus rapid transit system)[28], is funded from the following three main sources:

- Income from fares, which determine the system operating revenues and constitute its largest source of financing.
- Contributions, credits or liquidity facilities carry out by the local government (called district government) and/or TRANSMILENIO S.A.
- Returns generated by the assets of the firm.

Table 4.5. presents the evolution of fares income and expenditures for the public transport system in the city throughout the period 2009-2014[29]. Before 2013, year of the implementation of the SITP and Transmilenio phase III, the system exhibited a positive difference between fare revenues and operating costs derived from the compensation to transport operators. After this period, revenues collected from fares were able to cover only 70% of the cost thereby giving rise to an increasing deficit. Transfers from the local administration, as explained below, mainly bear the remaining part.

[28] For further information the reader is referred to the second report of this series, section 4.3.
[29] Unfortunately, the lack of more recent data in Bogotá makes an up-to-date analysis not possible.

Table 4.5. Evolution of fare income vs. operating costs of the SITP-TM system[1] in millions of Colombian Pesos ($)

Year	Operational costs ($)	Other compensation expenditures[2] ($)	Fare income ($)	Difference between costs and fares revenues ($)
2009	441.833	102.327	660.549	116.389
2010	527.114	112.660	735.922	96.148
2011	569.876	114.484	822.523	138.163
2012	666.621	148.452	834.150	19.077
2013	1.079.504	256.462	924.133	-411.833
2014	1.500.997	299.290	1.274.431	-525.856

[1] Currently, one million of Colombian Pesos is equivalent to 328,5 USD.
[2] it includes compensation to other agents different from operators (i.e TransMilenio S.A, `fiducia´, fare collectors), while the column "operational costs" presents the compensation to operators for the provision of services.
Source: Author´s elaboration based on Contraloría de Bogotá, 2015.

In addition to fares, other income is generated from advertising and property rental. Although these resources have been growing, they are still not significant within the public authority budget, amounted to $ 9.500 million of Colombian pesos in 2014.

Institutional framework

Since the late 1990s, the nation (central government) and the District (local government of Bogota) signed an agreement to promote the development of an integrated mass transit system. Since 2000, subsidies to the public transport system are being provided either to finance the BRT system or to ensure the financial sustainability of the entire integrated system as a whole. Transport subsidies are channelled and managed through Transmilenio S.A, the BRT local authority, which in addition has been entrusted the organization and management of the new integrated transport system in the city.

Table 4.6 shows the evolution of the contributions from both the central and the local government to the mass transit system (Transmilenio) in the city for the period 2010-2016, according to the agreement already in force. In total, the national government has provided $3.9 billion of Colombian pesos[30] (89.7% of its commitments set up in the agreement), and the District $2.4 billion of Colombian pesos (80% of its commitments set up in the agreement), for a total of $6.2 billion of Colombian pesos. Until now, central government grants make up 61.6% of the funding, while the local grants make up 38.4%.

[30] Currently equivalent to approximately 1 million of euros.

Table 4.6. Central and Local government contributions to the mass transit system in Bogotá for the years 2000-2016 (millions of Colombian Pesos $).

Year	Central Gov. contribution	Local Gov. contribution	Year	Central Gov. contribution	Local Gov. contribution
2000	206.216	0	**2009**	377.787	187.796
2001	123.941	148.248	**2010**	344.469	193.429
2002	152.239	152.695	**2011**	359.959	199.233
2003	205.764	157.275	**2012**	314.913	205.210
2004	230.887	161.994	**2013**	318.244	211.367
2005	197.193	166.855	**2014**	316.273	217.706
2006	245.559	171.860	**2015[1]**	317.222	224.238
2007	306.635	177.016	**2016**	380.121	230.966
2008	309.861	182.326			

[1] As this balance was made in 2015, values for 2015 and 2016 are presented as forecasts.
Source: Author´s elaboration based on Contraloría de Bogotá, 2015.

Contributions from the nation are financed to a large extent with credit resources from multilateral banking. On the other hand, subsidies from the local government also contribute to the financial sustainability of the system. For the subsystem Transmilenio " (phases I and II), financial sustainability was guaranteed by an initial contribution of the District through a loan of $ 20,000 million of Colombian Pesos to the Contingency Fund, created for compensating differences between operation costs and fare income, in accordance with the planning process for Transmilenio phase I and II. This reserve, initially established with public resources, has been used as a `clearance tool' for the financial balance of the system´.

Ever since the integration of bus rapid transit corridors with the network of bus routes on arterials and feeder zones (SITP as a whole), the financial sustainability has been safeguarded by a new tariff stabilization fund (Fondo de estabilización Tarifaria-FET[31]), created for covering the difference between the technical fare, which reflects the average cost per trip, and the real fee paid by users. In addition to the tariff differential, this fund also supports social transport (subsidies) for disadvantaged people in Bogota.

Table 4.7. shows the evolution of the local government contributions to the financial stabilization of the system. The total amount of grants awarded through this concept since the beginning of the operation of Transmilenio, amounted to one billion and a half of Colombian pesos. The data displayed below shows that the public resources transferred to the FET have grown exponentially since the beginning of the operation of the SITP. This fact has led to a greater pressure on resources for the city.

Table 4.7. Local government contributions to the financial stabilization of the system in millions of Colombian Pesos ($)

Year	Contingency fund ($)	Tariff stabilization fund (FET) ($)	Total ($)
2000[1]	20.000		20.000
2008[2]	15.000		15.000
2009	20.000		20.000
2010	30.000		30.000
2011	0	0	0
2012	68.500	31.500	100.000
2013	89.100	315.772	404.872
2014	0	647.800	647.800
2015 (april)	10.956	252.000	262.956
Total	253.556	1.247.072	1.500.628

[1] As explained before, this amount corresponds to an initial contribution to the contingency fund.
[2] No local contributions were made between 2000 and 2008 to the contingency fund.
Source: Author´s elaboration based on Contraloría de Bogotá, 2015.

Coordination between subsidies and public transport fares

Decisions about transport fares in Bogota are taken by the Mayor based on a number of considerations including the following two main premises: (i) affordability, since they must take into account the payment capacity of users; and (ii) financial sustainability, to cover as much as possible the average operation cost of the system.

If revenues from fare income are not enough to cover the remuneration owed to operators, the Tariff Stabilization Fund (FET) provides contributions to guarantee the financial sustainability of the system. For the period were Transmilenio operated by itself the tariff differential, revenue shortage was covered by the contingency fund. This gap was negligible until 2011. In fact, since 2014, Transmilenio did not require more resources from the fund for the remuneration of its operators. For its part, after the implementation of the SITP, a high negative differential can be found, which implies a growing need for FET resources to cover compensation to transport agents. Figure 4.6 below illustrates this fact by showing the evolution of income from fares in comparison to the compensation to operators since 2012.

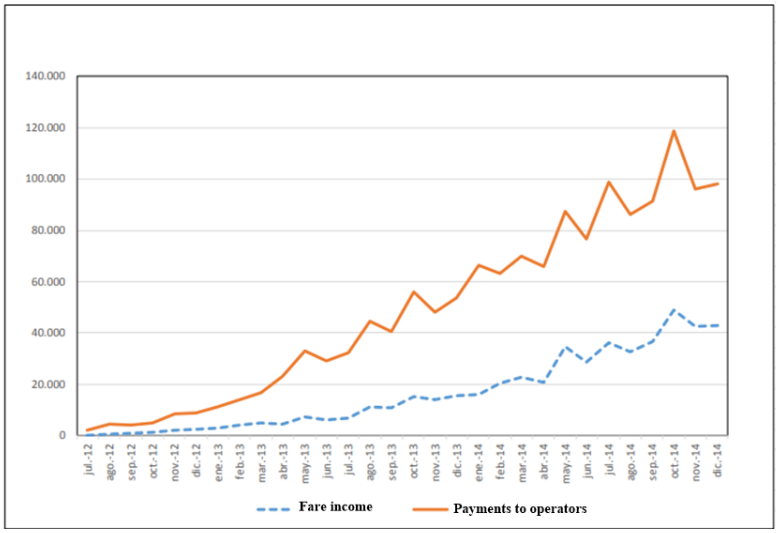

Figure 4.6. Fares income in comparison to the compensation to operators

Source: Transmilenio S.A. Fondos de Fase III.

Mechanisms for auditing and controlling transport subsidies

As previously explained, contributions from different levels of government are managed by city-nation co-financing agreements, which are periodically updated. Transfers between the central government, the local government and the transport authority are audited by the fiscal control body of the State named the General Comptroller of Colombian Republic (CGR by its Spanish abbreviation).

In addition, the Colombian law also contemplates other local agents for control and surveillance of public resources. Example of such an agents are the *Personería de Bogotá*, for monitoring the conduct of public servants and verifying the proper implementation of laws and agreements in the Capital; and the *Veeduría de Bogotá,* a public body that promotes transparency and prevents corruption in public management.

As for other cases previously explained, since subsidies come from public entities, the coordination between subsidies, deficit policy and the control of expenditure in government bodies public spending is carried out internally. In order to guarantee the financial sustainability of public transport subsidies, different mechanisms have been studied by Bogotá and Cundinamarca, the region where Bogotá is located. Some alternatives studied include setting a gasoline surcharge (already implemented), congestion charges, urban tolls, differential parking fees, valuation and the different mechanisms to capture land rents originated by public decisions and investments.

4.6 COMPARISONS ACROSS CASE STUDIES

After analysing each city on an individual basis, the present section conducts a cross-cutting assessment of the fulfilment degree of the three challenges of subsidy policies for public transport integration previously detailed in Section 4: (i) ensuring funding sources to provide subsidies, (ii)

setting the right fares for public and private transport means; and (iii) achieving the right coordination between transport costs, fares and funding contributions.

Table 4.8 provides a qualitative comparison of the different case studies described above. Each column defines to what extent the three aspects previously explained are met by each city. In order to facilitate the interpretation of the analysis, we follow the score already defined, that follows these principles: "●" for a challenge which is mostly covered; "≈●" for a challenge which is covered but could benefit from some minor improvements; and "○" for a challenge that is not fully covered, thereby requiring serious actions for improvement. The scoring comes from a consensus of the authors of this paper made after a careful review of the state of practice in the three cities analysed. This analysis serves as a point of reference for what should be considered acceptable for the right integration.

Table 4.8. Meeting the challenges of transport subsidies in London, Madrid and Bogotá

City/ Challenge	Ensuring funding source	Setting the right fares	Achieving the right coordination
London	● - A number of funding sources help to cover transport costs (e.g grants, income from the Congestion Charge, Community Infrastructure Levy, Business Rates Retention,). - Fare income is the largest single source for financing public transport in the city. - Autonomous and financially sustainable transport authority.	≈● - Clear criteria to define private car charges, considering objective economic, social and environmental criteria. - Public transport fares are set mostly based on political criteria. -The freeze on fares is helping customers save money and encouraging more people to use public transport. - Social fares benefiting less wealthy people.	● - Proper coordination among transportation costs, fares and public contributions. - Financial sustainability providing flexibility to adapt to new circumstances (Brexit, the loss of a proportion of operating grant funding, and the economic uncertainty caused by Brexit).
Madrid	≈● - The public transport system is not financially sustainable and greatly relies on grant funding from the central, regional and local government. - Other sources of income are not used to cover the needs of the system (e.g. charges for internalizing externalities from the private car, property taxes, etc.).	≈● - Fare policy decisions take into account socioeconomic criteria, but are mostly based on political criteria rather than efficiency driven. -Price discrimination derived in vertically equitable transport subsidies (young, elderly, unemployed, etc.).	≈● - The amount of subsidies to be provided depends very much on the evolution of the economy. -Non-existent ex-post evaluation of the financing programs. - The system could benefit from setting mechanisms to avoid that certain decisions are ultimately taken just based on political criteria (e.g. the case of the young travel pass).

City/ Challenge	Ensuring funding source	Setting the right fares	Achieving the right coordination
Bogotá	≈● - Although the public transport system is intended to be financially sustainable, in practice it requires large grant funding to cover its costs. - Other sources of income apart from grants and fare income are identified, but currently not implemented.	≈● - Politically sensitive nature of transport fares, although they consider in some way sustainability and affordability principles. - New scheme for targeting subsidies to the less wealthy people, with unprecedented social benefits but also with a considerable impact on the economic efficiency of the system.	≈● - Complex tariff system guaranteeing a proper coordination among transportation costs, fares and public contributions. - There is a need to explore new sources of income in order to ensure the financial sustainability of the system. - The system could benefit from more flexibility to deal with changing circumstances derived from the full SITP implementation.

Source: Author´s elaboration

5. TRANSPORT POLICIES FOR IMPROVING AIR QUALITY

5.1 INTRODUCTION

Since the concept of sustainability emerged as an international priority, there has been a growing interest in the study and implementation of strategies that promote economic growth, in conjunction with the preservation of the environment and social development. In this respect, impacts that transport policies can have on health and quality of life are particularly relevant.

As a response to the internationally growing concern to improve air quality in cities, many urban areas are implementing actions to reduce transport contribution to carbon and pollutant emissions, as well as to limit the impact of the adverse effects of traffic on public health. However, cities today are still confronted by serious environmental challenges. In the case of Latin America, at least 100 million people are exposed to air pollution levels higher than those recommended by the World Health Organization (WHO). The World Bank estimates that the impacts on health due to emissions in countries such as Bolivia, Guatemala, Ecuador, Peru and El Salvador, made up to 2% of the gross domestic product.

To face this problem, policy makers and planners have been active on several fronts. On the one hand, a normative framework has been developed to implement more respectful policies in dealing with natural resources to preserve the health and well-being of the population. On the other hand, a series of specific instruments have been adopted, including driving restrictions for vehicles in urban areas, the introduction of low emissions zones, incentives to renew the fleet and the promotion of electro mobility. However, all these efforts have not been enough to meet air quality needs in urban environments. In fact, atmospheric pollution continues to be a public health problem and one of the major issues in large cities, as pointed out previously.

Based on these considerations, the objective of this work is multiple. First, we intend to understand the relationship between air quality problems and transport in Latin American cities. Second, we seek to analyze existing experiences of transport policies aimed at improving air quality in some cities around the world in order to evaluate their effectiveness in reducing pollution, as well as other effects stemming from reducing congestion or improving in general travel times. Finally, through a critical evaluation, we expect to obtain useful lessons for the cities of LAC with the common objective of promoting a sustainable mobility, reducing pollution and contributing to mitigate global warming and climate change. In this chapter we mostly focus on measures aimed at influencing a more rational user behaviour. We do not get into much detail on the promotion of clean technologies such as electro mobility or LNG since it requires a multifaceted strategy -involving investment, subsidies, impact on noise and vibrations, infrastructure for recharging, etc.-, which goes beyond the scope of this analysis.

Apart from this introduction, the chapter proceeds as follows. Section 2 analyzes the current quality of Latin-American cities´ air. Section 3 identifies the main strategies implemented to improve air quality in different contexts. Section 4 explains the effects of transport policies in air quality and other sustainability goals. Section 5 examines in detail the implementation of transport strategies

for improving the environment in three cities: London, Madrid and Bogotá. Finally, in Section 6, a cross-sectional analysis of the various cases previously described is conducted aimed at providing recommendations for the case of LAC.

5.2 BACKGROUND: AIR QUALITY IN LAC CITIES

Air pollution in urban areas in LAC cities is considered a serious problem. More than 100 million people in LAC are estimated to be exposed to air pollution levels exceeding WHO guidelines (Cifuentes et al., 2005). Moreover, there is a high rate of rural population exposed to indoor air pollution due to household combustion of solid fuels for cooking or heating. During the last decades, important efforts have been made to stop air pollution in several urban areas of LAC. Large cities such as Mexico City, Bogotá, São Paulo and Santiago have undertaken different actions in order to reduce the concentration of pollutants such as imposing vehicular restriction, relocating industries, promoting public transport, etc. However, the emissions of particulate matter, sulfur dioxide, nitrogen dioxide and ammonia, and thus the corresponding concentrations of these pollutants and ozone levels in the air, have increased progressively in recent decades (Schwela & van der Wiele, 2011). As a consequence, air pollution continues to be a problem in the consolidated and growing urban areas of LAC, and it is becoming a worrying issue in the emerging cities of the region (CAI, 2012).

The health implications for the population in the short as well as in the long-term of the increasing deterioration of air quality are widely recognized (Dominici, 2006; Vanos et al., 2014). Air pollution is related to a broad range of acute and chronic health effects that costs billions of dollars annually in medical costs and productivity losses (CAI, 2012; Cohen et al., 2005). The most important air pollutants include particulate matter (PM10, PM2.5), black carbon (BC) —which is emitted as a component of PM—, carbon monoxide (CO), nitrogen oxides (NOx), volatile organic compounds and hydrocarbons, and photochemical oxidants such as ozone (O3). Particulate matter is considered the most harmful air pollutant to human health and is related to the most serious effects, including lung cancer and cardiopulmonary mortality (Cohen et al., 2005; Pope & Dockery, 1999). Moreover, other pollutants such as NOx, Sulfur dioxide (SO2), BC, Organic Carbon (OC) and ammonia (NH3) are important precursors to particulate matter. Table 5.1 shows a summary of the most health-relevant pollutants, their main sources and effects on human health. In the LAC region, it is estimated that approximately 259,000 deaths per year are directly caused by long-term exposure to air pollution, and 84,000 to household air pollution (WHO, 2018; WHO, 2018a).

Table 5.1. Sources of air pollution, effects, and WHO recommendations for selected pollutants

Pollutant	Main Sources	Effects	Health guidelines
Carbon monoxide (CO)	Exhaust gases from motor vehicles; some industrial processes.	Poisonous for humans when inhaled. CO reduces the ability of blood to carry oxygen and increases the pressure of the heart and lungs.	30 mg/m3 (25 ppm) for 1 hour 10 mg/m3 (10 ppm) for 8 hours

Pollutant	Main Sources	Effects	Health guidelines
Sulfur dioxide (SO_2)	Less contribution from mobile sources. Heat and electricity generators that use oil or coal with sulfur, sulfuric acid plants.	Irritating to humans, SO_2 produces atmospheric reactions that contribute to acid rain.	20 µg/m3 24-hour mean500 µg/m3 10-minute mean
Particulate matter ($PM_{2.5}$)	Soil, oceanic foam, bush burning, domestic burning, motorized vehicles, industrial processes and organic dust from plant material.	Contributes to the haze, increases the risk of cancer, effects on mortality, and aggravates respiratory diseases.	10 µg/m^3 annual mean 25 µg/m^3 24-hour mean
Particulate matter (PM_{10})			20 µg/m^3 annual mean 50 µg/m^3 24-hour mean
Lead (Pb)	Added to some fuels, the Pb is emitted from the exhaust gases of motor vehicles, lead smelters, battery plants.	It affects intellectual development in children; many other adverse effects.	0.5 µg/m^3 for 1 year
Nitrogen oxides (NO, NO_2)	A secondary effect of the combustion of high temperatures causing nitrogen and oxygen chains in the exhaust gases of motorized vehicles; generation of electricity and heat; nitric acid; explosives; fertilizer plants.	Irritant, precursor of the formation of photochemical smog.	40 µg/m^3 annual mean 200 µg/m^3 1-hour mean
Photochemical oxidants (ozone [O_3], acetyl nitrate peroxide [PAN] and aldehydes)	Formed in the atmosphere by the reaction of nitrogen oxides, hydrocarbons and sunlight.	An irritant, photochemical oxidants contribute to haze, material damage, aggravates respiratory diseases.	100 µg/m^3 8-hour mean

Source: Schwela & van der Wiele (2011).

Poor air quality is not only a threat for public health, but it has also a major impact on global climate change. Black carbon is, along with methane, tropospheric ozone and hydrofluorocarbons (HFCs), one of the four major short-lived climate pollutants (SLCPs). These agents remain in the atmosphere for a relatively short period of time compared to other greenhouse gases such as CO_2, and are the most important contributors to climate warming right after it (GNA, 2014a). Globally, there is evidence that black carbon emissions play a major role in accelerating the melting of the glaciers, and also affect temperature and weather patterns. In LAC, BC impacts are already being felt in the Amazon Basin and in the Andean glaciers (GNA, 2014b).

Air pollution in urban environments is primarily the result of the burning of fossil fuels, and the most relevant sources are the transport sector, the power generation, the industrial and manufacturing sectors, and the domestic use of fuel. Some factors that have contributed to the increase of emissions in recent decades in LAC include population growth without adequate land use and transport planning, heavy concentration of the population in large cities, industrial and economic development, and the growing (and aging) fleet of private and public transport vehicles (PAHO, 2002; CAI, 2012). All these factors have increased the demand for energy and transport, which are the main drivers of emissions in LAC (Riojas-Rodríguez et al., 2016).

During the twentieth century, many LAC countries considered rapid industrialization crucial to produce development, improve the quality of life and reduce existing economic and social inequality among the population. Most countries adopted import substitution policies from the 1930s until the late 1980s to create a self-sufficient internal market of industrialized products. As a

consequence, they experienced important economic and industrial development but rarely went hand in hand with policies aimed at protecting the environment (Romieu et al., 1991). During the 1970s and the 1980s, LAC countries started a gradual transition to open their economies. However, trade liberalization may put a greater burden in terms of pollution on developing countries, where the environmental regulation is less demanding. Jenkins (1998) shows the increase in industrial pollution in three different LAC countries (Argentina, Brazil and Mexico) in the period 1975-1995. It is worth noting that the most affected population by industrial pollution is that living in urban areas, since industrial processes are often concentrated in the cities.

At the same time, this region has experienced a strong population growth and a rapid urbanization that has boost the demand for transport infrastructure and services in urban areas. In 1950, there were no megacities of more than 10 million inhabitants in LAC. At the time of the writing of this paper, there are already three megacities and more than forty cities with more than 1 million inhabitants. The poor planning and the weakness of public policies have encouraged the expansion of cities in an unsustainable way, with the absence of accessible public spaces, strongly car-oriented to the detriment of public transport and maintaining or even reinforcing social and spatial segregation. Mobility policies implemented in LAC cities over the last decades have prioritized road construction to attend the increasing traffic demand rather than strengthening public transit policies (IDB, 2015). In addition, the lack of sufficient formal mobility solutions has been commonly addressed by collective modes of transport with less capacity and thereby more pollutant than other forms of public transport that have increased traffic congestion and worsen the serious problem of vehicular pollution (Jirón, 2011). In this context, the use of private modes of transport such as cars and motorbikes has steadily increased.

Another cause explaining the expansion of the use of private vehicles is the increase in the income of the population and the need to travel as a result of the increase in economic activity in the region. As per capita income increases, the people who may afford a car increases, especially in populations with medium and medium-low incomes. This trend has also been driven by the ease in credit access, the expansion of the local automobile industry and the availability of low-cost vehicles as a consequence of the reduction in import tariffs that came along with trade liberalization and the end of protectionist policies. All the above have generated an increasing desire for car ownership that has prompted LAC to be a region with very congested and polluted urban areas (CAI, 2016). Although almost every mode of transport emits air pollution from fossil fuel combustion, road transport emissions have a greater impact on human health since they are released very close to human receptors (Colvile et al., 2001).

Finally, the problem of air pollution has been worsened using poor quality fuels, particularly those with a high sulfur content that increases the amount of SO_2 emissions; the aging fleet of cars, trucks and buses together with the common lack of maintenance of the vehicles; and, the driving patterns associated with congestion (Cifuentes et al., 2005).

During the last three decades, several LAC countries have started to act more decisively to address the environmental problem. Some of the actions undertaken at the national level include the creation or strengthening of environmental institutions, the upgrading and extension of the air

quality monitoring network, the imposition of fuel quality standards and emission standards for industries and both old and new vehicles, and the establishment of air quality regulations for air pollutants (Cifuentes et al., 2005). Unfortunately, not all the pollutants are regulated in every country and the national standards set for those that are regulated are usually well above the World Health Organization Air Quality Guidelines (WHO-AQG). Riojas-Rodríguez et al. (2016) presented the average annual data of PM_{10} and $PM_{2.5}$ concentrations for the LAC cities that monitor those pollutants. They found out that only five out the 104 cities that measure PM_{10} and four out of the 57 cities that have $PM_{2.5}$ measurements levels complied with WHO-AQG guidelines (see Figure 5.1). Moreover, there is an insufficient level of monitoring infrastructure in LAC countries. Only 17 of the 33 countries of the region have official air quality monitoring stations and, in most cases, they are located in the capitals and a few large cities at best (Riojas-Rodríguez et al., 2016). Since monitoring is crucial to develop effective emissions reductions strategies, most governments have a limited capacity for air quality management (GDA, 2014b).

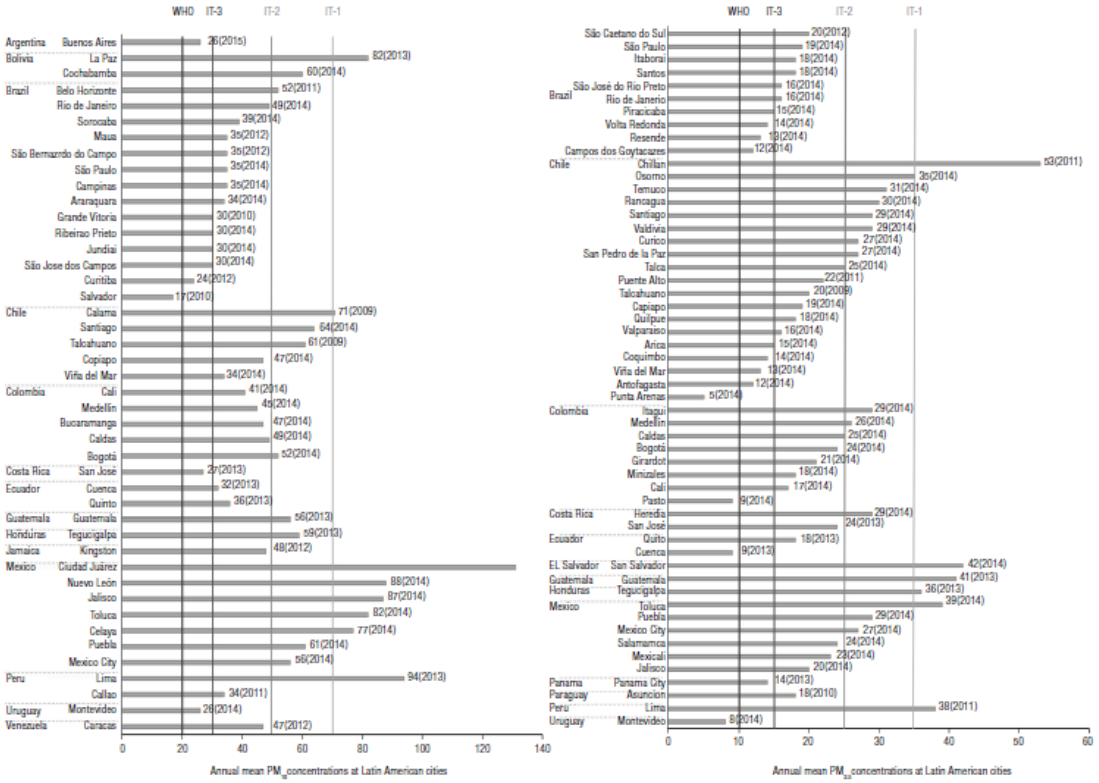

Figure 5.1. Particle matter PM10 and PM2.5 in LA cities and their situation compared with the World Health Organization-Air Quality Guidelines (WHO-AQG), 2010-2014.
Source: Riojas-Rodríguez et al. (2016)

The projections of population increase, industrial growth and private traffic, seem to indicate a tendency to increase the pollution levels and greenhouse gas emission rates in LAC cities. However, this situation can be prevented and even reversed if some actions are undertaken. The adoption of air quality standards according to the WHO-AQG guidelines and their enforcement is mandatory. To do so, it is necessary that the air quality monitoring infrastructure is properly developed within the

countries. A quality monitoring system is crucial to identify the source and type of emissions, and to evaluate the effectiveness of the emissions reduction strategies to be implemented (GDA, 2014b). In the next section, a review of the transport policies that are being implemented worldwide with the aim of improving air quality will be presented.

5.3 TRANSPORT POLICIES FOR IMPROVING AIR QUALITY

Due to environmental concerns and the close relationship between air pollution and human health, an increasing number of governments are implementing transport policies aimed at improving the quality of the air in urban areas. Thus, a diverse set of measures are being adopted worldwide to discourage or limit high-polluting vehicle traffic, including the establishment of Low Emission Zones (LEZs), the promotion of more sustainable transport modes, or the creation of incentives and subsidies for the purchase of cleaner vehicles, among others. Some of the most remarkable examples of these measures are displayed in **Table 5.*2***, along with a synthetized discussion of their main characteristics and supporting references (reference column of the table).

Table 5.2. Examples of the main air quality improvement strategies implemented worldwide

Type of Policy	Examples	Explanation	References
Restriction by engine type	• LEZ affecting all types of vehicles (Lisbon) • LEZ affecting heavy vehicles (London) • LEZ in the Mont Blanc tunnel affecting heavy goods vehicles (France)	Establishment of Low Emission Zones (LEZs) that impose restrictions on diesel, gasoline, light, heavy, commercial, and public transport vehicles. They require compliance with EURO standards (levels I to VI) according to the countries or cities. Some cities impose restrictions only on diesel powered and the older vehicles of the fleet.	- Ferreira et al. (2012) - Ellison et al. (2013)
Restrictions by license-plate	• Restriction based on even/odd license plates (Paris) • *Restricción vehicular* (Santiago) • *Hoy no Circula* policy (Mexico City) • *Pico y Placa* system *(Bogotá)* • *Rodizio (Sao Paulo)*	Permanent prohibition of circulation within certain city areas and periods of time (usually weekdays) of part of the car fleet according to a criterion based on the license plate numbers (e.g. odd and even). It may affect to both passenger and freight vehicles, but usually excluding the public transport systems. This policy is usually implemented for environmental reasons although in some cases it is motivated by high levels of congestion.	- De Grange and Troncoso (2011) - Davis (2008) - Cantillo and Ortúzar (2014)
Speed limitation measures	• Speed management policies (Barcelona) • Temporary Environmental Speed Limits during winter (Oslo) • *Bilbao 30-30* (Bilbao) • *Visión Zero* (Mexico City)	Traffic management strategies for reducing traffic emissions consisting in changing the speed patterns, usually by reducing the speed limit within the metropolitan area of the cities and in urban peripheral motorways.	- Bel and Rosell (2013) - Folgerø et al. (2017)

Type of Policy	Examples	Explanation	References
Environmental charges to vehicles	• *Congestion Charge* (London) • *Congestion tax* (Stockholm) • *Area Licensing Scheme* (1975-1998), *Electronic road pricing scheme* (1998-ongoing) (Singapore)	Permanent traffic restriction through the application of urban tolls that restrict vehicle access to central areas. This charge may be fixed or vary depending on the time driving within the designated area.	- Leape (2006) - Borjesson et al. (2012)
Development of walking and cycling infrastructure	• Pedestrian areas and véloparc Interchange Parking Spaces (Strasbourg) • City Bikes (Stockholm) • The Route Network (Houten)	Strategies aiming at improving the conditions for walking and cycling in the cities to make active modes safe and attractive alternatives to driving. It refers to developing additional walking and cycling infrastructure in the cities, providing secure bike storage facilities, removing space for motorized traffic from the current street configuration, etc.	- Song et al. (2017) - Panter et al. (2016) - Johansson et al. (2017)
Shared mobility initiatives	• *Sincropool, Comparto coche, Vayamos Juntos* (carpooling initiatives in Argentina) • *Carril BUS-VAO* (Madrid) • *Zazcar* (car-sharing system, Rio de Janeiro) • *eConduce* (motorbike-sharing system, Mexico City) • *Memphis Area Rideshare (MAR)* Program (Memphis)	Promotion of shared mobility initiatives that encourage greater vehicle occupancy and discourage car ownership, such as ride-sharing, car-sharing services, or development of high-occupancy vehicle (HOV) lanes to access the city centers.	-Caulfield (2009) - Baptista et al. (2015) - Shewmake (2011)
Incentives to change the vehicles fleet	• *Electric Vehicle Subsidy Scheme (EVSS)* (China) • Tax benefits for ultra-low emission vehicles (ULEVs) and Vehicle Tax exemption for electric vehicles (UK) • *Green Vehicle Purchasing Promotion Measures* (Japan) • *Energy Policy Act (US)* • *Public transport fleet renewal Plan (PAT)* (Bogotá, Colombia)	Regulations and economic incentives introduced by governments to renew the car and public transport fleet and thus reduce automotive air pollution. These incentives include tax benefits or exemptions for electric or low emission vehicles, subsidies for the purchase of clean vehicles or to replace diesel and the older vehicles for new clean technologies, etc.	- Hao et al. (2014)

Type of Policy	Examples	Explanation	References
Other measures to promote sustainable transport	• Bus Priority at traffic signals (London) • *Rede Integrada de Transporte* (Curitiba) • *Transmilenio* (Bogotá)	Measures oriented to promote the use of sustainable transport and discourage car usage, for example establishing preferential roads or giving traffic light priority to public transport (PT), implementing integrated public transport, rapid transit, subsidized PT fares, improve PT shelters, create park-and-ride parking facilities and interchangers to promote interoperability across modes, etc.	- Dinopoulou et al. (2013) - Wahlstedt (2011)

Source: Author´s elaboration

During the last two decades, there has been a global trend towards implementing measures with the aim to improve air quality in urban areas. As can be seen in Table 5.2, a various range of transport policies have been put in place in different cities. These measures are usually focused on either the supply or the demand side of transport. The first one, supply side, relates to the availability and quality of the infrastructure, transport modes and their management. The promotion of more sustainable alternatives of transportation such as walking, cycling, efficient public transport or car-sharing are included in this first set of measures. The second one, demand side, intends to change the transport behaviour of the motorists and usually includes regulatory measures and involves restrictions and/or penalties. Driving restrictions policies, speed limitation measures, or environmental charges to vehicles would fall into this second category of measures.

One important question is the extent to which these transport policies are effective in improving urban air quality and mitigating climate change. There is a broad consensus in the literature that overall, they do achieve such improvements, although some policies have obtained better results than others in addressing targets (Slovic et al., 2016). A thorough revision of the main effects of the different transport policies on the improvement of air quality will be presented in the following section.

5.4 EFFECTS OF TRANSPORT POLICIES AIMED AT IMPROVING AIR QUALITY

Air quality improvement measures are circumscribed within the framework of sustainable development. These policies therefore have effects on three fundamental areas, the ecological, social and economic sectors. Regarding the ecological impacts, they have significant effects on the reduction of air pollutants' concentrations, depending on the specific measure implemented, and contribute to the reduction of traffic and noise pollution. Given the close relationship between exposure to air pollutants and human diseases, a substantial reduction in their concentrations may lead to a reduction in mortality and morbidity (Pope et al., 2009). Finally, economic benefits such as productivity improvements and social savings derived from a reduction in congestion, accidents and travel times, and an increase in population health and quality of life (CAI, 2012) may arise from the implementation of these policies.

Impacts on air quality

Traffic restriction measures have been widely implemented in many cities worldwide with varying results. Generally, a positive response has been obtained regarding the concentrations of soot, NO_x and PM, traffic reductions, and slight decreases in noise. Browne et al. (2005) analysed the effects of the introduction in 1996 of an environmental zone that limited the access to vehicles older than 8 years in Stockholm (Sweden). The results showed a reduction in heavy vehicles' emissions of NO_x and PM of 10% and 40% respectively, and total concentrations of NO_x and PM were reduced respectively by 1.3% and 3%. Boogaard et al., (2012) assessed the implementation of low emission areas with EURO II and EURO III standards in five different Dutch cities. He obtained similar results regarding soot, NO_x and PM concentrations' reductions, although in most of the cases the results were not significant when compared with values measured outside the low emission zone. Indeed, according to a report on the efficiency of low emission areas in Europe published by ADEME[32] in 2016, the average annual concentrations of PM_{10} decreased by 12%, and the concentrations of NO_2 decreased in a range from 1 to 10%, varying from one context to another.

For its part, traffic restrictions by license-plate have in general obtained worse results than expected. Different studies have found that this type of restriction system does not have a positive impact on air quality, nor does it encourage shifting to more sustainable modes of transport (Davis, 2008). On the contrary, given the tendency of motorists to acquire an additional car —usually older and more pollutant— to circumvent the restriction, in the long run it tends to increase the size and the age of the car fleet, congestion and pollution (de Grange & Troncoso, 2011). Nonetheless, similar initiatives implemented in cities other than Santiago (Fresard, 1998) and Mexico City (Davis, 2008) have had better results. The "rodizio" system managed to reduce the fuel consumed, increase the traffic speed, and diminish CO emissions in São Paulo. The "Pico y Placa" program on its part, is supposed to have increased average traffic speed by 43%, decreased fuel consumption by 8%, and air pollution by 11% according to Bogota's authorities (de Grange & Troncoso, 2011). More detailed results on this matter will be presented in section 5.3.

Environmental charging policies are considered more efficient than traffic restrictions since they manage to reduce urban traffic, to shift motorists to public transport, and the revenues raised can be used to implement additional air quality improvement measures (Leape, 2006). The congestion charge applied in Stockholm meant a traffic reduction of around 22% across de cordon, thereby improving travel times. As a consequence of congestion relief, air pollutants were reduced between 10 and 14%, NO_x by 8.5%, and CO_2 emissions in the whole metropolitan area decreased by 2-3%. However, the congestion charge implemented in London did not reached such good results. The introduction of the charging scheme resulted in an 18% reduction in traffic volume and a 30% reduction in traffic congestion in the first year (Kelly et al., 2011). However, the program was not as effective as expected in terms of reducing air pollution. Although decreases in NO, PM_{10} and CO were achieved in certain areas within the Charging Zone, NO_2 and O_3 concentrations increased.

[32] ADEME (L'Agence de l'environnement et de la maîtrise de l'énergie). French Environmental and Energy Management Agency.

Finally, little evidence was found that the changes in NO_x levels, which happened to be rather small, were a direct consequence of the program (Atkinson et al., 2009). It is worth noting that the real impacts of charging policies on air quality are difficult to measure, since they are usually implemented in conjunction with other traffic and emissions interventions. A detailed analysis on this case will be presented in section 5.1.

Traffic management strategies are intended to smooth traffic flows and improve mobility and can involve different measures including traffic segregation, traffic signal control or modification of speed patterns, to name just a few (Gwilliam et al, 2004). Speed limitation measures are widely used because of the potential additional benefits that they might entail such as reducing emissions, fuel consumption, congestion, noise and accidents. However, few studies have investigated the effect of speed limitation on air pollution with confronting results (Folgerø et al., 2017). Whilst Baldasano et al. (2010) found that the 80 km/h speed limit implemented in Barcelona Metropolitan area achieve emissions and primary pollutants reductions up to 4% and 5-8% respectively, the analysis carried out by Bel & Rosell (2013) showed that the measure actually increased PM_{10} and NO_x concentrations by 5.3-5.9% and 1.7-3.2% respectively. Bel & Rosell (2013) also assessed the effects of the introduction of a variable speed system in the same area that showed reductions in the levels of PM_{10} by 14-17% and NO_2 by 8-17%. Folgerø et al. (2017) assessed the impact of the speed limit from 80 to 60 km/h implemented in Oslo over the 2004-2015 period to find out that it had no effect on local air pollution.

Different policies aimed at encouraging sustainable modal shift have attracted increasing interest over the last decade. These initiatives focus on changing people's travel behavior by promoting more sustainable and active travel options such as public transport, cycling and walking (Wall et al., 2017). Shifting towards active travel modes may contribute to reduce air pollution from burning fossil fuels, decrease traffic congestion, increase levels of physical activity, reduce exposure to air and noise pollutants, and increase social interaction (Song et al. 2017; Rissel, 2009). Johansson et al. (2017) assessed the impacts on air pollution derived from transferring car commuters living within 30 minutes from their workplaces to cycling in the County of Stockholm. They found that more than 111,000 inhabitants could potentially shift towards bike commuting with a consequent reduction in NO_x and BC concentrations ranging between 6.4% and 8.4%. The promotion and improvement of public transport has also contributed to improving urban air quality. Titos et al. (2015) evaluated the impact on air quality of two transportation measures carried out in two different cities: Ljubljana (Slovenia) and Granada (Spain). After the implementation of a traffic restricted zone in Ljubljana only available to public buses and taxis, BC levels were reduced by 72%. On its part, the re-organization of the Granada's bus system to avoid lines' overlaps together with the introduction of new buses with higher capacity and lower emissions managed to cut BC and PM_{10} concentrations by 37% and 33% respectively. The bus rapid transit (BRT) implemented in varies cities in Latin America has proven to be successful in reducing emissions of SO_2, CO, NO_x, $PM_{2.5}$ and PM_{10} (Bel & Holst, 2015; Turner et al., 2012).

The promotion of shared mobility initiatives that encourage greater vehicle occupancy and discourage car ownership may also have a positive impact on urban air quality. Besides the

individuals benefit of sharing journey costs, ride-sharing is estimated to contribute to reducing vehicle kilometres travelled (VKT), congestion, fuel consumption, accidents and emissions (Fellows & Pitfield, 2000). Caulfield (2009) estimated that 12,674 t of CO_2 emissions would be saved annually if Dublin citizens ride-shared when commuting. On its part, car-sharing systems have proven to be successful on reducing total CO_2 emissions, VKT, the average number of vehicles per household, and promoting the shift to transit and active modes (Shaheen & Cohen, 2007). Firnkorn & Müller (2011) forecasted a substantial CO_2 reduction per average car2go user and a net reduction in the car fleet of 1995 cars after five years of car2go implementation in Ulm (Germany).

Finally, other policies aimed at promoting the market penetration of electric vehicles (EV) or ultra-low emission vehicles (ULEVs) have been implemented in different countries. Since improved fuels and vehicle technology have a significant potential for reducing emissions at the vehicle level (Gwilliam et al, 2004), the higher the share of these vehicles in a vehicle fleet, the greater the impact on local air pollution and GHG emissions will be. However, subsidizing cleaner alternatives are found to be less efficient and cost-effective in reducing emissions than taxing more pollutant fuels and vehicles (Gwilliam et al, 2004; Morroe et al., 2010). Indeed, subsidies alone may not be a sufficient strategy for launching an EV market (Hao et al., 2014; Yang, 2010), and also appear to impede conventional vehicle fuel economy improvement (Morroe et al., 2010). Lesser (2018) also claims that a broader adoption of EVs would increase overall emissions of SO_2, oxides, nitrogen and PM when compared to new conventional vehicles because of the indirect emissions associated to the generation of electricity. Moreover, he states that the slight reduction of CO_2 emissions achieved would not have any positive impact on climate change. Despite all these efforts, they have not been sufficient to guarantee air quality in urban environments. In fact, atmospheric pollution continues to be a public health problem and one of the pending tasks in large cities, where the impact of transportation is significantly higher.

Other impacts

As abovementioned, air pollution caused by PM particles and NO_x in suspension is an important risk factor for respiratory, cardiovascular and cancer diseases (Invernizzi et al., 2011). As a result, measures intended to diminish the concentration of these pollutants are very likely to have direct and indirect health benefits. In fact, several studies have shown that a reduction in air pollution may lead to a reduction in mortality and morbidity (Pope et al., 2009). However, studies on the subject are scarce. Particularly, there are no studies on cities without cars that allow for comparative analysis. On the other hand, the improvement of air quality could have an impact on the number of respiratory and cardiovascular diseases contracted, which could also influence the number of sick days due to illness (DEFRA, 2017). Thus, this optimization would also bring economic benefits, particularly in relation to the health sector. For example, estimated health gains in relation to the low-emission area of the City of London amount to £ 100 million (Browne et al., 2005). On its part, the congestion charges introduced in Stockholm were estimated to avoid 20-25 premature deaths per year in the inner city, and a total of 25-30 premature deaths yearly in the metropolitan area (Forsberg et al., 2006).

Moreover, measures restricting diesel powered and old vehicles, fiscal policies taxing polluting vehicles and fuels, and subsidies and tax reliefs to purchase cleaner vehicles have fostered the transition towards a greener fleet (Lutz, 2009; Morroe et al., 2010). This trend is also observed in the cities of Madrid, Paris, Milan and Rome, where new concepts of logistics and distribution services have been developed by means of electric and hybrid vehicles.

Another important aspect to consider is that these environmental policies may also have benefits on road safety. On the one hand, the incentive to use newer vehicles that comply with recent environmental requirements will have an impact on their improved safety systems (Browne et al., 2007). On the other hand, the reduction of motorized traffic will lead to a reduction in traffic accidents (Green et al., 2016).

In addition to the above, the decrease in the number of vehicles in urban centres would mean a reduction in the demand for parking and road spaces, which would be beneficial for the development of green spaces and pedestrian zones. The consequent improvement in traffic flows, air quality and vehicle accessibility are associated to an improvement in the perceived urban environment not only by car drivers, but also for cyclists and pedestrians (Eliasson, 2014). Vehicle restrictions and the promotion of alternatives to private motorization such as integrated public transport, rapid transit and bike lanes also contribute to promote more sustainable and active transportation, influencing modal choice (Wall et al., 2017). The foregoing would undoubtedly translate into health benefits and higher quality of life for citizens in urban areas, contributing to safer and more sustainable communities.

It is also necessary to consider the costs associated with the application of the measures to analyze their cost-effectiveness. For example, the annual implementation and operating costs of the low emission area in London in 2008 amounted to 15.6 million euros, while the revenues generated (fines) were estimated at 6.4 million euros (ATMO, 2015). On its part, Morrow et al. (2010) estimated that subsidizing the purchase of new and cleaner vehicles would require the US government to invest $22-38 billion per year. Equally important is to assess the social and economic costs of the measures for the affected population. For example, Folgerø et al. (2017) estimated a net social loss[33] from the speed limit reductions in Oslo of 0.52 billion USD per year. Finally, the social equity of the measure to be implemented should be thoroughly assessed and additional measures compensating the most affected population should be encouraged. In this sense, low income people are the most affected by vehicle restrictions, fiscal policies that tax more pollutant vehicles, and the gradual and inexorable fleet renewal with less pollutant but more expensive vehicles.

5.5 INTERNATIONAL EXPERIENCE

As previously mentioned, London and Madrid in Europe, and Bogotá in LAC have implemented different policies aimed at reducing damaging pollutants, which harm human health and quality of

[33] The Cost Benefit Analysis considered potential private costs in terms of time loss, and private benefits included lower fuel consumption due to lower speed, and potential social benefits in terms of fewer accidents, less noise and better health outcomes due to better air quality.

life. This section seeks to analyse existing experiences of transport policies to improve air quality in these cities in order to evaluate their effectiveness in reducing pollution, as well as other effects derived from reducing congestion or improving overall travel times. In the following sub-sections, a summary of some of these strategies is presented, together with an identification of a wide range of economic, social and environmental benefits derived from their application. Some of these examples, constitute the city´s strategic vision for the future (as the case of Madrid) while others are strategies already underway (as the case of London and Bogotá).

The case of London in the UK

As most megacities in the world, London currently faces a range of environmental challenges. As a result, over 9,000 lives in the city end sooner than they should each year due to air pollution, imposing a cost of 3.7£ billion on the London´s economy (Greater London Authority, 2018). Under the future aim of having the best air quality of any major city in the world in 2050, the capital has put in place a number of policies and proposals. Some remarkable examples of these strategies are the Congestion Charge for promoting a shift to more sustainable transport modes, and the Low Emission Zone (LEZ) for reducing the number of polluting vehicles in the city. A description of the key elements of these iconic measures and their effects is provided below.

Transport policies for improving air quality

The London Environment Strategy sets out the city´s vision for improving the air quality and provides a holistic plan for tackling the environmental challenges. In relation to the transport system, this includes a range of policies and actions to be implemented until 2050, as shown in Figure 5.2. Among these set of policies and actions, existing road user charging schemes such as the Congestion Charge and the Low Emission Zone deserve attention as key components of the Mayor of London's Air Quality Strategy.

Defined as a charging zone across most of Greater London (see Figure 5.2) for vehicles that do not meet emissions standards for particulate matter (PM_{10}), the low emission zone scheme was introduced in 2008 with the objective of reducing the emissions of harmful pollutants from road traffic in the city while encouraging the most polluting heavy diesel vehicles to become cleaner. It applies to all types of vehicles regardless of their use (private or commercial), except for cars, motorcycles and vans of less than 1.5 tons. Under the reference to the `Euro´ emissions, the scheme —gradually implemented in phases— requires vehicles to meet certain emissions standards[34]. For instance, trucks of more than 3.5 tons and buses and coaches of more than 5 tons must meet EURO IV standards. In addition, EURO VI standards are required for urban buses. In the same way, vans between 1.5 and 3.5 tons and minibuses of less than 5 tons must comply with EURO III standards. Owners of vehicles that do not meet the minimum requirements of the low emission area and that decide to enter the area, are required to pay a penalty charge of £ 100 for vans and £ 200 for heavy vehicles (Transport for London, 2012).

[34] Euro emission standards describe the acceptable levels for exhaust gas emissions of new vehicles in the European Union.

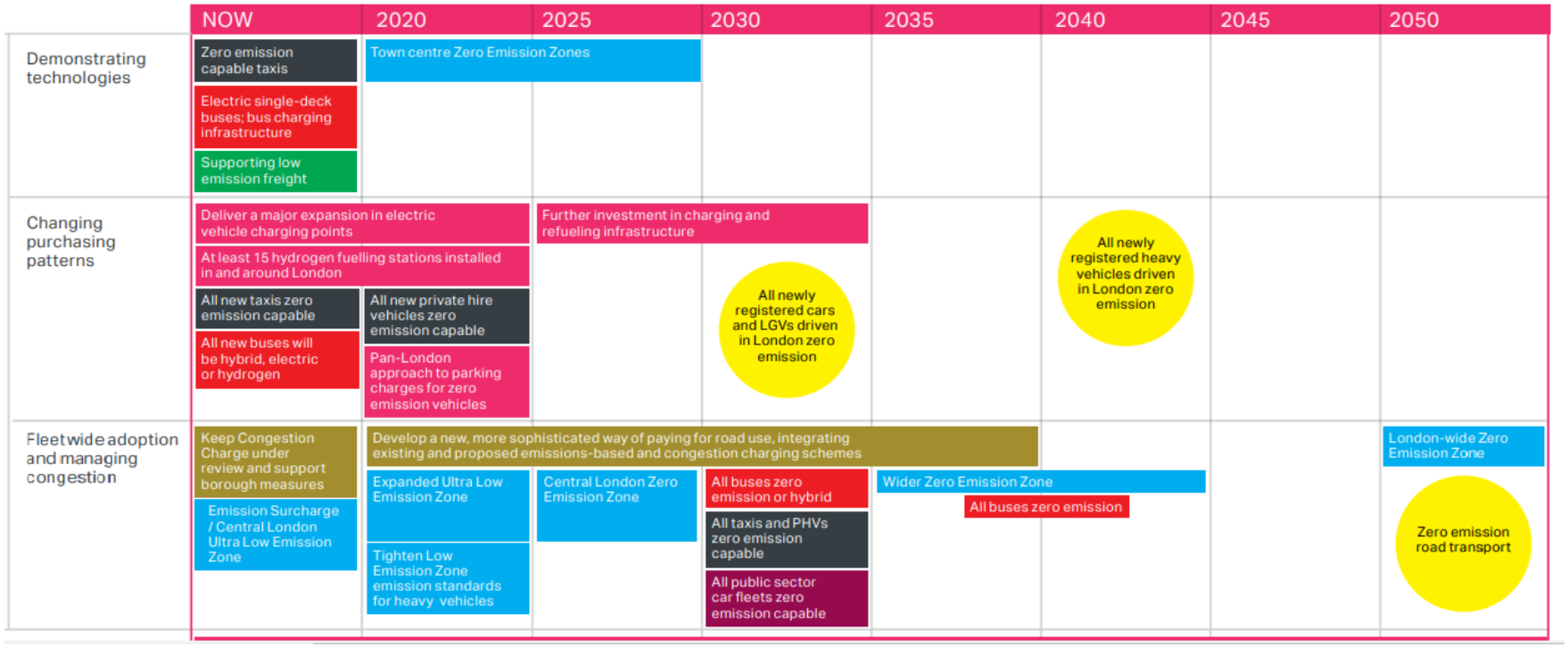

Figure 2 Roadmap to zero emission road transport in London. *Source: Greater London Authority, 2018.*

From April 2019, new tighter emissions standards were introduced, and a new version of the LEZ was launched, the Ultra Low Emission Zone (ULEZ). This new scheme imposes new standards to petrol and diesel vehicles including cars, motorcycles and vans. It will initially operate in central London in the same area as the Congestion Scheme, and from 2021 its size will be expanded.

As abovementioned, in addition to the implementation of these schemes aimed at promoting the earlier introduction of cleaner vehicles, London has applied a congestion scheme since 2003 to motor tricycles and quadricycles, cars, small vans, larger vans, lorries and specialist heavy vehicles. According to Transport for London (2008), the Congestion charging (CC) was initially designed to: reduce congestion, provide additional public transport capacity for road users, improve journey time reliability for car users, and make the distribution of goods and services more efficient.

However, the CC is also considered a powerful measure to reduce emissions by reducing the volume of traffic and allowing a more efficient distribution of the remaining traffic in central London —see Figure 5.3. Currently, a driver must pay £11.50 daily if she/he wants to drive within the congestion charge zone between 07:00 and 18:00 (Monday to Friday). To complement the `environmental nature´ of the CC, a charge named T-charge also applied in the same area of the operation of the CC, under which the following emissions standards should be met: Euro 4/IV for both petrol and diesel vehicles and Euro 3 for motorized tricycles and quadricycles. If vehicles do not meet this condition, they must pay the daily £10 additional charge.

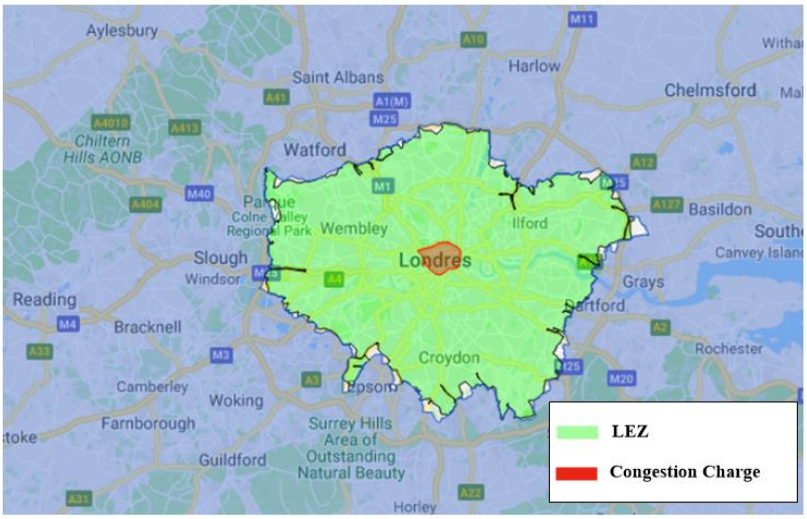

Figure 5.3. Low Emission Zone and Congestion Charge boundaries.
Source: Author´s elaboration based on google maps and TfL.

Impacts derived from these policies

It is interesting to analyze the impacts of the abovementioned transport policies to evaluate their effectiveness in terms of air quality, and to estimate their compliance with the environmental objectives of the Kyoto Protocol and the European Union for the period 2020-2030. However, given the complexity of the topic and the recent implementation of these measures, the effects derived from them has been scarcely studied in the literature.

One of the scientific studies analysing in greater depth the policies to abate atmospheric emissions from traffic in London has been carried out by Font and Fuller (2016). Based on the monitoring of air pollutants between 2005-2009 and 2010-2014 in London, the research concludes that despite the overall decrease in total traffic between 2005 and 2014 in the city, pollutant levels did not decrease globally as projected. The increase in NOx and NO_2 concentrations during 2005-2009 contrasted with the expected impacts as a result of tighter Euro class emissions. This phenomenon can be partly explained by the increase in the number of diesel vehicles (33%) for the whole United Kingdom (Department for Transport, 2015).

On the other hand, the study also concludes that in the period 2010-2014, NOx and NO_2 concentrations decreased along with $PM_{2.5}$. This can be explained by the creation of the low emission zone and the general decrease in total vehicles since 2010. The low emission zone, banned the most polluting diesel Heavy Good Vehicles (HGVs) and light good vehicles (LGVs), have categorically contributed to limit the pollutant emissions in this capital. In fact, PM_{10} concentrations within the area of low emissions have fallen by an average of 13% since its introduction. In addition, the introduction in 2008 of the EURO V standards for HGVs, caused a reduction of NOx emissions by 42% (compared to EURO IV).

Some other studies have pointed out the difficulty of reducing NO_2 concentrations as an important limitation to the air quality policies applied in this city. In this sense, a study carried out by Carslaw et al. (2016) have shown that significant reductions in vehicle emissions do not significantly affect NO_2 concentrations. For this phenomenon, reducing concentrations of nitrogen dioxide remains a key challenge across many European urban areas, including London. Hereby, despite the gradual reduction in pollution concentrations in the city, the annual NO_2 emissions[35] currently exceeded the European Union limit values (Greater London Authority, 2018).

In summary, despite the significant efforts made by the City of London to improve air quality, the results have not been as expected. In fact, although the area of low emissions has had positive effects (decrease or stability of annual concentrations of PM_{10}, reduction of traffic, reduction of concentrations of NO_x and NO_2,), the latter have been relatively small, and often not significant.

The case of Madrid in Spain

As in many others large metropolitan areas, air quality is a major environmental issue in Madrid. Particulate matter and nitrogen oxides are recognized as the most significant air pollutants causing health impacts to the population of the city. Even though, in general, air quality levels have improved in the city over the last decade, some pollutants like nitrogen dioxide (NO_2) remain a specific concern. The main source of contribution of this pollutant in Madrid is road traffic (53.3%). At the end of the year 2017, the monitoring stations exceeded the hourly limit value for NO_2 (200 mg/m^3) more than 250 times[36]. This situation forced the environmental authority of Madrid to

[35] Around half of nitrogen oxides (NOx) emissions come from road transport sources.

[36] While in 2012 it was exceeded 173 times, in 2013 it was limited to 169, in 2014 it was reached 215 times and in 2016, 222.

activate `high pollution protocols´, by imposing tighter speed limits, parking restrictions, and restrictions of vehicles according to license-plate number (e.g. odd and even) in Madrid inner-ring.

Under this panorama, Madrid Local Government have recently implemented an air quality plan called "*Plan A*", aimed at tackling such a public health problem. A description of the key elements of this iconic transport policy for improving air quality in Madrid and a description of its estimated effects is provided below.

Transport policies for improving air quality

As previously explained, transport policies to properly protect and enhance the environment in the city are set out in the recently launched *Plan A*, whose objectives are the following:

- To meet European and national air quality legislation.
- To achieve air quality levels for particles in suspension in line with the guideline value of the World Health Organization (WHO).
- To achieve by 2030 an over 40% reduction in total GHG emissions in the municipality of Madrid compared to 1990, thereby helping to meet the objectives of the Paris Agreement and the EU Climate Agenda, and in line with the new Covenant of Mayors for Climate and Energy.
- To fulfil the commitment to reduce GHG emissions caused by urban mobility by 50% by 2030 compared to 2012.
- To develop a climate change adaptation strategy in order to reduce urban vulnerability to the risks associated with global warming.

The plan is set under two horizons, a short-term horizon (2020) for the implementation of structural and technological measures resulting in significant reductions in emissions; and a longer-term horizon (2030) for the necessary urban regeneration, energy transition, renewal of the vehicle fleet and consolidation of a low emission city model. To that end, 30 strategies are proposed in the plan, including a low emission zone in the central area of the city, and the development of walking and cycling infrastructure. Table 5.3 presents a descriptive summary of some of the most relevant measures set out in *Plan A*. The complete list of the strategies can be found in *Ayuntamiento de Madrid* (2017).

Table 5.3. Examples of measures set out in *Plan A*

Measure	Brief description
Central zero emissions zone	A charging zone in central Madrid for vehicles that do not meet emission standards.
Redesign of the main access roads to the city center	Development of additional infrastructure for walking, cycling and public transport, removing space for motorized traffic from the current street configuration.
Priority for pedestrians and Improvement of the cyclist network	Improving public infrastructure for making walking and cycling easier. This includes infrastructure components (sidewalks, cycle lanes) as well as network elements for connecting cycling hire schemes with the rest of the public transport service of the city.

Measure	Brief description
Speed limits restrictions	Reducing the maximum speed limit down to 70 km/h on the Madrid inner ring. This strategy will be applied to both passenger and freight vehicles.
Development and enhancement of public transport infrastructure	Development —and prioritization— of public transport infrastructure in the city (e.g. Preferential routes for buses through reserved platforms, traffic light priority).
Incentives for cleaner vehicles	Subsidies to replace diesel and the older vehicles for new cleaner technologies.
Car-sharing promotion	Support to all shared mobility initiatives in order to improve and diversify the city's transport supply.

Source: Author´s elaboration based on Ayuntamiento de Madrid, 2017.

Despite the large number of measures included in *Plan A* to improve Madrid's air quality, most of them are currently under discussion due to a high social controversy. Then, the air quality strategy of the city is still mostly a list of good intentions, and need more work on the details, with few exceptions such as the case of the pedestrianization process of the *Gran Vía*[37]. It is also worth mentioning the process of banned gasoline vehicles registered before 2000 and diesel vehicles registered before 2006 in the Madrid Central area from November 2018.

However, the *Plan A* by itself constitutes a major environmental achievement of the city, bringing into discussion such an important topic posing major risks to the health and wellbeing of citizens: the improvement of the city's air quality. For the first time the environmental authority of the city elaborated a comprehensive strategy for addressing the serious environmental challenges currently being faced.

Impacts derived from these policies

It is not possible to evaluate the impacts derived from the implementation of *Plan A*, due to its recent launch. Instead, a brief estimation of the foreseeable effect of these measures will be presented in this section. These effects, calculated by the Madrid City council for the year 2020 under a methodological approach are shown in Table 5.4.

In general, data indicate that the implementation of *Plan A* will help to reduce population exposure to harmful pollutants in the city, which will bring Madrid nearer to achieving the targets set. For example, the annual average concentration of NO_2 corresponding to the municipality of Madrid would decrease from 17.2 µg/m3 in 2012 to 13.2 µg/m3 in 2020 (28%). This result suggests that Madrid will have no difficulty in complying with the required legal values for this pollutant, corresponding to 40 µg/m3 in one year. For particulate matter PM10, as well as for fine particulates (PM2.5) the situation is similar. If all the actions called by the *Plan A* are implemented, levels could be closed to those proposed by the World Health Organization.

[37] The *Gran vía* is one of the most iconic streets in the city of Madrid from the commercial, tourist and leisure point of view. It was built at the beginning of the 20th century.

Table 5.4. Reduction in concentration for different pollutants in Madrid after the implementation of Plan A (annual average)*

Pollutant	Reduction (%)		
	In the municipality	Inside Calle 30[38]	Central zero emissions zone
NO_2	23%	26%	30%
PM_{10}	8%	14%	24%
$PM_{2.5}$	9%	16%	24%

**With respect to a base year (2012). Source: Ayuntamiento de Madrid, 2017.*

Finally, an important pillar for improving air quality and reducing climate change plan (Plan A) has been the citizen participation. A recent study, aimed at developing a collaborative approach to ex-ante evaluate the implementation of transport policies for improving air quality in Madrid, found that stakeholders are committed towards adopting strategies to improve air quality at the city level, but they also tend to oppose to those measures which directly affect to motorized vehicles traffic (e.g. restrictions by license-plate, environmental charges) —see Universidad Politécnica de Madrid (2018). However, the study shows that via stakeholders' engagement is possible to find win-win solutions and to increase the acceptability and feasibility of those measures.

The case of Bogota in Colombia

Unlike the other major cities previously analysed, the main air pollutant in Bogotá is still the particulate matter PM_{10}. Moreover, the issue is still studied from the point of view of PM_{10} and not $PM_{2.5}$ as in European cities. As shown in Figure 5.4, PM_{10} annual concentrations in some areas of the city far exceed the maximum limits set by the World Health Organization (20 µg/m^3). In fact, in Bogota respiratory diseases are among the main causes of death of its inhabitants, especially of the most vulnerable groups such as children and the elderly (Cámara de Comercio de Bogotá, 2015).

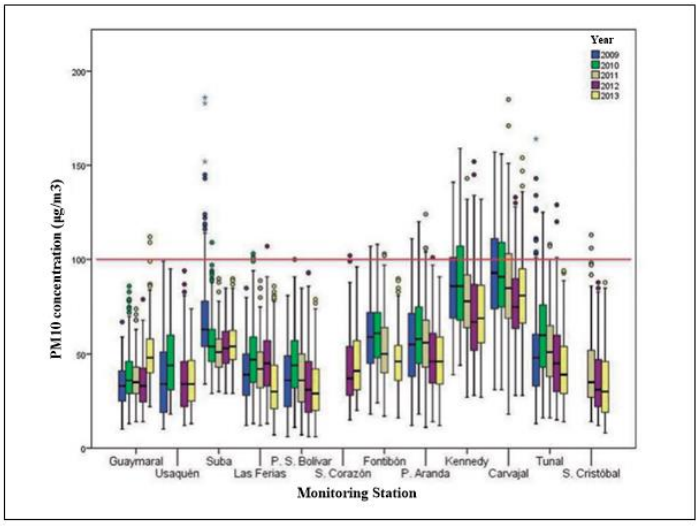

Figure 5.4. PM_{10} annual concentrations in different monitoring stations in Bogota.

[38] The road network in Madrid comprises four main beltways around Madrid city: two of them being ring roads (M30 —the inner ring, and M40 —the external ring), and the other two (M45 and M50) being semicircular roads.

Source: Cámara de Comercio de Bogotá, 2015.

According to the most recent inventory of pollutant emissions in the city, mobile sources contribute about 50% of the particulate matter (see SDA, 2011), causing a huge impact on health. In 2015, Bogota air pollution was linked to over 3,219 deaths (10.5%). The economic cost of these health impacts is estimated as being up to $4.2 billion of Colombian Pesos, equivalent to 2.5 % of the city's GDP (DNP, 2015).

Under this panorama, the city has adopted a number of policies and plans. Remarkable policy actions include the adoption of an air quality plan at the district level, and the implementation of several traffic restrictions (e.g *pico y placa, día sin carro*). A description of the key elements of these instruments and their effects is provided below.

Transport policies for improving air quality

In 2011, the environmental local authority of Bogota (*Secretaría Distrital de Planeación*) launched a plan for the decontamination of the air called "*Plan Decenal de Descontaminación del Aire de Bogotá*". The plan, formulated for the period 2010-2020, proposed a number of strategies focused on diesel buses, trucks and motorcycles including emission control systems for motorcycle and cargo transport vehicles, the implementation of the SITP —the integrated transport system of Bogota[39]— and the implementation of particulate filters in SITP buses. Table 5 presents a descriptive summary of some of the most relevant transport measures set out in the plan. The complete list of the strategies can be found in *Alcaldía Mayor de Bogotá* (2011).

Table 5.5. Examples of transport measures set out in the "*Plan Decenal de Descontaminación del aire de Bogotá*"

Measure	Brief description
Emission control systems in cargo transport vehicles	Implementation of catalysts for cargo transport vehicles emissions control in Bogotá. This requirement will also apply to new vehicles.
Emission control systems in motorcycles	Implementation of catalytic elements integrated into the exhaust system for motorcycle vehicle emissions in Bogotá. This requirement will also apply to new vehicles.
Implementation of the SITP	Implementation of the SITP and its fleet renewal and scrap program.
Emission control systems in SITP vehicles	Implementation of particulate filters in buses that will become part of the SITP fleet.

Source: Author´s elaboration based on SDA-Transmilenio-SUR (2010).

Theoretically, Bogota will be on track to reduce its emissions quickly enough to meet national regulations concerning PM_{10} (50 µg/m^3) through the implementation of those projects. However, in addition to the 10-year decontamination plan, the city has also implemented different programs in its pursuit of environmental objectives over the past years. Such actions have included:

[39] The plan set out that the total implementation of the SITP must be completed by December 2015.

- The implementation of the Bus Rapid Transit (BRT) system in the city. *Transmilenio* has — in some way— slowed down the vehicle pollution trend, since it has indirectly encouraged the reduction in the number and use of smaller, less efficient, obsolete, and/or poorly maintained traditional buses of conventional transport systems.
- Restrictions by license plate (*pico y placa*) and other environmental restrictions (*pico y placa ambiental*). Since 1998, Bogota implemented a driving restriction called *pico y placa*, which prohibits drivers from using their private vehicles according to their license-plates. In addition to this `traditional´ constraint, the city has adopted in 2006 a policy which banned collective transport and cargo vehicles from running in certain areas of the city declared as areas of high pollution (*pico y placa ambiental*).
- *Día sin Carro*, a total restriction made for private vehicles and motorcycles implemented in the city since 2001, once per year (sometimes more). According to the transport authority of the city, around 1,181,000 private vehicles and 338,000 motorcycles will stop circulating this day[40].
- Plan de Ascenso Tecnológico (PAT). This plan intends to promote the substitution of public transport vehicles powered by fossil fuels for hybrid, electric and LNG vehicles in order to reduce pollutant emissions and CO_2. To that end the program promotes, among other measures, several pilot projects to test and demonstrate one electric bus, one hybrid bus, one LNG bus and 50 electric taxis.

Impacts derived from these policies

A study conducted by the environmental local authority of Bogota found, as a result of the implementation of the air quality plan, historic reductions in the levels of PM_{10} concentration, as well as in other air pollutants —see SDA, 2017. Table 5.6 shows the average trend over the years for NO_2, SO_2 and PM_{10} concentrations, respectively, at sites in the Bogota Air Quality Network. In general, there has been a gradual reduction Bogota´s pollution concentrations. This result is important since, overall, the average air quality is improving in the city. However, the PM_{10} limit value is being exceeded in some specific areas where the PM_{10} health-based guidelines are far from being met.

Despite this progress, the implementation of all the strategies included in the plan has been challenging and there is still much to be done to improve Bogota´s air. One of the main problems has been the poor quality of diesel in Colombia, the few existing incentives to buy or operate clean fleets, the non-installation of particle control systems, etc. For a detailed description of the development of the measures displayed see the "*Plan Decenal de Descontaminación del Aire de Bogotá*". The reader is referred to SDA, 2017.

[40] Data Baseline: february 2018

Table 5.6. Concentrations in µg/m^3 for different atmospheric pollutants after the implementation of the air quality Plan in Bogota.

Year	PM_{10} Particulate matter	NO_2 Nitrogen Dioxide	SO_2 Sulfur Dioxide
2008	67	40	23
2009	59	40	27
2010	59	39	9,4
2011	52	35	9,1
2012	48	29	7,9
2013	48	30	8,6
2014	52	31	4,2
2015	44	35	3,3
2016	45	32	3,9

Source: SDA, 2017.

Alongside this plan, as explained before, other actions have been implemented in Bogota to reduce emissions quickly enough to avoid the worst impacts of climate change. Unfortunately, the results shown below are not encouraging as:

- No evidence of an improvement in air quality or a reduction in car use was found from the implementation of the *pico y placa*. On the contrary, gasoline consumption, vehicle ownership, and carbon monoxide tended to slightly increase when these drastic restrictions were implemented (Bonilla, 2016).
- In fact, some research works have found that the use of the license plate-based driving restriction in Bogota has encouraged the purchase of a second car, which even may increase air pollution above previous levels (Zhang et al., 2017).
- Despite the *pico y placa ambiental* has proven to be effective and one of the most successful strategies applied to the most polluting diesel vehicles (public transport and cargo), its scope of application of small and this constraint their impacts at the city level.
- During the *Día sin Carro*, the levels of damaging pollutants have not shown significant improvements. In fact, PM_{10} concentrations in some areas of the city tended to slightly increase due to a higher use of public transport operating mostly with polluting vehicles (Universidad de los Andes, 2018).

5.6 COMPARISONS ACROSS CASE STUDIES

After analyzing each city on an individual basis, the present section conducts a cross-cutting assessment of the transport policies implemented for improving air quality in the three cities analyzed. Table 5.7 provides a summary and a qualitative comparison of the different case studies described above.

Table 5.7. Summary of transport policies for improving air quality in London, Madrid and Bogotá

City	Transport policies implemented	Results obtained	Future challenges
London	-A long history in applying a range of effective measures for improving air quality (e.g. congestion charge, T-charge, low emission zone, ultra-low emission zone, among others).	- Overall, the city is already reversing many of its pollutants negative trends. Nevertheless, NO_2 EU annual mean limit values are being exceeded in many places of the capital and the PM health-based guidelines are far from being met.	- Achieving legal compliance as soon as possible. In particular, the city is failing to meet the legal limit for NO_2 and $PM_{2.5}$. - Encourage the use of more sustainable means of transport (walking, cycling) and the use of zero emission technology vehicles.
Madrid	-Very recent environment strategy (2017), as a result of a political decision of the present local government in accordance to EU legislation. -A range of transport policies to be implemented in the short and medium term.	- According to the estimates, Madrid will be able to meet the legal limits for air pollutants after the implementation of the Plan. However, this is only a forecast at this stage.	-Ensuring the proper implementation of the measures set out in the plan. - Key issues to be addressed in the implementation process for some measures (e.g. the impact on local economy and stakeholders' acceptability from the traffic restriction in the city center).
Bogotá	-Recent implementation of the air quality plan (2010), adopting a range of technological measures such as the implementation of emission control systems. Other strategic actions are not considered in this plan (i.e. congestion charge, Priority for pedestrians, etc.).	- Average rates shows the achievement of the limits set out in the city´s environment strategy. However, there are some further studies that need to be conducted in order to validate these results (e.g. personal exposure). -Reinforcing strategies (*día sin carro, pico y placa*) have not been successful to improve air quality, clean up the natural environment and reduce vehicle use.	- Currently, Bogota is far from achieving limits in terms of personal exposure to fine particle and black carbon (Segura and Franco, 2016; Betancourt et al., 2017) - Policy makers have mainly focused on implementing technological changes rather than adopting more strategic policies that offer multiple benefits for the environment in the long term.

Source: Author´s elaboration

The main conclusion obtained is that, in many ways, a coordinated policy —such as the London environment strategy— may result in real progress to improve air quality. However, all efforts to tackle air pollution (linked to asthma, heart disease, strokes, and other disorders) are welcome, as long as they prove to be effective for the environment. In this respect, Madrid has started its way towards cleaning up the air of the city. This strategy seems to cover plans and transversal actions of different nature in an encompassing form. Finally, megacities in LAC as Bogota, have also moved towards the reduction of transport emissions. Nevertheless, its efforts have been mostly focused on technological changes to address environmental challenges rather than on effective transport policies.

This comparative analysis allows us to obtain a general assessment of the main actions implemented in different cities to reduce conventional air pollutants. On this basis, next section proposes a potential agenda for air pollution mitigation in LAC cities.

6. LESSONS FOR LATIN AMERICA AND THE CARIBBEAN

This chapter gathers a set of lessons to be learned from the policies previously reported, and its implementation to the three case studies. These lessons intend to give response to the following critical challenges:

- Which are the most effective mechanisms for implementing integration policies in LAC cities? What are the key drivers for success in achieving such an integration?
- Are subsidies to public transport services in large cities effective means of improving the efficiency of the whole transport system? Which are the key drivers ensuring good practices to finance public transportation and rightly manage subsidies in metropolitan areas?
- Which transport policies aimed at improving air quality may be the most effective ones in the Latin American context? Which are the expected impacts stemming from the implementation of transport policies to improve air quality?

The following paragraphs provide the main findings giving answer to the questions previously discussed. The general recommendations for LAC cities are divided in three sub-sections, corresponding to the transport policies studied throughout this report. As above-mentioned, these recommendations may be not directly applicable to every LAC, given the great variety of contexts in the region. Furthermore, the cases studied are based on large and relatively developed cities for each national context.

6.1 RECOMMENDATIONS WHEN IMPLEMENTING TRANSPORT INTEGRATION POLICIES IN LARGE CITIES

The analysis conducted across this report provides many interesting lessons applicable to LAC cities regarding transport integration:

- Despite the difficulties of reaching full integration, many cities in developed countries, such as London and Madrid, have demonstrated that with the right will, this goal can be achieved. The first lesson is that integration is possible.
- Experiences in cities like Madrid and London show that integration was possible only after a single transit authority with enough autonomy was created. Setting up the right governance approach is hence a crucial issue.
- Even though physical and fare integration are not for free, the cost for their implementation is much smaller than, for instance, large-scale undertakings such as the construction of new metro lines. Transport integration is not that costly compared to other transport investments.
- Integration encourages greater public transport patronage, thereby reducing the use of the private vehicle and mitigating congestion.
- Integration contributes to improving quality of life for society in urban areas from different perspectives. Physical integration enhances the urban landscape; fare integration makes public transportation more affordable and easy to use; and, information integration helps better assign transport demand.

- The beneficiaries of integrated transport in urban areas are not just public transport users, but also car users and citizens. This fact justifies that they contribute to finance the costs of transport integration through taxes or cross financing approaches.
- Public transport authorities should be aware of the need of safeguarding financial sustainability. One of the main problems of achieving integration is to do it at the expense of putting at risk the financial sustainability of the municipality. Transport integration measures should be hand in hand with a plan aimed at guaranteeing over time the necessary resources to finance the system regardless of the economic cycle.
- A final aspect should be outlined regarding fare integration and the use of unique travel cards. Most cities in LAC still face problems with electronic fare collection systems due to lack of interoperability with other providers. Cities are more than often captured by a provider-specific characteristic at the time of integrating extensions and new lines. A recommendation can be given regarding the importance of setting up technical standards in the bidding terms to guarantee interoperability in order to ensure the participation of diverse types of suppliers in future purchases of equipment.

6.2 RECOMMENDATIONS WHEN IMPLEMENTING SUBSIDY POLICIES TO PUBLIC URBAN TRANSPORT

The implementation of subsidies to public transport systems in large cities is a multifaceted issue that still requires a greater knowledge from both theory and practice. Chapter 4 of this report shows how iconic metropolitan areas in the world (such as London and Madrid), and also important large cities in LAC (such as Bogotá), have progressively set complex approaches to finance public transportation and manage subsidies.

From the analysis conducted —both the literature review, practical experiences and the selected case studies— the following lessons for LAC cities may be pointed out:

- Unlike what some decision makers may think, providing subsidies to public transport services in large cities may be an effective way of improving the whole transport system efficiency insofar as shifting people from the private car to public transportation contributes to alleviate congestion and reduce externalities. In addition, subsidizing public transport is also a suitable way of promoting inclusion for less wealthy people. Decision makers should not be afraid of implementing subsidies as long as they are rightly targeted and designed.
- However, setting up a reasonable and sustainable subsidy policy is a complicated challenge for policy makers. Subsidies are the result of very sensitive policies such as: the definition of public transport fares, the availability of budgetary resources, and a credible investment policy for transport networks. Unfortunately, in many cities the ultimate decision about the aforementioned policies is taken on by political leaders who sometimes decide on the basis of electoral reasons rather than on the grounds of efficiency and sustainability. To prevent this problem, it is advisable that cities define a public transport financing framework founded on economic, social and environmental criteria; which, while allowing enough flexibility to the political leaders to take their decisions, clearly establish the limits of rationality.

- Financial sustainability over time is one of the most important goals that transport authorities should ensure at the time of receiving subsidies. This goal requires setting stable and reliable sources for subsidies, and being able to adjust the funding model if changing trends make it necessary.
- The provision of subsidies to public transport authorities should be designed in order to incentivize the efficiency of the operators from the economic, social, and environmental point of view. In this respect, subsidies should be awarded only if transport operators strive to reach a set of predefined objectives in terms of ridership, cost efficiency, productivity, environmental indicators, etc.
- Public transport in large metropolitan areas impact different governmental levels (local, regional, central, etc.), all of them benefited from an efficient public transport system. It is therefore essential to set up a framework agreement aimed at defining the role of every government to contribute with subsidies, and ensure its long-term commitment to provide them.
- An important issue for the region is the decision of implementing demand-side subsidy programs or supply-side subsidy policies. On the other hand, it is worth mentioning that the concept of free public transportation is gaining importance in the region. Expected impacts from a free of charge public transport system (greater public transport usage, zero transaction costs, etc.) may be inspired by experiences in other European cities such as Tallinn and Hasselt.

6.3 RECOMMENDATIONS WHEN IMPLEMENTING TRANSPORT POLICIES FOR IMPROVING AIR QUALITY

Many urban areas in LAC are experiencing a relentless growth in population and economic development that is encouraging urban sprawl. Unfortunately, the enlargement of the city size is not always accompanied by the development of a good public transportation system. Wealth growth along with urban sprawl are encouraging the use of private cars in many LAC cities. As many people in LAC cannot afford to buy new ecologic automobiles, the average age of the fleet is higher than desired and henceforth more pollutant than it should be. This has been worsening the quality of the air in many cities thereby increasing the risk of the population of contracting severe diseases and reducing life expectancy. Even though in the last few years some measures have been adopted to curb this trend, there is still a long way to go to reach a truly sustainable transport policy that guarantees acceptable levels of air quality in many LAC cities.

The analysis conducted in Chapter 4 of this study, along with the experience in the three cities analysed, provides the following lessons:

- Cities in developed countries are getting more aware about the need of implementing transport policies aimed at tackling poor quality levels. This concern has been crucial to trigger different types of measures, even developing pilot programs to promote electric vehicles. A first lesson for LAC is that the awareness of municipal authorities about the problem, along with their willingness to solve it, is a first step to start implementing policies aimed at improving air quality.
- Different policies have been applied to improve air quality, but not all of them have been equally effective. For instance, strategies such as forbidding the traffic of vehicles according to number

plates have not been able to improve air quality. A second lesson for LAC is hence that potential policies to be implemented have to be previously assessed on the basis of the experiences in other cities and a specific evaluation of their impact on each metropolitan area.

- The report proves how the policies implemented may also have a large impact on crucial economic and social issues that are sensitive to different stakeholders (commuters, retail businesses, freight delivery companies, tourism activities, etc.). In this respect, a good lesson to learn is to open a dialogue with the stakeholders before a certain measure is implemented in order to develop application strategies that minimizes the damages to the stakeholders as much as possible.
- Awareness of the population about the need to change their behavior to face the problem of air pollution and is also a key aspect to take into account. A good lesson in this respect is to conduct campaigns aimed at promoting public awareness of the advantages of behaving in a more sustainable to improve air quality in the city centers. An overall positive conscience will undoubtedly facilitate the implementation of these types of measures.
- Electro mobility is gaining momentum all over the world. However, the successful implementation of this technology in LAC requires overcoming several barriers such as assessing the affordability of governments at implementing incentive measures, development a widespread re-charging infrastructure, and quantifying the impact on the grid.

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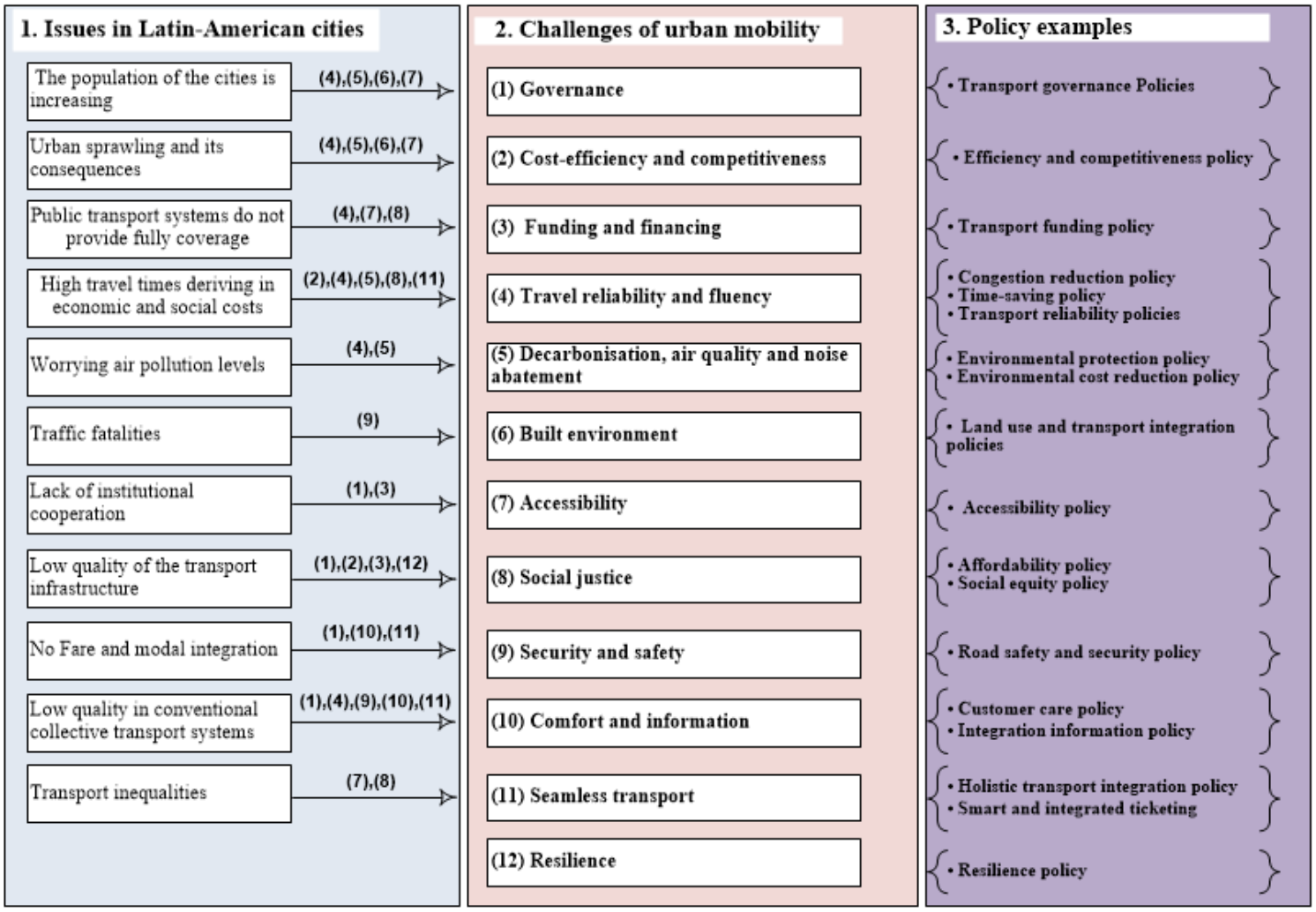
ANNEX 1: ROADMAP FOR CHAPTER 1



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4. Instruments

Constituting a single transport authority *Challenges addressed* *(1), (11), (8)*	**Setting value capture mechanisms** *Challenges addressed* *(1), (5), (8)*	**Ensuring competitive tender of transport services** *Challenges addressed* *(2)*
Enforcing road safety *Challenges addressed* *(8), (9)*	**Densification** *Challenges addressed* *(2), (4), (7), (8)*	**Land-use mix** *Challenges addressed* *(6), (7)*
Mobility plans *Challenges addressed* *(2), (4), (7), (11)*	**Contingency plans** *Challenges addressed* *(9), (10), (12)*	**Underground, interchanges, bus and cycle lanes** *Challenges addressed* *(4), (7), (10), (12)*
Fare and mode integration *Challenges addressed* *(2), (7), (8), (10), (12)*	**Public transport subsidies** *Challenges addressed* *(4), (5), (8)*	**Benefits for employees** *Challenges addressed* *(4), (5)*
Subsidies to renew the fleet *Challenges addressed* *(5)*	**Walking, Pedestrianization, Cycling** *Challenges addressed* *(5)*	**Pricing policies** *Challenges addressed* *(3), (4), (5)*
Parking restriction policies *Challenges addressed* *(3), (4), (5)*	**Diesel powered vehicle restrictions** *Challenges addressed* *(4), (5)*	**Internet of things and sensor deployment for Smart city platforms** *Challenges addressed* *(2), (4), (9), (10), (12)*
Deployment of intelligent transport systems (ITS) *Challenges addressed* *(2), (4), (5), (10)*	**Promoting MaaS** *Challenges addressed* *(2), (5), (7), (10), (11), (12)*	**Smart ticketing** *Challenges addressed* *(4), (10), (11)*
Teleworking *Challenges addressed* *(4), (5)*	**Jobs-housing balance** *Challenges addressed* *(4), (5), (6), (7)*	**Distance learning** *Challenges addressed* *(4), (5),(8)*
Electronic shopping *Challenges addressed* *(4), (5)*		

POLICY DIMENSION		
	Legal, governmental and regulatory	Push and Pull
	Land use and transport planning	Ditalization and new technologies
	Infrastructure and service improvement	Policies for reducing mobility needs