PONTIFICIA UNIVERSIDAD CATOLICA DE CHILE

SCHOOL OF ENGINEERING

ACCESSIBILITY AND AFFORDABILITY IMPACTS ON TRANSPORT-RELATED INEQUALITIES AND POVERTY: THE CASE OF SANTIAGO, CHILE

IGNACIO ANDRÉS TIZNADO AITKEN

Thesis submitted to the Office of Graduate Studies in partial fulfillment of the requirements for the Degree of Doctor in Engineering Sciences

Advisors:
JUAN CARLOS MUÑOZ
RICARDO HURTUBIA

Santiago de Chile, July 2020

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To my parents. This achievement is both yours and mine. I will always be in your debt.

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To my parents, Juan Carlos and Mónica. I will never find the proper words to express how fortunate I am to have you in my life. Your endless and unconditional love inspires me to be a better man every day. Thanks for always giving me your best and encouraging me to seek my dreams. I wish to have enough time to demonstrate how grateful I am for all that you have done for me.

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ESCUELA DE INGENIERIA

ACCESSIBILITY AND AFFORDABILITY IMPACTS ON TRANSPORT-RELATED INEQUALITIES AND POVERTY

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ABSTRACT

Interventions on urban transport or land use systems produce several impacts on cities, affecting different segments of their population in different ways. First, a lack or a severe deterioration of accessibility could turn into significant difficulties to reach opportunities for work, study, recreation, health, and social interaction, triggering the social exclusion phenomenon. Second, cities' form and internal structure have a substantial impact on affordability, a concept that alludes to the financial stress faced by households to cover housing and transport expenditures. Third, (lack of) transport may be the cause or the solution for many aspects of poverty and inequity, depending on how it tackles (or not) the needs of the most deprived groups and how (un)fairly it distributes the benefits from transport projects.

Two of the 17 Sustainable Development Goals set by the United Nations are related to the three social issues mentioned above: "No poverty" and "Sustainable cities and communities." Among other actions, providing affordable housing, improving access to transport and essential services, and enhancing public transport can help to achieve these goals. These objectives are especially important for developing regions like South America, in which social segregation and inequality are particularly high.

Considering that the relationship between poverty and transport is often absent or not adequately addressed, neither in the literature nor in the design of infrastructure and transport-related public policies, this thesis aims to study accessibility and affordability issues derived from the interaction between the transport and land-use systems, and how these issues contribute to the reduction, production, or maintenance of transport-related inequity and poverty in cities, particularly in Santiago, Chile.

To achieve this goal, mixed research methods are used under a dominant quantitative strategy. Quantitative methods are used, including (i) the formulation and calculation of accessibility, affordability, and urban space indicators, (ii) spatial and graphical analyses

using large volumes of transport and housing data, and (iii) probabilistic methods for housing and transport affordability analyses. Also, qualitative methods are used, specifically focus groups under a content analysis framework, complementing and deepening the analyses carried out in objectives 2 and 3. All objectives use Geographic Information Systems tools to visualize the main findings.

This research quantifies and makes visible the inequity gap affecting the most vulnerable groups of the population, i.e., low-income people, women, elders, families with children, and those located far from the activity centers. This inequity is multidimensional, including access to public transport, quality of the mobility-related urban environment, accessibility to opportunities, the level of service experienced using public transport, and the possibility of freely choosing housing-location and transport alternatives. Moreover, it is possible to conclude that there are population groups who are systematically disadvantaged in three out of the four factors contributing to transport poverty: mobility, accessibility and affordability.

This thesis made several contributions. First, methodological contributions to expand the concept and operationalization of accessibility, including the use of mixed methods. On the one hand, the research includes the perceived level of service into accessibility measures by user profiles and the quality of the urban walking environment. On the other hand, the research proposes a new theoretical framework to enhance quantitative accessibility analysis through qualitative data collection and analysis. Second, these findings and methodologies contribute to policy discussions and formulations on the intersections between accessibility and affordability issues in Santiago, particularly the educational case, distance-based fares, and social integration areas. Finally, housing and transportation costs distributions are estimated using spatial clusters and probability functions, and then used to analyze the "freedom of choice" that low-income people have, given their budget constraints.

The research provides useful inputs for integrated planning between transport and land use. The results are expected to be suitable for the prioritization of public investment (public space, basic services, transport, and housing) and the formulation of comprehensive and intersectoral public policies to reduce the inequality gap and poverty in Santiago.

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Santiago, July 2020

PONTIFICIA UNIVERSIDAD CATOLICA DE CHILE
ESCUELA DE INGENIERIA

IMPACTOS DE LA ACCESIBILIDAD Y ASEQUIBILIDAD EN LA DESIGUALDAD Y POBREZA ASOCIADA AL TRANSPORTE

EL CASO DE SANTIAGO DE CHILE

Tesis enviada a la Dirección de Postgrado en cumplimiento parcial de los requisitos para el grado de Doctor en Ciencias de la Ingeniería.

IGNACIO ANDRÉS TIZNADO AITKEN

RESUMEN

Intervenir los sistemas de transporte y uso de suelo producen diversos impactos en las ciudades, afectando de diferentes maneras a los grupos de población que habitan la ciudad. Primero, la falta o deterioro severo de la accesibilidad puede causar dificultades significativas para acceder a oportunidades de trabajo, estudio, recreación, salud e interacción social, desencadenando el fenómeno de exclusión social. Segundo, la forma y estructura interna de una ciudad tienen un impacto sustancial en la asequibilidad, concepto que alude al estrés financiero que enfrentan los hogares al cubrir sus gastos de vivienda y transporte. Tercero, (una falta de) transporte puede ser la causa o la solución de muchos aspectos vinculados a la pobreza e inequidad, dependiendo cómo aborde o no las necesidades de los grupos de población más necesitados o cuan (in)justa sea la distribución de los beneficios asociados a inversiones de transporte.

Dos de los 17 Objetivos de Desarrollo Sustentable definidos por las Naciones Unidas se relacionan a los tres problemas antes mencionados: “Fin a la pobreza” y “Ciudades y comunidades sustentables”. Dentro de otras acciones, proveer de vivienda asequible, mejorar el acceso al transporte y oportunidades, y promover el transporte público puede ayudar a lograr tales objetivos. Estos objetivos son especialmente importantes para regiones como Sudamérica, donde la inequidad y segregación social es particularmente alta.

Considerando que la relación entre pobreza y transporte a menudo está ausente o no se aborda adecuadamente en la literatura ni en el diseño de infraestructura y políticas públicas relacionadas con el transporte, el objetivo principal de esta investigación es estudiar los problemas de accesibilidad y asequibilidad derivados de la interacción entre los sistemas de transporte y uso de suelo, y cómo estos problemas contribuyen a la reducción, producción o mantención de la inequidad y la pobreza relacionadas con el transporte dentro de las ciudades, particularmente en Santiago, Chile.

Para lograr este objetivo, se emplean métodos mixtos de investigación bajo una estrategia cuantitativa dominante. Se utilizan métodos cuantitativos, incluyendo (i) la formulación y cálculo de indicadores de accesibilidad, asequibilidad y entorno urbano, (ii) análisis gráficos y espaciales usando datos de transporte y vivienda y (iii) métodos probabilísticos para analizar la asequibilidad de transporte y vivienda. Además, se utilizan métodos cualitativos (grupos focales bajo un marco de análisis de contenido), complementando y profundizando el análisis de los objetivos 2 y 3. Todos los objetivos se apoyan de herramientas de Sistemas de Información Geográfica para visualizar los resultados principales.

Los resultados obtenidos muestran una brecha de inequidad que afecta principalmente a los grupos más vulnerables (personas de bajos ingresos, mujeres, adultos mayores, familias con hijos y aquellos localizados lejos de los centros de actividades). Esta inequidad es multidimensional e involucra el acceso al transporte público, la calidad del entorno urbano, el nivel de servicio experimentado y la posibilidad de elegir libremente la localización del hogar y alternativas de transporte. Además, es posible concluir que existen grupos de población que están sistemáticamente en desventaja en tres de los cuatro factores que contribuyen a la pobreza del transporte: movilidad, accesibilidad y asequibilidad.

Esta tesis realiza diversas contribuciones. Primero, contribuciones metodológicas para expandir el concepto y la operacionalización de la accesibilidad, incluido el uso de métodos mixtos. Por un lado, la investigación incluye la percepción del nivel de servicio en las medidas de accesibilidad y la calidad del entorno urbano. Por otro lado, la investigación propone un nuevo marco teórico para mejorar el análisis de accesibilidad a través del análisis de datos cualitativos. En segundo lugar, estos hallazgos y metodologías contribuyen a la formulación de políticas en temas de accesibilidad y accesibilidad, como el caso de educación, las tarifas basadas en la distancia y las áreas de integración social. Finalmente, se estiman distribuciones de costos de vivienda y transporte utilizando agrupaciones espaciales y funciones de probabilidad, y luego se utilizan para analizar la "libertad de elección" que tienen las personas de bajos ingresos, dadas sus limitaciones presupuestarias.

La investigación proporciona insumos útiles para la planificación integrada del transporte y el uso del suelo. Se espera que los resultados permitan la priorización de la inversión pública (espacio público, servicios básicos, transporte y vivienda) y la formulación de políticas públicas intersectoriales para reducir la brecha de desigualdad y la pobreza en Santiago.

Miembros de la Comisión de Tesis Doctoral:
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1. INTRODUCTION

The relation between transport and land use shapes and modifies the urban structure of cities (Newman & Kenworthy, 1996; Chang, 2006). Urban mobility patterns and externalities influence land-use evolution, which impacts the transport-related decision-processes (trips, routes, modes, and destinations), and the location of housing and activities. These changes determine the attractiveness of specific areas of the city and the accessibility level they offer (Figure 1-1).

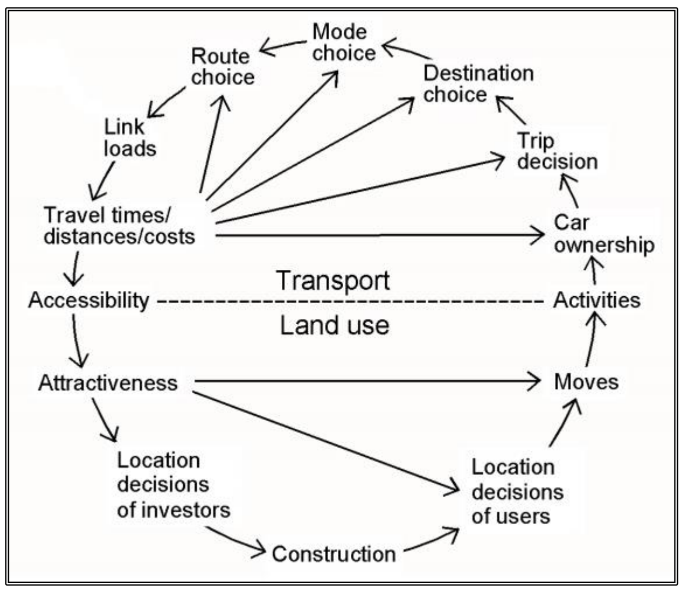

Figure 1-1. Interaction between land use and transport

(Source: Wegener, M. & Fürst, F., 1999).

By intervening transport or land use systems, different population segments dwelling in the city may become affected in several different ways. This thesis aims to study accessibility and affordability issues derived from the interaction between the transport and land-use systems, and how these issues contribute to the reduction, production, or maintenance of transport-related inequity and poverty in cities, particularly in Santiago, Chile.

The concept of accessibility has been defined numerous times in the literature from different disciplines (Hansen, 1959; Dalvi, 1978; Ben-Akiva & Lerman, 1979; Martinez, 1995; Handy & Niemeier, 1997; Geurs & van Wee, 2004). Probably the most assertive definition corresponds to the degree to which the transport and land-use system allow activities to be achieved through (a combination of) different transport modes (Geurs & van Wee, 2004). Thus, a lack or a severe deterioration of accessibility could turn into significant difficulties to reach opportunities for work, study, recreation, health, and social interaction. This scenario can dramatically hurt communities' progress and trigger the social exclusion phenomenon (Lucas, 2006; Sanchez et al., 2003). According to Rajé (2003), social exclusion prevents people from participating in the usual activities of the society and is a multidimensional problem, linked not only to the lack of accessibility to goods and services but also to low income or poor quality of housing (Social Exclusion Unit, 2001).

The urban form and internal structure also have a substantial impact on affordability. This concept alludes to the financial stress faced by households attempting to cover housing and transport expenditures, determining their location, access to opportunities, consumption, and time available for daily activities. In recent years, several studies have been developed worldwide to explore the joint effect of housing and transportation costs (Guerra et al., 2018; Dewita et al., 2018; Coulombel, 2018), especially in American (Salon et al., 2016; Smart & Klein, 2017; Luckey, 2018) and Australian cities (Li et al., 2018; Mattingly & Morrissey, 2014; Saberi et al., 2017; Vidyattama et al., 2013). Notwithstanding clear contextual differences, all these studies show similar patterns: housing is more expensive close to the central business district (CBD) and cheaper in outer zones, as well-establish models from the urban economics literature predict (Alonso, 1964; Mills, 1967; Muth, 1969). These models, also predict that if transport costs are considered, people living in the urban periphery will face higher transport expenditures because of longer distances and more inadequate public transport connections; which, in turn, leads to a dependency on cars or forced car ownership (Banister, 1994; Currie & Senbergs, 2007; Mattioli, 2017). Considering this trade-off between housing and transport costs, it is possible to define 'affordability thresholds' (see for example, Hulchanski, 1995; Nepal et al., 2010; CNT, 2012) to identify households that struggle with these expenditures.

Consequently, transport can be a mechanism that produces, maintains, and/or reduces poverty and inequity conditions (Gannon & Liu, 1997). On the one hand, there is evidence that reinforces the link between poverty and transport inequities in several geographical contexts (for example, Stokes, 2015; Grieco, 2013 y Satterthwaite, 2003). On the other hand, the creation or improvement of infrastructure and services, which can reduce transport disadvantages, does not necessarily address the most deprived population needs (Booth et al., 2000; Hettige, 2006; Mu & van de Walle, 2011) and benefits from transport projects are not generally shared equitably (Foth et al., 2013; Starkey & Hine, 2014; Niehaus et al., 2016). This way, transport interventions could generate contradictory results, creating new forms of social fragmentation (Bocarejo et al., 2016) or accessibility losses (Guzmán, Oviedo & Cardona, 2018).

Reducing inequities in their different dimensions and guaranteeing access to a range of urban services lie at the heart of the sustainable development goals (SDG) set out by the United Nations Development Programme (United Nations, 2018), especially "No poverty" (SDG #1) and "Sustainable cities and communities" (SDG #11). In the context of urban transport, these issues become matters of distributive justice, that is, how the costs and benefits of transport systems are currently distributed and how they should be distributed (Martens, 2017). The question that arises, therefore, is whether there are population groups who are systematically disadvantaged in terms of mobility levels, lack of accessibility, the monetary cost of transport services and exposure to negative externalities, the four factors identified as preponderant in what has been defined as transport poverty (Titheridge et al., 2014; Lucas et al., 2016).

These four factors are especially important for developing regions like South America, in which social segregation and inequality are particularly high. The traditional 'predict and provide' approach for road transport (Owens, 1995) has led to mobility-based urban solutions, aiming at (quite ineffectively) reducing congestion by increasing speed and transport capacity, leaving aside environmental and equity considerations. Therefore, it is essential that urban transport studies effectively address people's needs around the city (Lucas et al., 2013), considering that the relationship between poverty and transport is often absent or not adequately addressed neither in the literature nor in the design of infrastructure and transport-related public policies (Lucas et al., 2016).

In this thesis, several research gaps are addressed. First, to study how different socioeconomic groups are affected by their use of the transport system and the externalities it generates, a new methodology for an integral analysis of transport-related inequalities is proposed. Second, given the widespread interest in mobility as both a cause and effect of social disparities and equity outcomes, this thesis contributes with a critical literature review from growing scholarly works that provide accessibility-based evaluations in Latin America. Third, the public transport accessibility analysis proposed so far in the literature usually does not consider the level of service of the transport system as it is perceived by the user (Lucas et al., 2016; Martens, 2017) nor the quality of the walking environment while accessing to public transport stops (Cheng & Chen, 2015). Thus, this thesis made methodological contributions to expand the concept and operationalization of accessibility, including the use of mixed methods. On the one hand, the quantitative dominant strand, including the perceived level of service into accessibility measures by user profiles and the quality of the urban walking environment. On the other hand, a complementary qualitative strand, proposing a new theoretical framework to enhance quantitative accessibility analysis through qualitative data collection and analysis. These findings and methodologies are then applied to three practical policy issues in Santiago: education, distance-based fares, and social integration areas. Finally, combining income, housing, transport and census data, housing and transportation costs distributions are estimated, using spatial clusters and probability functions, and then used to analyze the "freedom of choice" that low-income people have, given their budget constraints.

1.1 General Objective

The main aim of this research is to study accessibility and affordability issues derived from the interaction between the transport and land-use systems, and how these issues contribute to the reduction, production, or maintenance of transport-related inequalities and poverty in cities, particularly in a highly segregated and unequal setting like Santiago de Chile.

1.2 Specific Objectives

The thesis project is composed of eight chapters, and all of them are applied to Santiago, Chile. A specific objective for each of them and their interrelation is shown in Figure 1.2.

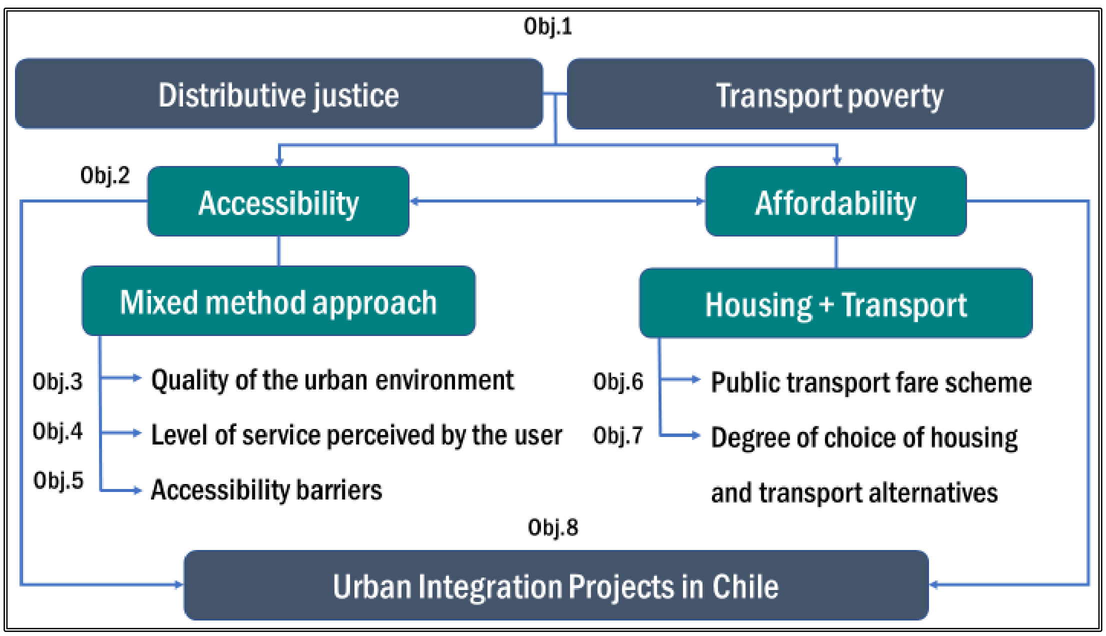

Figure 1-2. Topics and objectives of the dissertation (Source: Own Elaboration)

The objetives are:

i) Describe and quantify the transport-related inequalities among socio-economic groups in Santiago

ii) Examine the main advances and challenges in the academic works devoted to socially oriented accessibility evaluations in Latin American cities

iii) Analyze accessibility to public transport stops characterizing the quality of the urban walking environment and exploring the equity and justice issues involved when these two dimensions are simultaneously considered.

iv) Define, calculate and test a new measure of accessibility to opportunities through public transport, incorporating the level of service (reliability, waiting time, walking time, transfers, and comfort) perceived by the user, and analyse how these additional elements decreases or accentuates current accessibility gaps.

v) Develop a theoretical framework to analyze qualitative attributes that inhibit or enhance access to opportunities within the city, enriching accessibility characterization according to user travel experiences and "socially constructed" narratives for buses and Metro

vi) Evaluate the progressiveness of the current and alternative public transport fare scheme, providing low- and medium-income populations more affordable access to opportunities.

vii) Understand and measure the housing and transport affordability at a household level, analyzing the "degree of choice" that low-income people have given their sociodemographic characteristics and budgetary constraints.

viii) Evaluate the proposed criteria for promoting socially integrated housing projects in Chile

1.3 Specific Hypotheses

The set of hypotheses raised to answer the specific objectives are:

i) Transport-related benefits and costs are unevenly distributed in Santiago, Chile, silently strongly contributing to a very unequal society through the four factors constituting transport poverty

ii) Despite the advances in accessibility measurements in Latin America, key conceptual and methodological improvements are needed for better assessments and policy actions to enhance equity.

iii) The accessibility levels to and through public transport between areas are very dissimilar due to the dissimilar transport level of service, the activity concentration and high socio-spatial segregation in Santiago, increasing inequity across citizens.

iv) The accessibility inequity is increased if the analysis includes the quality of the urban environment and the relative perception of the different attributes that affect the level of service experienced when people use public transport

v) Contextual factors such as socioeconomic status, house location, mobility-related built environment, and available transport alternatives determine how people perceive public transport and their relationship with it

vi) A distance-based fare scheme would harm lower-income people living in peripheral areas who need to travel further by public transport to access key opportunities

vii) Individuals from low-income households must trade-off between housing and transport costs to decide where to locate their home and which transport mode to use, facing an active and strong budget constraint affecting their freedom to choose

viii) The current accessibility criteria for socially integrated housing projects is blinded to public transport supply and its level of service, as well as the quality and competition for opportunities in the city

1.4 Methodology

To achieve the aforementioned goals, mixed research methods are used under a dominant quantitative strategy (Johnson, 2007). For objectives 1, 2, 3 and 5, quantitative methods are used, including (i) the formulation and calculation of accessibility, affordability, and urban space indicators, (ii) spatial and graphical analyses using large volumes of transport and housing data, and (iii) probabilistic methods for housing and transport affordability analyses. Objective 3 uses qualitative methods, specifically focus groups under a content analysis framework, that complements and deepens the analyses carried out in objectives 1 and 2. All objectives used Geographic Information Systems (GIS) tools to visualize the main findings and discussing policy and practice implications.

This dissertation uses two main data source types: existing data and collected data. For all the quantitative analyses, existing data are used. The qualitative strand of this thesis uses collected data. The description of each of these data sources is presented below.

1.4.1 Existing data

i) <u>Origin-destination data:</u> This is the primary source of information used in transport planning and provided key information on mobility patterns in each city. The most recent origin-destination survey for Santiago (2012) was used. This survey provides georeferenced information on travel patterns, socioeconomic characteristics of travellers, detailed information on motorized and non-motorized trips, including vehicle occupation and level of service. The

Ministry of Social Development (MDS) advised by the Executive Secretariat of the Transportation Infrastructure Planning Commission (SECTRA), mandates the application of these "Mobility Surveys", which are open and free access.

ii) Automated Fare Collection data: Public transport in Santiago requires using a smartcard that records the time and place of each validation in both buses and Metro stations. Since there is no card validation when people alight from any public transport service in Santiago, the methodology proposed by Munizaga and Palma (2012) is used to estimate the time and station in which each trip stage ends and to connect sequential trip stages belonging to the same trip.

iii) Automated Vehicle Location data: For buses, every vehicle releases a GPS information every 30 seconds, from which the exact arrival time at each stop can be estimated. For Metro, the trains schedules are inferred from the arrival and departure times for every train at every network station. The information is provided by the two official responsible agencies: Directorio de Transporte Público Metropolitano (DTPM), the public transport agency in Santiago, and Metro de Santiago.

iv) Housing data: Rent and purchase values for new and used housing in Santiago de Chile between 2014 and 2018 are used. For each rent record, the location, surface (square meters), and the number of bedrooms and bathrooms are known. The same data is available for each purchase, with the exception of the number of bedrooms and bathrooms, which is estimated based on the surface using the rent database values. This data is provided by TOC-TOC, a company specialized in housing data in Chile, under the program "City with All: Balanced Densification" (translation from "*Ciudad con Todos: Densidad Equilibrada*") of the Public Policy Center at Universidad Católica de Chile. (PPC-UC, 2019)

v) Census information: Two data sources are used. First, pre-census georeferenced information of 2011, in which trained surveyors evaluated each city block in Santiago in terms of urban quality (considering the quality, presence, and condition of urban furniture) and road network (sidewalk and street quality). Second, the last National Census of 2017 is used for demographic and household analysis at census track and comuna level.

vi) Education data: Two primary data sources are used. First, the School's Directory is used to geocode each educational establishment with the number of public-school students. Second, to determine a quality benchmark, the National Performance Evaluation System (SNED in Spanish) is used, which evaluates the quality of subsidized educational establishments based on 6 factors: effectiveness, overcoming, initiative, improvement, equal opportunities, and integration-participation. Both sources are public information from the Ministry of Education (MINEDUC) website.

vii) Geographic data: Georeferenced routes, stations, and stops from the bus and Metro networks are used. Furthermore, origin-destination, census and public transport zoning are used for the different spatial analyses carried out.

viii) Other sources of information: Among the multiple sources of data used in the thesis development, the following ones also stand out: (i) data about road safety from CONASET, (ii) survey for socio-economic characterization in Santiago (Ministry of Social Development, MDS), (iii) square meters built by land-use type in 2009 and 2015 (SII), (iv) income levels from National Statistics Institute (INE) and (v) poverty lines and basic consumption Santiago (Ministry of Social Development, MDS).

1.4.2 Collected data

i) Focus groups: To fulfill the qualitative strand objectives, four focus groups are conducted in two different municipalities of Santiago. Two of them are conducted for mostly public transport users and the rest for mostly private transport users. Each focus group is composed of 8 to 10 people, so a total of 35 people participated in the study. Participants are men and women in an age group between 28 and 53 years, with a higher women representation to capture gender differences and to explore different topics of concern. All the participants regularly travel during the week, and there are no requirements for occupation or household composition.

ii) <u>Survey:</u> Before each focus group, a brief survey is carried out to systematize and characterize the participants, obtaining information that would complement the focus group narrative with quantitative data provided by each participant. This survey is divided into 4 sections: the first sought to obtain a basic socioeconomic characterization of the respondent, the second to obtain primary mobility data, the third some details about the most frequent trip each person made and, finally, some questions about the evaluation and perception about the public transport in Santiago.

1.5 Contents and contributions

This thesis describes the most relevant findings through eight different articles, each one presented in a different chapter (Chapter 2 to Chapter 9). These chapters are briefly described in the next subsections, highlighting their structure, their main contributions, and how they are related to each other. Several of these articles are already published or have been submitted for publication. Chapters 2 and 3 set the context, studying transport-related inequalities in Santiago, Chile, and socially oriented accessibility assessments in Latin America. Chapters 4, 5, and 6 contribute with new methodologies to expand the concept of accessibility, by including user perception, the quality of the urban walking environment, and socially constructed narratives. Chapters 5, 7 and 8 apply some of these findings and methodologies to three different policy issues in Santiago (education, distance-based fares, and social integration areas) and Chapter 9 focuses on housing and transport affordability issues. Chapter 10 summarizes the main contributions and conclusions obtained, discussing policy implications and answering the objectives defined in sections 1.1 and 1.2. Chapter 11 proposes four main paths for further research.

Finally, appendixes 1 to 3 show the details of the qualitative research, providing the questionnaire carried out, the guideline for focus groups and the main quotes that support the content analysis, as well as an online link for complete transcripts. Finally, appendix 4 shows a summary and a link for a conference proceeding article of a collaborative research project between postgraduate students from Massachusetts Institute of Technology (MIT) and Pontificia Universidad Católica de Chile (PUC) through MISTI MIT-CHILE-PUC Graduate Student Seed Fund program. The project seeks to explore whether the use of a visualization tool based on accessibility measurements can encourage improvements in the urban transportation planning process in Santiago, Chile.

1.5.1 Chapter 2 – How uneven is the playing field? An analysis of transport-related inequalities among socioeconomic groups in Santiago, Chile

This article proposes a methodology for analyzing how investment in transport infrastructure and non-housing construction, mobility levels (trip distances, times and speeds) and the associated trip costs (monetary, accidents, pollution and energy consumption) are distributed across the different socioeconomic quintiles of a city. The methodology is applied to the real-world case of Santiago de Chile, quantifying how fair is the distribution of mobility-related costs and benefits.

The results show that compared to the lowest income quintile, people in the highest income quintile made 1.2 times more trips at an average speed 1.6 times higher. In terms of costs, the richest quintile generated 6.7 times as much pollution and used 7 times as much energy but consumed a significantly lower share of their income (10% vs 45%). In addition, the top quintile was the beneficiary of 2.5 times more investment in both transport infrastructure and new construction space for commercial activities and services over the period considered. Finally, private car use in the top quintile was 5.3 times greater. This transport mode accounts for 6.8 times more of the accident rate than public transport, bicycles or walking combined.

These facts encourage us to examine deeply mobility as both a cause and effect of social disparities. The goal is to contribute to the understanding of social inequality in Latina America, which has received an increasing stream of work in the last decades, through the lenses of accessibility to opportunities.

This chapter has already been published as ISI paper and policy paper:

1. Iglesias, V., Giraldez, F., Tiznado-Aitken, I., & Muñoz, J. C. (2019). How Uneven is the Urban Mobility Playing Field? Inequalities among Socioeconomic Groups in Santiago De Chile. Transportation Research Record 2673(11), 59-70. DOI: https://doi.org/10.1177/0361198119849588*

* Ignacio Tiznado-Aitken contribution: *Supervisor of two undergraduate students (Iglesias & Giraldez). He participates in the study conception and design, data collection, analysis and interpretation of results and draft manuscript preparation.*

2. Tiznado-Aitken, I., Muñoz, J.C., Iglesias, I. & Giraldez, F. (2019). Las inequidades de la movilidad urbana: Brechas entre los grupos socioeconómicos en Santiago de Chile. Documento para Políticas Públicas. Centro de Desarrollo Urbano Sustentable. Available at: https://www.cedeus.cl/wpcontent/uploads/2019/04/Inequidades-MovilidadUrbana_CEDEUS_2019-1.pdf

1.5.2 Chapter 3 – Transport and equity: socially-oriented accessibility assessments in Latin America

Accessibility emerges as an evaluative approach that contributes to understand how the combination of a transport and a land use system allow individuals to move and participate in social life, providing key indicators to address social urban inequalities across the world.

This article aims at critically reviewing the growing scholarly works that, providing accessibility-based evaluations, has examined issues of transport and equity in Latin America. Proposing a novel conceptual framework that considers the underlying ethical stance, components of accessibility and implications for planning and policy, this work examines what approaches, features and indicators are present in the current literature, as well as what settings have been taken into consideration by scholarly research. Moreover, the review has an explicit operational interest, to define what indicators are relevant or missing to assess accessibility in the light of social concerns, as well as to consider the current and potential implications that such research findings have on transport planning and policy.

The review contributes to (i) understanding what implications accessibility-oriented academic research findings may have on transport planning and policy, identifying current and potential impacts that different accessibility measures and approaches could have, and to (ii) assess the Latin American state of the art, identifying key research gaps that could be addressed by both researchers and practitioners in the future. Some of these research gaps are addressed in the next two chapters.

This chapter has already been published as: *Vecchio, G., Tiznado-Aitken, I. & Hurtubia, R. (2020). Transport and equity in Latin America: a critical review of socially oriented accessibility assessments. Transport Reviews 40(3), 1-28. DOI: https://doi.org/10.1080/01441647.2020.1711828*

Ignacio Tiznado-Aitken contribution: *All the work was equally shared with the first author (Vecchio). He participates in the study conception and design, data collection, analysis and interpretation of results and draft manuscript preparation.*

1.5.3 Chapter 4 – Accessibility to public transport and the quality of the urban walking environment

Most studies of public transport accessibility have focused on proximity to stops and walking distances or time to reach them. This approach ignores other accessibility barriers that have received less attention, such as the quality of the urban environment of these walks.

This article analyzes together both accessibility to public transport stops and the quality of the urban walking environment, exploring measurements of equity and justice issues linked with these two dimensions. The proposed methodology considers two indicators: walking accessibility to public transport stops and quality of the walking environment, considering different attributes and dimensions. These indicators are later used to develop a fairness analysis at the local and metropolitan level, using Lorenz curves, Gini coefficient, and Foster-Greer-Thorbecke (FGT) poverty measures.

The results show that 12 out of 34 communes in Santiago, Chile, are deprived of one or both dimensions not managing to achieve minimum fairness standard. Therefore, in terms of public policies, we suggest that the first issue should be fairness, based on sufficiency and egalitarianism considerations, and then environmental sustainability.

This analysis provides a contribution to a more precise description of access for public transport users, but we consider it still limited. Thus, in the next Chapter we develop a methodology to include how people perceive the different level of service attributes, closing the gap between perceived and measured accessibility.

This chapter has already been published as: *Tiznado-Aitken, I., Muñoz, J. C., & Hurtubia, R. (2018). The Role of Accessibility to Public Transport and Quality of Walking Environment on Urban Equity: The Case of Santiago de Chile. Transportation Research Record, 2672(35), 129-138.*

1.5.4 Chapter 5 – Public transport accessibility measures incorporating the level of service perceived by the user: an educational application

This chapter proposes a methodology to analyze access to opportunities through public transport incorporating the user's perception of attributes that impact the level of service on his/her trip. Using data from Santiago, Chile, we apply the proposed methodology to analyze accessibility to higher-quality public primary schools. We compare total travel time (TTT) with a proposed measure of total generalized travel time (TGTT) using potential and competitive accessibility indicators, accounting for the perception of walking time, travel time, waiting time, comfort and transfers, and translating them into in-vehicle time units.

Results show, as expected, that the worst level of service is concentrated in medium and low-income population, located in peripheral and pericentral areas of the city. In these zones, the difference between TTT and TGTT is the largest, with users experiencing on average 1-2 transfers, 4-5 passengers per square meter and 15-minute waiting. Moreover, around 20% of the zones in Santiago have at least a 50% deficit of higher-quality public education and 71% of them are in peripheral areas.

The proposed methodology and its application provide a more comprehensive way to understand accessibility, allowing authorities to determine how and where to intervene to improve accessibility equitably in a way that public transport users will value it. However, the approach is based in quantitative indicators only. Complementing this research with qualitative methods to explore accessibility barriers and travel experiences is the next step to improve the accuracy and the usefulness of the results obtained in terms of public policy.

This chapter was submitted for publication and currently is under the second review in the Journal of Transport Geography. Two early versions of this work have been published:

1. Tiznado-Aitken, I., Hurtubia, R. & Muñoz, J.C. (2017). How equitable is access to opportunities and basic services considering the impact of the level of service? The case of Santiago, Chile. Income Inequality, Social Inclusion and Mobility. Roundtable Report 164, pp. 79-104. Available at: https://www.itf-oecd.org/sites/default/files/docs/income-inequality-social-inclusion-mobility.pdf

2. Tiznado-Aitken, I., Muñoz, J.C. and Hurtubia, R. (2018) Accesibilidad a oportunidades mediante transporte público considerando el impacto del entorno urbano y el nivel de servicio. Intersecciones 2016, II Congreso Interdisciplinario de Arquitectura, Diseño, Ciudad y Territorio. ARQ Ediciones, pp. 134-148

1.5.5 Chapter 6 – Opportunities or barriers? Enhancing the understanding of accessibility through public transport

Our previous work has highlighted the importance of incorporating the quality of the walking environment and attributes of public transport services within accessibility indicators. Building on these works, this qualitative research seeks to further improve the characterization of accessibility according to users' travel experiences, as described by those attributes that inhibit or enhance access to opportunities.

Our main contribution is to develop a theoretical framework to analyze qualitative data on how people relate and discuss their public transport accessibility experiences. Using content analysis of focus groups, data gathered in a brief survey and socio-spatial analysis, we generate a range of concepts or labels to explain their perceptions about the mobility-related built environment. We apply these theoretical contributions to analyze the unique urban morphology of two municipalities of Santiago de Chile.

We identify different 'socially constructed' narratives for buses and Metro. The participants focuses more on barriers to accessibility, showing an important relationship between these barriers as well as substantial differences in their overarching positive perception of Metro and negative for buses. Furthermore, we found a dissimilar perception of transport environment when disaggregating the analysis by gender, age and location. From these 'real world' experiences and our previous work, we are able to critically question the formulation of Chilean urban policies that claim to aim better accessibility for the most deprived population.

This chapter was submitted for publication and currently is under the second review in the Journal of Transport Geography.

1.5.6 Chapter 7 – Accessibility for all? Analyzing criteria to define areas of "Urban Integration Areas" in Chile

The Chilean Government, *Ciudad con Todos* and the National Urban Development Council (CNDU) have proposed several conditions that urban areas must fulfill to be the recipients of regulatory incentives for socially integrated housing projects. In this work, we critically analyze those proposed principles, evaluating whether these are enough to ensure adequate accessibility to public transport and urban opportunities, in addition to provide an adequate capacity for high densification.

Our analysis show that the current accessibility standards, proposed by both the government and other actors, appear to be insufficient, lacking a broad understanding of accessibility. The criteria analyzed consider accessibility to public transport and urban opportunities as exclusive dimensions and only from the territorial proximity or walking distance perspective. The proposed criteria do not adequately contemplate load capacity, considering only areas of influence and ignoring the public transport capacity, which can be already operating under significant levels of overcrowding.
Based on these results, we suggest guidelines and new standards that can help to formulate better criteria when defining areas for densification with social housing quotas. Following this work, we expand our contribution to another critical policy question in the public transport sector: fares. In the next Chapter we explore the equity outcomes of implementing a distance-based public transport fare scheme.

This chapter is a working paper and should be submitted for publicationin Revista INVI.

1.5.7 Chapter 8 – Distance-based public transport fare scheme: accessibility, urban form and equity implications in Santiago de Chile

In Santiago de Chile, 60% of households do not own a car and depend on public transport for daily mobility. Moreover, Santiago shows a somewhat monocentric structure, oriented towards the wealthiest neighborhoods, which could exacerbate the difficulty of accessing opportunities for some socioeconomic groups.

In this chapter, we compare the current flat fare scheme and the distance-based fare scheme in the public transport system of Santiago de Chile through the lens of accessibility, affordability, and equity. We compare (i) accessibility levels between both fare schemes and (ii) equity outcomes within the city, analyzing if the distance-based fare scheme could be a progressive policy or quite the opposite.

Our results show that the current flat fare scheme in Transantiago is preferable over a distance-based scheme. People living in 62% of the municipalities in Santiago would pay more with a distance-based scheme. Twelve of the municipalities have over 50% of their population on the two lowest income quintiles and these groups would be harmed by a 30% average fare increase required under a distance-based fare scheme. on average. Unsurprisingly, seven peripheral zones of the city, located mainly in the south, are the most harmed, paying on average 57% more per each public transport trip under the distance-based fare scheme. Furthermore, the distance-based fare exacerbates the current accessibility problems in the city, increasing the generalized travel cost up to 25% for residents of some municipalities.

After quantifying the profound impact of the public transport fare in the low-income groups, we decided to address the affordability of transport and housing at the household level, analyzing how free are their location and transport choices.

This chapter was submitted and accepted for publication. Currently is under copy editing for an Elsevier book about Urban Form and Accessibility.

1.5.8 Chapter 9 – Freedom of choice? Housing and transport affordability issues in Santiago de Chile

Housing and transport affordability (HTA) analysis have been receiving increasing attention among academics and practitioners around the world. Most of the work done has focused on thresholds to define unaffordable H+TA considering average values over a given spatial disaggregation and has been devoted to Global North settings. Thus, little attention has been payed to the distribution of HTA across space in Latin American cities, which face important inequality, poverty and urban segregation issues

Our work seeks to contribute to fill those gaps by understanding and measuring housing and transport affordability using different types of households in Santiago de Chile as a case study. Combining income, housing, transport and census data, we estimate H+T costs using spatial clusters and probability functions for housing and transport costs, analyzing the “degree of choice” that low-income people could have given their budget constraints.

The results show that most of the municipalities (comunas) are forbidden locations for low-income household location given the high costs of H+TA, especially those comunas located where most services and commercial activities are placed. These individuals from low-income households must trade-off between housing and transport costs to decide where to locate their home, facing an active budget constraint affecting both cost dimensions. Finally, we briefly discuss about possible policies to address the issues identified, discussing their spatial impacts and feasibility.

This chapter was submitted as full paper for a conference. New findings and reviewer comments will be included to submit it to a journal (target: Cities, Transportation Research Part A, Urban Studies).

2. HOW UNEVEN IS THE URBAN MOBILITY PLAYING FIELD? INEQUALITIES AMONG SOCIOECONOMIC GROUPS IN SANTIAGO DE CHILE

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2.1 Introduction

Reducing inequities in their different dimensions and guaranteeing access to a range of urban services lie at the heart of the sustainable development goals set out by the United Nations Development Programme (United Nations, 2018). The challenges facing their achievement are particularly visible in the world's larger urban areas, where continual growth in both population and extension means that to access opportunities for work or study, increasing millions of the cities' inhabitants must travel ever longer distances taking up more and more of their time. In many such cities, there are deep disparities between different income groups regarding (i) how they use the transport system (frequency of trips, distances travelled, mode of transport used), (ii) their access to, and use of transport infrastructure and services, and (iii) the costs imposed by the associated negative externalities (hereafter simply “externalities” unless otherwise indicated). Understanding these disparities is essential to define what actions must be undertaken if the inequities they imply are to be reduced.

In the case of Latin America and other developing countries, the study of poverty and other inequities has revolved around the economic aspects, with particular focus on the linkages between urban segregation and the socioeconomic distribution of the resident populations. In the context of urban transport, these issues become matters of distributive justice, that is, how the costs and benefits of transport systems are distributed currently and how they should be distributed (Martens, 2017). The question that arises, therefore, is whether there are population groups who are systematically disadvantaged in terms of mobility, accessibility, exposure to externalities and affordability, the four factors identified as preponderant in what has been defined as transport poverty (Lucas et al., 2016).

The purpose of the present article is to propose a methodology for an integral analysis of how different socioeconomic groups are affected by their use of the transport system and the social costs it generates. More specifically, we attempt to analyze the distribution of transport systems investments (infrastructure and services), mobility levels (distances, travel times and speeds) and the social costs (monetary, accidents, pollution and energy consumption) of the trips made by the different population groups in a city. To illustrate the methodology we apply it to the case of Santiago, Chile and its inhabitants grouped by income quintiles. Based on the results we attempt to determine how equitable is the socioeconomic distribution between quintiles and what are some public policies on transport that could be adopted in Santiago to achieve a fairer distribution.

The remainder of this article is organized into five sections. Section 2.2 reviews the literature on transport equity and notes how the present study intends to contribute to it; Section 2.3 describes the general methodology; Section 2.4 applies the proposed methodology to a case study of transport in Santiago, Chile; Section 2.5 sets out the results of this application; and finally, Section 2.6 discusses the results and some implications for public policy.

2.2 Literature review

The distribution of the costs and benefits of transport system use in an urban setting influences the inequities that exist between different resident population groups through its impact on the quality of life. This phenomenon has been investigated in depth in the literature by a variety of authors. For example, Delbosc & Currie (2011) and Welch & Mishra (2013) have studied equity in transport provision while Manaugh et al. (2012) and Foth et al. (2013) have attempted to address directly the question of who benefits from new transportation infrastructure and transit provision. The importance of studying these issues lies in the role they play not only in understanding transport inequities and injustices (Martens, 2017; Banister, 2018) but also in preventing social exclusion (Rajé, 2003; Lucas, 2006) and the social disadvantages associated with transport (Currie & Stanley, 2007; Hine & Mitchell, 2017).

In a similar vein, various researchers have unearthed evidence of the connection between poverty and transport inequities (Grieco, 2015). According to Titheridge et al. (2014) and Lucas et al. (2016), transport poverty may be caused by factors such as lack of accessibility (Golub & Martens, 2014; Martens & Bastiaanssen, 2014), the monetary cost of transport services (Carruthers et al., 2005; Falavigna & Hernandez, 2016) and exposure to negative externalities (Booth et al., 2000; Feitelson, 2002). These phenomena point clearly to the importance of analyzing the distribution among the population of the costs and benefits of transport and determining whether transport poverty disproportionally impacts the least favoured socioeconomic groups, deepening their social disadvantages.

Where this is indeed the case, Litman (2018) argues that the appropriate authorities must intervene in order to achieve greater vertical equity and thus reduce these social inequalities by favouring the most vulnerable groups in society through progressive policies. Although the point has seldom been addressed in the literature, the principles underlying a more desirable distribution are governed by either an equalitarian or a sufficientarian approach (Martens, 2017; Pereira et al., 2017). In the former case, all are treated alike and benefit equally while in the latter case, minimum standards are established to prevent “severe suffering” (Crisp, 2003).

In the present article we set out to analyze in a holistic manner the inequities between different socioeconomic groups associated with transport. Vasconcellos (2005) made the first contribution to this kind of analysis in his “transport metabolism” study, that is, the interaction that occurs in the process of transport-related consumption of resources and production of externalities in the case of Sao Paulo. Building on this work, we hope to bring further evidence to the debate from a different geographic context, using disaggregated data and incorporating both investment in infrastructure and services and the costs generated by each population group’s travel. This forms the basis for an approach focused on progressive public policies that should be adopted by cities in order to achieve a more just scenario.

2.3 Methodology

Our proposed methodology estimates the distribution among five different socioeconomic groups, defined as income quintiles, of transport system benefits, mobility levels, resources consumed, and costs generated. The approach considers six main elements:

1. A mobility diagnosis of each quintile, based on estimates of the number of trips each group makes using each transport mode and their main characteristics (distance travelled, travel time and average speed).
2. The pollution generated by each quintile, based on the distance travelled in each transport mode and the respective emission factors of the modes' technologies.
3. The energy consumed by each quintile, based on the annual energy consumption of each mode and the proportion of total trips made in each mode by each group.
4. The number of accidents caused by each quintile, based on the annual number of trips made in each mode by each group and the accident rate for each mode.
5. The investment in infrastructure by each income quintile, based on public investment in each mode and private investment in new non-housing construction space in the various districts of the city.
6. The resources spent on transport by users, based on public transport fare levels, private transport operating costs and the energy consumed in using non-motorized modes.

How this methodology would be applied to a particular city depends on the quantity and quality of data available. For the city of Santiago, the subject of our case study, there is sufficient publicly available information to conduct a reasonably complete disaggregated analysis. In the next section we detail the context set by the Santiago transport and land use system and explain the measurement of the indicators defined for the six elements just described.

2.4 Real-world application: The case of Santiago, Chile

Santiago is the capital and largest city of Chile, and Greater Santiago is the main urban nucleus of what is officially named the Metropolitan Region. Made up of 34 comunas or districts, Greater Santiago covers an area of 640 km2 and has a population of 6 million inhabitants (MDS, 2013a; 2015). The local public transport system, known as Transantiago, consists of bus services and a Metro that operate under an integrated fare system. The networks of bus routes (2,821 km) (DTPM, 2016) and Metro lines (118 km) as of July 2018 are shown on the map in Figure 2-1.

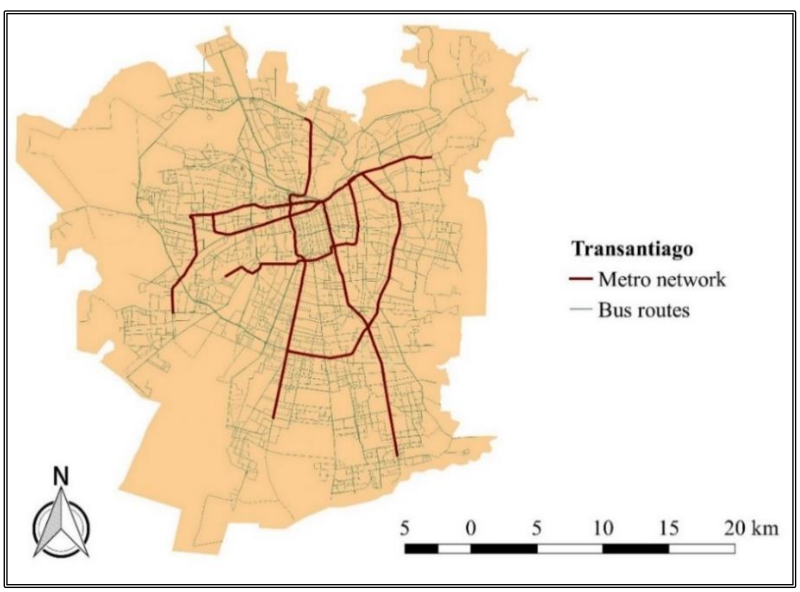


Figure 2-1 Transantiago public transport networks (Source: developed by the authors, based on DTPM (2016)).

According to a report by the OECD (2013), Santiago leads the world in urban segregation. This is due in large part to policies that have relegated social housing to the outer areas of the city, depriving their residents of easy access to employment opportunities and green spaces, among others (Figure 2-2). As a result, there is little mixing of the city's social classes, as is illustrated by the map in Figure 2-3 showing the population ratios of the two highest income quintiles to the two lowest income quintiles for Santiago's different comunas. Thus, the larger the ratio, the less mixing among the quintiles.

Figure 2-3 also shows that the east central sector of the city, made up of 7 comunas containing more than 80% of the main population of the richest quintile (AB class), is highly segregated from the other four socioeconomic groups, with ratios of between 2.5 and 25. This sector also has the highest land values (Trivelli & Cia, 2016) and the best urban furniture and environmental quality (Tiznado-Aitken at al., 2018), a reflection of how the spatial aspect plays a decisive role in the city's inequities.

This extreme social segregation makes Santiago a particularly interesting case study of how the costs and benefits of transport use are distributed between different socioeconomic groups. In what follows, we describe the application of the proposed methodology to the characteristics of the city as they were in 2012-2013. The five income quintiles into which we have divided the city's population are defined in accordance with the socioeconomic data from Ministry of Social Development (MDS, 2013a; 2015).

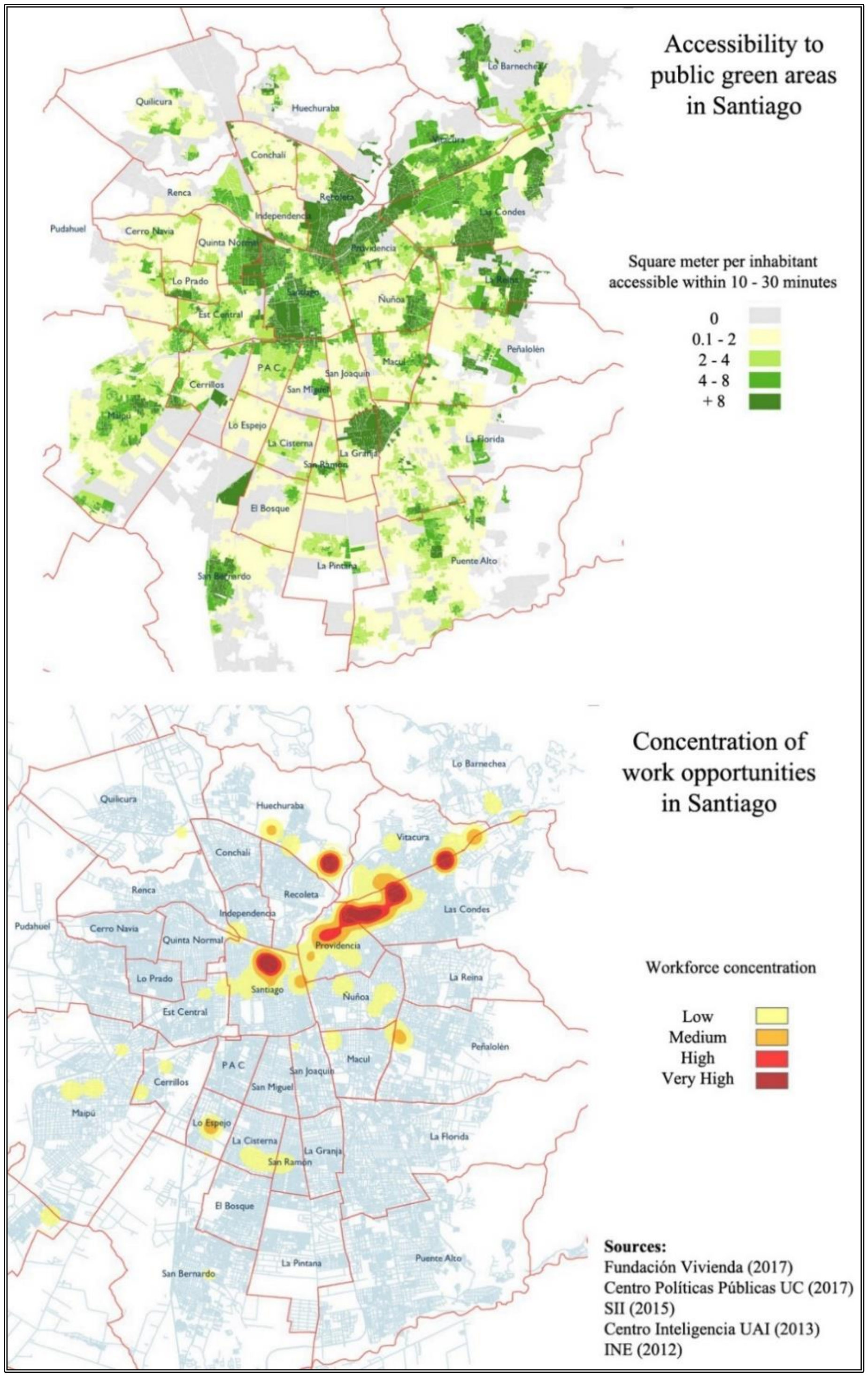
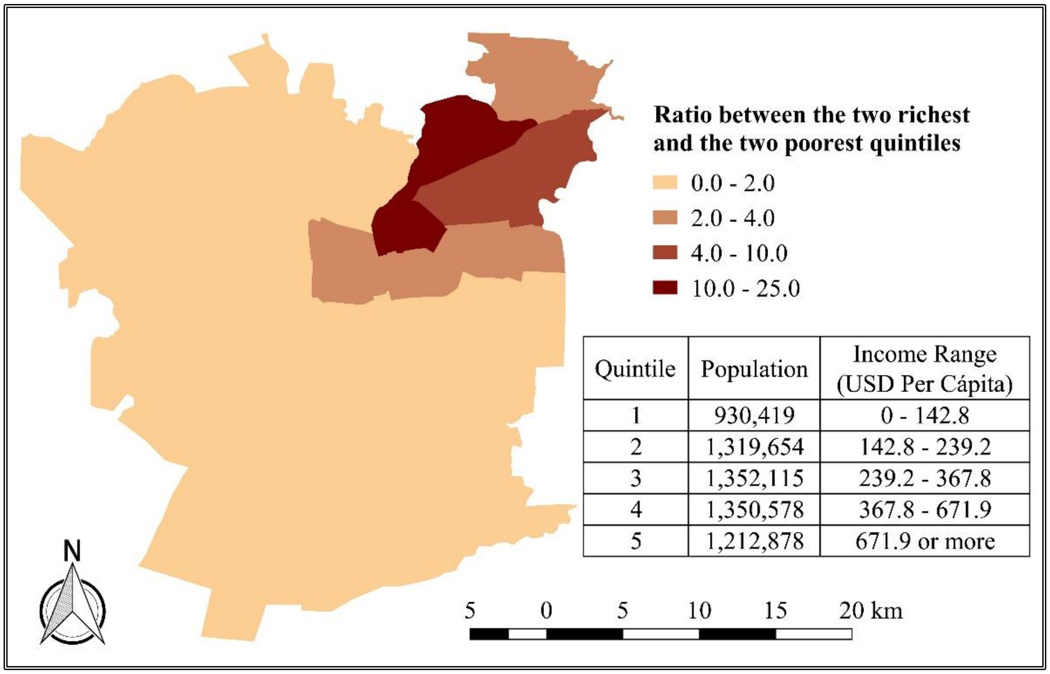


Figure 2-2 Map showing the accessibility to public green areas and concentration of work opportunities in Santiago (Source: Juan Correa - Fundación Vivienda (2017), translated into English language).



Quintile	Population	Income Range (USD Per Cápita)
1	930,419	0 - 142.8
2	1,319,654	142.8 - 239.2
3	1,352,115	239.2 - 367.8
4	1,350,578	367.8 - 671.9
5	1,212,878	671.9 or more

Figure 2-3 Map showing the low level of social mixing in Santiago (Source: developed by the authors based on data in Ministry of Social Development, MDS (2013a), assuming an exchange rate of USD = 525 CLP for 2013).

2.4.1 Mobility diagnosis

The number of trips made by each quintile in each transport mode and the trips' main characteristics (distance travelled, travel time and average speed) were estimated using data from an origin-destination survey of Santiago (2012) (SECTRA, 2015). The survey gives the number of trips generated by individuals on a normal weekday between different zones of the city. The trip data are disaggregated by purpose (work, education, other), mode (private vehicle, public transport, walking, bicycle, share taxi) and are broken down by the individual's monthly income. From this information it was also possible to know the distance covered, travel time and average speed for each trip. These items were then disaggregated into income quintiles using the individual's monthly income (MDS, 2013a).

2.4.2 Pollution

The annual emission C_{iq}^{k} of pollutant i by persons in quintile q on their trips by mode k was estimated by Equation 2.1, where $f_i^{k,l}$ is the emission factor of pollutant i per kilometre travelled in a vehicle of mode k using technology l, $d^{k,l}$ is the distance travelled in kilometres by such vehicles and s_q^k is the proportion of annual passenger-kilometres travelled in mode k by persons in quintile q (SECTRA, 2015).

$$C_{iq}^{k} = s_q^k \cdot \sum_l f_i^{k,l} \cdot d^{k,l} \qquad (2.1)$$

The pollutants considered in the analysis were carbon monoxide, particulate matter 2.5 and nitrogen oxide. Their emission factors $f_i^{k,l}$ (in grams per kilometre) were derived by the COPERT 5 model, a Tier-2 method as described in (COPERT, 2013). The values were disaggregated for each mode by type of fuel (gasoline or diesel) and the vehicle's Euro emissions standard classification.

To determine the annual distance travelled by private cars, we used the results of the MODEM (2016), calibrated for Santiago, which indicates the average distance travelled by light vehicles in a one-year period, broken down by vehicle age. The numbers of cars meeting the different Euro standards were determined from the vehicle registry (MODEM, 2016) on the assumption that each one met the standard in force at the time it was purchased. To differentiate between gasoline and diesel-powered vehicles, we used the proportions by fuel type for the total number of vehicles in the country as of 2013 (ANAC, 2018).

In the case of buses, we turned for information to DTPM (2013), the Santiago public transport authority, which provided the necessary data on distances travelled by Transantiago buses in 2013 and the Euro standard classifications of each vehicle in the system's fleet.

2.4.3 Energy consumption

Energy consumption E_{kq} by each quintile q for transport in mode k was estimated in a manner similar to that described in the preceding section and is stated formally in Equation (2.2), where r_k is the fuel efficiency rating for each mode k and d_k is the total distance travelled by mode k vehicles in 2013.

$$E_{kq} = s_q^k \cdot r_k \cdot d_k \tag{2.2}$$

In the case of cars, we assumed a fuel efficiency, measured in grams of oil equivalent (goe) per kilometre, of 77.68 [goe/km] (BTS, 2018) while for the Santiago Metro we used the system's reported figure of 2-4 [kWh/vehicle-km] and its conversion to goe of 206.63 [goe/km] (Metro S.A., 2014). As regards the buses, we set the figure at 294.72 [goe/km] based on the experience reported by the Transantiago route operators. To obtain the distance travelled, for cars and buses we used the same distance noted in Section 2.4.2 whereas for the Metro we took the number of kilometres for all vehicles in the network in 2013 (Metro S.A., 2014).

2.4.4 Accident rate

The estimates of accidents caused were based on the number of accidents that occurred in 2012 in Greater Santiago according to data reported by the Comisión Nacional de la Seguridad del Tránsito (CONASET), the national traffic safety commission (CONASET, 2012a). Since a breakdown by mode for the city alone was not available, the city's accidents were assigned to each mode on the basis of the national breakdown (CONASET, 2012b).

With these data and the numbers of passenger-kilometres travelled in each mode, we estimated accident rate indicators as the number of accidents per million kilometres travelled and per million trips in each mode. Although the idea in this study was to assign the different factors to income quintiles, in this case we decided not to do so since the location of an accident is not necessarily indicative of the comuna of residence of the person responsible. In this sense, the present case differs from our quintile assignments for the other factors, which could be made either directly or indirectly based on location. From the available data it was also not possible to assign responsibility to the modes involved in a given accident.

2.4.5 Investment in transport infrastructure and services

To identify the magnitude of investment in transport infrastructure for each mode, we obtained official data for the years 2010-2016 (Ministerio de Hacienda, 2016). The amounts were classified by the mode that benefitted from the investment as indicated by the description of each project so that the appropriate total could be attributed to each mode for the indicated period. Each investment was then assigned to the socioeconomic groups on the basis of the share of trips in each mode that were made by users from each quintile (MDS, 2013a; 2015). For investment in services, we utilized information from the Servicio de Impuestos Internos (SII, 2009; 2015), the Chilean tax department, to determine the trends in new non-housing construction space in each comuna. Then, with additional information taken from the national household survey conducted by the Ministry of Social Development (MDS, 2013a; 2015) on socioeconomic composition at the comuna level, we estimated the benefits to individuals in each income quintile on the basis of their place of residence.

2.4.6 Costs

To assign an annual mobility cost to each quintile, we considered the case of an adult engaged in necessary activities (work, study or other) on 20 days per month at a location 8 kilometres from their residence, i.e., we use potential mobility for the analysis. This is a reasonable set of assumptions for comparison purposes given that among the lower income quintiles, trips are fewer and shorter (SECTRA, 2015). The transport modes included were private car, share taxi, public transit and bicycle. Walking was excluded as unlikely in this case given the trip distance considered.

To calculate the costs for the car mode, we took a representative automobile for the year 2013 (ANAC, 2017). Fuel costs were based on the car's average fuel economy (Fuel Economy, 2018) and the average fuel price per litre (CNE, 2018). Also taken into account was spending on mandatory accident insurance, driving licence fees (SII, 2013) and monthly amounts for maintenance and depreciation calculated using the methodology due to Salinas et al. (2016).

As for public transport costs, we used the Transantiago peak hour fare (DTPM, 2013) for the Metro, the most expensive of the two transit modes in the system. Since share taxi fares depend on the operator serving the route, we took an average, which was the equivalent of approximately USD 1.2 for 2013.

In the case of a bicycle, we based ourselves on the physical energy expended to make a trip. Barbosa et al. (2004) suggests a method of calculating this value of this factor using the formula in Equation 2.3, which we applied for a person weighing 80 kg with a metabolic rate of 4.0.

$$G\ \left[\frac{kcal}{min}\right] = 0.0175 * METs * Peso = 5.6\ \left[\frac{kcal}{min}\right] \tag{2.3}$$

We then derived a monetary value for the use of a bicycle assuming an average speed of 16 km/hr and the average monthly expenditure in Chile for a quantity of food that would ensure a daily intake of 2,000 kcal (MDS, 2013b). Finally, to calculate the cost impact of each mode for the different income quintiles, we used two measures. The first was each quintile’s spending on each mode as a percentage of their average monthly income and the second was the percentage of each quintile’s monthly income that was spent on all modes of transport after taking into account the quintiles’ respective modal shares (SECTRA, 2015).

2.5 Results

2.5.1 Mobility Diagnosis

The average per-capita trip generation rate of the richest quintile is 1.2 times greater than that of the lowest quintile. The distribution of these trips by purpose is shown in Figure 2-4 for each income quintile. As income increases, the proportion of work trips grows while the proportion for study purposes declines. These results are complemented in Figure 2-5 by a breakdown of the quintiles according to their personal status, which shows that the proportion who are workers grows with income level. This explains in part the situation of persons in the bottom quintile, who have relatively low labour force participation rates and low rates of pay given their lower education levels (INE, 2017).

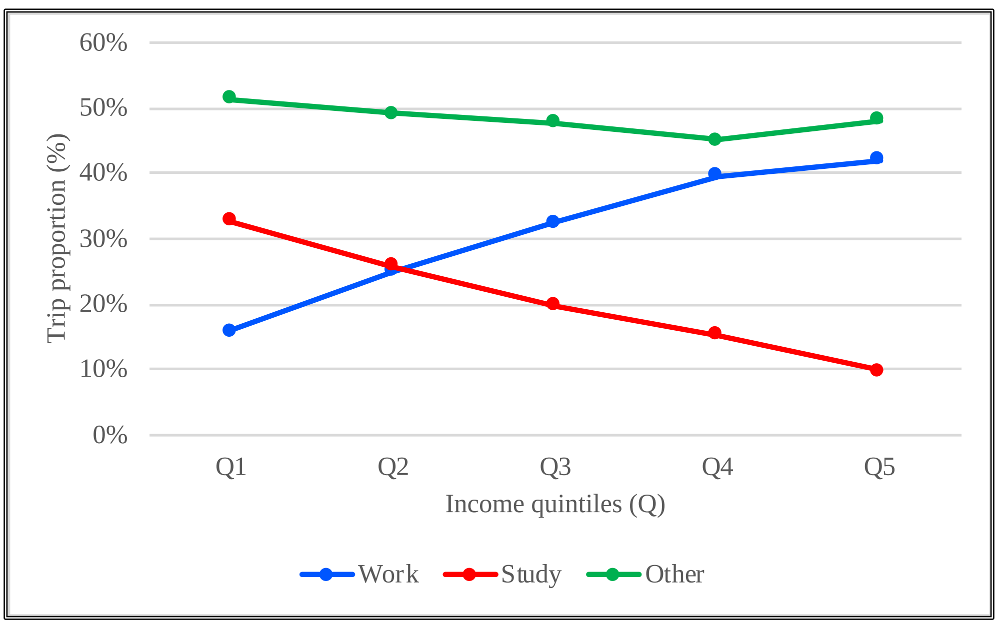


Figure 2-4 Trips distributed by purpose and quintile (Source: developed by the authors, based on data in SECTRA (2015)).

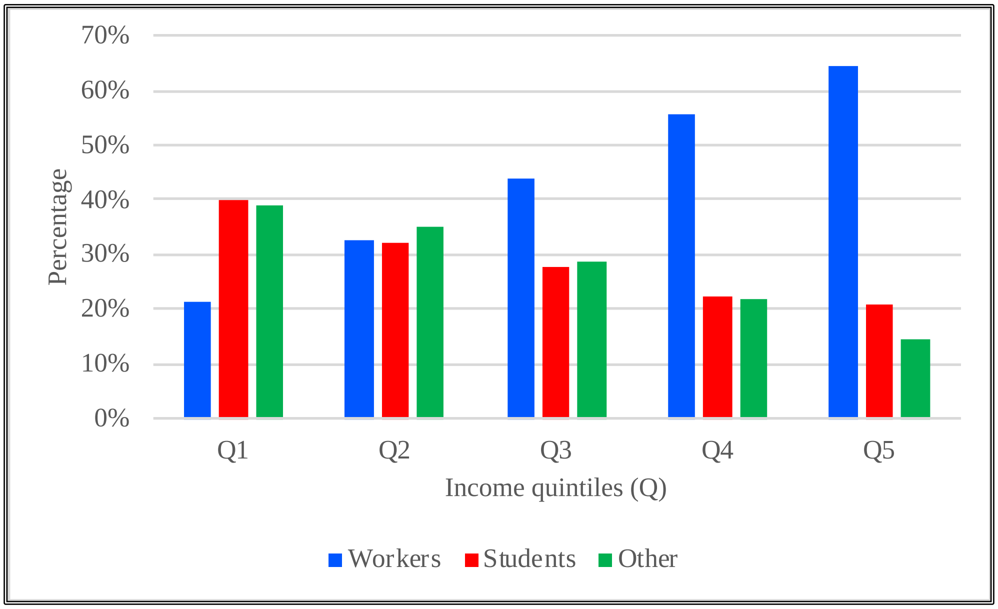


Figure 2-5 Proportion of workers and students in each quintile (Source: developed by the authors, based on data in SECTRA (2015)).

As regards the modal share, the data in Table 2-1 clearly indicate an increase in private car use and a decrease in walking as income rises. Public transport increases slightly from the first through the fourth quintile, reaching almost a 25% share, but then falls to less than 17% in the top quintile. Bicycle use shows no clear trend, remaining fairly stable across the quintiles at about 4%.

In the case of the mobility indicators, there are no marked differences between the quintiles for any particular mode. Table 2-1 reveals that for the motorized modes, travel time by public transport is almost double that of private cars while the mean speed for the latter is 53.5% higher. In the case of non-motorized modes, distances are short, the average trip length being just 2.3 km for bicycles and 0.5 km for walking. Therefore, taking into account each group's modal share, for the lowest income quintile average trip length is 35.4% shorter and average speed 38.5% lower than for the highest income quintile. This implies that the lower income quintiles where non-motorized modes predominate have substantially less access to the city's opportunities (work, education, health care, among others) given that the latter tend to be concentrated far from the areas where these quintiles reside.

Table 2-1 Mobility indicators and modal share by income quintile (Source: developed by the authors, based on data in SECTRA (2015)).

	Mobility indicators			Modal share by quintile				
Mode	Travel time [min]	Distance [km]	Speed [km/hr]	Q1	Q2	Q3	Q4	Q5
Car	30.1	8.3	16.2	9.3%	13.8%	19.7%	31.1%	48.7%
Public transport	58.9	10.4	10.3	22.8%	23.2%	24.8%	24.9%	16.5%
Share taxi	31	4.7	9	4.7%	3.3%	3.9%	2.3%	0.8%
Bicycle	17.1	2.3	8.2	4%	4.1%	3.8%	4.7%	3.4%
Walking	7.4	0.5	3.7	47.4%	43.8%	36.6%	27.9%	22.3%
Other	-	-	-	11.8%	11.9%	11.2%	9.1%	8.2%

2.5.2 Pollution

Cars and buses emit 48,400 tonnes of pollutants in Santiago every year, the use of cars accounting for 89.77% of this amount. Disaggregating the percentage by type, we find that 97.51% of the CO, 74.20% of the Nox and 90.86% of the PM2.5 are attributable to cars. By way of contrast, about 25% of all trips in Santiago are by car while 22% are by bus (SECTRA, 2015). Thus, although both modes play a significant role in urban mobility, their respective impacts as regards pollution are very different.

Casting the pollution data in terms of income levels, we find that the richest quintile is responsible for 35.5% of emissions due to its intense use of private cars while the poorest quintile can be blamed for only 5.3%. But as can be seen in Figure 2-6, in every quintile cars still make the biggest contribution to the city's pollution. Thus, for the lowest income quintile, although fewer than 10% of their trips are made by car, those trips are the cause of 74% of the pollutants they emit.

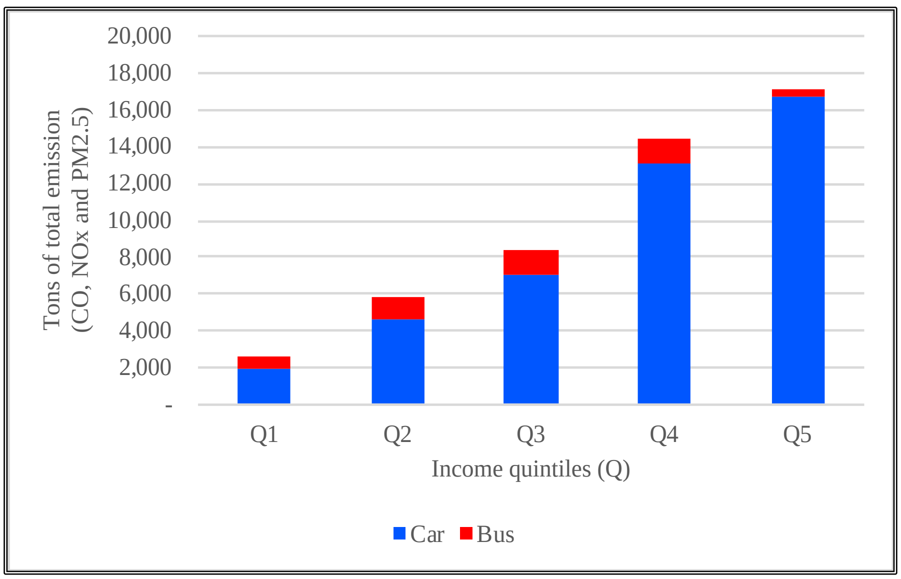


Figure 2-6 Share of pollutants emitted by quintile and mode (Source: developed by the authors).

2.5.3 Energy Consumption

Every day in Santiago, 5.255 billion grams of oil equivalent are consumed in transport, of which 91.33% are accounted for by private cars, 7.13% by buses and 1.54% by the Metro. The high figure for cars is due to the fact that despite their greater fuel efficiency in goe/km than the other modes, they have a higher goe per trip ratio, equal to 1,012. This is because their average occupancy rate is low at 1.47 passengers (SECTRA, 2015), demonstrating their inefficiency compared to public transport. The effect of occupancy on fuel efficiency is graphed in Figure 2-7, showing that a car at the average occupancy rate of 1.47 passengers is less efficient than a bus with 6 passengers or a Metro train carriage with 4.

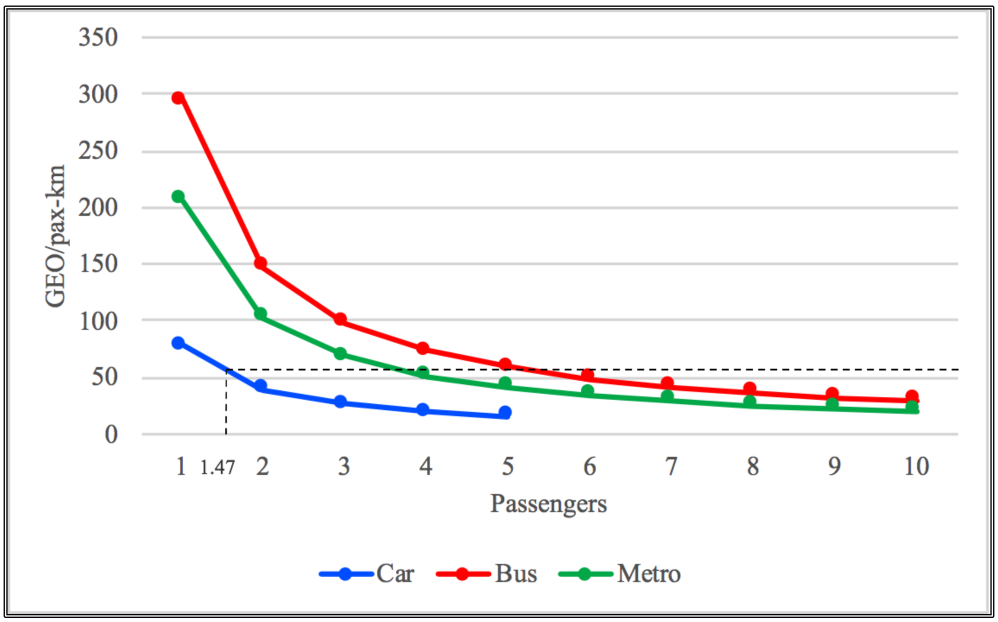


Figure 2-7 Energy consumption by mode and occupancy (Source: developed by the authors).

Regarding the breakdown of energy consumption by income quintile, Figure 2-8 shows that the higher the quintile, the greater the consumption. As with pollution, this is due to the intense use by higher income groups of private cars. Thus, the richest quintile consumes 7 times more energy than the poorest one.

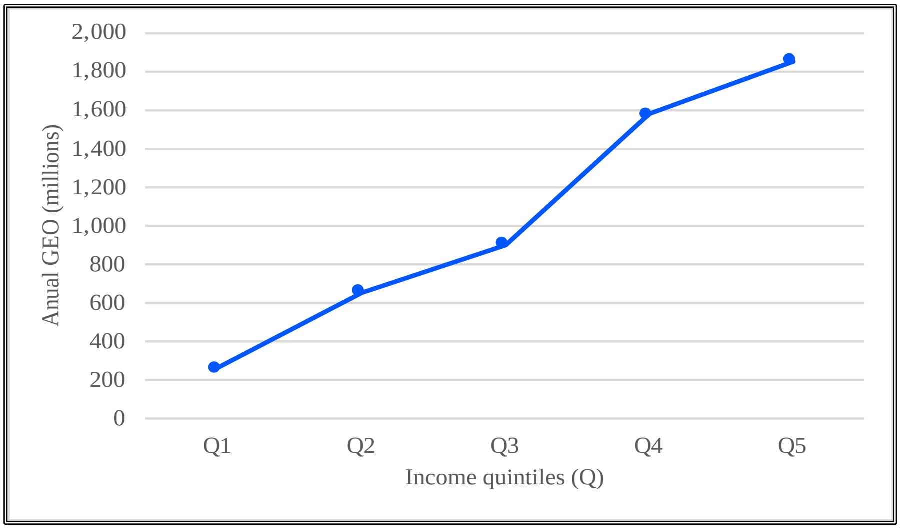


Figure 2-8 Energy consumption by quintile (Source: developed by the authors).

2.5.4 Accident rate

The disaggregation of the 28,502 accidents registered in Santiago in 2012 revealed that the accident rate per million kilometres travelled was highest for buses and lowest for private cars. But a complete analysis must take into account the mean vehicle occupancy and average distance travelled. We therefore express the results for each mode in rates per million trips, shown in Figure 2-9.

As can be seen, on this indicator private cars have the highest accident rate, in contrast to buses and walking which have rates 8 and 7.35 times less, respectively. Although as explained in Section 2.4.4 we cannot break these rates down by quintile, the greater use of cars by higher income groups allows us to expect that they contribute more to the external cost of accidents than lower income groups. Note also that non-motorized modes and public transport, used primarily by those with lower incomes, have a combined rate 6.8 times lower than cars.

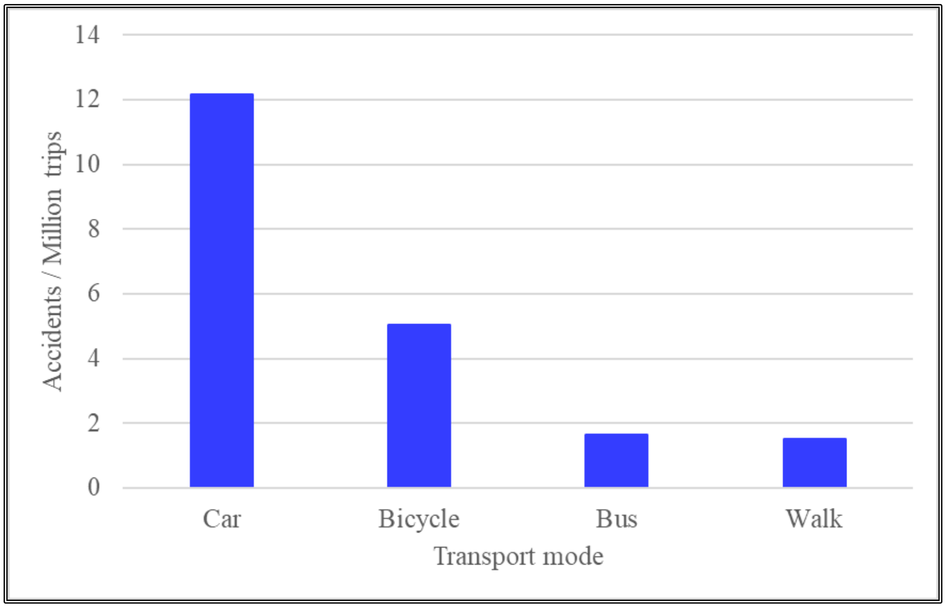


Figure 2-9 Accident rate by mode (Source: developed by the authors).

2.5.5 Investment in transport infrastructure and services

During the period 2010 to 2016 a total of USD 3.8 million were invested in transport infrastructure projects. The breakdown by mode is graphed in Figure 2-10, which captures an evident disparity between the two public transport modes in the system. Whereas the Metro has been the recipient of large-scale funding for new lines and extensions of existing ones that benefit some medium and low-income populations, investment in the bus system has been limited. This raises an important issue for transit planning given that more than 70% of trips using public transport include bus travel for some segment of the journey (SECTRA, 2015).

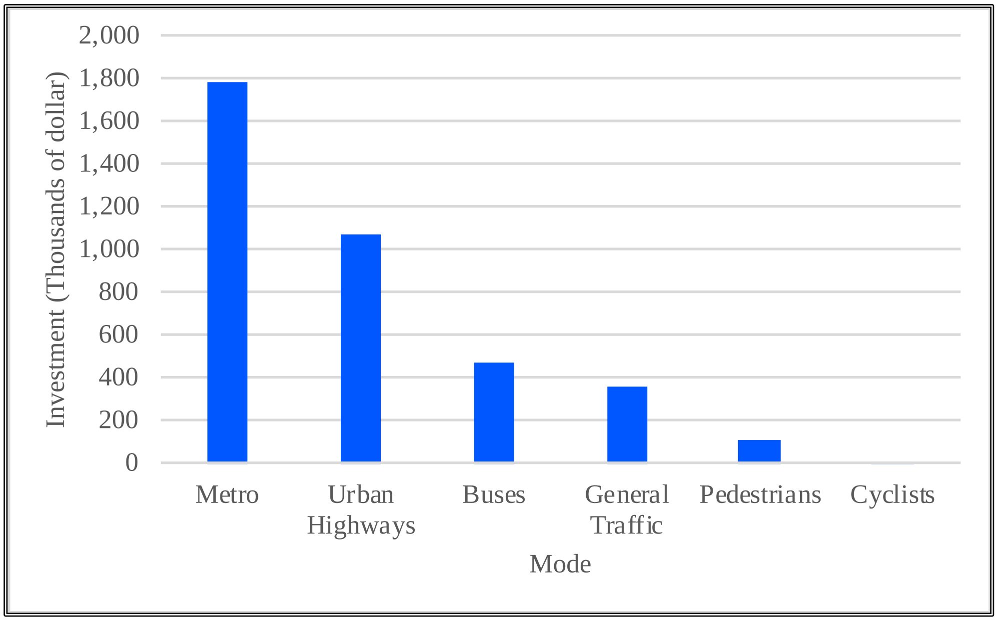


Figure 2-10 Investment in infrastructure by mode (Source: developed by the authors).

Considerable investment has also been put into urban highways, which have received 28.13% of the total for the indicated period. The beneficiaries are mainly private car users and to a lesser extent road haulage operators given that less than 1% of public transport trips in Santiago use this infrastructure (SECTRA, 2015).

As for walking, one of the principal modes for lower income quintiles, investment is minimal at just 2.78% of the total, which translates into poor quality infrastructure for pedestrians. But the situation is even worse for these groups than this percentage would suggest, as much of it is the responsibility of the individual comunas whose budgets are highly dependant on the income of their residents (for further detail, see Tiznado-Aitken et al., 2018). Funding for bicycle infrastructure is lower still even though this mode represents some 4% of trips and has positive external effects in terms of health and pollution.

As a consequence of the foregoing, the distribution of transport investment by quintiles clearly favours the two highest quintiles, as is apparent in Figure 2-11. The group benefitting the most is actually the second highest (Q4) given that its members not only make heavy use of private cars but are also major users of the public transport system, unlike the richest quintile where ridership on the system is much lower.

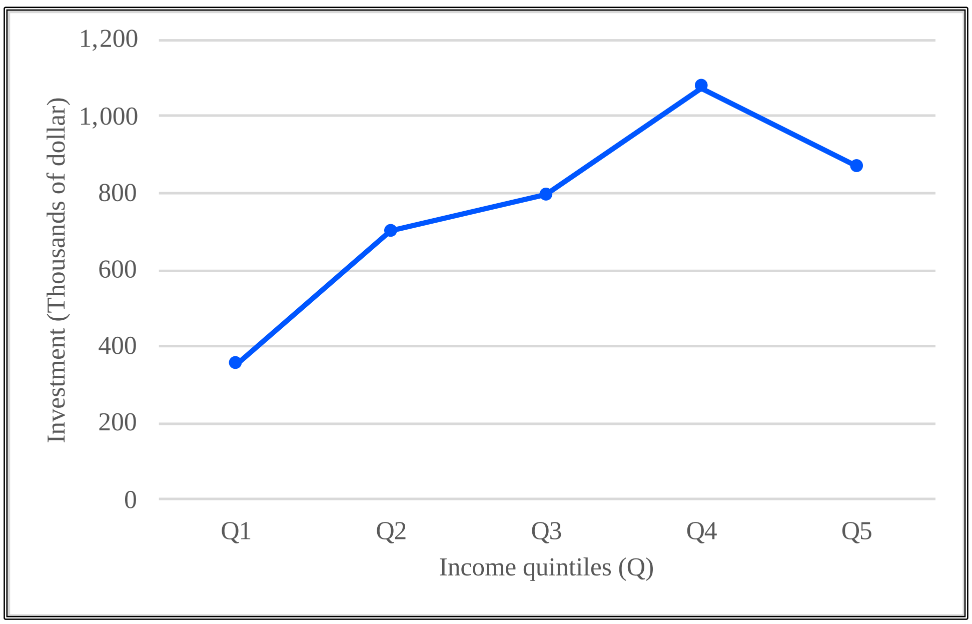


Figure 2-11 Transport infrastructure investment by quintile (Source: developed by the authors).

Turning now to investment in services, new construction space per inhabitant for the top quintile is 81.3% the combined amount for the bottom three quintiles (Figure 2-12). This is consistent with the analysis by Suazo (2017), who shows that 12% of Santiago's total area within the higher income northeast sector of the city accounted for 67% of new construction space in services during the period 1990-2015. Thus, the focus of economic activity has shifted away from its traditional location in the city centre, which has the effect of forcing a significant percentage of the generally lower income population resident in the outer areas of the city to take longer trips to their places of work or study.

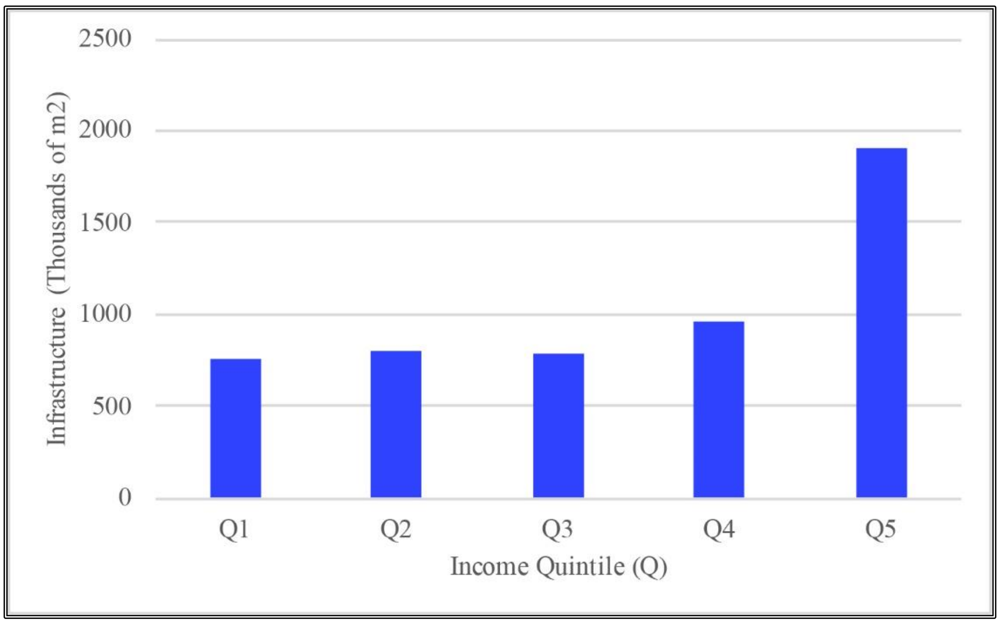


Figure 2-12 Investment in services by quintile (Source: developed by the authors).

2.5.6 Costs

The monetary costs of using each of the transport modes in both absolute terms and percentage of per capita monthly income for each quintile is set out in Table 2-2. These data show that to travel by car, the average person in the bottom quintile must spend 16.8 times more relative to their monthly income than the top quintile. Furthermore, individuals in the bottom two quintiles must spend more than 27% of their income on public transport. By contrast, the top two quintiles, thanks to their high incomes, have access to all four modes and can choose the one that is the most convenient, which in practice means heavy use of private cars.

Table 2-2 User cost of transport modes relative to average monthly income, by quintile (USD = 525 CLP for 2013) (Source: developed by the authors).

Income	Average Monthly Income (Per capita in USD)	Transport mode: Car (Monthly Cost: USD 280.1)	Transport mode: Public transport (Monthly Cost: USD 51.8)	Transport mode: Share taxi (Monthly Cost: USD 49.5)	Transport mode: Bicycle (Monthly Cost: USD 25.3)	Relative cost considering current modal share
Quintile 1	90.8	308.5%	57.1%	54.5%	27.9%	45.2%
Quintile 2	189.6	147.8%	27.3%	26.1%	13.4%	28.1%
Quintile 3	299.9	93.4%	17.3%	16.5%	8.4%	23.7%
Quintile 4	490.6	57.1%	10.6%	10.1%	5.2%	20.9%
Quintile 5	1531.6	18.3%	3.4%	3.2%	1.7%	9.5%

Table 2-2 also shows spending of transport by all modes combined as a percentage of each quintile's monthly income taking into account their observed mobility, that is, trips by mode for each quintile (modal share). As the data show, this relative cost indicator falls as income rises. This implies that although the bottom quintile makes intense use of non-motorized and public transport, accessing activities in the city consumes a significantly higher share of their income compared to the richest quintile (45 vs 10%), which heavily uses the most expensive mode, that is, private cars.

Finally, note in Table 2-2 that the bicycle is the mode with the lowest cost. Yet as we saw in Section 5.1, it accounts for the lowest modal share at less than 5% in every quintile, owing to the lack of investment in dedicated infrastructure. Greater investment could promote the use of this mode, as has been demonstrated by Dill & Carr (2003) and as it has been observed in the important growth of bicycle use in more affluent sectors of Santiago (SECTRA, 2015) where more dedicated infrastructure has been provided. Similarly, the cost of share taxis – whose fares, unlike public transport, depend on distance – is relatively low yet its modal share in the various quintiles is also low due to its limited network in the city and the lack of integration with the public transport system.

2.6. Conclusions

A multi-factor methodology was presented for calculating the benefits and costs associated with urban transport among different socioeconomic groups as defined by income quintiles. The proposed approach can be used to evaluate the distribution across quintiles of these benefits and costs and thus serve as a pointer to the challenges facing policy makers seeking to achieve a more equitable distribution.

The methodology was applied to the real-world case of Santiago, Chile. It was found that compared to the poorest quintile, the richest quintile generated 1.2 more trips at an average speed 1.6 times higher. In terms of costs, the richest quintile generated 6.7 times as much pollution and used 7 times as much energy but consumed 4.8 times less of their income. In addition, the top quintile was the beneficiary of 2.5 times more investment in transport infrastructure and 2.5 times the area in new construction space for commercial activities and services over the period considered. Finally, private car use in the top quintile was 5.3 times greater. This transport mode accounts for 6.8 times more of the accident rate than public transport, bicycles or walking combined. These results clearly indicate that there are population groups in the city who are systematically disadvantaged as regards mobility, affordability, externalities, and access to work or education opportunities and other services, all of which have been previously identified as the principal factors in what has been called transport poverty.

As regards transport benefits, investment has been low in buses and non-motorized transport modes (bicycle and pedestrian infrastructure), precisely those heavily used by the lower income quintiles, while funding has been generous for urban highways used mainly by the highest income group. Of all public investment during the period studied, only about 3% was aimed at the non-motorized modes. This negatively impacts individuals with lower incomes and underlines the need for investing in these alternatives, which would also reduce the production of externalities, particularly in the higher quintiles. Also, new construction is excessively focussed on areas of the city inhabited primarily by the higher income groups, facilitating access to their daily activities at the expense of access by those in outer areas where the lower income groups tend to be concentrated.

In terms of the costs associated with transport, the bottom quintiles generate the smallest amount of externalities such as accidents, pollution and energy consumption. Furthermore, the cost of using motorized transport modes imposes a significant economic burden on them in terms of the proportion of their income, in effect making these modes less accessible and increasing the use of more sustainable ones. But this sustainability, though positive in environmental terms and conducive to a “friendlier” city, masks a significant social problem in that these modes, being non-motorized, are much slower and cover shorter distances. This has a serious negative impact on their ability to access the opportunities offered by the city.

In light of this inequitable scenario, the question that arises is how to design public policies that counter these harmful effects on the lower income groups in Santiago. One approach would be to seek a more rational use of private cars by charging users the true cost they impose on the city. Currently, the social cost of this mode is disproportionate to its real use in Santiago given that it accounts for only 1 in 4 trips.

To implement such an approach, the literature proposes such policies as disincentives to investment in urban highways, increases in parking costs and driving licence fees and the implementation of road pricing. Another step in that direction would be to implement targeted subsidies and incentivize development of sectors of the city populated heavily by groups currently disadvantaged by the existing set of inequitable incentives.

Our study could be extended in the future, especially by refining some of the indicators used for the analysis or adding new ones. For example, in this chapter we did not analyze the operational subsidy and costs involved with different transport modes. This would have led us into contrasting public transport subsidies, gas tax, diesel tax, tolls, etc. Also, some dimensions analyzed in the chapter could have been addressed with more detail as some papers in the literature have done in the Chilean context. For example, Rizzi & De la Maza (2017) estimate the marginal external costs per kilometer for cars and buses in Santiago de Chile in terms of congestion, road damage, accidents, air pollution and noise. Mena-Carrasco et al. (2012) quantify the health benefits to promote the use of natural gas in the transport sector in Santiago de Chile, while Jiménez and Bronfman (2012) analyze the overall impact on health that 15 categories of vehicles impose on Chilean society, clustering by category, emission abatement technology and fuel type, and pollutant emission. For future research it is proposed to extend this methodology to other Chilean cities given the availability of recent mobility surveys. Maintaining the simple methodology presented in this document will allow comparisons among them.

Furthermore, the authors intend to investigate the evolution of the indicators presented here during the 2001-2012 period, the years for which an origin-destination survey data was taken for Santiago. Such an analysis should also allow us to evaluate the impacts of various public policies implemented over that period. The study would also attempt to estimate which measures and policies should be promoted affecting the various factors discussed here in order to reach a more equitable scenario between the top and bottom income quintiles of the population.

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3. TRANSPORT AND EQUITY IN LATIN AMERICA: A CRITICAL REVIEW OF SOCIALLY ORIENTED ACCESSIBILITY ASSESSMENTS

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3.1 Introduction: Transport and equity in a highly unequal region

A growing concern for mobility-related social inclusion and equity is evident from both academic research and planning best practices. An expanding debate on the ethical dimensions of mobility (Martens, 2017; Van Wee, 2011; Pereira, Schwanen, & Banister, 2017) complements the established literature on mobility and social exclusion (Lucas, 2012; Kenyon, Lyons & Rafferty, 2002; Preston & Rajé, 2007; Stanley & Vella-Brodrick, 2007). While manifold theoretical approaches and consequent operational implications are discussed, the idea of accessibility as the main aim of transport planning is gaining consensus (Martens, 2017; Van Wee & Geurs, 2011; Miller, 2018). In this perspective, mobility is a meaningful activity because it allows people to access key places and opportunities in the city. Accessibility emerges thus as the evaluative approach that better conveys how transport and land use systems allow individuals to move and participate in social life, becoming crucial to address the social inequalities that characterise manifold settings across the world.

Latin America is a highly unequal region. The social inequality is determined by the interrelation of socioeconomic status, gender, race, ethnic origin, age and life cycle, with remarkable differences between urban and rural territories (CEPAL, 2016). The region achieved significant inequality and poverty reductions (Székely & Mendoza, 2015); nonetheless, several forms of inequality and exclusion remain nowadays, such as significant mobility-related inequalities, impeding equitable progress (Deneulin & Sanchez-Ancochea, 2018). In a region whose population is mainly urban (Montezuma, 2003, p. 177), Latin American cities show increasingly more complex travel structures in settings continuously under expansion but served mainly by low-quality formal and informal transport systems (Hidalgo & Huizenga, 2013), generating transport problems similar to those in other developing countries (Vasconcellos, 2014). This leads to inequalities visible in the location of the inhabitants, their mobility practices and their access to urban opportunities (Câmara & Banister, 1993; Jirón, 2007; Jouffe, 2011; Rodríguez, 2008).

Drawing on these elements, the widespread interest in mobility as both a cause and effect of social disparities has generated an increasing stream of work that examines Latin American settings through the lenses of accessibility. The chapter aims at critically reviewing the growing scholarly works that, providing accessibility-based evaluations, investigates issues of transport and equity in Latin America. To do so, we propose a novel analytical framework that examines accessibility evaluations considering the underlying ethical stance, the different components of accessibility and the implications for planning and policy. Using this approach to review works that develop explicit quantitative accessibility-based evaluations, our work examines what approaches, features and indicators are present in the current literature, as well as what settings have been taken into consideration by scholarly research.

The chapter intends to examine this growing academic interest for accessibility in a specific context, considering the forms it assumes when highly unequal settings are considered. Moreover, the review has an explicit operational interest, to define what indicators are relevant or missing to assess accessibility in the light of social concerns. The debate on urban mobility and social inclusion agrees on the relevance of accessibility, referring to the specific Latin American setting (Hernández, 2012). However, there are difficulties to operationalise this concept (Miller, 2018) and to provide solid empirical evidence through reliable indicators and data (Jaramillo et al., 2012; Keeling, 2008). The review contributes thus to (i) consider what implications such academic research findings may have on transport planning and policy, identifying current and potential impacts that different accessibility measures and approaches could have, and to (ii) assess the Latin American state of the art, identifying key research gaps that could be helpful for both researchers and practitioners.

3.2 Methodology

3.2.1 Searching for relevant literature

The chapter proposes a systematic literature review of accessibility-based works discussing transport and equity in Latin America. Latin American scholars have widely contributed to the debate on both accessibility and the social dimensions of mobility. On the one hand, significant contributions have been made to the understanding of accessibility, its benefits, and the implications it has for transport modelling (see for example Jara-Diaz, 1986; Martínez, 1995; Ortuzar & Willumsen, 2011). On the other hand, a growing body of research influenced by the 'mobilities turn' has investigated on manifold forms of mobility and what these mean for people, using different qualitative approaches to reconstruct experiences, perceptions, aspirations and practices related to everyday urban mobility (see for example Avellaneda & Lazo, 2011; Benites & Rodríguez, 2013; Imilan et al., 2018; Jirón 2007, 2010; Jouffe & Lazo-Corvalan, 2010; Soldano, 2017). Nonetheless, our review intendedly limits its scope to works that have combined these two dimensions, developing quantitative accessibility assessments that have a clear interest in the social implications of mobility, discussing issues of transport and equity.

A first search in Google Scholar using accessibility, equity and Latin America as keywords in English, Spanish and Portuguese found 94,500 different results for the former and 19,400 for the latter. While a high number of results included local websites, newspapers or practitioners' reports, reflecting a growing concern and interest for these topics from local authorities and governments in Latin America, the number of academic publications in relevant journals remains low. The same research was then conducted using Scopus and Web of Science[1], searching for relevant research through different combinations of keywords referred to the object of study (transport/mobility/accessibility), the adopted social perspective (equity/justice/social inclusion), and the chosen setting (Latin America). To include significant works in Spanish or Portuguese (the two main languages of Latin America), we expanded our search to papers published in the Latindex and Scielo databases. Considering only those papers that develop an explicit quantitative accessibility-based evaluation, which is the main object of our review, 65 papers were selected.

Table 3-1 Core papers of the analysis

List of core papers of the review			
Country	**Territorial scale**	**Place**	**Papers**
Argentina	Urban	Buenos Aires	De Pietri, Dietrich, Mayo, Carcagno & Titto, 2013 Kralich, 2002 Quirós & Mehndiratta, 2015 Pucci, Vecchio, Bocchimuzzi & Lanza, 2019
Bolivia	Urban	La Paz	Aliaga, Artega, & Taco, 2015
Brazil	Metropolitan	Fortaleza	Holanda de Souza & Loureiro, 2018
	Urban	Belém	Rodrigues da Silva et al., 2015
		Belo Horizonte	Lessa, Lobo & Cardoso, 2019
		Curitiba	Boisjoly, Serra, Oliveira & El-Geneidy, 2019 Rodrigues da Silva et al., 2015 Tucker & Manaugh, 2018

[1] The research was conducted in two stages: first, in October 2018 for most of the articles and then, an update in July 2019.

Table 3-1(cont.) Core papers of the analysis

List of core papers of the review			
Country	**Territorial scale**	**Place**	**Papers**
Brazil	Urban	Goiânia	Rodrigues da Silva et al., 2015
		Itajubá	Rodrigues da Silva et al., 2015 Sakamoto & Lima, 2016
		Juazeiro do Norte	Rodrigues da Silva et al., 2015
		Porto Alegre	Duran, Anaya-Boig, Shake, Garcia, Rezende, & Hérick de Sá, 2018
		Recife	Boisjoly, Serra, Oliveira & El-Geneidy, 2019 Duran, Anaya-Boig, Shake, Garcia, Rezende, & Hérick de Sá, 2018
		Rio de Janeiro	Boisjoly, Serra, Oliveira & El-Geneidy, 2019 Duran, Anaya-Boig, Shake, Garcia, Rezende, & Hérick de Sá, 2018 Girão, de Aquino Pereira & Fernandes, 2017 Pereira, 2018 Pereira, 2019 Tucker & Manaugh, 2018
		Salvador de Bahia	Duran, Anaya-Boig, Shake, Garcia, Rezende, & Hérick de Sá, 2018
		São Carlos	Capasso da Silva & Rodrigues da Silva, 2016
		São Paulo	Moreno-Monroy, Lovelace, & Ramos, 2018 Boisjoly, Serra, Oliveira & El-Geneidy, 2019 Duran, Anaya-Boig, Shake, Garcia, Rezende, & Hérick de Sá, 2018 Pritchard, Tomasiello, Giannotti & Geurs, 2019a Pritchard, Tomasiello, Giannotti & Geurs, 2019b Arbex, Alves & Giannotti, 2016 Slovic, Tomasiello, Giannotti, de Fatima Andrade & Nardocci, 2019
		Uberlândia	Rodrigues da Silva et al., 2015

Table 3-1(cont.) Core papers of the analysis

List of core papers of the review			
Country	**Territorial scale**	**Place**	**Papers**
Chile	Metropolitan	Concepción	Martínez & Rojas, 2016
		Santiago	Cox & Hurtubia, 2016
	Urban	Concepción	Jara & Carrasco, 2010
		Los Ángeles	Rojas, Martínez, De La Fuente, et al., 2019
		Santiago	Contreras, Navarrete & Arias, 2017 Figueroa Martínez, Hodgson, Mullen, & Timms, 2018 Guimpert & Hurtubia, 2018 Niehaus, Galilea, & Hurtubia, 2016 Reyes Päcke & Figueroa Aldunce, 2010 Salazar & Cox, 2014 Shirahige & Correa, 2015 Steiniger, Fuentes, Villegas, Ardiles, Rojas, & Poorazizi, 2018 Tiznado-Aitken, Muñoz, & Hurtubia, 2016 Tiznado-Aitken, Muñoz, & Hurtubia, 2018
		Temuco	Rojas, Páez, Barbosa, & Carrasco, 2016
		Valdivia	Rojas, Páez, Barbosa, & Carrasco, 2016
Colombia	Metropolitan	Bogotá	Guzman, Oviedo, & Rivera, 2017

Table 3-1(cont.) Core papers of the analysis

List of core papers of the review			
Country	**Territorial scale**	**Place**	**Papers**
Colombia	Urban	Bogotá	Bocarejo & Oviedo, 2012 Bocarejo, Escobar, Oviedo, & Galarza, 2016 Bocarejo, Portilla, & Melendez, 2016 Brussel, Zuidgeest, Pfeffer, & van Maarseveen, 2019 Guzman & Bocarejo, 2017 Guzman & Oviedo, 2018 Guzman, Oviedo, & Cardona, 2018 Lecompte & Bocarejo, 2017 Oviedo, Guzman, & Oviedo, 2019 Vecchio, 2019 Rodriguez, Peralta-Quirós, Guzman, & Cárdenas Reyes, 2017 Teunissen, Sarmiento, Zuidgeest, & Brussel, 2015
		Cali	Delmelle & Casas, 2012 Jaramillo, Lizarraga & Grindlay, 2012
		Manizales	Younes, Escobar, & Holguín, 2016 Escobar, Martínez & Moncada, 2016
		Medellin	Bocarejo et al., 2014
		Quibdó	Escobar, Urazán & Moncada, 2017
Mexico	National		Duran-Fernandez, & Santos, 2014
	Regional	Estado de México	Chias Becerril, Iturbe Posadas, & Reyna Sáenz, 2001
		Meseta Purépecha, Michoacán	Marr & Sutton, 2007
		Oaxaca	White & Barber, 2012

Table 3-1(cont.) Core papers of the analysis

List of core papers of the review			
Country	**Territorial scale**	**Place**	**Papers**
México	Urban	San Luis Potosí	Terán-Hernández, 2017
		Querétaro	Esquivel-Cuevas, Hernández-Mercado & Garnica-Monroy, 2013
Perú	Urban	Lima	Oviedo, Scholl, Innao, & Pedraza, 2019
Uruguay	Urban	Montevideo	Hernandez, 2017 Hernandez, 2018

Latin America has been at the forefront of innovative projects and measures that tackle inequalities through mobility-related interventions. For example, introducing new public systems, as the renowned cases of Medellin and Bogotá show; or restructuring existing ones, as in Curitiba and Buenos Aires; or developing ambitious plans for non-motorised modes, as in the plan for walking in the centre of Santiago de Chile (Ardila-Gómez, 2004; Brand & Dávila, 2011; Buenos Aires Ciudad, 2013; ITDP, 2017; Vecchio, 2017). However, most of these projects do not provide explicit quantitative accessibility measurements, so they were not considered in our work.

3.2.2 The analytical framework

To examine the selected papers, we developed an analytical framework that considers accessibility assessments from a socially-oriented perspective (figure 3-1). The analysis aimed to consider not only the components of accessibility present in each work, but also the underlying ethical stance that structures each paper as well as eventual implications for planning and policy eventually.

The *underlying ethical stance* defines the perspective from which issues of transport and equity are considered. Its first two elements are interrelated: the social issue to be faced and the ethical goal. The former includes concepts such as exclusion, fragmentation, inequality or injustice, referring to the social unequal effects that transport may have. The latter includes concepts such as inclusion, equity or justice, referring to the desired social condition assumed as reference. There is an interplay between social issues or ethical goals, which reciprocally define each other (for example, if social exclusion is the problem to be faced, its desirable counterpart is inclusion). Such relationship, discussed in detail in section 3.3, also defines the main ethical theories and their evaluative principles in the transport field (Van Wee & Geurs, 2011), influencing the way in which the components of accessibility are examined.

The *components of accessibility* are here considered using Geurs and Van Wee (2004)'s categories, as to map the components and the typologies of accessibility measures. These include four components that contribute to accessibility and are estimated by different evaluative approaches, that is, land-use, transportation, time and individuals; consequently, four basic perspectives on measuring accessibility are identified (infrastructure-based, location-based, person-based, utility-based).

Finally, the eventual *implications for planning and policy* are considered, primarily in relation to the four components of accessibility, but also more generically referred to the (transport) planning practice as well as to other policy domains (for example, a lack of access to jobs may be addressed also providing new local job opportunities). These implications involve primarily planning and policy measures enhancing or limiting accessibility, such as land use and transport taxes or subsidies and other economy-oriented measures. These measures may apply to an entire territory, such as a city, as well as to parts of it. For example, congestion and pollution charges could be applied in the city center using results from studies like Escobar et al. (2016), which analyses the relationship between accessibility and PM10 pollution.

The results of the review are examined as follows. First, the investigated settings are mapped (section 3.3 of this chapter), considering the places taken into exam and the scale of the analysis (that may refer to a neighbourhood, city, metropolitan area, region, or country). Second, the reviewed accessibility analyses are examined following the analytical framework, that is: we discuss their underlying ethical stance (section 3.4), the components of accessibility they consider (section 3.5), and the eventual planning and policy implications deriving from the reviewed works (section 3.6). Finally, section 3.7 briefly discusses the main findings and recognizes the key gaps in the literature, identifying future paths for policy and research to enhance the accessibility-based evaluations in the region.

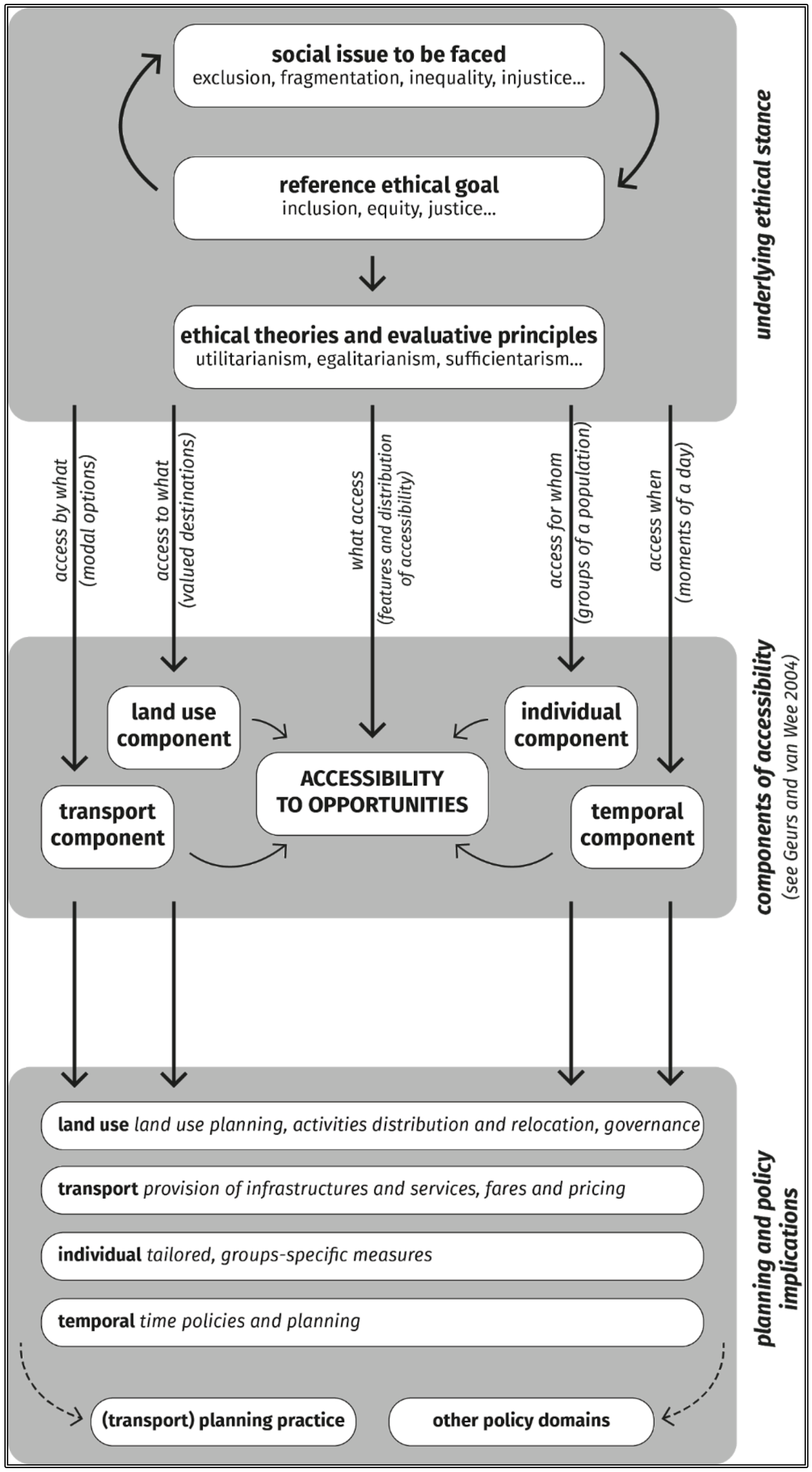

Figure 3-1 Analytical framework for socially-oriented accessibility assessments (Source: Own elaboration)

3.3 Geography of the results: The incomplete representation of a continent

3.3.1 Examined countries and territorial scales

The accessibility-based papers dealing with transport and equity in Latin America provide a partial representation of the continent. The reviewed works cover 31 cities and 3 regions in 8 countries, all belonging to South America (Argentina, Bolivia, Brazil, Chile, Colombia, Perú, Uruguay), except for Mexico. Chile, Brazil and Colombia have the most developed body of literature on the topic, having the highest amount of papers and showing the most refined analyses amongst those reviewed; accordingly, Santiago de Chile, São Paulo and Bogotá are the cities to which more works are devoted (10, 7 and 12, respectively). Instead, small states in Central America, South America and the Caribbean are completely absent from the analysed papers.

Almost all the studies have an urban focus. Apart from a few works with a metropolitan perspective (Guzman et al., 2017; Holanda de Souza & Loureiro, 2018; Martínez & Rojas, 2016; Cox & Hurtubia, 2016), the main object of study are well-defined cities or specific parts of them. For example, we found punctual infrastructural interventions, as in the case of Medellin's cableways (Bocarejo et al., 2014), or a focus on municipalities and neighborhoods (Salazar & Cox, 2013; Esquivel-Cuevas et al., 2013; Capasso da Silva & Rodrigues da Silva, 2016; Escobar et al., 2017), including more detailed accessibility analyses of slums or block villages where vulnerable population lives (Arbex et al., 2016; Shirahige & Correa, 2015). The dimension of these urban settlements is variable, ranging from small- or middle-sized cities (as in Brazil or Chile; see Rodrigues da Silva et al., 2015; Rojas et al., 2016; Rojas et al., 2019) to some of the main Latin American metropolises, which are the object of most studies. Instead, the regional and the national scale are almost absent from the reviewed works, except in the case of Mexico (Chias Becerril et al., 2001; Duran-Fernandez & Santos, 2014; Marr & Sutton, 2007; White & Barber, 2012).

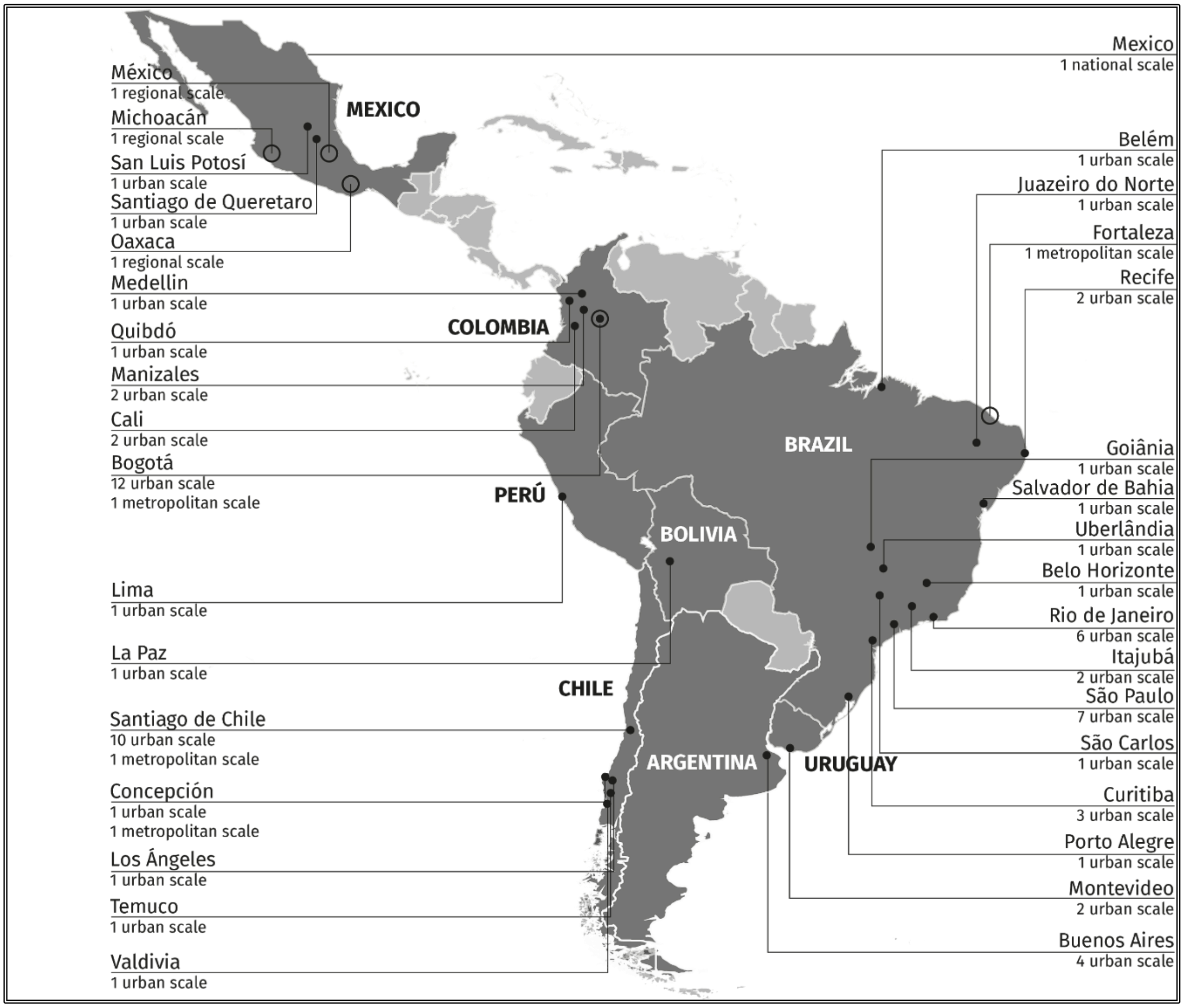

Figure 3-2 Countries, cities and territorial scales in the reviewed works (Source: Own elaboration)

3.3.2 Limitations and ways forward

The review highlights two main critical points in the corpus of accessibility-based works devoted to Latin American settings: the partial representation of the continent and the different level of detail of the works. As for the first point, entire areas of the continent are not object of accessibility-based research, a limitation that affects particularly the small-sized countries of the region. This limitation seems to go together with the almost exclusive urban focus of the reviewed papers, focusing on neighbourhoods, cities or metropolitan areas, which overlook the regional and the national scales. This could be explained considering that a huge percentage of the Latin American population lives in cities and that resources and power are usually concentrated in a few urban settings. As a result, huge rural regions – for which specific forms of transport could be significant, as international works devoted to remote regions show (Halpern & Bråthen, 2011; Laurino, Beria, Debernardi, & Ferrara, 2019; Yamaguchi, 2007) - are excluded in many of the countries under exam.

Similarly, evaluations at the regional or national scale would be more suitable for the small countries of the region, such as those in Central America (between Mexico and Colombia) and in the Caribbean. The possibility to use accessibility-based evaluations and policies for rural areas (as Sakamoto & Lima, 2016 did) and for small countries would be relevant to fill a current, huge gap in the research on transport and equity in Latin America. Moreover, this additional work would have a huge relevance in terms of policy, being a relevant element also for other policy aims such as the contrast to the growing rural poverty (FAO, 2018), the promotion of tourism (Porto et al., 2018), the study of human past movement in pre-

Columbian places (White & Barber, 2012), and even peacebuilding after armed conflicts, as the case of Colombia demonstrates (Cardona, 2017).

The partial representation of Latin American settings can be explained by the lack of data referred to these countries, which may also determine the differentiated quality of the reviewed works. The scarce availability of reliable data referred to mobility and accessibility has been already highlighted as a factor impeding the development of works on transport and equity in Latin America (Bocarejo & Oviedo, 2012; Jaramillo et al., 2012; Keeling, 2008). In the reviewed papers, some cities - usually the capital of each country or big urban settlements - are the object of refined works. They can consider several variables referred to the land use, individual and transport components of accessibility. This is for example the case of cities examined in several works, such as Bogotá and Santiago de Chile, where incremental knowledge has been built through the research developed throughout the last decade. Other cities instead are object of much simpler evaluations, assuming few variables and considering aggregate data (as the next sections discuss). The differentiated complexity of the reviewed works suggests that not all the examined settings may have the necessary data to develop sophisticated measures, able to incorporate each of the accessibility components with high levels of detail.

Considering the relevance that accessibility-based evaluations may have not only for research but also for different policy aims (referring primarily, but not exclusively, to fairer transport systems providing access to opportunities), as well as the structural lack of relevant data, a twofold operational approach may be proposed. On the one hand, it becomes necessary to assume a realistic stance and foster the adoption of easy accessibility evaluations. These can contribute to improve the current knowledge of transport systems and the approaches to planning and policy, especially in those middle-sized cities or rural settings for which complex data may be absent, or in those countries where no established accessibility indicators are available. On the other hand, the metropolises where data and technical tools are available can pursue a refining of the existing evaluations, especially in those settings where more elaborated works are already available. These contexts may increase the complexity of accessibility-based evaluations and expand the number of relevant variables taken into account, as to enhance the contribution of this tool to a fairer transport planning.

3.4. Ethical perspectives on accessibility: Towards a deeper philosophical engagement

The reviewed works deal with the ethical implications of transport planning, expressing in most cases a clear interest in mobility-related social exclusion and the principles to tackle it. However, such interest is developed with different focuses and depth: in some cases, ethical concepts and evaluative principles are explicitly discussed, emphasising diverse crucial features of the relationship between transport and equity; however, most reviewed works show a superficial engagement with the ethical implications of transport planning, resulting in many cases in the lack of a clear ethical stance.

3.4.1. Social issues to be faced

Most works provide a discussion of the relationship between transport, social exclusion and inequality, but assume different focuses, emphasising alternatively the issue to be faced or the guiding ethical goal to deal with it. In relation to the problem to be considered, social exclusion is the most cited issue (Jaramillo et al., 2012; Moreno-Monroy et al., 2018), reflecting a rich literature that has already explored mobility-related exclusion both theoretically and empirically (see for example Jirón et al., 2010; Avellaneda García, 2007; Hernandez & Titheridge, 2016). Inequality is widely mentioned in most of the reviewed papers as well, even if no clear definition is provided to explain what inequality is or what it refers to. Most works examine the unequal distribution of accessibility to specific opportunities, while others highlight unequal travel times (see for example Pereira, 2018), the dissimilar access to the transport network (see for example Chias Becerill et al., 2001) or uneven combined proximity to and accessibility by public transport (Boisjoly et al., 2019).

In some cases, inequality is referred not only to the transport field but also to economic and urban dimensions as segregation and housing (Figueroa-Martínez et al., 2018). Also, social fragmentation – intended as the loss of relationships or linkages with the surrounding urban continuum by a social group – is an element of concern (Bocarejo et al., 2016). Instead, concepts that are more directly referred to mobility - for example, transport poverty (Lucas et al., 2016) - are not used when examining Latin American settings. Considering the issue to be faced and the subjects who experience it, a certain ‘flat’ representation seems to emerge: inequality is mentioned as an obvious problem characterising mobility in Latin

America, but without specifying what it refers to, swinging between the availability of transport infrastructures, the accessibility they provide and the travel times they determine.

Social exclusion and fragmentation are considered almost exclusively in relation to the worst-off strata of a population, those who experience an economic disadvantage that results in their limited possibility to participate in social life. ‘Low income people’ or ‘poors’ are by far the main target population, sometimes even explicitly mentioned in some titles (Bocarejo et al., 2014; Guzman & Oviedo, 2018). Much less developed is the analysis of gender or age as elements determining different opportunities of access (Lecompte & Bocarejo, 2017; Rojas et al., 2016). The impacts of disability are absent from accessibility evaluations, given that the existing research rather focuses on the design concept of ‘universal accessibility’ and how it affects the travel times of subjects with and without disabilities (Mundi Blanco et al., 2019). Thus, the main discussed dimension of inequality is the economic one, emphasising not affluent subjects but leaving in the background other relevant significant features related to gender, age, ethnicity and disabilities.

3.4.2 Ethical goals, theories and evaluative principles

Equity is the dominant ethical goal assumed as reference to deal with mobility-related social exclusion. Many works declare an interest in equity (Bocarejo & Oviedo, 2012; Delmelle & Casas, 2012; Hernandez, 2017, 2018; Terán-Hernández, 2017; Tucker & Manaugh, 2018) or even in ‘spatial urban equity’, defined as “equal access to employment opportunities” (Guzman & Bocarejo, 2017, p. 4494). Some even mentions justice as a reference principle

(Younes et al., 2016), in line with a current academic debate on what just transport and mobility should be (Martens, 2017; Sheller, 2018).

Nonetheless, often no clear definition of equity is provided. Most of the reviewed works do not define what should be an equitable distribution of activities, transport systems or accessibility to opportunities. The declared interest for equity tends to simply set the context for accessibility-based evaluations and does not shape the different evaluative approaches. However, some interesting practical applications were found. A first example are works that use different measures of inequality to describe the distribution of accessibility among different groups of a population, such as the Gini coefficient (Aliaga et al., 2015; Guzman & Bocarejo, 2017), Lorenz curves (Guzman et al., 2017), and the Palma ratio (Guzman & Oviedo, 2018; Pritchard et al., 2019b).

A second example are instead works that derive their evaluative criteria explicitly referring to strands of thought, adopting egalitarian and/or sufficientarian approaches (Tiznado-Aitken et al., 2018), generating evaluative frameworks that explicitly refer to Rawls' distributive justice and Sen's capabilities (Pereira, 2018, 2019; Vecchio, 2019). Interestingly, this emerging approach engages with distributive justice and equity concerns in transport, by adopting the assumption that a more comprehensive analysis of how well are distributed the impacts of different transport policies "should take account of the setting of minimum standards of accessibility to key destinations and the extent to which these policies respect individuals' rights and prioritise disadvantaged groups, reduce inequalities of opportunities, and mitigate transport externalities" (Pereira et al., 2017, p. 170).

3.4.3 Limitations and ways forward

Considering the reference theories and the operational application they receive in the reviewed works, the engagement with the ethical dimensions of accessibility appears as a growing but still underdeveloped dimension of the research on transport and equity in Latin America. This element appears to be relevant not only in scholarly but also in operational terms: assuming a clear stance would help to recognise what is the issue to be faced, what should be the objects and the beneficiaries of mobility policies, and what results a policy may intend to achieve. Amongst the reviewed works, analyses using egalitarian or sufficientarian approaches provide a first example in this sense (see Pereira, 2018, 2019; Vecchio, 2019; Tiznado-Aitken et al., 2018). Nonetheless, for a further development of the ethical stance at least four issues and research gaps emerge:

1. The reference terms need more clarity: there is a focus on inequality as a problem and equity as a guiding principle to tackle it, but no clear or unambiguous definitions are provided. Moreover, other relevant concepts are mentioned, such as disparities or needs (Jaramillo et al., 2012) and justice (Younes et al., 2016). It would be relevant to explore if and how these concepts would determine different conceptualizations of the relationship between transport and equity;

2. The representation of inequality is partial, being almost exclusively focused on income-related disparities and overlooking significant sociodemographic variables such as gender, age and ethnicity. Instead, a focus on assessing accessibility to relevant opportunities is visible, in line with the idea that accessibility should be the

main aim of transport planning (Martens, 2017). This suggests drafting accessibility evaluations that assume the multiplicity of individuals, considering those variables that determine different kinds of inequality as well as the different opportunities that each persona may value;

3. A deeper engagement with different ethical or political philosophy theories (such as egalitarianism, capability approach, and even the utilitarianism at the core of traditional transport planning) and their operational reflections is required. Such principles determine different understandings of what accessibility is for and how it should be distributed among a population. This concern would refer to the ethical goals (for example, equality, justice or equity) and to the features taken into account (for example, one's mobility needs or capabilities);

4. Regarding the latter insight, the different ethical or political philosophy theories should inform consistent evaluative approaches, being aware that different principles would necessarily generate different distributive outcomes (Martens & Golub, 2012). The growing engagement of transport research with different ethical theories requires thus to be developed further, as to generate practical evaluative approaches that are better able to tackle social inequalities by defining what kind of transport systems we intend to create for what societies.

3.5. Accessibility measures and its components: The need for more comprehensive analyses

3.5.1 Access by what: The transport component

Very few studies examine accessibility using infrastructure- (Chias Becerril et al., 2001; García et al., 2019), utilitarian- (Niehaus et al., 2016) or person-based (Aliaga et al., 2015) approaches. The two former approaches received several critics in the literature. For example, the infrastructure-based analysis focuses on the quality of the transport network but does not consider the land use component nor the experienced accessibility levels (Benenson et al., 2011). Similarly, utilitarian-based approaches are not widely used in the literature (see Holanda de Souza & Loureiro, 2018 for an example), given that their interpretation and communication is difficult, the expected utility used in the logsum measure is different from the one experienced, and the use of logsum refers to changes in accessibility (Geurs et al., 2013).

The dominant approaches to accessibility are thus still the traditional and, in several cases, the simplest ones. Following a worldwide trend, the reviewed works show a high preference for location-based measures (Hansen, 1959; Koenig, 1980), mainly focusing on cumulative opportunities within a certain time threshold (Moreno-Monroy et al., 2018; Pereira, 2018; 2019) or using an impedance function to weight differently the opportunities depending on the time needed to reach them (Bocarejo et al., 2016; Hernandez, 2018). This choice has advantages but also some drawbacks. The use of simple measures could be a good approach to engage decision-makers and practitioners since the measures are easy to understand, interpret and communicate (Geurs & van Wee, 2004). Moreover, for cities without a proper availability of high-quality data, this approach might be the most appropriate, in order to generate a body of work from which researchers and policy-makers can build on.

However, most of the reviewed measures present some biases, especially in terms of people demanding opportunities in cities. Some studies made an attempt using accessibility per capita for each zone, to normalize values considering people of interest in each zone (see for example Bocarejo & Oviedo, 2012 and Guzman et al., 2017). Few works (Terán-Hernández, 2016; Moreno-Monroy et al., 2018) consider competitive accessibility measures proposed by Shen (1998), focusing mostly on the supply side of the analysis. This could lead to misleading conclusions, especially for services that are highly competitive and not well distributed across space, as workspaces, healthcare services and educational opportunities. The results obtained could be highly different and therefore, the policy implications may differ drastically.

As Páez et al. (2012) state, there are two main approaches for accessibility: normative and positive. Normative measures of accessibility consider "how far it is reasonable for people to travel whereas positive accessibility measures are defined in terms of how far people actually travel" (Páez et al., 2012, p. 142). Normative measures of accessibility prevail in the reviewed papers, considering potential opportunities and measuring desired or assumed opportunity to travel to a certain activity. The revealed travel behaviour and people's preferences that in fact could show the actual participation in activities ('proof of access'; Morris et al., 1979) is not the focus of most studies analysed in this chapter. Nonetheless, there are some exceptions like Guzmán et al. (2017) or Lessa et al. (2019), who analysed both accessibility and effective mobility. Moreover, one work proposes a methodology to incorporate perception of different attributes of the public transport system in the accessibility metrics (Tiznado-Aitken et al., 2016). There is a growing body of literature on this topic (Cascetta et al., 2013; Lättman et al., 2016a; 2016b) highlighting the perceived accessibility levels and how different are from traditional objectives measures, pointing out the importance to close the gap between approaches.

Since the main motivation declared by most of the reviewed studies is the pursuit of a more equitable city, public transport prevails in the accessibility evaluations. The emphasis on public transport can be explained since it is the most affordable motorized transport mode and most low-income subjects rely on this mean to be mobile every day. Other forms of collective transport such as taxis and collective taxis instead are not considered and, despite being easily available also for low-income groups (Jirón, 2011), in general, not much research is devoted to them (see for example Domarchi et al., 2019).

As for public transport, most works consider the accessibility to opportunities it provides, while others consider the accessibility to the public transport network itself. In the first case, public transport is considered not only for the possibility it provides to reach different areas of a city (Bocarejo et al., 2014; Figueroa Martinez et al., 2018; Hernandez, 2018), but other constitutive features such as fares are included in evaluations that assess the affordability of such systems for low-income groups (see for example Gomez-Lobo, 2011; Guzman & Oviedo, 2018; Lecompte & Bocarejo, 2017).

In the second case, some studies analyse the accessibility to transit stops by walking (see for example Delmelle & Casas, 2012; Da Silva et al. 2015; Oviedo, Scholl et al., 2019; Hernández, 2017), even considering the quality of the surrounding urban environment (Tiznado-Aitken et al., 2018). Given that from a justice perspective transport is relevant for the access it provides to opportunities (see for example Martens, 2017), the accessibility of a transport system should not be the object of a self-standing evaluation. Rather, it may complement evaluations of the accessibility provided by public transport, estimating to what extent the urban environment features enhance or impede the possibility to use the public transport system.

Regarding active modes, they are present in very few studies. Guimpert & Hurtubia (2018), Reyes Päcke & Figueroa Aldunce (2010), and Rojas et al (2016) analyse access to urban green areas by walking in Chilean cities. Likewise, Steiniger et al. (2017) study walkability scores considering key destinations and different user profiles. Some recent studies were found on the bicycle use, such as Tucker & Manaugh (2018)'s work on the use of bicycle to access commercial areas in Brazilian cities or Pritchard et al. (2019a) considering bike as access mode for transit trips. Given the high modal split of active modes in Latin American cities and especially among low-income people and women, quantifying the accessibility levels and identifying paths to improve their conditions should be key for an environmental and socially sustainable transport planning in developing countries.

Despite the growing role of the car and the disproportionate priority that transport planning has given it also in Latin American cities (see Beckmann, 2001 and Sheller & Urry, 2000 for a more comprehensive context on automobility), the accessibility analysis in the region did not focus on this mode. Only few studies show a proper car-based accessibility evaluation, comparing car and public transport (Quirós & Mehndiratta, 2015; Guzmán et al. 2017; Niehaus et al., 2016; Pritchard et al., 2019b) or computing travel times for cars (Cox and Hurtubia, 2016). Other qualitative works focused on mobility practices, to discuss more in deep the role of car for granting everyday accessibility (see for example Apaloaza et al., 2016; Cáceres Seguel, 2015).

The scarcity of car-based evaluations can be explained with at least three reasons. First, the interest in equity leads to consider mostly public transport services that, differently from cars, are accessible to low-income groups. Second, cars are still less relevant than other transport modes, covering the 22% of urban trips in the region (CAF, 2017, p. 126). Third, the focus on urban settings does not consider periurban and rural areas, where the scarce provision of public transport raises issues of forced car ownership for accessing opportunities (Mattioli, 2017). Similarly, no specific work on motorcycles has been found, despite the relevance of this mode in the Latin American setting (Hagen et al., 2016). Comparisons between motorized modes could be interesting in the region, allowing to quantify the gaps between modes and the population groups that each one serves. Moreover, mixing accessibility and affordability evaluations for car dependant low-income populations could lead to progressive policies towards a better public transport system.

Likewise, more recent and emergent services such as vehicle sharing and ridesharing are almost absent from the analysis too. These kinds of systems are relatively new in the region, as the limited available research demonstrates (for the case of Santiago, see Tirachini & del Río, 2019). The only example in our review was Duran et al. (2018), that provide an analysis of the unequal social and spatial distribution of bike-sharing facilities among five cities in Brazil. Finally, intermodal approaches are neither the focus of accessibility-based evaluations unless walking to access public transport. In cities with high motorization rates, park-and-ride systems should be evaluated and considered, taking advantage of big investments in public transport across the region, as well as bicycle integration with public transport (see for example Pritchard et al., 2019), providing a feasible option for people experiencing high travel times and inadequate level of service.

3.5.2 Access to what: The land use component

In terms of the land use component and what opportunities are usually considered, the reviewed works analyse mainly accessibility to workplaces and schools. For example, apart from Delmelle & Casas (2012) and Jaramillo et al. (2012), all the works devoted to Colombia consider only these opportunities. Work and study are mandatory activities and transport planners in developing countries usually focus on them, leaving aside non-mandatory trips for different travel purposes like accessibility to leisure or recreation, shopping/commerce, healthcare or green areas, or even trips for caring a person’s beloved ones. The latter purposes are key to analyse the participation of socio-demographic groups that are commonly overlooked or excluded from traditional analysis, and therefore essential to improve equity in cities.

Moreover, most evaluations tend to consider the simple amount of available opportunities, without any reference to the quality or standard of those opportunities. A few works take into consideration the different quality of the available opportunities, referring for example to jobs (Bosjoly et al., 2017), schools (Moreno-Monroy et al., 2018), and health services (Terán-Hernández, 2017; Pereira, 2018; De Pietri et al., 2013; Bascuñán & Rojas, 2016), trying also to assess what jobs are available for what individuals depending on the entry requirements of a job and the education level of a person (Pereira, 2019; Oviedo, Guzman et al., 2019). Some works instead consider desirable characteristics of opportunities, for example declaring what the surface of green areas should be (Reyes & Figueroa, 2010). Further research lines could derive from these studies, thinking for example of matching health care facilities and individual insurances granting access to them, even if this would require complex analyses.

3.5.3 Access for whom: The individual component

As stated before, person-based measures are not the focus of the studies in the region. The individual features considered into the analysis are mainly their socioeconomic characteristics. This is consistent with the equity approach taken in several works, that try to quantify the gaps between socioeconomic groups and how poor-served are the low-income populations compared to more wealthy groups (see for example Guzman & Oviedo, 2018; Hernandez, 2018; Pucci et al., 2019). Moreover, there is usually a focus on a 'generic' or 'average' user, not much characterized (or assumed to be male and fully able to move autonomously). Issues of age and gender are rarely considered, despite their relevance: a large body of literature demonstrates that elderlies and women experience different accessibility barriers and give more importance to certain attributes of the travel experience (see for example Musselwhite & Haddad, 2010; Nordbakke, 2013). Therefore, while current accessibility evaluations provide a useful starting point for considering how equitable a transport system is, it would be relevant to aim at better characterising individuals. However, the limited presence of people-based measures and the prevalence of place-based evaluations are issues that characterise also the research devoted to European or North American settings.

While the person on the move is not much characterised, also the interdependency that characterise mobility is not considered. The relational dimension of mobility, which is especially relevant for care-related travels that are predominantly performed by women (see for example Sagaris & Tiznado-Aitken, 2018), is almost completely absent. For example, the trip chaining of a parent who brings a child to school before going to work or the relation between trips among household members are not addressed in the accessibility analyses. Different methods should be adopted to properly describe this situation, moving towards more household-based accessibility metrics that could be informed by travel diaries and activity-based models.

3.5.4 Access when: The temporal component

The temporal dimension is almost totally absent and regularly is not even mentioned in the methodology. In the reviewed articles, two temporal elements can be found: on the one hand, features that explicitly determine accessibility levels, such as the examined moment of the day, the opening hours of activities and the assumed travel time thresholds; on the other hand, a framework that provides a clear temporal horizon for the proposed evaluations, considering for example its variations over long timespans.

As for the features that shape accessibility evaluations, most works focus on mandatory activities and therefore examine peak hours, when most of work- and study- related trips are performed (see for example Moreno-Monroy et al., 2018). Most works tend to describe the available accessibility considering standard travel time thresholds, such as 30 minutes and 60 minutes (see for example Vecchio, 2019, ch. 2), without discussing them in depth (Pereira, 2019 is an exception in this sense). These temporal features of accessibility evaluations require further attention, though. First, it would be relevant to consider also off-peak hours, when other, non-mandatory activities are performed. Second, accessibility measures should consider the temporal variability of accessibility, going beyond GTFS data or average observed travel times, and considering also reliability metrics like percentiles, coefficient of variation, standard deviation, among others. Finally, variations in the opening hours of certain activities should be considered, too. For example, elements such as night shifts, or the eventual mismatch between working hours and the opening hours of some facilities are not addressed in the examined works.

Temporal changes of accessibility are used sometimes for evaluating the impact of specific policies or projects. For example, Niehaus et al. (2016) use the peak morning period to compare and evaluate the effect of two Metro line extensions in Santiago between 2005 and 2010, while Bocarejo et al. (2014) and Oviedo, Scholl et al. (2019) assess the impact on job accessibility provided by Medellin’s cableways and Lima’s BRT. Others consider the long-term evolution of accessibility, examining large time-spans: Marr & Sutton (2007) analyse the changes in accessibility in the Meseta Purépecha between 1940 and 2000 in México, while Contreras, Navarrete & Arias (2016) analyse travel time, accessibility and attractivity changes using two OD data sets from 2001 and 2012. This approach probably deserves more attention, since it goes beyond the simple description of a certain setting and can highlight to what extent a certain policy or project was able to generate accessibility gains.

Finally, some studies show temporal components for both metrics and for comparison. For example, Pereira (2018) analyses departures every 20 minutes from 7 am to 7 pm, accounting for different time periods, and compare the BRT system between April 2014 and March 2017 in Rio de Janeiro. This approach could be useful since gives a broader understanding of the time dimension, usually overlooked in accessibility assessments in the region.

3.5.5 Limitations and ways forward

Considering the main components of the accessibility measurement, four main paths emerge as crucial when considering transport and equity in Latin America:

1. Regarding the transport component, it would be important to go beyond the current focus on public transport and consider active modes, comparing them with motorized ones. Similarly, more attention should be deserved to the spreading forms of 'smart' mobility and their eventual impact - positive or negative - on a fair mobility (see for example Hamidi, Camporeale & Caggiani, 2019). These advancements could be relevant to quantify accessibility gaps and propose long-term policies for benefitting

disadvantaged populations and addressing key sustainability issues. Moreover, the competitive accessibility measures, as the analysis proposed by Moreno-Monroy et al., 2018,could allow a more comprehensive and realistic analysis that contrasts the distribution of the opportunities and the demand for them within the city;

2. Incorporating non-mandatory activities could be relevant for accessibility analysis, going beyond the current focus on basic opportunities such as jobs and schools (see Rojas et al., 2016 for an application on green areas)Similarly, an effort to estimate the quality of opportunities and their eventual matches with different groups of a population would be crucial for a more realistic description of the currently available accessibility. This would be relevant also for developing policy proposals that can better tackle the current forms of social exclusion;

3. Accessibility assessment may incorporate person-centered evaluations, overcoming the limitations of analyses based exclusively on the location (Fransen & Farber, 2019). The target population for the measurement of accessibility should not only be low-income people, but also other disadvantaged populations that experience different barriers in their daily mobility, given their gender, age, ethnicity and relational networks (on this last point, see Carrasco & Lucas, 2019);

4. Despite the relevance of peak hours in mandatory activities, the accessibility analysis should deepen the study of off-peak periods. The measurement of accessibility differences between periods (see Fransen et al., 2015), as well as the reliability of the

transport modes analysed (as Stewart, 2018 did for public transport), would allow a better characterization of the level of access of the population.

3.6 Planning and policy implications: Scattered suggestions for still unequal cities

3.6.1 A critical view on "pro-poor" transport strategies

The works dealing with transport and equity in Latin America consider settings that are characterised by relevant socioeconomic inequalities, for which devoted transport measures can provide relevant (although partial) solutions. Most works provide overall comments on the investigated settings and in some cases offer operational suggestions for addressing urban mobility issues. In general, the view on Latin American cities is linked to persisting inequalities due to structural imbalances caused by the uneven distribution of inhabitants, urban opportunities, and transport systems. Exceptions are places traditionally foreign to inequalities, like Montevideo (Hernandez, 2018, p. 201).

In such unequal setting, the reduction of socio-spatial imbalances has often been the main argument used by policymakers for promoting the implementation of mobility projects or strategies, even if the achieved results are somehow ambiguous. In fact, the creation of new, pervasive public transport systems was a partially effective strategy, as a varied set of reference experiences demonstrates. For example, successful projects developed transport interventions that provided accessibility gains and, more importantly, fostered wider urban regeneration, as in the case of Medellin's cableways (Bocarejo et al., 2014). Less clear are the results of similar interventions in other settings, such as La Paz (Aliaga et al., 2012).

Likewise, BRT systems show contradictory results, despite celebrated public transport strategy such as Bogotá's Transmilenio. For example, the Transmilenio enhanced accessibility in the areas it serves, but also originated new forms of social fragmentation (Bocarejo et al., 2016). Moreover, the complementary bus network introduced to enhance the system coverage actually brought accessibility losses (Guzman et al., 2018), so that mainly middle class citizens benefited from it (Vecchio, 2017). In other cases, cities that went after Bogotà's BRT-based strategy only partially improved accessibility, as in Cali (Cahill Delmelle & Casas, 2012), or even more contradictorily, the BRT did not benefit the poorest citizens of Lima (Oviedo, Scholl et al., 2019).

Similarly, projects promoted to enhance the transport opportunities available to low-income people did not bring the expected results. This is the case for Rio de Janeiro's public transport projects associated with the city's Olympic bid file, which promised - and did not deliver - accessibility improvements thanks to new infrastructure and bus routes rearrangements (Pereira, 2018). Finally, partial have been also the attempts to promote more sustainable modes. Cities like Bogotá have promoted cycling (Teunissen et al., 2015), while other cities - for example in Brazil - did not provide significant cycling investments (Rodrigues da Silva et al., 2015).

3.6.2 Suggestions for planning, policy and practice

To the partial effectiveness of the Latin American socially-oriented mobility strategies, the reviewed works respond with scattered operational suggestions. In most cases, generic exhortations are made, such as promoting better land use - transport coordination or bringing public transport to the areas more in need. For example, Hernandez (2017) provides a synthetic agenda for transport policy in Latin America, based on basic coverage, affordability and quality of public transport. More precise are the suggestions for the practice of transport planning, asking for refined evaluative tools - for example, more sensitive to different travel time thresholds (Pereira, 2019) – and for a better assessment of costs and benefits of infrastructure projects (Bocarejo et al., 2014), involving also multicriteria analysis (Niehaus et al., 2016). Only in some cases, there is a stronger engagement with setting-specific policy measures, with recommendations referred for example to public transport fares (as in Bogotá, where some suggestions were even adopted by the municipal institutions; see Bocarejo & Oviedo, 2012; Bocarejo, Portilla, et al., 2016; Guzman & Oviedo, 2018) and traffic pricing (Guzman et al., 2017). Another example is the recognition of priority areas for intervention enhancing accessibility to basic opportunities such as jobs (Pucci et al., 2019).

These suggestions do not refer exclusively to transport but involve other policy fields, such as safety (Tucker & Manaugh, 2018), green areas (Reyes Päcke & Figueroa Aldunce, 2010; Rojas et al., 2016) and health provision (Terán-Hernández, 2017). Another significant element is the call for institutional arrangements dealing with transport and planning issues at the metropolitan rather than at the urban scale, as a way to address more effectively the transcalar needs of mobility (Guzman et al., 2017). Thus, the emerging picture is that the current research does not yet consider fully the operational implications of socially-oriented transport strategies: accessibility-based works recognise the relevance of a focus on the worst-off groups of a population and sometimes provide operational, context-specific suggestions for enhancing more equal access, but often refrain from a more direct engagement with planning and policy practice.

3.6.3 Limitations and ways forward

Research on transport and equity in Latin America may have a wider practical impact by considering both the current transport planning practices and the complex urban dynamics that generate uneven mobilities. First, the gap between the work of scholars and practitioners deserves more attention, considering how to generate equity-sensitive accessibility evaluations useful for technicians and decision makers. The work of intergovernmental organizations (such as the United Nations) and international financial institutions (such as the World Bank and the Development Bank of Latin America) deals with mobility issues but shows significant limitations when considering the social implications of mobility, not considering this aspect or developing ineffective analytical tools. For example, in some cases the focus is exclusively on transport infrastructure, their management and economic sustainability, neglecting their contribution to enhanced accessibility (as reports devoted to Latin American BRT systems demonstrate, see for example Hidalgo et al., 2010). In other cases, ineffective analytical tools are developed, focusing on transport supply and therefore considering the access to the simple transport infrastructure rather than the accessibility transport can provide to activity locations (as for the UN's Sustainable Development Goal indicator referred to urban access, see Brussel et al., 2019). In this sense, would be useful a recognition of the extent to which accessibility indicators are part of the transport planning practice (a European example is provided by Papa et al., 2015). Moreover, the usability of socially-sensitive accessibility measures would improve considering also its possible interaction with established analytical frameworks, such as the 4-step model (Martínez, 1995), the growing data science-driven tools and the traditional methodologies for cost-benefit analysis (Niehaus et al., 2016).

Second, the technical suggestions provided by the reviewed accessibility-based works need to consider the wider context that shape transport systems. This implies a stronger engagement with the complexity of transport and spatial issues. The provision of infrastructures and services is highly determined by policy and political mechanisms that raise issues of governance, rarely considered in transport research (Marsden & Reardon, 2017). Also, the contribution of transport to the reduction of socioeconomic imbalances is a relevant but partial one, due to consolidated inequalities and forms of 'spatial mismatch' that require long-term planning strategies, for example, relocating opportunities (Bocarejo & Oviedo, 2012; Delmelle & Casas, 2012; Moreno-Monroy et al., 2018). Transport may also have a negative effect, reinforcing existing segregation dynamics (as in Santiago, see Figueroa Martínez et al., 2018) or may even produce the expulsion of low-income residents when the land use value increases due to the introduction of new transport systems (as in Bogotá, see Rodriguez & Targa, 2004). Such imbalances question directly the role of the State as a key actor that can regulate transport systems (Hernandez, 2018; Kralich, 2002). Nonetheless, it may be also possible to reverse the unequal condition of a place, especially when unprecedented occasions for rethinking the future of a territory emerge (as in the case of mega events, whose relevance was demonstrated in Rio de Janeiro; see Pereira, 2018; 2019).

3.7 Conclusions

Latin America is one of the most interesting settings to consider issues of transport and equity, thanks to relevant research and practice approaches that nonetheless still show space for significant improvements. Latin American cities and countries emerge as highly unequal ones, and mobility is at the same time a cause and an effect of such structural imbalances. Regardless of their different analytical approaches, most of the reviewed works highlight a significant gap in the accessibility that different socioeconomic groups have to daily activities and assess the relevant but still insufficient contribution that new public transport projects have provided to reduce such gap. Thanks to advanced researches and real-world experimentations promoting public transport under the banner of social inclusion, Latin America appears as a suitable reference for other settings – developed and not – dealing with issues of transport and equity (as already happened for example with Bogotá's Transmilenio; see Wood, 2015).

The reviewed analyses show a growing but still limited body of work devoted to transport and equity in Latin America, suggesting academic, technical and operational avenues to enhance it:

- from an *academic* perspective, it would be relevant to expand the scope and the reach of accessibility-based analyses. First, their geographic scope is still limited to the main countries and metropolises of the area, while issues of transport and equity are significant also for small States and rural areas. Second, a clearer theoretical stance should define what concepts are assumed as reference – be them inequality or exclusion, equity or justice – and what these mean in operational terms. Third, a higher sensitivity to age, gender and ethnicity-based differences should complement the current prevailing attention to economic inequalities between population groups. It is relevant to clarify that the two latter limitations are widely shared with accessibility-based analyses devoted to European and North American settings;

- from a *technical* perspective, more elaborated analyses are feasible and may usefully be implemented in certain Latin American settings. In particular, the complexity and multiplicity of individuals' options, preferences, resources, needs and habits deserve more attention, differentiating relevant opportunities and available modal choices according to the different population groups taken into account. However, this refinement of accessibility-based analyses is possible only when relevant data is attainable and consolidated, as well as technical skills are available to carry out such analyses. Therefore, a twofold approach such as the one proposed in section 3.3 – fostering the adoption of easy accessibility tools and refining them where possible – may provide a suitable course of action;

- from an *operational and policy* perspective, the main priority is to assure that research on transport and equity becomes a relevant input for transport planning. In this sense, the results of the reviewed works should be easily communicable and implementable, for both practitioners and decision makers. For example, it would be crucial to develop simple tools for accessibility evaluations, that can be easily used to assess current transport systems and develop new ones especially there where the resources available for planning are scarcer. Also, crucial would be the complement and interaction with established transport planning approaches, like the 4-step model. Equally significant would be the development of more precise guidelines for policy, addressing specific features of transport systems, going beyond the current exclusive focus on public transport and considering also active modes.

Despite the discussed limitations of the reviewed body of research, Latin America provides consistent research and complex examples of practice on this topic, offering relevant real-world evidence and making once more the case for assuming accessibility as the main aim of transport planning. To enhance its contribution, key is the possibility for scholars to interact with practitioners and actively contribute to transport planning and policy. Further research along the mentioned axes may enhance further the contribution that work on transport and equity can provide to both understand and plan transport systems that contribute to a better human and urban development.

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4. URBAN EQUITY AND FAIRNESS MEASURED THROUGH PUBLIC TRANSPORT ACCESSIBILITY AND THE QUALITY OF WALKING ENVIRONMENT: THE CASE OF SANTIAGO DE CHILE

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4.1 Introduction

Urban transport planning has traditionally focused on improving the performance of its system. The main goal has been increasing the efficiency (high speed and capacity) and targeting congestion, mostly leaving aside equity considerations. This has created a privileged scenario for those who have transport alternatives such as the car because, at least in the Chilean scenario, most new infrastructure projects are car-oriented. This has generated a significant deterioration for those who are excluded from its use and usually reach their daily activities in other transport modes (Martens, 2017).

Poor accessibility to transport has relevant social consequences, since it reduces opportunities for work, study, recreation, health and social interaction, which impact on the people's social and economic development and may cause social exclusion (Sanchez et al., 2003; Lucas, 2006). Given this context, multimodal transport planning based on accessibility aiming at how easily can people reach opportunities and basic services, becomes a key element.

To promote this alternative transport planning paradigm, public transport plays a key role. From a fairness perspective, the most vulnerable groups are often those lacking a car and forced to use both active and public transport. From a sustainability perspective, it provides alternatives to car use which has grown significantly in Latin America in the last decade. In the case of Santiago de Chile between 2001 and 2012 the use of the car increased in 5.1% while the number of trips walking and by public transport decreased in 10.1% (SECTRA, 2015). It can be argued that despite the purpose declared by authorities of fostering sustainable transport modes and hindering car use, the current planning model is not achieving its goals and therefore should be questioned.

Most studies approaches to public transport accessibility focus on proximity to stops in terms of walking distance or time to reach them (e.g. Zhao et al., 2003; Olszewski & Wibowo, 2005). However, other important types of accessibility barriers have received less attention, such as the quality of the walking environment. Urban attributes as the quality of stops, sidewalks and roads and the safety level perceived by users affect public transport accessibility. By incorporating these attributes into accessibility analysis we would give importance to elements that directly affect pedestrians and bicycle users experience, commonly ignored by traditional transportation planning (Koglin & Rye, 2014).

Therefore, the aim of this research is to analyze both accessibility to public transport stops and the quality of the urban walking environment under a common framework, exploring fairness issues through a sufficientarian and egalitarian approaches (see Pereira et al., 2017 for a review). By applying this methodology to the case of Santiago de Chile, we determine which areas should be prioritized in terms of public policies to improve the accessibility experience to public transport and promote modal shift.

The chapter is structured as follows: Section 4.2 presents a brief literature review of accessibility, built environment and walkability literature, highlighting the research gap this work fills. Section 4.3 presents the methodological approach to measure and analyze accessibility to public transport stops and quality of the urban walking environment while in Section 4.4 we apply the methodology to the city of Santiago, Chile. Finally, Section 4.5 presents the main results of this research and a brief discussion. The chapter closes with policy recommendations for Santiago authorities and future work in Section 4.6.

4.2 Quality of walking spaces and access to public transport

Accessibility has been the focus of extensive research over the years. The concept has been defined and addressed in several disciplines, like transportation, geography, sociology and economics, among others (Dalvi & Martin, 1976; Ben-Akiva & Lerman, 1979; Cass et al., 2005; Geurs & van Wee, 2004). In this work, we adopt a traditional definition from the transport field: the ability of reaching different activities or opportunities through the transport system from each particular location (Dalvi & Martin, 1976).

Murray and Wu point out that accessibility through public transport has two main factors: access to public transport stations or stops given an influence area (by walking, bicycle or car) and the geographic coverage of public transport given a certain time budget (Murray & Wu, 2003). However, this approach is limited since it does not account for the level of service in the analysis. In the case of the first factor, the quality of the walking environment is key while, in the second case, attributes like waiting time, comfort, transfers and reliability should be considered.

In this work, we tackle the first gap related to the quality of the walking environment. Most of the studies in public transport accessibility focus on proximity to public transport stops analyzing walking distances to reach them (Lei & Church, 2010; Mamun et al., 2013). Nevertheless, considering only proximity is quite limited approach. Taylor & Fink classify the factors that could improve the public transport experience and promote ridership into internal, such as fare or level of service, and external, such as convenient and safe access to public transport stops (Taylor & Fink, 2003).

There is extensive research about walkability and the influence of the built environment into modal choice. The literature reports the influence of several built environment elements such as density, diversity, design, accessibility to destinations and distance to public transport in this choice (Cervero & Kockelman, 1997; Ewing & Cervero, 2001). For example, the absence of a pedestrian-friendly environment (connected walking paths, fewer car lanes, and wide sidewalks, among others) and lack of mixed land use influences people to drive instead of walking and using public transport (Tilahun & Li, 2015).

Regarding the walkability, the literature analyzes the characteristics of the physical environment contributing to a neighborhood being walkable. Some of the most important factors influencing walkability according to these studies are sidewalk capacity, quality of the environment, perceptions of safety and comfort (Landis et al., 2001), the attractiveness of pedestrian network (Khisty, 1994; Krambeck & Shah, 2005), mixed land use, urban design and facilities to connect destinations (Humpel et al., 2002).

Tilahun et al. found that a safe walking environment has a positive impact in ridership and is decisive in how travelers solve their "last mile" problem (Tilahun et al., 2016). For example, Tilahun & Li conducted a survey in Chicago where they found that access time, safety, and footpath availability were important factors in deciding to reach public transport by foot. They also found that crime perception associated to access a stop or station increases the perceived disutility in a magnitude equivalent to 6 minutes in access time, while the absence of paths in the equivalent of 5.9 minutes (Tilahun & Li, 2015). Additionally, pedestrians not always choose the shortest routes, but instead one that delivers a good level of service in terms of infrastructure (Muraleetharan & Hagiwara, 2002).

Therefore, this chapter jointly analyzes the access to public transport stops and the quality of their walking environment, setting priorities in terms of public policies after a fairness analysis that will be detailed in the methodology section.

4.3 Methodology

The methodology considers the definition of two indicators: walking accessibility to public transport stops, called here as physical accessibility, and quality of the walking environment, considering different attributes and dimensions. These indicators are later used to develop a fairness analysis at the local and metropolitan level, using Lorenz curves, Gini coefficient and Foster-Greer-Thorbecke (FGT) poverty measures. Below we describe in detail each of them.

4.3.1 Physical Accessibility

To measure accessibility to stops, we propose to use location-based measures, specifically potential (i.e. considering all possible destinations within a threshold or buffer). To determine how much a station contributes to the accessibility of the location, we use a decay function based on a resistance parameter (see Equation 4.1). We prefer this indicator over isochronous access measures that use arbitrary thresholds and equally counts the opportunities regardless of proximity. Also, location-based measures have advantages on operationalization, interpretability, and communicability, which are key to influence planning and public policies (Geurs & van Wee, 2004).

$$PA_i = \sum_{j \in \varphi_i} F\left(\frac{d_{ij}}{v}\right) \quad \forall\, i \in \omega \tag{4.1}$$

In Equation 4.1 i is the subindex for locations (origins) within the city ω, j corresponds to the subindex of all public transport stops that are within a threshold or buffer around location i (φ_i) and $F\left(\frac{d_{ij}}{v}\right)$ corresponds to impedance function, which depends on the distance (d_{ij}) and walking speed (v). The indicator is later normalized by dividing it by the maximum value of PA_i across all zones in the city, so all PA_i keep a value between 0 and 1. The results obtained will depend on the impedance function chosen, the use of Euclidean or network distance, and the value of the walking speed. This will be discussed later in the case study Section.

4.3.2 Urban walking environment

Like any transport mode, walking provides a certain 'level of service' determined by its intrinsic characteristics and the environment in which it occurs. We propose to include the presence of urban furniture and the quality of the urban environment and road network (including the amenities while travelers wait at stops), into an indicator that would yield the experience faced from the moment a user starts walking from a home to a stop, until (s)he boards a vehicle.

Since the construction of this indicator strongly depends on data quality and availability, we propose an indicator that can be adapted to different contexts, following the basic structure shown in Equation 4.2.

$$U_i = \sum_{k \in \vartheta} P_{ki}(s) \quad \forall\, i \in \omega \tag{4.2}$$

In Equation 4.2, i is the location (origin) and k corresponds to different categories of the urban environment (safety, comfort, infrastructure, furniture, cleanliness, among others). Meanwhile, ϑ is the set of categories and $P_{ki}(s)$ is the quantifiable level of each category in each location i based on scale s (for example, binary to define the presence of some attribute or Likert to evaluate attribute quality).

4.3.3 Fairness analysis

Distributive fairness analysis is usually addressed through an egalitarian or a sufficientarian approach (Pereira et al., 2017). In simple words, the first approach addresses how evenly distributed is a certain attribute within population and the second one defines a minimum or sufficient standard for that attribute that must be achieved by all people.

In the first approach we propose the use of Gini coefficient (G), probably the most widely used measure of inequality. While the most common application for this indicator is income distribution, several works have been proposed in the literature using the Lorenz curves and Gini coefficient as a measure to analyze equity in the public transport supply or the accessibility provided by the system (e.g. Delbosc & Currie, 2011; Welch & Mishra, 2013; Guzman et al., 2017). We can calculate the Gini coefficient using Equation 4.3, where X_s represent the cumulative proportion of the households or population variable and Y_s typically represent the cumulative proportion of income variable, with $s = 0 \dots n$, $X_o = Y_o = 0$ and$X_n = Y_n = 1$.

$$G = 1 - \sum_{s=1}^{n} (X_s - X_{s-1})(Y_s + Y_{s-1}) \tag{4.3}$$

In the second approach, we propose to adapt a poverty indicator related to private income (y_p). In Equation 4.4 z is a consumption or income poverty threshold and q corresponds to all subgroups p that are below the minimum threshold ($y_p < z$) with n_p being the population of subgroup p. This formula, well-known as FGT measures, has different interpretations based on the poverty aversion parameter (α>=0, chosen by the analyst), since "a larger α gives greater emphasis to the poorest poor" (Foster, Greer & Thorbecke, 1984). This formulation have been used in several topics, including Accessibility Fairness Index (AFI) to analyze severity of the accessibility deficiency in a region (Martens, 2017).

$$FGT_\alpha = \frac{1}{N} \sum_{p=1}^{q} n_p \left(\frac{z - y_p}{z}\right)^\alpha \tag{4.4}$$

We propose to adapt both indicators to measure fairness by replacing income by accessibility levels and scores of urban walking environment. We describe this process in the next section.

4.4 Application to Santiago, Chile

Santiago, the capital of Chile and its largest Metropolitan region, has over 6.5 million inhabitants within an area of approximately 640 km^2. This city shows an important socio-spatial segregation. The high-income elite lives mainly in the northeastern area, which has grown much faster than the rest of the city in the last decades, attracting productive activities, commerce, and services (Suazo, 2017). This development has harmed the low-income population, especially those living in the periphery as a consequence of housing policies, because they see their distance to activity centers systematically increasing over the last few decades.

In 2007 a new city-wide public transport system, called Transantiago, was implemented. After a very rough start the system has improved, increasing the number of bus routes by 37%, the number of public transport stops by 20% and the length of Metro network by 22% between 2007 and 2015 (DTPM, 2016). However, Transantiago still does not work as expected. The aforementioned social segregation, and the lack of coordinated and integrated transport and land use planning produces high inequalities regarding access to transport (Shirahige & Correa, 2015).

We analyze here the 34 communes covered by Transantiago (Figure 4-1). Below we describe each indicator and data needed to carry out the previously proposed methodology.

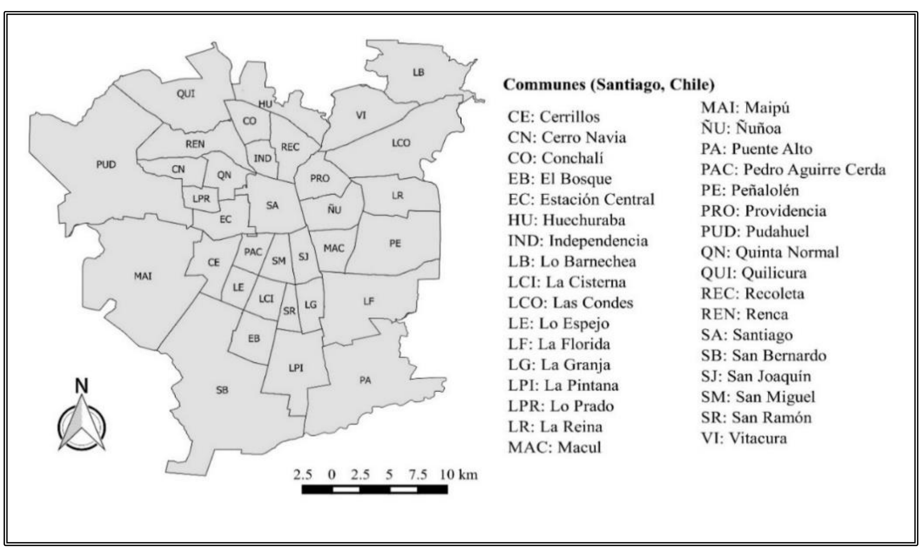

Figure 4-1 Communes of Santiago to be considered for analysis (Source: Own elaboration).

4.4.1 Physical Accessibility Indicator (PAI)

In this work, we approach accessibility through its positive instead of its normative aspects (Páez et al., 2012). This means that we focus our analysis on actual user travel experiences, not what is reasonable or desirable for people to experience. This means that the impedance functions $F(\,)$ are calibrated based on actual travel times.

To compute walking accessibility to public transport stops we use OpenTripPlanner (OTP), an open source platform for multi-modal journey planning (OpenTripPlanner, 2016). For the spatial analysis, we subdivide the territory using a grid, with cells of 200x200 meters (city blocks) as trip origins. We divided this cells further to make it compatible with the Transantiago Zoning, consisting of 804 zones defined by The Metropolitan Public Transportation Agency, which manages and regulates public transport in Santiago. If a cell shared 2 or more zones it was divided into smaller cells, resulting in a total of 35,784 cells.

We define the set φ_i of public transport stops accessible from origin *i* (the centroid of a cell), as those located within 1,000 meters (Euclidian distance) around it. This distance threshold was selected because 95% of bus users and 100% of Metro users in Santiago reports a walking distance below that value (BRT, 2013). In some locations, the number of stops satisfying this condition was large, thus we limited the calculation to the the 10 closest to each location i. While this may bias our indicator, all these locations have not accessibility problems, so it does not affects the analysis regarding the most vulnerable low-accessibility zones which is the focus of this work.

We obtained walking times from each location centroid to public transport stops based on network distance (d_{ij}) and the OTP average walking speed (v = 4.8 km/hr). Using the formulation shown in Equation 4.1, we calibrate the parameters through information from the origin destination survey in Santiago (SECTRA, 2015) as explained next.

Using the Mamun et al. method (2013), we observe that 95% of public transport users walk less than 15 minutes to their initial stop, so we define an access value of 0.05 for a 15-minute walk. Using the same procedure, we define an access value of 0.2 and 0.7 for 10-minute and 5-minute walk respectively, allowing us to calibrate the functions. Finally, Figure 2 shows a comparison between the Richards (1959) and Negative Exponential impedance functions. Despite the second one being one of the most used accessibility formulations, we use Richards's function following Martínez & Viegas who argue that it represents better people's perceptions by softening accessibility decay for low travel times, unlike the Exponential function (Martinez & Viegas, 2013).

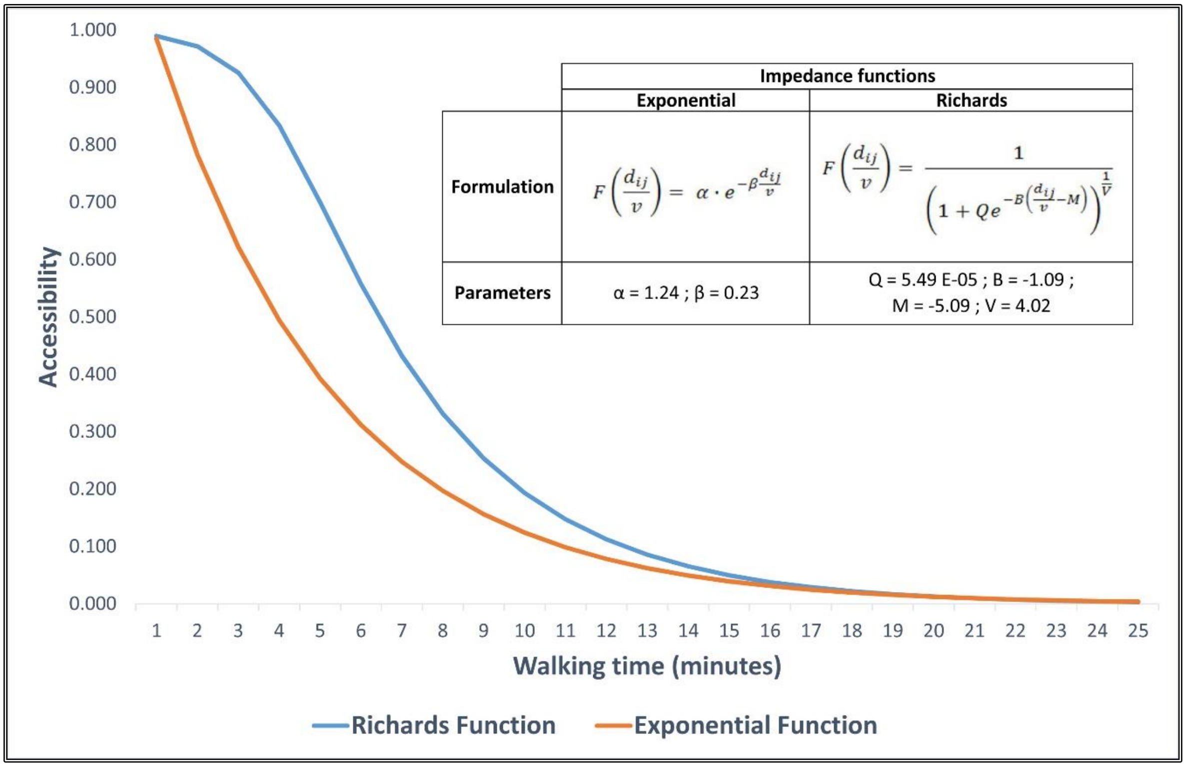

Figure 4-2 Differences between Richards and Negative Exponential impedance functions for Physical Accessibility in Santiago (Source: Own elaboration).

4.4.2 Urban walking environment

In 2011, for a pre-census activity groups of trained surveyors evaluated each city block in Santiago in terms of urban quality, considering the quality, presence, and condition of urban furniture and road network. The aspects evaluated are mostly binary (1 meaning the presence of the element and 0 meaning lack of the element), while sidewalk and street quality are rated with a scale of 0 to 5, with 0 meaning very poor conditions and 5 meaning excellent conditions.

We used this georeferenced information (INE, 2011) to obtain a proxy measure of the 'walking level of service'. Grouping elements according to their similarity, four indexes were created (Table 4-1). Together, these elements form the Environment and Urban Quality Index (EUQI) with values ranging between 0 and 19.

Table 4-1 EUQI components and values (Source: Own elaboration, based on INE (2011))

Index	Components	Range of values
Security/Safety	Luminary, road signs and roofed bus stops	0 to 3
Environment	Gardens, seats, sport fields and playground	0 to 4
Cleanness	Garbage bins and rubble	0 to 2
Infrastructure	Sidewalks and streets quality	0 to 10

4.4.3 Fairness analysis

For the egalitarian approach, we calculate the Lorenz curves and Gini indexes replacing income by PAI and EUQI. In both cases we use the most disaggregated analysis unit: 35,784 zones in the first one and 154,488 zones in the second one.

For the sufficiency approach, we use the framework proposed by Martens (2017) to calculate Accessibility Fairness Index (AFI) and Environment Fairness Index (EFI). We adapt Equation 4.4 using a_p as the PAI/EUQI of that commune, q as the number of groups with

PAI / EUQI below the PAI/EUQI minimum threshold ($a_p < z$) and n_p represents the total population of the *p-th* commune for 2016 (INE, 2016).

We decide to use α = 2 to reflect both poverty and inequality in terms of accessibility to public transport stops and the quality of walking environment. Finally, to determine z we use two different percentiles of the distribution of a_p across all communes: 10^{th} and 20^{th}.

4.5 Results

In general terms, Santiago has good accessibility to public transport stops, with 0.67 out of 1 as the average value. These areas are mostly located in central and pericentral zones (Figure 3a). About 11,000 public transport stops contribute to an extensive network that has achieved wide coverage and has grown significantly in recent years. This is consistent with the proximity perception to public transport that more than 85% of the people of the 34 communes analyzed have (MINVU, 2010).

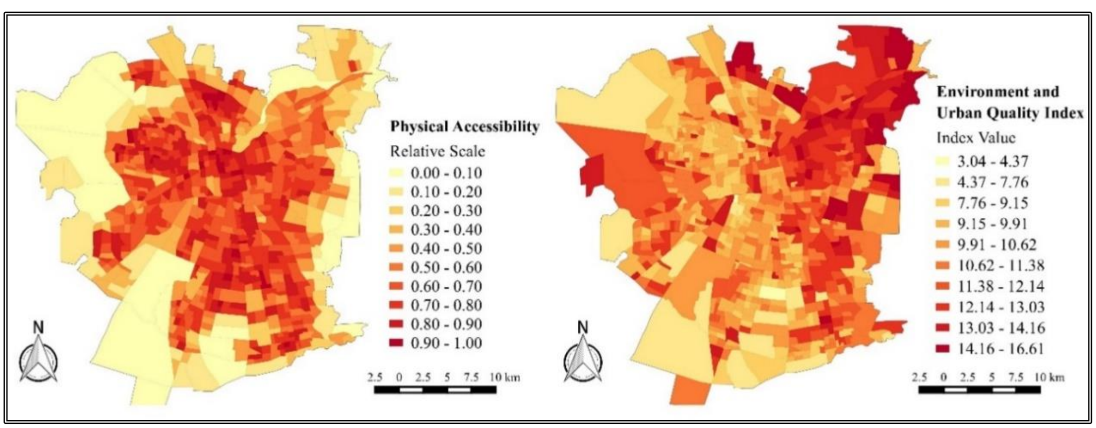

Figure 4-3 Physical Accessibility (4-3a, left side) and Environment and Urban Quality Index (EUQI) (4-3b, right side) for Santiago (Source: Own elaboration).

However, as we expected, the periphery has lower accessibility levels comparing to central and greater productive areas of the city (Figure 4-3a). In northwest and southwest sectors of Santiago, there is little accessibility to public transport. Communes such as Pudahuel and Lo Barnechea have areas with significantly lower access than more central communes such as Santiago and Lo Prado. To translate this in practical terms, while the areas with greater accessibility have 10 public transport stops reachable in 4 minutes on average, others less-benefited areas can access fewer stops in more than 20 minutes on average.

Thus, it is recommended that the implementation of new stops should be focused on deprived zones whose urban growth precedes the presence of public transport. In some cases, these zones also match with lower income communes like San Bernardo, Pudahuel or La Pintana. These zones show a very high public transport modal share, so improving proximity is a key factor. Additionally, richer communes like Vitacura or Lo Barnechea have the highest modal split of car use. If authorities want to promote more sustainable transport modes, providing good physical accessibility could be the first step.

As we said before, choosing public transport for a trip depends not only on proximity but the quality of the experience, like pedestrian-friendly environments and sidewalk availability. Figure 4-3b shows that high quality urban environment is concentrated mainly in the north-east sector of the city, composed by 6 communes: Vitacura, Las Condes, Lo Barnechea, Ñuñoa, Providencia and La Reina (see Figure 1). Those communes have 17% of the population concentrating 62% of the high-income population, and earning more than 6,000 dollars per household-month on average (GfK Adimark, 2015). These communes have an average EUQI indicator of 12.7, while the average of the 28 remaining communes has only 10.5.

Also, central zones, with better accessibility as we shown in Figure 4-3a, do not have high EUQI index values as high income communes such as Vitacura and Lo Barnechea. This creates a clear mismatch between these key factors to promote ridership and a better experience using public transport. A likely explanation for this situation is that each of the 34 communes analyzed has its own Major, budget, and regulations. Therefore, high-income communes can provide better infrastructure and public spaces given their budget, producing important differences in terms of urban environment within the city.

Thus, improving infrastructure and services for pedestrians need planning and policy support through urban design guides (Khisty, 1994; Krambeck & Shah, 2005). Moreover, to deal with the dissatisfaction that exists in the population, where more than 40% evaluate poorly the streets, sidewalks, and parks (MINVU, 2010), it is necessary to ensure a minimum standard. The definition of this standard or sufficiency threshold may be useful also for physical accessibility, closing the gap between both EUQI and physical accessibility levels to achieve a more equitable scenario.

Adapting the Gini index for PAI and EUQI, we obtain revealing results (Figure 4-4). The Gini index value for EUQI is equal to 0.168, revealing a relatively equitable scenario. However, for Physical Accessibility the value is significantly higher: 0.442, which is similar to the Gini coefficient for income distribution in Chile.

The high value presented by the Gini of PAI is affected by many blocks of the city being deprived of access (50% of localities have less than 20% of total access, as can be seen in Figure 4-4). The value of the Gini index for EUQI may be counterintuitive when looking at Figure 4-3b, where a clear quality of the environment concentration is observed. However, a possible explanation for these results is related to the magnitude of the indicators, where the differences between PA and EUQI are usually lower than those found in terms of income. In addition, the spatial aggregation unit used in the calculation also affects the results obtained for the Gini indicator, so this is an issue that should be analyzed in greater depth in future work.

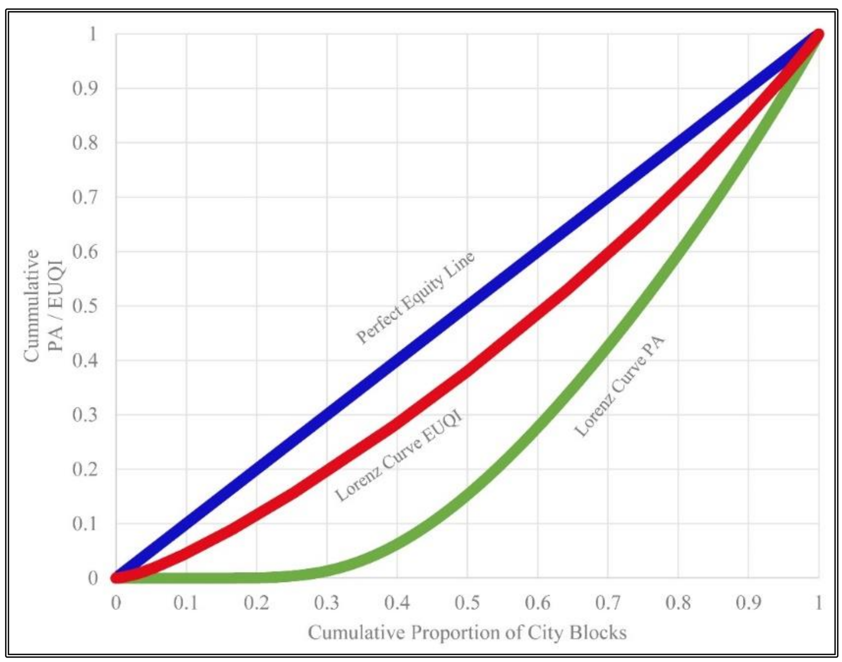

Figure 4-4 Lorenz curves for PAI and EUQI in Santiago (Source: Own elaboration).

On the other hand, Table 2 presents the AFI and EFI values for Santiago. In this analysis we are interested mainly on disadvantaged communes, so we calculate these indicators using 10th (AFI10 and EFI10) and 20th percentile (AFI20 and EFI20) as threshold. Since the indicator represents the severity of the deficiency of accessibility to public transport stops and the quality of the walking environment, the greater the percentage contribution to the indicator, the worse the situation of the analyzed commune.

We can see that San Bernardo is probably the most deprived commune of Santiago in these terms, since in the AFI20 contributes more than 50% and 4% in EFI20. This situation is detrimental for its population since San Bernardo made 9% of total trips by public transport and 47% by walking. A similar situation can be observed for Pudahuel, despite its EUQI being above the threshold. This commune contributes with more than 20% in AFI20 and the modal share is similar to San Bernardo, with 76% of trips made by public transport and walking.

A different situation happens in Lo Barnechea and Vitacura, having the second and sixth best EUQI respectively, but they have low accessibility to public transport stops with a contribution of about 10% and 3% respectively in AFI20. This may not be a problem for most of their population since more than 60% of their trips are made by car. However, these are high-income communes where a strong the urban development has been observed in recent years. Thus, citizens from all around the city must travel to Lo Barnechea and Vitacura for their commute, using public transport for the return trip. Also, to promote sustainability and a modal shift from car to both public and active transport, walking must be an attractive experience so its conditions should be improved.

Table 4-2 Accessibility Fairness Index (AFI) and Environment Fairness Index (EFI) for Santiago's case (Source: Own Elaboration)

	Name	**AFI10**	**AFI20**	**EFI10**	**EFI20**
Indicators	Standard (z)	0.34 (10th percentile)	0.46 (20th percentile)	9.4 (10th percentile)	9.7 (20th percentile)
	Value	0.01	0.03	4.30E-04	7.58E-04
Contribution of each commune to the indicator value (%)	**San Bernardo**	**78.75%**	**55.20%**	0%	**4.29%**
	Pudahuel	**15.28%**	**21.89%**	0%	0%
	Lo Barnechea	5.98%	9.33%	0%	0%
	Quilicura	0%	7.10%	0%	0%
	Maipú	0%	3.38%	0%	0%
	Vitacura	0%	2.96%	0%	0%
	Peñalolén	0%	0.13%	0%	0%
	La Pintana	0%	0%	**87.50%**	**74.05%**
	P.A. Cerda	0%	0%	**9.58%**	**12.89%**
	Quinta Normal	0%	0%	2.92%	6.43%
	Renca	0%	0%	0%	2.15%
	Conchalí	0%	0%	0%	0.18%
	Total	*100%*	*100%*	*100%*	*100%*

If we now analyze the largest contributors in terms of EFI10 and EFI20, we have La Pintana and Pedro Aguirre Cerda communes. These are low-income communes (approximately the 25th percentile of income) (MDS, 2013a) and therefore have a low budget to improve their urban and walking environment. They made between 67% and 71% of trips by walking and public transport since less than 40% of households own a car. As captive users of public transport, improving the walking stage of their journey would improve their travel experience. Unfortunately, Santiago does not have a metropolitan authority nor a system that allows effective fund redistribution between communes to ensure a coherent and equitable development of the city, generating discontinuities of the urban environment, basic transport structure for pedestrians, cyclists and public transport users.

4.6 Policy recommendations and future work

Santiago has grown without integrated land use and transport planning during the last four decades, generating urban segregation that has brought clear inequalities in terms of access to services and urban quality. High-income communes have greater proximity to sub-centers that concentrate activities and opportunities and can provide better infrastructure and public spaces. This, in turn, makes these communes even more attractive for the location of new activities, services, and high-quality real estate developments, creating a negative loop of segregation and concentration of opportunities around high-income areas. This urban development pattern stresses accessibility conditions for lower income people, who are usually located in the periphery and are more likely to be captive public transport users.

This work highlights the importance of analyzing both proximity to public transport stops and urban walking environment together since both elements are essential to understanding the accessibility experience and use of public transport. In Santiago, the majority of the communes have at least a sufficient level of access and urban walking environment. However, 12 out of 34 communes have problems that need to be addressed. On one hand, we have communes like San Bernardo that are deprived of both dimensions. On the other, there is a mismatch in some communes where only one of these two elements achieves a minimum standard. For this reason, it is essential that a metropolitan authority ensures a coherent development in the different communes that improves the conditions of the most disadvantaged population.

We suggest that priority should be put first in those communes that actually do not achieve a sufficient standard of access and urban quality, with special emphasis on those that have greater use of public transport and walking. After that, the aim should be to reduce the gaps in the urban environment and accessibility levels (especially in the latter given the results obtained) between socioeconomic groups, in order to ensure an equitable city. Finally, the goal should be to make both public transport and walking more attractive in high income zones. The population of these communes has transport alternatives and generally does not have problems in access to opportunities, so the relevance here is focused on fostering more sustainable modes, giving a relevant role to active and public transport instead of the car. Therefore, in terms of public policies, we suggest that the first issue should be fairness, based on sufficiency and egalitarianism considerations, and then environmental sustainability.

The analysis proposed here is the first step to improve access for public transport users but is still limited. Future work should also include public transport level of service and how people perceive different attributes like comfort, waiting times and transfers. This kind of analysis will help to close the gap between perceived and measured accessibility, which is a key element if our goal is to retain current users and attract people who currently use the car. Clearly, a bad level of service in every stage of public transport trips and poor quality of public spaces may trigger a shift from public transport and walk to the car. Thus, focusing on improving access by public transport and discouraging car use should be a priority in public policy if we want to achieve fairer, equitable and sustainable cities in terms of access.

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5. PUBLIC TRANSPORT ACCESSIBILITY MEASURES INCORPORATING THE LEVEL OF SERVICE PERCEIVED BY THE USER: AN EQUITY ANALYSIS OF EDUCATIONAL OPPORTUNITIES IN SANTIAGO DE CHILE

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5.1 Introduction

Transportation planning has evolved significantly through the years. Few decades ago, the traditional ‘predict and provide’ approach for road transport (Owens, 1995) led to mobility-based urban solutions. Focusing in improving speed by providing infrastructure to address traffic growth and congestion (Banister, 2008) relegates public transport, and particularly non-motorized modes, in a planning process that ends up feeding the long-term trend of greater use of the car (Kenworthy, 2006).

This car-centered development implies a greater use not only of energy but also of urban space, a scarce resource that should be distributed among users of different modes in an equitable and efficient way. This paradigm also generates significant negative environmental impacts due to externalities such as congestion and pollution. From a social justice perspective, focusing mainly on cars relegates the needs of most of the disadvantaged population who usually relies more on both public and active transportation.

Thus, the target of this planning strategy directly impacts the 3 sustainability dimensions: economic, environmental and social. Several cities around the world have drifted from the car-oriented planning paradigm, understanding that more than offering fast and high capacity mobility solutions, the prime goal is to provide access to opportunities and basic services in all transportation modes, promoting sustainability and social inclusion (Banister, 2008; Martens, 2017).

To achieve this goal, cities should encourage planning strategies that seek to meet the accessibility needs of people by hindering long trips and promoting sustainable modes: walking, cycling and public transport (Banister, 2005, 2006). Furthermore, cities should have structures allowing most residents to be close to their daily activities (Hall & Pain, 2006) through these modes. Therefore, transportation and land use planning should be addressed simultaneously.

However, in developing countries, and particularly in Latin America, transport and land use planning are usually not integrated or coordinated. In cities from this region it is usual to observe most low-income households located far from places where opportunities, like work or study, are abundant. In these cases, non-motorized transport is often not an option and, given low car access, these households become captive users of the public transport system.

In many cases, the system presents a spatially heterogeneous level of service, which is usually deficient in low income areas of the city. Thus, public transport plays a fundamental role in developing a sustainable and equitable city that provide access to everyone.

Despite the complexity of accurately characterizing the trips made by this mode (Martin et al., 2002), several advanced methods have been proposed in the public transport accessibility literature, including attributes like congestion, time schedules, travel time reliability and opening hours for different services (Weber & Kwan, 2002; Delafontaine et al., 2011; Neutens et al., 2012; Fransen et al., 2015). However, public transport accessibility measures proposed so far in the literature usually do not consider the level of service of the transport system as it is perceived by the user (Lucas et al., 2016; Martens, 2017). This would require disaggregating the traditional attributes into more detailed characteristics.

This work seeks to fill this gap in the literature, by proposing a new methodology for addressing accessibility through public transport. Our main contributions are (i) incorporating the user's perception of attributes that impact the level of service on his trip (walking times, waiting times, crowding conditions and number of transfers), ii) accounting for competition over the activity opportunities on destinations, comparing the results with traditional potential measures and (iii) using disaggregate stop-to-stop data of actual trips and the level of service that each user experienced, instead of information from GTFS-based platforms that usually consider non-realistic public transport operational plans. We believe the results obtained from this application to a real case study help validate our methodological proposal, by demonstrating that differences between total travel time (TTT) and total generalized travel time (TGTT) are not only significant, but heterogeneously distributed across the city, and correlated to income distribution.

The chapter is structured as follows: Section 5.2 presents a research context including a brief literature review about accessibility that sustains the research gaps exposed. Section 5.3 presents the methodology for our approach to measure accessibility while Section 5.4 presents an application of this methodology to a case study related to education in Santiago, Chile. Finally, Section 5.5 presents the main results of this research, closing the chapter with a brief discussion of key findings, conclusions and future work in Section 5.6.

5.2 Accessibility through public transport: brief review and research gap identification

Accessibility has been defined several times in the literature. In this chapter, we understand it as “the extent to which the land-use and transport systems enable (groups of) individuals to reach activities or destinations by means of a (combination of) transport mode(s)” (Geurs & van Wee, 2004). Therefore, poor access to transportation could mean a lack of economic, social and recreational opportunities, which may lead people to not participate in the usual society activities, or to a social exclusion phenomenon (Rajé, 2003).

Multiple accessibility indicators have been proposed in the literature. Some of them consider transportation, land use, temporal and/or individual components (see Bhat et al., 2000; Baradaran & Ramjerdi, 2001; Geurs & Van Wee, 2004 and Sclar et al., 2014), with pros and cons regarding theoretical basis, operationalization, interpretability and communicability criteria (Geurs & Van Wee, 2004). These indicators have been applied to several transportation modes: active or non-motorized transport (Chin et al., 2008; Iacono et al., 2010; Vale et al. 2015), public transport (Ryus et al., 2000; Polzin et al., 2002; Mamun et al., 2013) and comparisons between private car and public transport (Lovett et al., 2002, Kawabata, 2009, Benenson et al., 2011).

Since the provision of an efficient, reliable and sustainable public transport system is one of the major challenges that medium-size and large cities face today, in this research we analyze accessibility through this transport mode. Murray & Wu (2003) points out that accessibility through public transport has two main dimensions: (i) access to public transport stations or stops given an influence area (by walking, bicycle or car) and (ii) the geographic coverage of public transport given a certain time budget.

Many of the studies in this topic focus only on the access to stations or stops (Lei & Church, 2010; Mavoa et al., 2012; Mamun et al., 2013), considering aggregate measures for transport supply and leaving aside a detailed geographic coverage. Such accessibility indicators are blind to the opportunities that can be reached from these stations and the conditions under which people would travel to reach them.

Some works seek to incorporate coverage and level of service elements to public transport accessibility through the inclusion of aggregate attributes. For example, the Public Transport Accessibility Level indicator (PTAL) uses aggregate attributes like access time and waiting time to evaluate transport equity in UK (Wu & Hine, 2003), while Currie (2004) incorporates fares, transfer penalties, waiting and walking multipliers to account for total travel cost at aggregate level at Hobart, Australia. The average frequency at public transport stops (Sánchez et al., 2004), travel length (Weber, 2003) and other elements have also been incorporated into accessibility indicators (for further details, see Fu & Xin (2007) and Mamun & Lownes (2011)). However, the way these elements are interpreted by users and how this may affect perceived accessibility has been less addressed in the literature.

Including user perceptions is a big challenge that could allow accessibility indicators to gain more behavior-realism (van Wee, 2016). Chaloux et al., (2019) propose a new accessibility measure accounting for user satisfaction with the travel time and found discrepancies with traditional measures. Moreover, Lättman et al. (2016b) state that conventional accessibility indicators measure cost and time, but that the perception may be dependent on elements associated with the quality of the service. The authors built a Perceived Accessibility Scale (PAC) to capture this perception in public transport (Lättman et al., 2016a), concluding that the quality perception of transport, the feeling of safety, frequency of use and age predict the results of PAC (Lättman et al., 2016b).

In this work, we contribute with a public transport accessibility measure that explicitly considers the level of service of the transport system as it is perceived by the user, extending and improving on previous work (Tiznado-Aitken et al., 2016). Nowadays, the increasing availability of data in the general transit feed specification format (GTFS) provides highly detailed information on public transit (Karner, 2015), allowing a more disaggregated analysis. However, these data do not consider key elements in travel experience, such as reliability or crowding conditions. As we mentioned before, our work seeks to contribute calculating accessibility indicators using high-detailed data from actual trips made in public transport considering different level of service attributes. The proposed methodology is explained next.

5.3 Methodology

We propose a new approach to measure accessibility by public transport. The method has 3 main steps: i) calculation of walking accessibility to stops/stations, ii) estimation of the total generalized in-vehicle travel time, and iii) generation of aggregate accessibility indicators. First, we estimate the average walking time to public transport stops for any zoning or spatial aggregation at which the data available. Second, we calculate a measure of the travel experience incorporating the user's perception of attributes that impact the level of service stop-to-stop (waiting time, travel time, crowding conditions and number of transfers) and transforming them into a generalized cost measure using in-vehicle time units, which we call total generalized travel time (TGTT). Finally, we compute accessibility indicators to consider both opportunity supply and demand for every zone, i.e., potential and competitive accessibility indicators.

Generally, measures that seek to incorporate level of service elements of public transport do so through aggregate attributes. We propose an indicator that considers the TGTT, as perceived by the user from the initial stop to the final one. Our approach is to account for different dimensions of the level of service (walking time, travel time, waiting time, comfort and transfers), disaggregating and transforming them into equivalent in-vehicle time (IVT) units (Wardman, 2001). Therefore, each component of the equivalent IVT has a different weight based on user's perception.

The formulations proposed for the aggregate Public Transport Accessibility indicator from a location i (PTA_i) are a potential accessibility measure (Hansen, 1959; Koenig, 1980) shown in Equation 5.1 and a competitive accessibility measure (Shen, 1998) ($PTCA_i$) shown in Equation 5.2:

$$PTA_i = \sum_{k \in \omega} f(\theta, t_{ik}) \cdot D_k \quad \forall\, i \in \omega \tag{5.1}$$

$$PTCA_i = \sum_{k \in \omega} \frac{f(\theta, t_{ik}) \cdot D_k}{\sum_{j \in \omega} f(\theta, t_{jk}) \cdot P_j} \quad \forall\, i \in \omega \tag{5.2}$$

In these formulations, ω is the set of all zones in which the region has been divided and $f(\cdot)$ is an impedance function for accessibility (decreasing with time, distance or travel cost). The impedance function most used in the literature is the exponential function (with a negative θ parameter), but different impedance functions will be considered in our case study, as discussed in the next section.

We also introduce a competitive accessibility measure to capture the dynamics between supply and demand, analyzing if certain population groups are underserved. On the one hand, the measure shown in Equation 5.2 considers the number of people in each location j demanding these opportunities (P_j) and its impedance function to reach them. On the other hand, the attractiveness of each destination is represented by D_k, allowing the model to distinguish between destinations with different levels of opportunities. For example, accessibility to education should consider people demanding not only the number of educational establishments (i.e., schools, universities or technical educational centers) but also the probability of a student being accepted, and/or an indicator of the quality offered by the institutions, such as their teachers per student ratio or their results on standardized tests. In Section 5.4 we apply the proposed accessibility model exactly to this case, highlighting the insights that the method provides.

The variable t_{ik} is a measure of the TGTT of all registered trips made between origin i and destination k using bus services, subway lines or a combination. The TGTT, described in Equation 5-3, is composed by the weighted sum of 4 attributes: walking time (t_c), waiting time (t_w), travel time (t_t) and number of transfers (n_t). Each t_{ik} can be computed using the average of all trips or extreme values (for example the 90th percentile of all trips), allowing us to measure the necessary time threshold so that practically all users can access their activities.

$$t_{ik} = \alpha_c \cdot t_c + \beta_w \cdot t_w + \varepsilon_c \cdot t_t + p_t \cdot n_t \tag{5.3}$$

with

α_c: Parameter that transforms the walking time into IVT

β_w: Parameter that transforms the waiting time into IVT

ε_c: Crowding parameter, which is multiplied by in-vehicle time

p_t: Transfer penalty expressed in terms of IVT

The values for these parameters (including θ) will vary depending on the case study and could even be specific to types of individuals (n) in the population, meaning that a t_{ik}^{n} measure could be estimated. We show the application of this method to a case study in the following section.

5.4 Accessibility to higher-quality public education in Santiago, Chile

Chile is a highly unequal country. If we analyze its income distribution, Chile has the second highest Gini coefficient of all OECD countries (0.454), while the average income for the top 20% of its population is 10 times higher than for the bottom 20% (OECD, 2015). In Santiago, the capital of Chile and its largest Metropolitan region, these inequalities spread out beyond income, generating an important socio-spatial segregation. These circumstances have a big impact on the access to transportation and to opportunities from different locations, which is the focus of this work.

Santiago has a population of over 6.5 million people within an area of approximately 640 km^2. The high-income population lives mainly in the northeastern area (municipalities in grey color in Figure 5-1), which has grown much faster than the rest of the city in the last decades, attracting investments for productive activities, commerce and services (Suazo, 2017). This pattern matches with the urban structure model proposed by Griffin & Ford (1980) for Latin American cities, where the activity center tends to spread towards the greater income zone within the city.

This uneven urban development has been accompanied, since 1980, by housing policies in which low-income informal settlements were displaced from central and high-income areas towards the periphery (municipalities in blue and light blue in Figure 5-1). In this process, the high-income center was freed of these settlements, strengthening urban segregation. In this scenario, the low-income population living in the periphery require increasingly longer commutes to reach business centers, where job opportunities accumulate (Sabatini et al., 2001; Rodriguez, 2008). This development produces inequalities regarding access to transport (Shirahige & Correa, 2015) and basic services such as employment and education (Asahi, 2014). Furthermore, it makes cycling and walking unfeasible for most commuting trips. If we add that 60% of the households in Santiago does not own a car (SECTRA, 2015), and recognize that most of them are located in 20% of the municipalities where 2 out of 3 households have a car, many inhabitants of low income areas of Santiago are captive to the public transport system to satisfy several basic needs.

Transantiago, the integrated public transport system since 2007 in Santiago, comprises buses and Metro. The system, operating in 34 municipalities of the metropolitan area (Figure 5-1), had a chaotic start due to its poor service coverage (among several other reasons described in detail in Muñoz & Gschwender, 2008; Muñoz, Ortúzar & Gschwender, 2009; Muñoz, Batarce & Hidalgo, 2014). Even though the number of services being provided has increased significantly (Table 5-1), the user perception has not improved substantively, being evaluated on average with a 4.4 grade of a maximum of 7 (DTPM, 2014a).

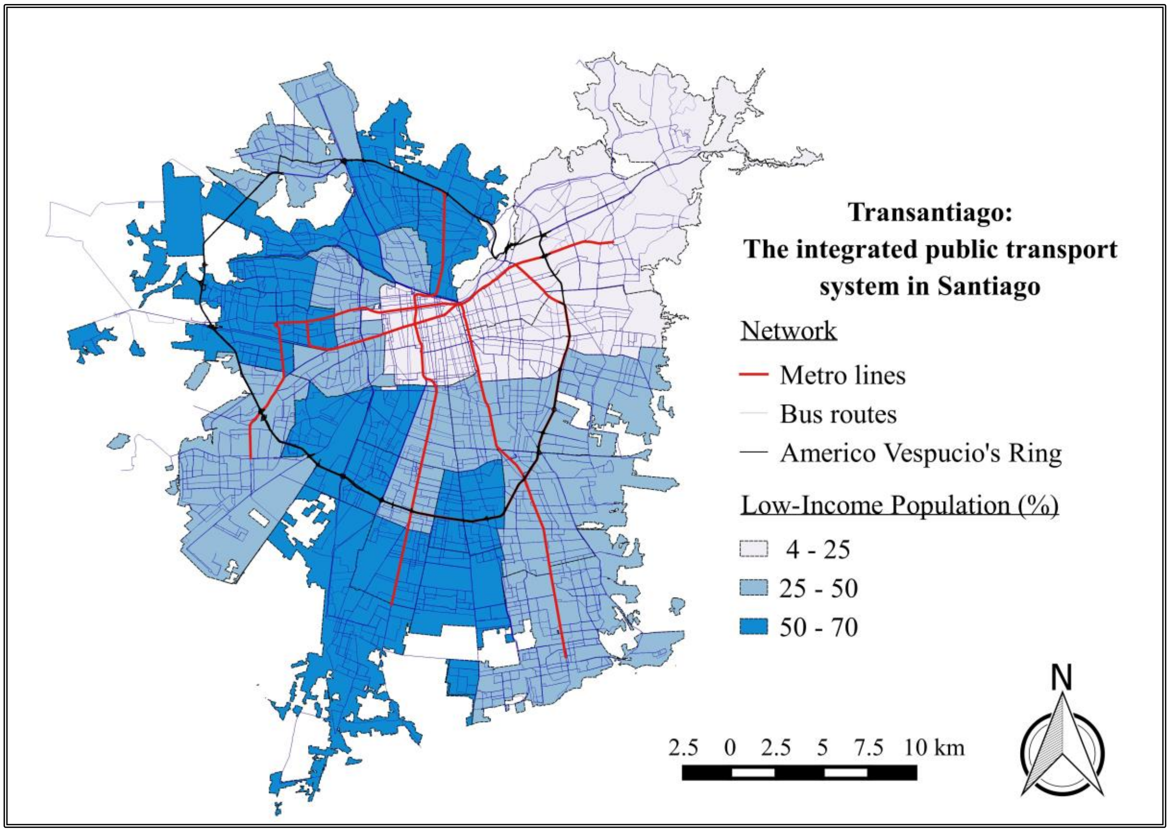

Figure 5-1 The spatial network distribution of Transantiago, the integrated public transport system in Santiago (2016), and the percentage of low-income population in each municipality. The low-income population belongs to the two bottom socio-economic quintiles, which earn less than US 923 a month per household. (Source: Metro S.A. (2007), MTT (2013), MDS (2015) and DTPM (2016))

Table 5-1 Transantiago evolution (2007-2016). Source: own elaboration based on Metro S.A. (2007), MTT (2013) and DTPM (2016)

	Transantiago			
Mode	**Buses**		**Metro**	
Year	**2007**	**2016**	**2007**	**2016**
Network extension	276 routes	378 routes	5 lines	5 lines
	2100 km	2821 km	85 km	103.6 km
Stops/stations	9397	11339	92	108

We applied the method described in section 5.3 to the analysis of educational access to the top primary free public schools of Santiago. In this work, we used a positive instead of a normative vision of accessibility (Páez et al., 2012). This means that we focused our analysis on actual user travel experiences in Santiago, instead of analyzing what is reasonable or desirable for people to face. In practice, this means that public transport accessibility is based on actual trips and the level of service they experienced and not information from GTFS based platforms. It also means that the impedance parameter θ of the accessibility functions (equations 5.1 and 5.2) is calibrated over data from observed trips.

The following sections describe the data and the multipliers that will allow us to transform each attribute into a generalized cost measured in IVT units (see Equation 5.3). Then, we describe the primary school data in Santiago and how we structure it to establish where the higher-quality educational opportunities are. Finally, we show the accessibility indicator to educational opportunities considering the total generalized travel cost in IVT units and the impedance function used.

5.4.1 Computing the level of service attributes

a) Walking times to public transport stops

To compute walking times to public transport stops we used OpenTripPlanner (OTP, https://www.opentripplanner.org/). We divided the city into a grid of cells of 200x200 meters and calculated the walking time from each cell centroid to its closest public transport stop. We aggregated the results at the "Transantiago-Zoning" level, consisting of 804 traffic analysis zones defined by The Metropolitan Public Transportation Directory, which manages and regulates public transport in Santiago. To do this, we calculated a weighted average of the overlapping squares, obtaining an estimate of average walking times for each of the 804 transportation zones.

b) Waiting time, travel time and transfers

Using Automated Vehicle Location and Automated Fare Collection data from Santiago, we obtained an indicator of the waiting time, travel time and number of transfers experienced by each trip in morning rush hour. Since there is no card validation when people alight from any public transport service in Santiago, we used the methodology proposed by Munizaga and Palma (2012) to estimate the time and station in which each trip stage ends and to connect sequential trip stages belonging to the same trip. For this work, we used the output of this methodology for a week of April 2015 (DTPM, 2015a) for which over 80% of the trips have been successfully characterized, incorporating expansion factors to account for unobserved trips.

To select the trips included in the accessibility calculation, we filtered the database selecting all trips satisfying the following criteria based on Núñez (2015):

- Trips where we have complete origin-destination data, including services used
- Trips between 350 meters and 50 km, considering minimum and maximum distance between public transport stops
- Trips which show speed between 4 and 70 km per hour. The lower limit was defined based on a lower bound of average walking speed and the upper limit based on average speed of express bus services which his route pass through highways.

Thus, more than two million trips were used for the analysis, corresponding to trips performed in the morning peak hour of a standard workday. This data allows us to characterize each trip since its first validation at a bus stop or a Metro station but does not yield information on waiting time in the first trip stage. To estimated it, in the case of Metro, we used headway series at each station (Metro S.A., 2015a). In the case of each bus service, we used headway series at 3 of its stops, which are the control points used to calculate indicators of the level of service (DTPM, 2015b). With this information, we calculated the average waiting time for a passenger arriving to stop (or station) *i* at any moment of the morning peak (with equal probability) to take service *k* through Equation 5.4 proposed by Osuna & Newell (1972).

$$t_{esp_{ik}} = \frac{\mu_k}{2}\left(1 + {CV_{ik}}^2\right) \tag{5.4}$$

where:

$$CV_{ik} = \frac{\sigma_{ik}}{\mu_k}, with\ \sigma_{ik} = headway\ standard\ deviation\ of\ service\ k\ at\ stop\ i$$

$$\mu_k = headway\ average\ of\ service\ k$$

This estimation assumes that the passenger will always board the first arriving vehicle during the first leg of their trip which is true for the large majority of users, but strictly not for everyone. Since we do not have an indicator of the average number of vehicles that decline access to a passenger due to capacity constraints at each stop, we decided to neglect this effect. We imputed $t_{esp_{ik}}$ as the waiting time of the first trip stage of each trip in the database starting with service *k* at stop *i*.

c) Comfort (crowding)

To estimate the number of passengers travelling in each bus service, we built load profiles for each bus route during the peak-morning period based on smart card validations in the public transport system (DTPM, 2015a). We considered the 90th percentile of all loads obtained at each bus stop of the route *r* ($\overline{P_r}$), highlighting the worst moment that the users experienced during their trips using a certain service. We corrected these values by average fare evasion rate (F_e) and a regularity factor (F_r) to consider variability among bus expeditions, obtaining the number of people travelling in each route *r*.

Then, using information about number of seats (S_r) and standing surface inside each bus (A_r) for each vehicle model in each service (Muñoz et al., 2015; DTPM, 2015c; MTT, 2017), we obtained a density measure (standing passengers/m^2) for the peak morning period ($\overline{DB_r}$).

$$\overline{DB_r} = \frac{max\left(\frac{\overline{P_r}}{F_e \cdot F_r} - S_r\ , 0\right)}{A_r} \tag{5.5}$$

To estimate Metro occupation inside each train indicating comfort conditions for each trip, we used the output of the CALDAS software for the morning rush hour (Metro S.A., 2015b). This software estimates the passenger flow between any consecutive stations a and b every 15 minutes for a typical work day of a given month (P_{ab}). This value can be divided by the average number of trains passing through these two stations (Metro S.A., 2015a) to obtain the average passenger load of a train (N_{ab}). Then, using the average seats available (S_{ab}) and average standing surface (A_{ab}) per train in each line (Metro S.A., 2015c), we estimated the average standees density (passengers/m^2) between two consecutive stations during the morning peak period as follows:

$$\overline{DM_{ab}} = \frac{max\left(\frac{\overline{P_{ab}}}{N_{ab}} - S_{ab}\ ,\ 0\right)}{A_{ab}} \tag{5.6}$$

5.4.2 Parameters used to transform each level of service attribute to IVT

Since the 1960's the value of time has been extensively studied in the literature (for a review, see Wardman (1998)). In addition to obtaining a monetary value, it is possible to derive an equivalence between different trip attributes by expressing them in the same time units, usually IVT (Wardman, 2001). Several studies have been carried out with this purpose under different contexts. For this work, the following values were used (Table 5-2).

Table 5-2 Parameters to transform each level of service attribute to IVT (Source: Own elaboration based on Raveau et al., 2014; Tirachini et al., 2013; Batarce et al., 2016; Tirachini et al., 2017; Guevara et al., 2018)

Attribute	**Measure**	**IVT equivalency**	**Value**
Walking time	Minutes	Multiplier (α_c)	2
Waiting time	Minutes	Multiplier (β_w)	2
Crowding	0 standing-passenger/m^2	Multiplier (ε_c)	1
	1 standing-passenger/m^2		1.25
	2 standing-passenger/m^2		1.5
	3 standing-passenger/m^2		1.76
	4 standing-passenger/m^2		2.01
	5 standing-passenger/m^2		2.26
	6 standing-passenger/m^2		2.51
Transfers	Quantity	Penalty (p_t)	10.2

The values reported in Table 5-2 are justified below:

- α_c and β_w: Steer Davies Gleave (1997) recommends using a factor of 2 and 3 for walking and waiting times. However, Wardman (2001) argues that walking and waiting time should receive the same weight, based on British evidence on time valuations controlling for different influences. Business values of walk and wait time are 1.8 $\pm$ 0.35 on average in terms of IVT. For simplicity, in this work we weight walk and wait time at twice IVT.

- ε_c: Recent studies attempting to obtain crowding multipliers in Santiago are consistent with each other (Tirachini et al., 2013; Batarce et al., 2016; Tirachini et al., 2017; Guevara et al., 2018). In this work we use a linear approach based on a stated and revealed preferences model, where "the marginal disutility increases 25% for each increment of one standing-passenger/m^2" (Batarce et al., 2016).

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- p_t: Raveau et al. (2014) developed a route choice model focused on Santiago' Metro system. This study identified that IVT equivalent penalties associated for each transfer depend on the type of transfer. Their values fluctuate between 4.93 and 13.36 minutes, depending on whether the transfer is upward or if there are escalators. For simplicity and given our inability to distinguish the type of transfer of each trip, 10.2 minutes is assumed as a transfer penalty, which is the result of "weighting each valuation for the number of transfer of each type made on a regular day" (Raveau et al., 2014, p. 192).

5.4.3 Supply and demand concentration: the educational case

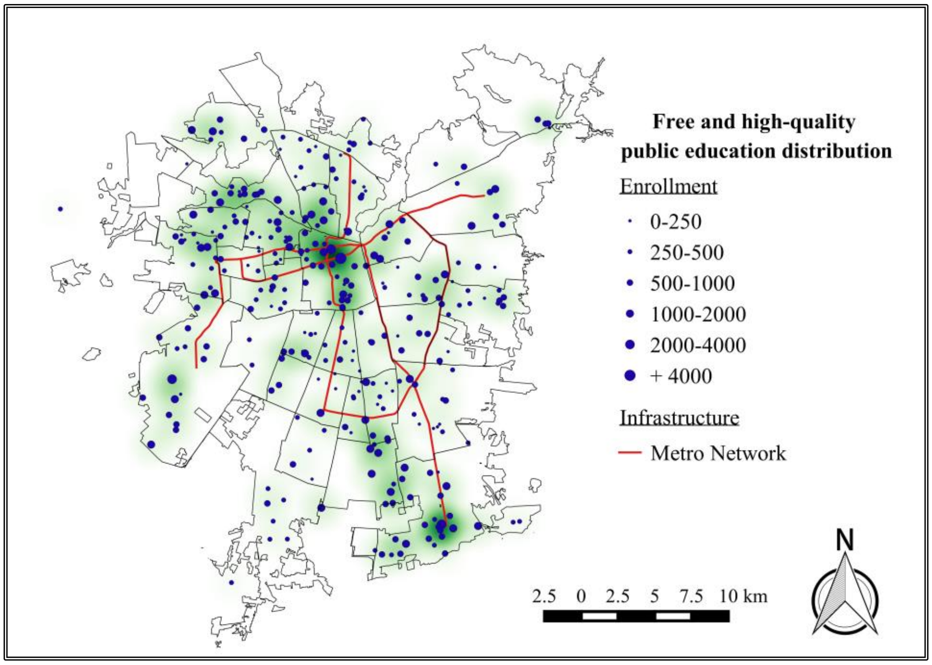
In Chile, two main systems of primary education coexist: private and public/subsidized. Private schools reach financial funds only through monthly tuition and fees from their students. Subsidized schools can be divided into three categories: (i) administrated by municipalities with no fees for students, (ii) administrated by private organizations and funded only with fiscal resources (called private subsidized) or (iii) administrated by private organizations in which parents provide funds incremental to the fiscal funds (called private subsidized with copayment or shared financing) (Aedo, 2000).

In this work we focused our analysis on the distribution of higher-quality public/subsidized primary schools in Santiago. We geocoded each establishment using the School's Directory (MINEDUC, 2016) and, to determine a quality benchmark, we used the National Performance Evaluation System (SNED in Spanish) which evaluates the quality of subsidized educational establishments based on 6 factors: effectiveness, overcoming, initiative, improvement, equal opportunities and integration-participation (MINEDUC, 2017).

The SNED values reported for the 1,426 establishments studied were in the range between 43.8% and 97.5%. The establishments with high SNED receive two-year subsidies, from the Ministry of Education. To allocate these funds the Ministry creates school clusters according to sociodemographic characteristics of their students, assigning the subsidy to the top 35% schools within each cluster.

In our work we used the SNED indicator of the last establishment selected for subsidy (65.4%) as the threshold for high quality performance. We focused our analysis in the 317 free and high-quality primary schools and 190,574 enrollments offered exceeding this threshold, providing the panorama of accessibility to high quality free education. These schools are particularly attractive for the most vulnerable population as they represent an opportunity for social mobility. The spatial distribution of these schools is presented in Figure 5-2, also displaying a green heat map in which the higher the color intensity, the higher the concentration of high-quality establishments. The size of each dot indicates the students' enrollment of the school. Thus, in our accessibility models (Equations 5-1 and 5-2) we will denote D_k as the total enrollment offered in public schools exceeding the high-quality threshold that are in zone k.

Finally, using the National Census (2017) and MINEDUC (2016) data, we estimate the number of students between 6 and 18 years studying in municipal schools, allowing us to analyze if any location is underserved or overserved when access to higher-quality public education (Figure 5-2). Thus, in our second accessibility model (Equation 5-2) we will model P_j as the total number of students living in zone j that study in public schools. The total population estimated was 230,203 students.



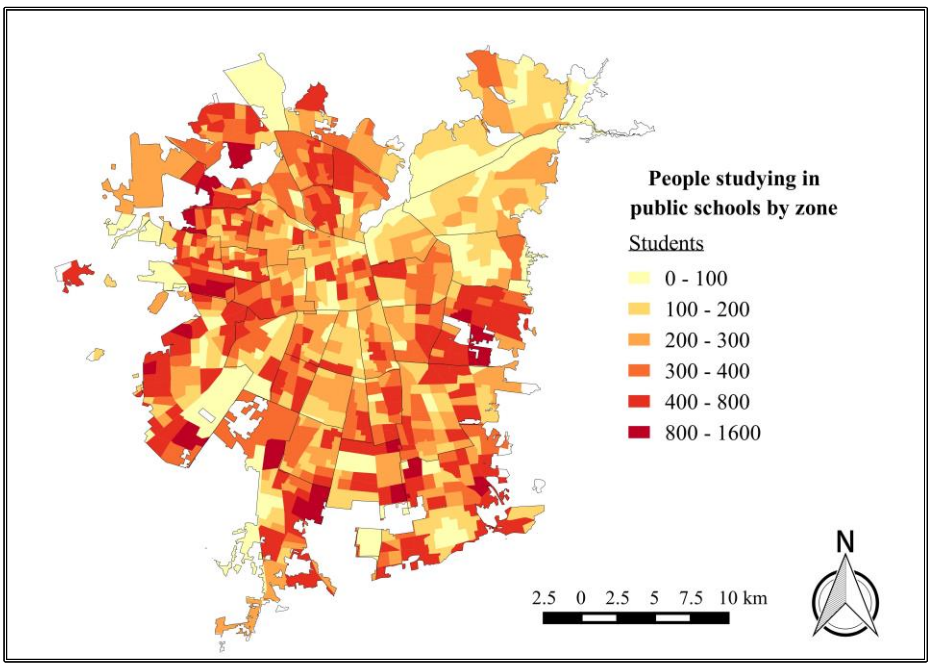


Figure 5-2 In the top (Fig. 5-2a), free and higher-quality public education distribution. The higher the intensity of color of the green heat map, the higher the concentration of top-quality establishments. At the bottom (Fig. 5-2b), people studying in that public schools by zone (Source: Own elaboration, based on MINEDUC (2016) and National Census (2017))

5.4.4 Total generalized travel cost in IVT units

Thus, we have all the elements estimated to calculate our accessibility indicators through public transport considering level of service,: (i) walking time (t_c), (ii) in-vehicle travel time (t_t), waiting time (t_w) which includes time spent on transfers and waiting time in the first trip stage, number of transfers (n_t) and comfort (average standing-passenger/m^2 along the trip) measured by the crowding parameter ε_c for each trip stage, (iii) the location of free and higher-quality public education in each zone (D_k) and (iv) the number of students between 6 and 18 years studying in municipal schools (P_j).

Then, we were able to calculate t_{ik} (Equation 5-3) for every O-D pair at the Transantiago Zoning level. To do this we computed their average and 90th percentile considering $\{t_t, t_w, n_t, \varepsilon_c\}$ attributes for every trip matching the O-D analyzed (Figure 5-3). We use the 90th percentile to identify the worst traveling experiences which might be hidden in the average values. This variability may be an evidence of different levels of service within sub-areas of the OD pair, different choices of users, or service variability within the same replicable trip. This last type is particularly important because users tend to associate their satisfaction with public transport to their worst experiences (see for example Guiver (2007) for social constructions of bus users).

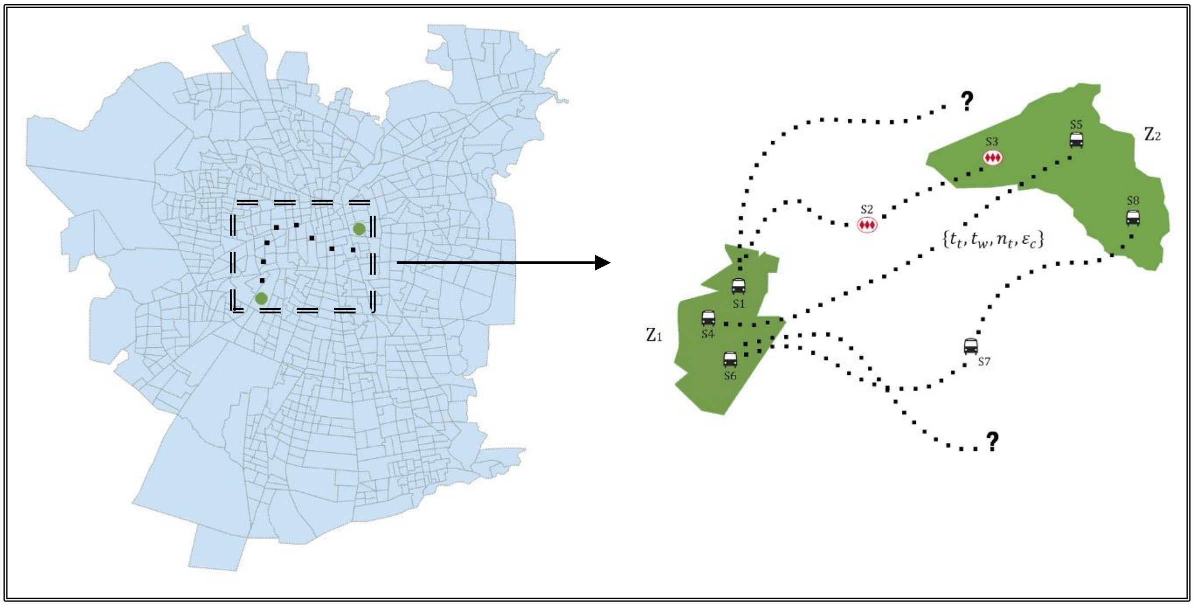


Figure 5-3 Estimation for travel time, waiting time, number of transfers and comfort for each O-D pair of zones, obtained from GPS information and validations. In this case, the Z1-Z2 measure considers average and 90th percentile of $\{t_t, t_w, n_t, \varepsilon_c\}$ considering all the observed trips (S1-S3, S4-S5 and S6-S8). (Source: Own elaboration)

We calculated accessibility through public transport to higher quality public education considering the level of service perceived by the user using Equations 5-1 and 5-2. We computed the t_{ik} values for each OD pair using the parameters introduced in section 5.4.2 while the values of D_k and P_j are associated to supply and demand for higher quality public schools in each zone according to the description given in section 5.4.3.

We used TTT as a measure of the objective travel time without considering perception (i.e. walking time, waiting time and vehicle time are given equal weight, while crowding conditions and transfers are ignored) to compare with our proposal. In the case of TGTT we used perception-based multipliers to weight them. To calibrate the impedance function needed $f(x)$ in each case, we used the method proposed by Mamun et al. (2013), setting an accessibility value between 0 and 1 according to the total travel time (TTT) and the total generalized travel time (TGTT) percentiles (0 to 100). For example, for percentile 50, we have a 0.5 accessibility value linked to 35.6 average total travel time (TTT) and 71.5 minutes average total generalized travel time (TGTT), both in-vehicle time units. Similarly, we have 0.3 accessibility value for percentile 30 and so with the rest of the values.

Since the TGTT are perceived, the values obtained are greater than TTT and therefore, if we had used the parameters calibrated in TTT for TGTT we would have obtained extremely low access values for the latter. For this reason, we decided to calibrate different impedance functions for TTT and TGTT, managing to capture the relative differences in both indicators. Those values allow us to calibrate different impedance functions: exponential function, Richards (1959) function and a linear approximation (LAP) between 11 percentiles from real data (Figure 5-4).

As we can see, the difference between exponential function and LAP is significant only for low travel times. In this work, we used LAP since it seems reasonable to us that the accessibility remains high for travel times under 15 minutes in the case of TTT and under 25 minutes in the case of TGTT.

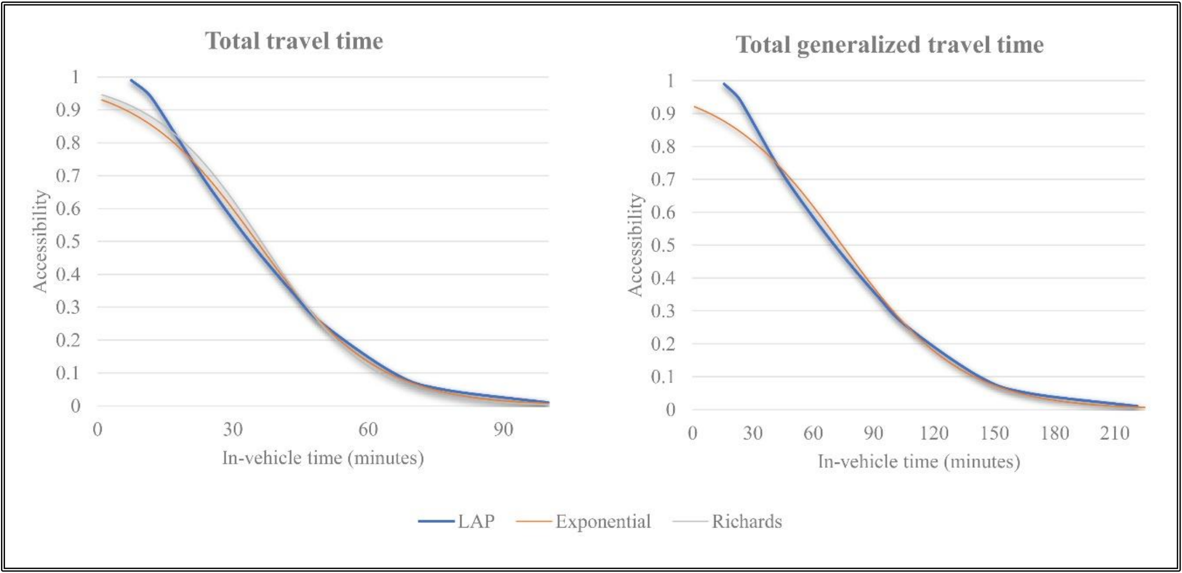


Figure 5-4 Impedance functions for accessibility calculation (Source: Own elaboration)

5.5 Results and discussion

In this section we show the main results. First, we compare the accessibility indicators obtained by both approaches (TGTT and TTT) using average and percentile 90 metrics, analyzing the main differences, some equity implications, and discussing why the full traveling experience should be considered when public transport interventions are prioritized. Second, we display the accessibility to educational opportunities indicating how well-served are people in different locations. In that case, we compare the two indicators to analyze access to educational opportunities: potential (Equation 5-1) using TTT and competitive (Equation 5-2) using TGTT, identifying their differences, quantifying the outcome gaps between the two and highlighting some equity issues and policy implications.

5.5.1 Total travel time versus total generalized travel time: some equity implications

First, we compare the average and 90th percentile for TTT and TGTT. To facilitate its visualization, we include in our maps of Santiago the Metro lines and the primary roads of the city, highlighting the Americo Vespucio's Ring (AVR), a circular road of almost 65 kilometers, 52.5 of which it consists of an urban highway. This ring is often used to delimit the perimeter between the city core and its suburbs, even though the urbanization has largely surpassed this ring in most directions. Nowadays, around 56% of Santiago's inhabitants live outside of it (National Census, 2017). This ring helps us to highlight some of the medium and low-income population living in pericentral and peripheral zones (see Figure 5-1). This population does not include those living in the north-east area, composed mainly by 7 municipalities, where the high-income elite lives and towards where the activity center has continuously expanded in the last 30 years (Suazo, 2017).

Figure 5-5 presents average and 90th percentile public transport TTT observed from each zone in the city. Unsurprisingly, the public transport trips starting in downtown areas have much shorter travel times than those starting from the periphery of the city. Interestingly, this difference significantly grows when we compare the 90th percentile of the trips. If we compare the zones with shortest (Q1) and longest average travel times (Q5), the trips starting in the former set of zones are on average 28 minutes shorter. This difference grows to 36 minutes when we compare the 90th percentile. The figure clearly shows the impact of Metro stations in reducing travel times due to operational efficiency and segregated infrastructure that allow trains to avoid the traffic congestion that buses face. People living in periphery of

Santiago (especially those in the south-west), often facing inadequate bus connections and forced to transfer to reach their destinations, experience the longest travel times.

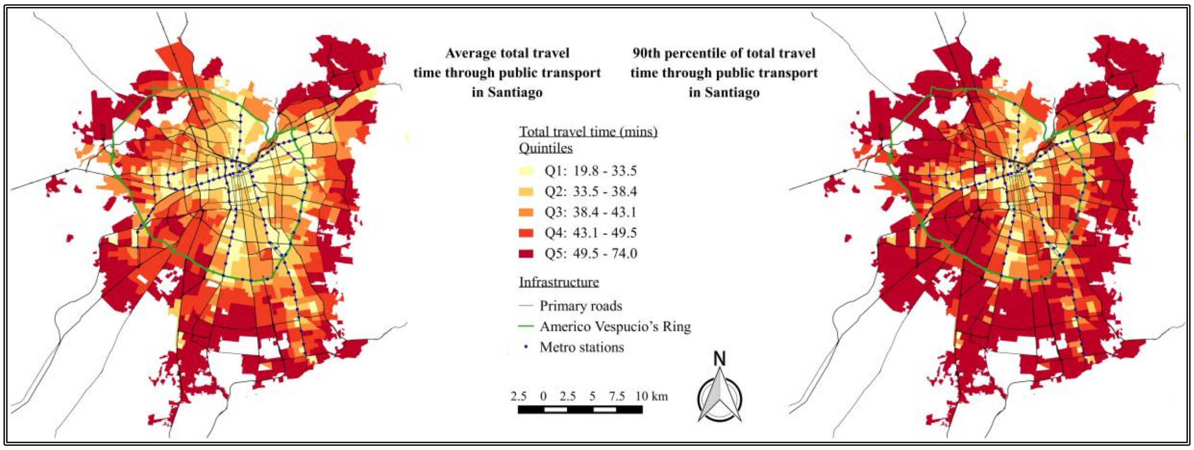


Figure 5-5 Average and 90th percentile of total travel time through public transport in each zone in Santiago. The travel time thresholds defining the limits between quintiles are obtained from average travel times for both figures (Source: Own elaboration)

In Figure 5-6 we repeat the analysis but now presenting the average TGTT and the difference between 90th and average of the TGTT. First, we observe that the average TTT and TGTT show the same pattern, with no remarkable changes in the city. Some areas in the north improve their relative performance, however the middle and low-income areas in the west and south are still the most disadvantaged, now showing substantial problems in the level of service experienced and its variability, as we can infer from the difference between 90th percentile and the average (Figure 5-6b). Again, the best performing zones are located around the Metro lines, although their experience generalized travel times get worse mainly due to the comfort factor, which profoundly impacts this transport mode in Santiago's morning rush hour. The speed and reliability offered by Metro is highly valued by the population, increasing its productivity but also its crowdedness.

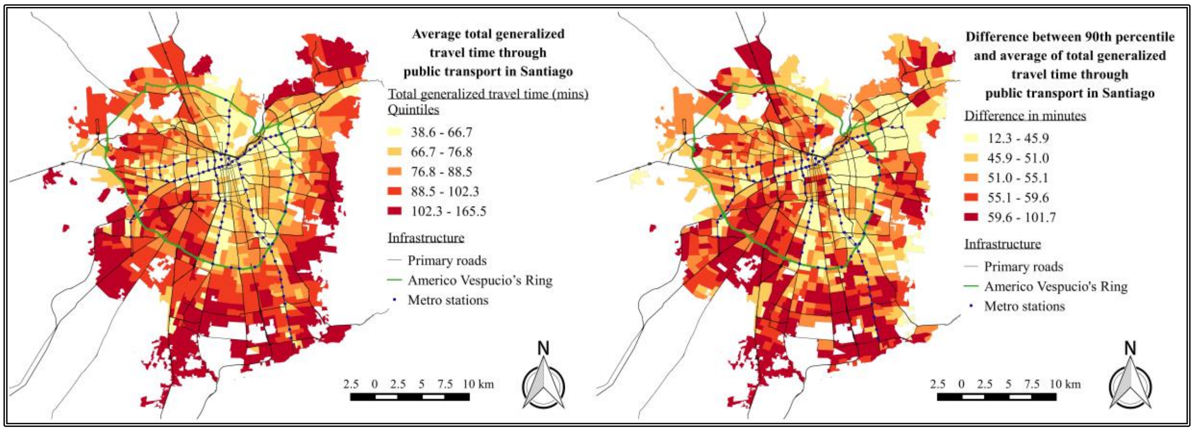


Figure 5-6 (a) Average and (b) difference between percentile 90 and average of total generalized travel time through public transport in Santiago (Source: Own elaboration)

From Figures 5-5 and 5-6, we realize that the average TGTT were approximately twice the average TTT, indicating that the time strictly traveled corresponds to only half of the generalized cost as perceived by the user. However, this ratio shows an important variability across different zones in the city, as is displayed in Figure 5-7.

This figure shows that the areas with the biggest difference between TTT and TGTT are again mainly located in the south and center-west of Santiago. In some of these areas, the ratio between both travel time indicators can reach up to 2.4 for average values and 3.5 for 90^{th} percentile values, since many travelers experience one or two transfers, 4 or 5 passengers per square meter and 15-minute waiting during the morning peak.

In other areas, this indicator reaches values as low as 1.5, reflecting short waiting times (less than 8 minutes on average) and acceptable crowding conditions (around 2-3 passengers per square meter on average). Noticeably, the affluent north east sector showed these quite low ratios. This is a result of having attracted most of the jobs for this group towards this area, so they access those opportunities quite directly (few transfers). Also, most of the morning rush flow in public transport is headed towards this area, allowing its residents to travel against the main flow, thus avoiding high crowding. Moreover, residents from areas that are poorly served by public transport avoid it by using their cars and, although not considered in computing these indicators, the urban facilities under which public transport users walk and wait in these neighborhoods are significantly more attractive than in the rest of the city (see Tiznado-Aitken et al. (2018) for an accessibility analysis considering these aspects).

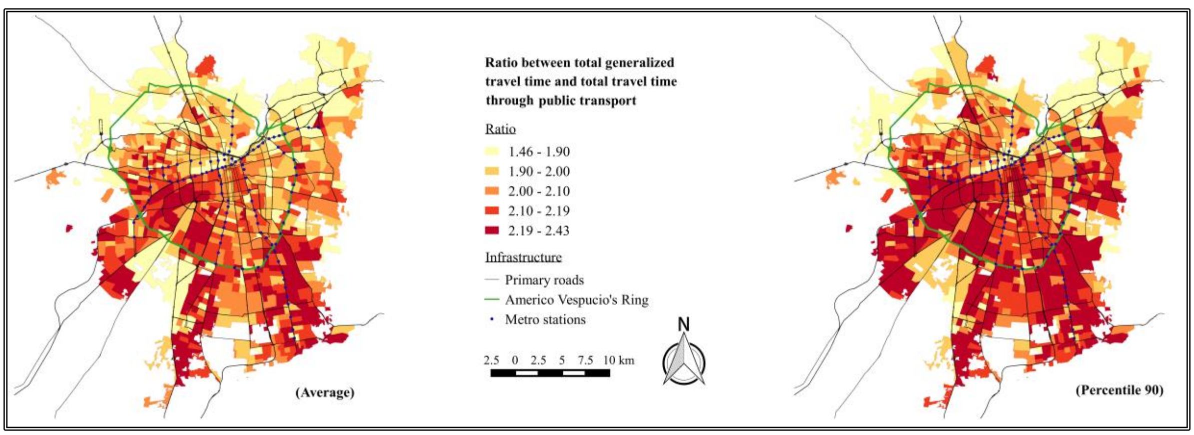


Figure 5-7 Ratio between total generalized travel time and total travel time for average and 90^{th} percentile (Source: Own elaboration).

Basing this analysis in quite small zones allowed us to identify ‘hidden’ or ‘postponed’ areas. Also, the analysis highlights that Metro stations and bus corridor stops have a positive local effect that tend to vanish as the walking distance to access them grows. If we were to follow a more aggregate geographic approach by considering larger zones like municipalities, accessibility inside these zones would take mid values, losing the variability observed when small zones are used.

5.5.2 Application to educational opportunities for the most disadvantaged population

The travel time analysis presented in the previous section from different areas in Santiago provides a general understanding of the accessibility gaps to current trip destinations by public transport for their residents. In this section, we focus our analysis in how these gaps affect the effective access to a basic service, but also one of the most highly segregated ones in Santiago: good quality primary public schools.

We have shown that the most disadvantaged zones in Santiago in terms of TTT and TGTT for their daily trips are mostly located in its periphery and some pericentral zones (Figures 5-5 and 5-6). In Figure 5-8, we compute public and free higher-quality primary school accessibility levels using TTT and considering the total enrollment offered in each school. The figure shows a big gap between zones inside and outside AVR, indicating that zones in periphery could reach less and low-quality education comparatively to central zones. In other words, the distribution of free and high-quality educational establishments does not improve the scenario shown in Figures 5-5 and 5-6, rather maintains or deepens the existing inequality.

The Figure 5-8 shows medium-low scores for the affluent north-east zones. This is due to most of its students attending private schools instead (which systematically show better results than public schools in SIMCE and PSU standardized tests) (AMUCH, 2016). Due to the high revenues that these municipalities gather, their public schools, although few, are among the best in the country. Indeed, many of their students come from other zones in the city traveling long distances to reach them. This tells us that characterizing opportunities simply by considering the offer available may not show the full picture. The process would be more precise if the opportunities are adjusted considering how many people city-wide compete for them (in which those living nearby are stronger competitors than those living far away).

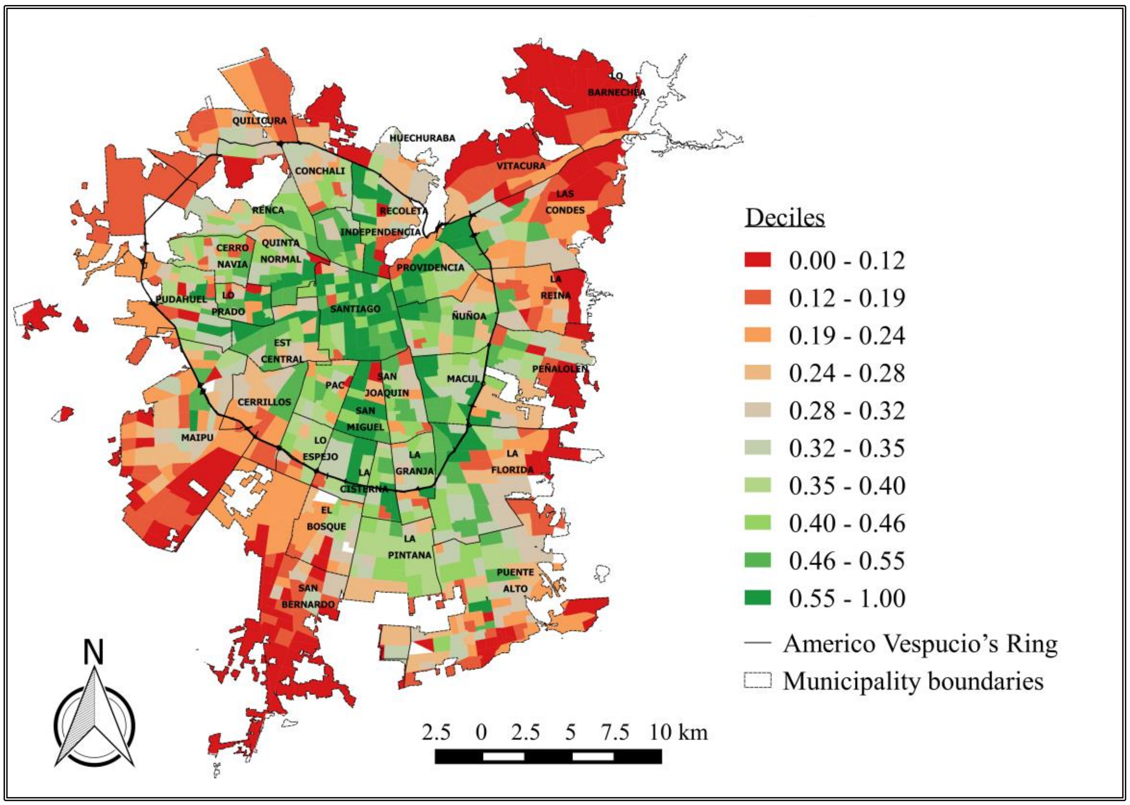


Figure 5-8 Accessibility to free and higher-quality public education through public transport considering the total travel time (Source: Own elaboration)

Thus, while informative, Figure 5-8 does not account for the competition for these educational opportunities, i.e. considering not just supply, but also the demand they face. It is also based in TTT instead of TGTT, which shows an important impact in accessibility as shown in Figures 5-5, 5-6 and 5-7. Thus, we compute the average competitive accessibility using expression 5.2 and considering TGTT. Results are displayed in Figure 5-9. Interestingly, a quite different distribution emerges. First, the results are easiest to interpret: the value obtained reflects the amount of opportunities that each person can access in a certain area. Thus, if the value is 0.5, it implies that 50% of the population of the area cannot access free and higher-quality public education.

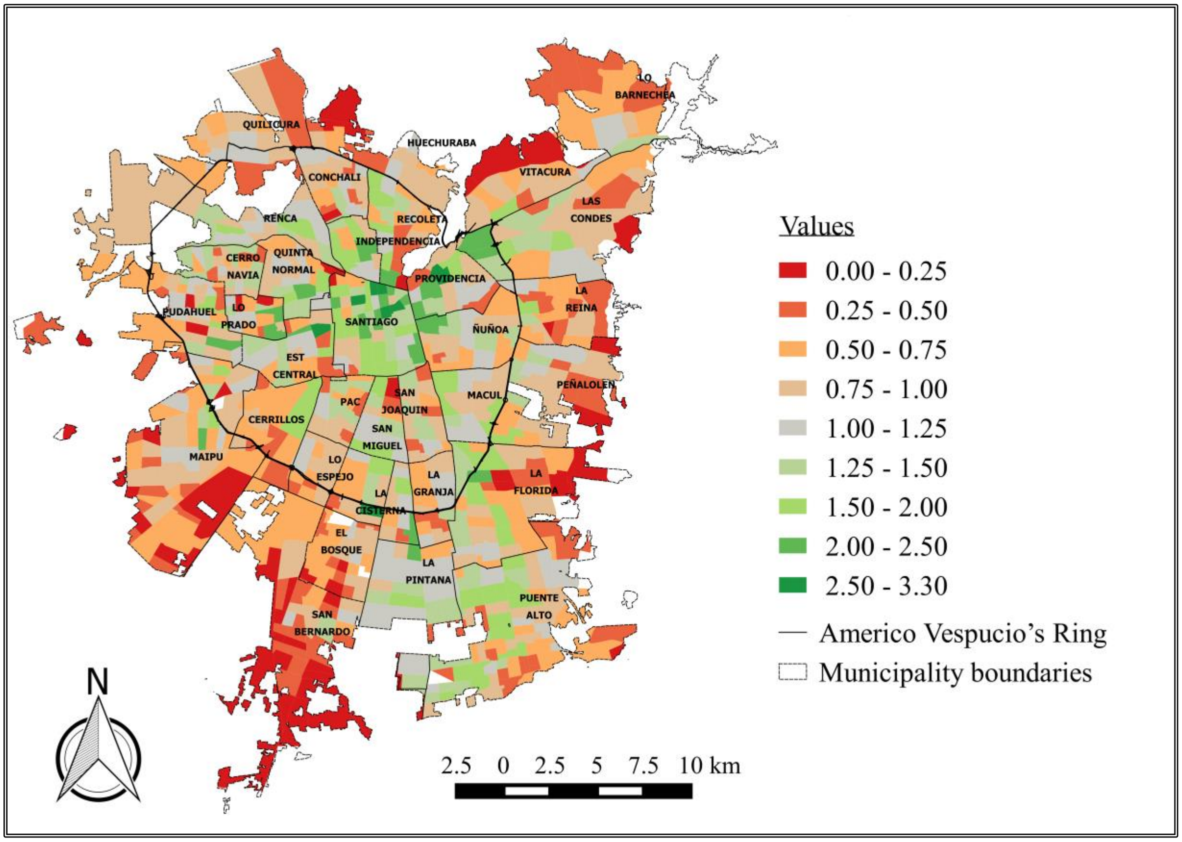


Figure 5-9 Accessibility to free and high-quality public education through public transport considering the total generalized travel time (Source: Own elaboration)

Two main analysis are derived from Figures 5-8 and 5-9. First, comparing both approaches, the results are highly different, especially if we concentrate on the less favored people in terms of access to free higher quality education. Overall, we observe that in zones inside AVR, the accessibility levels in Figure 5-9 are worse than in Figure 5-8. We rank the zones according to their public transport competitive accessibility ($PTCA_i$) using TGTT from Figure 5-9 and we display, in ascendant order, the bottom 20% of the zones and their accessibility values in the green line (Figure 5-10). Following the same 'zones order', we display the accessibility values with the ones obtained by the Public Transport Accessibility (PTA_i) using TTT (blue line), setting the 20th percentile of those values with a yellow line. We observe that the two sets of indicators do not follow the same trend, and their relative order differs significantly. In fact, 22% of the zones analyzed have Public Transport Accessibility (PTA_i) values above the yellow line. Therefore, identifying low accessibility zones through each indicator to improve their educational opportunities could lead us to a quite different set of zones. For example, analyzing the ranking between zones in the city, we found 30% of discrepancy for the 10% lower scores in the two accessibility indicators. This may cause an important drift of efforts and resources, which is relevant when the available budget to improve the educational conditions of people living in poor areas is scarce.

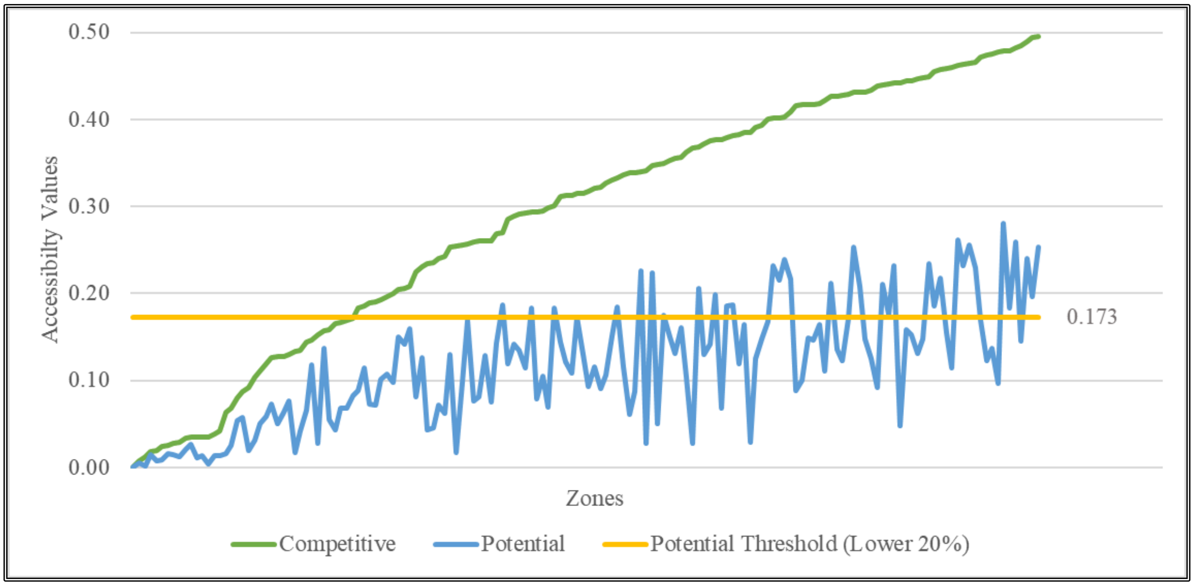


Figure 5-10 Comparison between a competitive accessibility measure using TGTT and a potential measure using TTT (Source: Own elaboration)

Second, according to Figure 5-9, peripheral and pericentral locations are underserved of higher-quality education. It is important to note that a structural deficit of 17% was found only analyzing students in public schools and higher-quality education opportunities aggregated, revealing an educational supply problem. However, a problem of distribution of the existing supply is also present. As we can see in Figure 5-11, around 20% of the zones in Santiago have at least a 50% deficit of higher-quality education and 71% of them are located outside the AVR. These zones showed a remarkable difference with central and higher-income zones like Santiago and Providencia, where the population can have even 300% of oversupply of education. In fact, 12% of the zones in Santiago have at least 25% of oversupply of higher-quality education and almost 70% of oversupplied zones are located inside the AVR. On average, people in more central zones (inside AVR) are slightly overserved (1.06) versus the peripheral ones (outside AVR) that have around 25% deficit

(0.76). In other words, the former population group has 1.4 times more accessibility to higher quality education than the latter one, showing once again the inequality between these locations.

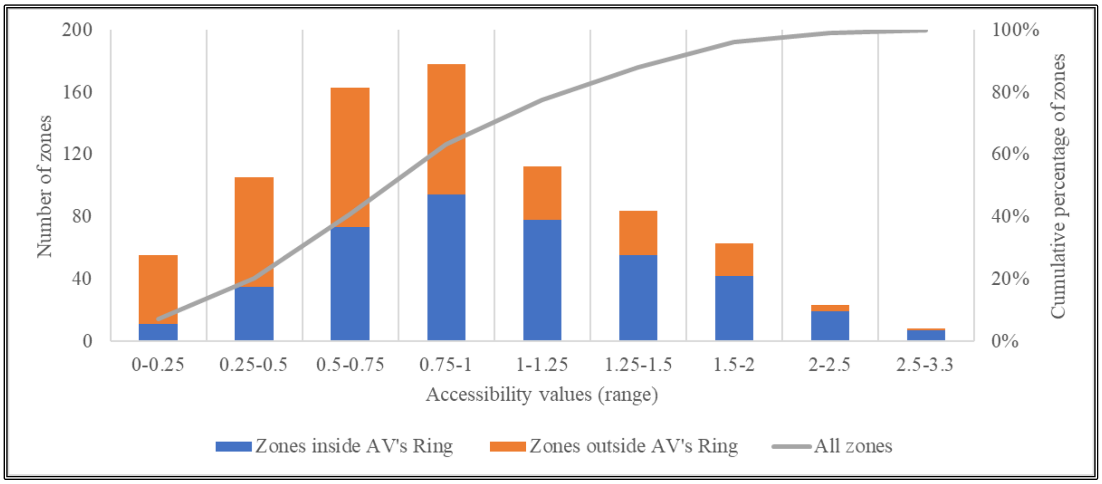


Figure 5-11 Competitive Accessibility Distribution (Source: Own elaboration)

Beyond the overall results, some interesting examples in terms of spatial (in)equity emerge from Figure 5-9. Both inside and outside AVR we observe low income areas with good accessibility. Several zones in La Pintana, Puente Alto and La Florida, all located outside AVR, and Estación Central, Renca and Independencia, inside AVR, have a good accessibility to education (values over 1.25) and present a high proportion of low-income population as we saw in Figure 5-1. Despite the inadequate public transport level of service that most of these zones present (see Figures 5-5, 5-6 and 5-7), their proximity to educational opportunities, as we saw in Figure 5-2, allow the students located in these areas to enjoy good accessibility levels despite the competition for those opportunities. These examples, outliers of the overall pattern shown in this chapter, should be a model to replicate in other vulnerable areas where more disadvantaged and low-income populations reside, locating more high-quality educational opportunities.

5.6 Conclusions

Our work contributes in both methodological and practical terms. The proposed methodology provides a new and more comprehensive approach to accessibility by incorporating the user travel experience, which has been commonly neglected in this type of analysis. Since previous studies have found low agreement between perceived and objective accessibility measures (Ball et al., 2008 and Gebel et al., 2011), this work is a step forward bridging the gap between the two. This approach measures real differences in terms of unequal access to opportunities and provides tools to assist decision-making and public transport planning, allowing to determine how and where to intervene to effectively improve accessibility, with a focus on urban equity.

We focused our analysis in comparing TTT and TGTT and studying the accessibility to higher quality and free public-schools with both potential and competitive measures. All in all, people living outside AVR, in more peripheral areas, are consistently disadvantaged compared to people located inside the AVR. Results show that the worst public transport level of service is concentrated in medium and low-income population, located in peripheral and pericentral areas of the city. In these zones, the difference between TTT and TGTT is the largest with people experiencing on average 1-2 transfers, 4-5 passengers per square meter and 15-minute waiting. Moreover, using competitive accessibility measures and TGTT we found a different pattern compared to potential measures and TTT. We found that around 20% of the zones in Santiago have at least a 50% deficit of higher-quality public education and 71% of them are in peripheral areas, which on average have 1.4 less accessibility than the areas inside AVR.

Although this is not a simple problem to tackle, there is an opportunity to improve this situation by intervening in the land use and the transportation systems through a comprehensive plan. People that face the longest travel times in public transport also suffer the worse travel conditions that affects their level of service the most. In the case of educational opportunities, this is mainly because many people living in periphery do not enjoy these opportunities nearby. Quite the opposite, they must face a deteriorated level of service in public transport to access them. Furthermore, they must compete with others coming city wide to take advantage of these opportunities. These findings should impact investment priorities to improve the quality of service of public transport in Santiago, and also the location of educational facilities.

Beyond improving coverage and quality of public transport, promoting a better distribution of opportunities across the territory should become a priority for cities like Santiago, specially in the current context of climate emergency. Our analysis for higher-quality and free public-school accessibility shows that most of the opportunities are concentrated in more central and pericentral zones. This suggests that peripheral areas, where a big proportion of the public-school demand resides, need closer opportunities to improve their access to this essential service. Land use policies should promote the settlement of higher-quality primary schools in vulnerable urban locations, allowing their residents to access them through non-motorized transport modes. Unfortunately, the location of new quality educational opportunities is not a short-term measure, requiring joint efforts between urban planning, transportation and the educational system.

Activity concentration around higher-income municipalities in Santiago make these municipalities more and more attractive for new activities, services, and high-quality real estate developments. They also provide convenient locations for the daily trips of those deciding where to install them. A fragmented governance and a deeply segregated residential locations in Santiago tend to feed this loop: affluent municipalities favor new opportunities to be located in their area, while affluent people benefiting from short travel times and better level of service. This scenario creates a negative loop of segregation and opportunity concentration, stressing accessibility conditions for low-income people that mostly live far from these areas and who are quite likely to be captive public transport users (Tiznado-Aitken et al., 2018) with inadequate level of service.

Investing in high capacity transport solutions that allow low income periphery groups to reach the opportunities located in high income sectors faster may prove highly beneficial on cost-benefit analysis (CBA) made over the current flow structure and its expected trends. However, these investments may feed a vicious cycle in which affluent groups locate their residences farther and farther from downtown and, at the same time, attract job and educational opportunities closer to them. Finishing this vicious cycle require a long-term vision for the city in which new sectors attracting opportunities are planned and fostered. The accessibility indicators proposed in this chapter should help to identify where these opportunities should be installed, complementing CBA methodology and seeking to break the tendency to focus on issues of economic efficiency issues despite equity (Murray & Davis, 2001). Thus, this chapter adds more evidence about the urgency of planning the land use and transport systems together. Unfortunately, too often they are not.

Future work should focus on incorporating other attributes from the level of service not considered in this work (e.g. reliability), or the quality of urban environment, both key for the user experience. Complementing this research with qualitative methods to explore accessibility barriers and how differently the quality of travel experience by different type of users is perceived should be the next step to improve the accuracy and the usefulness of the results obtained in terms of public policy.

Acknowledgements

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6. OPPORTUNITIES OR BARRIERS? ANALYZING QUALITATIVE DATA TO ENHANCE THE UNDERSTANDING OF ACCESSIBILITY THROUGH PUBLIC TRANSPORT

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6.1 Introduction

Innumerable theoretical and methodological advances in accessibility have already been developed in the last decades, associated with its conceptualization, measurement and (less so) its operationalization in practice (van Wee, 2016). Particularly, the quantitative measurement of accessibility through public transport has become more complex and specific over time. This is partly thanks to the greater availability of smartcard and general transit feed specification (GTFS) data, and partly due to the improved robustness of the methods to include elements such as congestion, real-time bus schedules, daily changes in travel times, service opening hours, among others (Weber and Kwan, 2002; Delafontaine et al., 2011; Neutens et al., 2012; Fransen et al., 2015). However, many of the deeper nuances of how people experience their travel environments are not usually included in the accessibility analysis.

In this wider context, our previous works has highlighted the importance of incorporating passengers' travel experiences within accessibility analysis, considering the quality of the urban environment where people walk to public transport stops (Tiznado-Aitken et al., 2016) and users' perceptions of level of service attributes, considering an in-vehicle time equivalence (Tiznado-Aitken et al., 2018). Nevertheless, other key elements still need to be explored in depth in order to improve the characterization of accessibility according to users' travel experiences.

This chapter explores the use of qualitative methods to further improve the characterization of accessibility experiences, as a function of attributes that inhibit or enhance users' accessibility to opportunities within the city. Besides the financial, physical, temporary and organizational barriers (Cass et al., 2005), we highlight barriers linked to a disparate perception of the built environment around transport infrastructure, which create a 'socially constructed' narrative for travelling in buses and Metro. Due to spatial and socio-demographic heterogeneity, this perception and narrative differs among inhabitants, having a direct impact on the perceived access within the city and consequently, the exclusion that these groups can experience (Lucas, 2006).

We propose a theory-driven analytical framework and a qualitative methodology to analyze accessibility, focusing on how people relate their public transport accessibility daily experiences. We apply our method to the geographical context of two municipalities of Santiago de Chile, an interesting case study since it is a city with quite a good public transport system, including an integrated fare, but also with some key features typical of Latin American cities, such as high socio-spatial inequalities and a marked car-centred urban planning in the last few decades, despite most of its population not having access to cars (SECTRA, 2015).

Using content analysis of focus groups, data gathered in a brief survey and socio-spatial analysis, we raise relevant issues within the traveller experience, generating qualitative concepts or labels for perception and narratives of the transport environment. From these ‘real world’ experiences it is thus possible to determine some overlooked attributes that should be considered when analyzing accessibility through public transport for different population groups.

6.2 Opportunities or barriers? A review

Accessibility has been widely addressed in the literature from several disciplines including transport, geography, sociology, economics, public policy, among others (Dalvi and Martin, 1976, Ben-Akiva and Lerman, 1979, SEU, 2003, Cass et al.., 2005). In quantitative transport and geography studies, probably the most common way to understand and operationalize accessibility is as the potential of opportunities for interaction, considering not only the ease to overcome spatial separation but also travel costs and the intensity or size of the activity (Hansen, 1959).

However, several different approaches can be used to understand and measure accessibility. It can be understood as a property of space or a property of people (Kwan, 1998), which translates into location-based or person-based measures (Geurs and van Wee, 2004). It variates across individuals (Handy and Niemeier, 1997), making possible that two persons living in the same place experience very different accessibility levels due to their different needs, abilities and preferences. It can be described through positive or normative measures (Páez, Scott and Morency, 2012), estimating the desired/declared access to an activity or it can be computed from observed travel behaviour ('proof of access'), i.e., the number of trips or the participation in activities (Morris et al., 1979; Páez, Scott and Morency, 2012)

Regardless of the approach, the four key elements to operationalize the concept of accessibility within transport geography are the transport network, land uses, temporal factors and individual characteristics (Geurs and Van Wee, 2004; Sclar et al., 2014). The former three elements are related to supply, considering the transport infrastructure and the provision of opportunities and their opening hours. The latter two elements are related to people's abilities and time constraints. These components allow us to measure overall large-scale accessibility to opportunities, but they do not allow us to analyze at an individual level all the barriers that people experience accessing to activities (Jirón, 2009).

In terms of barriers to accessibility, Hagerstrand (1970) developed the two main limitations for access through time-space geography, where three types of constraints are identified: (i) capacity, associated with the demographic characteristics, skills/abilities and resources of each individual, (ii) coupling, linked to space-time synchronization between people and opportunities to fulfil access and (iii) authority, which control when and where activities can be carried out through institutional and power relations (Wong, 2018). Similarly, Cass et al. (2005) reported economic and organizational constraints besides these physical and temporary barriers.

Under a broader analysis, Kenyon et al. (2002) suggested nine dimensions that can generate social exclusion, among which are mobility, economic, temporal and public space barriers. Likewise, Church et al. (2000) identified seven dimensions that function as accessibility barriers and that could generate exclusion. The first five (physical, geographical, economic, temporal and spatial) are the usual categories, but the authors raised two further interrelated dimensions that have not previously been addressed: (i) fear in public/private spaces and (ii) security, design, surveillance and management barriers to use public and quasi-public transport spaces.

Jirón (2009), through an ethnographic research using mobile ethnographies, showed that mobility barriers (financial, physical, organizational, temporal, skills and technology) affect accessibility levels, which impacts the daily individual mobility practices depending on gender, income, age and life cycle. The author uses the concept of ‘thickness’ as a metaphor for the ‘density of accessibility barriers’ in everyday life (Jirón, 2013). For example, a low-income woman living far away from city centre with two children could experience thickness because the financial, temporal, geographical and gender barriers are concentrated and deny her ‘fluid’ urban daily mobility.

Thus, all the dimensions and barriers mentioned will impact differently on individuals depending on their personal circumstances. As an example, Law (1999) stated that access to resources, the use and relationship with technology and the labour division can generate an important mobility barrier for women compared to men. Likewise, in her study of gender mobility, Loukaitou-Sideris (2016) stated that women face specific cultural, economic, physical and psychological barriers, which have direct effects on their travel pattern. The recent FIA Foundation (2018) study for three different Latin American cities (Santiago, Quito and Buenos Aires) provided more evidence on these findings, exposing that the fear of harassment and the transport environment impacts women chooses of transport routes, modes, and time.

Therefore, from the literature we conclude that there are two main approaches to analyse accessibility: opportunities and barriers. Unlike the opportunities approach, usually dominated by quantitative methods, the study of the accessibility barriers has been dominated by qualitative methods. For the latter, the analysis has focused on the barriers using specific modes of transport and the travel experience for the most vulnerable population groups. Most of the work done used focus groups, interviews or participant-observer, but the former two are the most widely used techniques to obtain detailed information from a research subject, particularly in the transport area (Hagman, 2003, Guiver, 2007, Beirão and Cabral, 2007).

In the transport field, these qualitative techniques could be used as a complement for the quantitative approaches (Clifton and Handy, 2001) but usually are carried out independently.

This hinders to set the strengths, boundaries and complementarities with the quantitative methods, especially when aim to incorporate the user experience and perception into a broader context of accessibility analysis. We contribute to fill this shortcoming proposing a theory-driven analytical framework and a qualitative methodology to enrich accessibility research. We focused on how people relate their public transport accessibility daily experiences according to different barriers and dimensions of the opportunity-based analysis, shaping or creating a ‘socially constructed’ narrative for buses and Metro that should be considered to further improve the characterization of accessibility.

6.3 Methodology

In this work we undertook focus groups, analyzing them using content analysis and a theoretical framework derived from the literature review. Also, we undertook a brief survey in order to complement and characterize better the participants of the focus groups. Below we describe each one.

6.3.1 A theoretical framework for accessibility analysis

Based on the literature review, we created a theory-driven analytical framework (Figure 1) to guide our analysis. From the accessibility concept, two main branches were identified to study it: (i) an opportunity-based accessibility analysis where quantitative indicators are the dominant approach using different indicators based on potential opportunities or observed behaviour and (ii) a barrier-based accessibility analysis that is qualitative predominant, using different techniques like focus groups, interviews, ethnographic approaches, travel diaries, among others.

In both quantitative and qualitative approaches, there are main dimensions or attributes to describe the accessibility levels experienced or the elements that inhibit or enhance accessibility within the city. Clear links between dimensions in each branch can be found. For example, the transport, land use and temporal components should allow a proper coupling, related to space-time synchronization between people and opportunities to fulfil access. Also, the individual component gathers capability, physical and gender barriers. The latter example allows us to understand that for a more detailed study of the accessibility experience for different groups, the analysis of the barriers is mandatory.

Setting out the framework this way, we concluded that both approaches are complementary. For a high-scale accessibility evaluation, the indicators that include transport, land use, temporal and individual dimensions are useful, even when they are not approached with a high level of detail. If we want to go deep in the accessibility experiences and how different is the impact in different users, a more detailed approach to describe barriers and difficulties should be used, considering the limitations that this approach has in terms of coverage and representativeness.

The emphasis of this work was qualitative, seeking to explore deep and to characterize better the accessibility experience for different individuals, providing some insights on how to merge some of the findings into a more comprehensive accessibility analysis using quantitative and qualitative approaches. Despite some recent efforts in the literature (see for example Cascetta et al. 2013; Scheepers et al., 2016; Lättman et al., 2016a; 2016b; Tiznado-Aitken et al., 2016), the perceptual dimension usually is not fully captured by standard quantitative accessibility approaches and this framework could be useful to provide a common ground to explore complementarity between approaches.

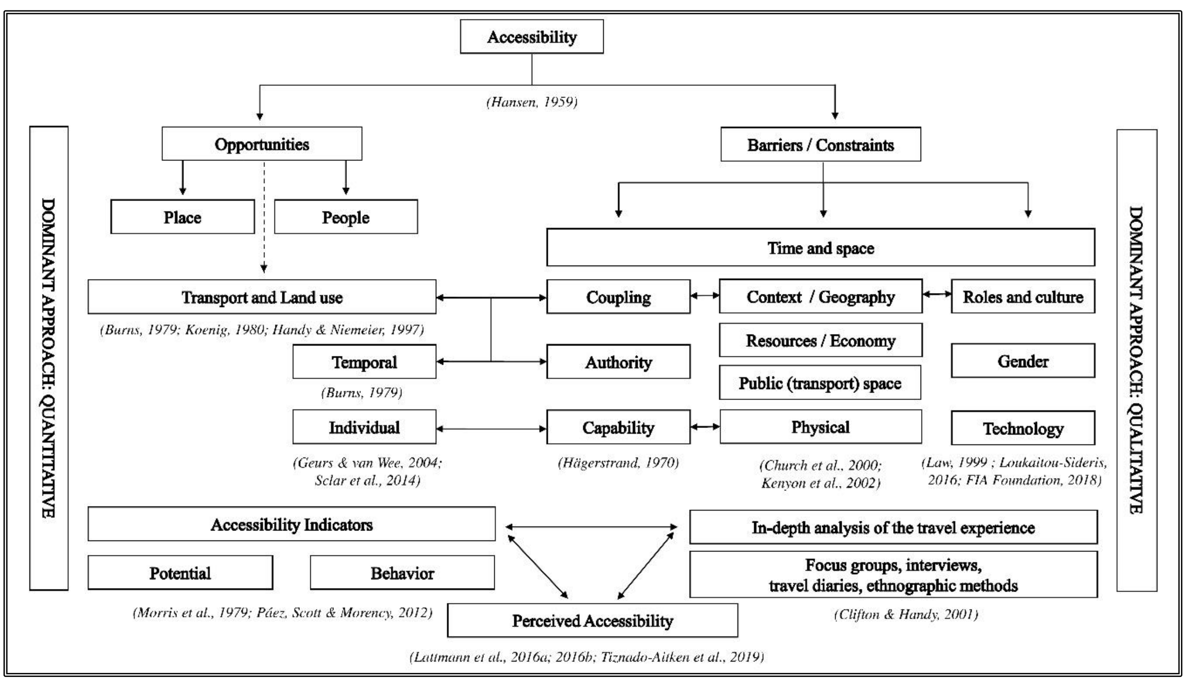

Figure 6-1 Theoretical framework for accessibility analysis (Source: Own elaboration)

6.3.2 Content analysis of focus groups

We used the proposed theoretical framework to analyze the focus groups through content analysis. This method may have a quantitative or qualitative approach. Despite both having their advantages and disadvantages (Vigar et al., 2011), in this work a qualitative approach was adopted since it allows a deeper analysis of the discourse meaning (Mariné Roig, 2013). To focus on the interactions and reactions during the instance, we recorded each focus group and then a transcript was made in order to analyze deeply the ways in which people refer to all topics, identifying in which of them are consensus or dispute (Guiver, 2007). We structured the analysis using concepts, categories, macro categories and accessibility components or barriers. In the initial open coding, we assigned conceptual labels to the different topics, identifying dimensions that were refined through repeated inspection. Then, we performed a two-step secondary or axial coding (Gardner and Abraham, 2007), analyzing first the relationships between labels and general conceptual categories, and then the links between categories to create macro categories. During this process we were open to find new macro categories and dimensions, different from those identified prior to each focus group instance: the travel experience and the 'socially constructed' narratives around public transport.

After the coding of qualitative concepts, categories and macro categories for perception and narratives of the transport environment, we labelled each one using the dimensions identified in the framework. This way, we can analyze if people refer most to opportunities or barriers in the narrative of their accessibility experience. As we would see later, we found barriers linked to a disparate perception of the built environment around transport infrastructure and the public transport itself, which create a ‘socially constructed’ narrative for buses and Metro.

It is important to note that the content analysis developed here was interpretative and not generalizable. This means that the collective discourse obtained in focus group reflects micro-scale dynamics, so the findings should be not treated as a common rule or generalizable for the whole community given the heterogeneity within them. Thus, our objective was to find qualitative dimensions at a micro scale to better represent accessibility analysis. The main insights and findings should be used with cautious since our study is not seeking to fully understand the perception or social discourse of all the inhabitants of the Greater Santiago nor the municipalities selected for the case study.

6.3.3 Survey

Before each focus group, a brief survey was carried out to systematize and characterize the participants, obtaining information that would complement the focus group narrative with quantitative data provided by each participant. This survey was divided into 4 sections: the first sought to obtain a basic socioeconomic characterization of the respondent, the second to obtain basic mobility data, the third some details about the most frequent trip the person made and, finally, some questions about evaluation and perception of public transport in Santiago.

6.4 Setting out the context: Santiago de Chile and its public transport system

The Greater Santiago, the main urban center of the Chile’s Metropolitan Region, is composed by 34 municipalities, with a population of 6.12 million inhabitants and an urban extension of 640 km2 (National Census, 2017). The dimensions of the city and the uneven spatial and social distribution of resources makes the provision of inclusive and efficient access to opportunities through public transport one of the major challenges for Santiago.

In 2002, dissatisfaction with the public transport system was widespread across the population of Santiago, being one of the worst evaluated services (Díaz, Gómez-Lobo and Velasco, 2004). This system, the so-called "Micros Amarillas” (yellow buses) was based on atomized and private operators softly regulated (Muñoz and Gschwender, 2008). Operators obtained their profits based on the number of passengers in their routes, which generated on-the-street competition between buses (Díaz et al., 2004). Furthermore, the high percentage of accidents and environmental externalities (Muñoz and Gschwender, 2008), made imperative to find a way to improve the public transport within the city.

As a result, a new public transport system was implemented in 2007 called Transantiago, comprising buses and Metro. The new system formalized bus operators into few firms, integrated the underground and the private bus networks following a ‘trunk-feeder’ service structure and integrated fare payment through a touchless smart-card (Muñoz and Gschwender, 2008). After a very rough start, numerous improvements have been made, such as more frequent services, more buses, new routes and shorter waiting times. However, the user perception has not improved substantively, being evaluated on average with a 4.5 grade of a maximum of 7 (DTPM, 2018), showing that the system still does not fulfill the people's expectations.

Despite integrating buses and metro, the image of the public transport system is regularly dissociated, linking the name Transantiago only with buses, while Metro is usually assumed to be independent. The wicked social image that Transantiago has as a 'brand' motivated a political and communicational campaign of the current Chilean government in March 2019, proposing a rename for the transport system called RED, a "double entendre" since the word means network in Spanish but, at the same time, new buses are coming in red color. This modification was promoted by the Ministry of Transport and Telecommunications (MTT) including the incorporation of 200 new electric buses, 490 ecological buses (Euro VI standard) and Line 3 of Metro, becoming the largest network in Latin America with a total of 140 kilometers. Also, this modification included the construction of the future Lines 7, 8 and 9 of the Metro, along with the extensions of Lines 2,3, 4 and 6, as well as the projects of commuter suburban trains such as Melipilla and Batuco (MTT, 2019).

The new name will gradually leave behind the Transantiago brand as new buses are added along with the upcoming public transport system tenders. The objective of the new identity is to reflect the change in the standard of public transport that the Government is implementing for both metropolitan and region public transport systems. In addition to a new fleet, the change includes features that aim to generate a more comfortable trip, such as air conditioning, chargers with USB ports, padded seats, universal accessibility, safe cabins for bus drivers and a more harmonious design of internal spaces MTT, 2019).

Despite these important innovations and the efforts to improve the standards for a better level of service, buses are not receiving a high relevance in road space distribution, giving priority to private transport and lacking specialized infrastructure for public transport. In fact, the plans mentioned consider only 20 extra kilometers of new bus lanes. This is especially detrimental for the users, since 26% of the trips in Santiago are made by public transport, from where 52% of them being bus only, 22% Metro only, and 26% involving bus-Metro combinations (SECTRA, 2015). This is why a deep understanding of the travel experiences when accessing opportunities in the city using public transport is key, which requires exploring the dimensions or barriers linked to the dissimilar perception of transport environment by different users that creates a ‘socially constructed’ narrative for buses and Metro.

6.5 Case study: Cerrillos and Peñalolén

In our study, we did not address the macro scale of the Greater Santiago. Instead, we analyze two municipalities: Cerrillos and Peñalolén (Figure 2). Their distance to the historical CBD is around 10 kilometers, with Cerrillos in a peri-central location and Peñalolen in a peripheral one. The two selected municipalities share some other key attributes that make them attractive for this study (Table 1). Both municipalities have very similar demographics, household composition and gender indicators. As we can see in the table, on average, both are medium-income municipalities, presenting a relatively similar monthly income per worker (BSC, 2018) but with an important mixture in their composition.

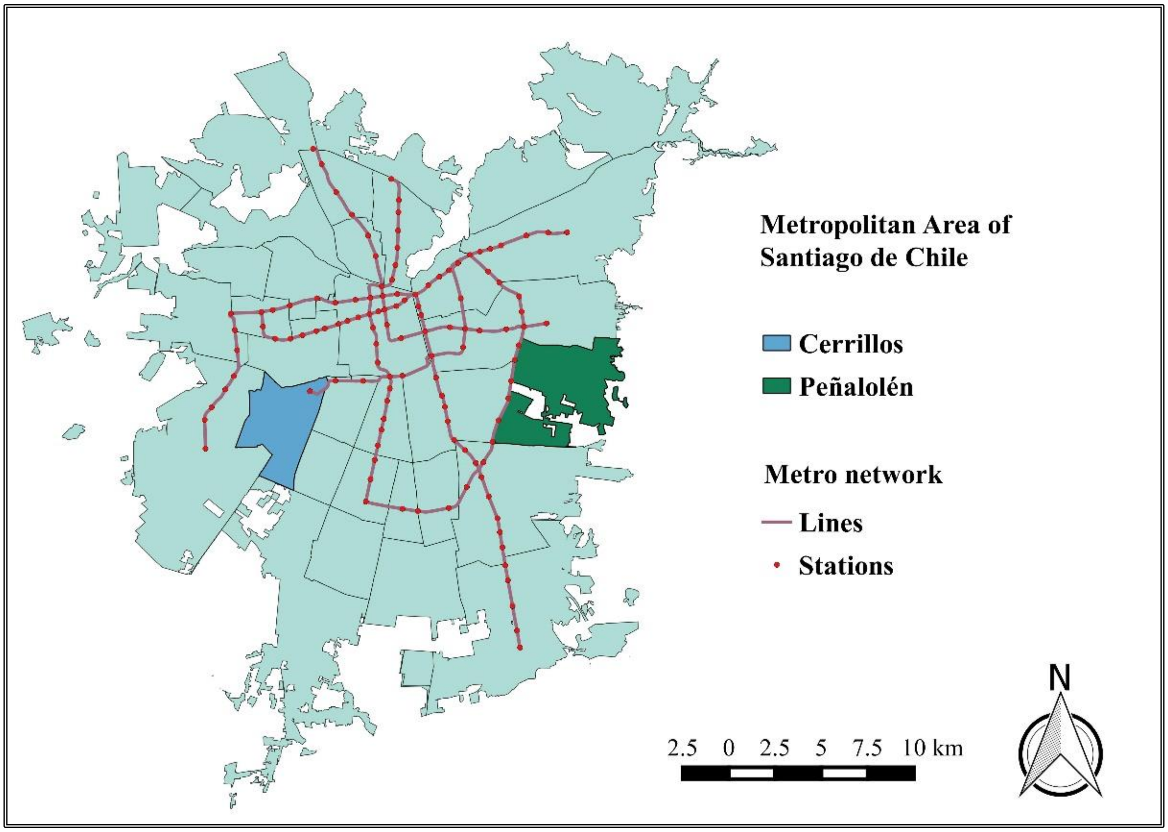

Figure 6-2 Peñalolén and Cerrillos, the two municipalities of our case study. As we can see, Cerrillos have a metro station. This station belongs to the new Metro Line 6 and the focus groups were undertook one month after the inauguration. (Source: Own elaboration).

Table 6-1 Key attributes of Peñalolén and Cerrillos. Both municipalities share social, economic and demographic characteristics, but hide a high heterogeneity (Source: Own elaboration, using National Census (2017) and BSC (2018) data).

Key attributes **(National Census, 2017; BSC, 2018)**	**Cerrillos**	**Peñalolén**
Demographics		
Population	80,832	241,599
Population density	4506 inhabitants/km^2	4819 inhabitants/km^2
Average age	35.7 years	35.2 years
Child/Young (15 years or less)	20.1%	20.3%
Elderly (65 years or more)	11.9%	10.3%
Household composition		
Single	13.2%	12.2%
Single parent with children	13.0%	13.2%
Couple without children	11.0%	9.7%
Couple with children	30.2%	32.8%
Social and economic indicators		
Educational background (Head of the household)	10.6 years	11.1 years
High education finished	72%	74%
Average raw income per worker	1228 USD	1429 USD
Multidimensional poverty	19.7%	20.7%
Gender		
Women working	42%	45%
Women head of the household	44%	43%

We can see this in Figure 3, where we showed the years of study of the head of the household. Despite the income distribution is not available, the number of years of study is highly correlated with household income. The figure shows a highly heterogeneous distribution: on the one hand, 30% of the population in both municipalities have 8 or less years of study, which corresponds to primary education; on the other hand, 55 to 58% of the population in both municipalities have at least 12 years of study, which corresponds with professional degrees or postgrads studies. Another proof of this heterogeneous composition is the multidimensional poverty indicator which considers education, health, work, housing, environment, network and social cohesion elements (MDS, 2015). Despite the middle-income average, 1 out of 5 inhabitants in both municipalities are poor.

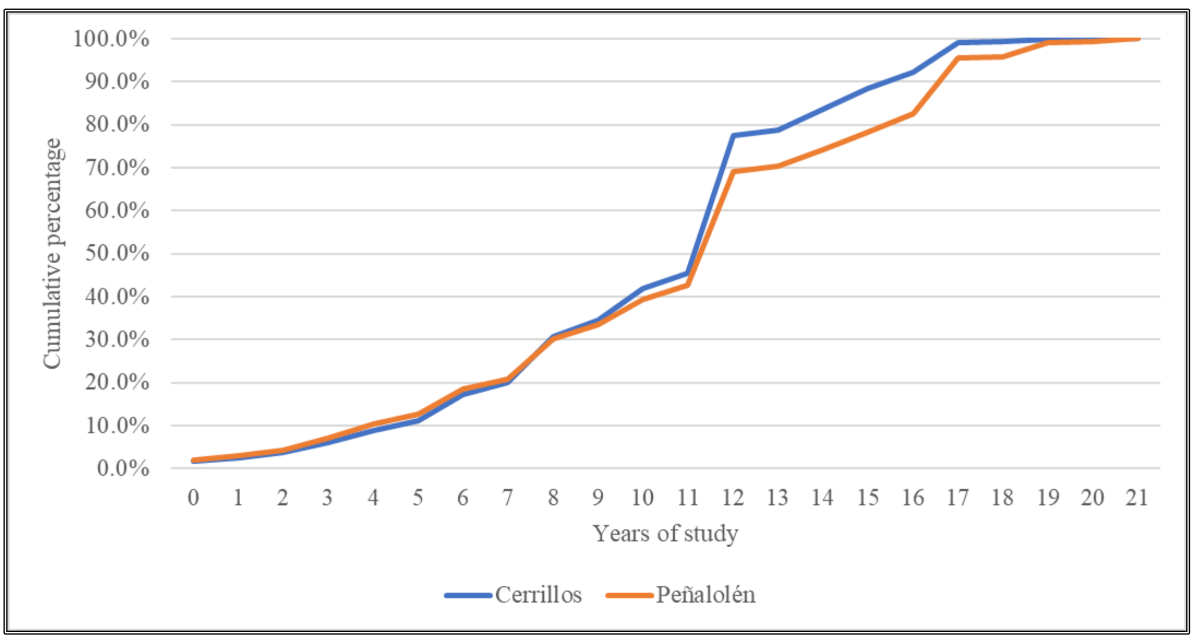

Figure 6-3 Year of study of the head of the household in Cerrillos and Peñalolén (Source: Own elaboration, based on National Census (2017)).

Therefore, we can see that both municipalities share a lot of characteristics and shows an important socioeconomic mixture. Our intention in this case study is not to compare the accessibility of rich and poor people, but instead, to go deep into the perception and experience of the inhabitants of middle-income municipalities, which are usually overlooked in the transport planning process and also present socioeconomic similarities but differences in terms of accessibility and public transport quality, as we will see in the next subsection.

6.5.1 Focus groups participants and their spatial context

We used focus groups aiming to obtain a wide range of experiences on accessibility and public transport in the urban context. The underlying approach used here is social constructivism, which assumes that 'common sense knowledge' of daily reality is a collective product of social interaction (Berger and Luckmann, 1966). We observed how people express their thoughts, defend their ideas and construct a vision in a conversation with others. In this debate ideas can be modified (Wilkinson, 1998), so people face the challenge to make collective sense of their experiences and beliefs (Morgan and Spanish, 1984).

The sampling method was an intentional or purposeful sampling (Marshall, 1996). We selected a purposeful sample to answer our research question and to obtain data richness considering limited resources (Schatzman and Strauss, 1973; Patton, 1990; Patton, 2002). Thus, we expected that the socio-spatial characteristics of the sampling and the individual knowledge about the phenomenon of interest would allow us to explore deep (Ritchie et al., 2003; Cresswell and Plano Clark, 2011) into the topics of accessibility, transport environment and public transport travel experience

We conducted 4 focus groups, 2 in each municipality. In each one, we conducted one for mostly public transport users and another for mostly private transport users. Both groups can sporadically use the other mode, so it's useful to compare perceptions of the system. As shown in Table 2, each focus group were composed of 8 to 10 people, so a total of 35 people participated in the study. Participants were men and women in an age group between 28 and 53 years, with a greater women representation to capture gender differences and to explore different topics of concern. All the participants traveled regularly during the week and there were no requirements for occupation or household composition.

Table 6-2 Composition of the focal groups (Source: Own elaboration)

	Participants			
Location	Men	Women	Target users	Age group (years)
Peñalolén	2	6	Public transport	30 to 49
Peñalolén	5	3	Car	29 to 53
Cerrillos	3	6	Public transport	28 to 45
Cerrillos	1	9	Car	31 to 51

Each focus group was between 60 and 90 minutes and was semi-structured, using open questions to guide the discussion. The main topics were (i) the travel experience, talking about the usual trip, the experiences and difficulties accessing and using public transport,

(ii) the most important attributes of the transport environment, and (iii) the 'socially constructed' narratives around public transport, talking about Transantiago, its transport modes and a comparison with the previous system ("Micros Amarillas").

We used the Metropolitan Public Transport Directory zoning, which divides the city into 800 zones, to show the residential location of the focus group participants (Figure 4). This figure present population density, the built environment quality and accessibility to public transport stops in these zones respectively. The 35 participants reside in 17 out of 41 areas in which the municipalities are divided: 7 in Cerrillos and 10 in Peñalolén. It is possible to observe that, in the case of Cerrillos, the participants are mostly concentrated in the central-southern and western zones, while in Peñalolén, they live in the central-northern and western zones. Thus, the participants live in both high- and low-populated areas.

In Tiznado-Aitken et al., 2018, we create two indicators for all Santiago municipalities: (i) a Environment and Urban Quality Index (EUQI) with values ranging between 0 and 21 and (ii) a Physical Accessibility Indicator (PAI) to analyze accessibility to public transport stops with values ranging between 0 and 1. When we looked at Peñalolén and Cerrillos, and specifically the location of focus group participants, we found a large heterogeneity in the two aforementioned indicators (Figure 4 and Table 3). Some participants are located in low-quality urban environments with low accessibility to public transport, meanwhile others lived in well-connected and high-quality environments, reflecting the relevance to study the micro scale of the experience while people access to public transport.

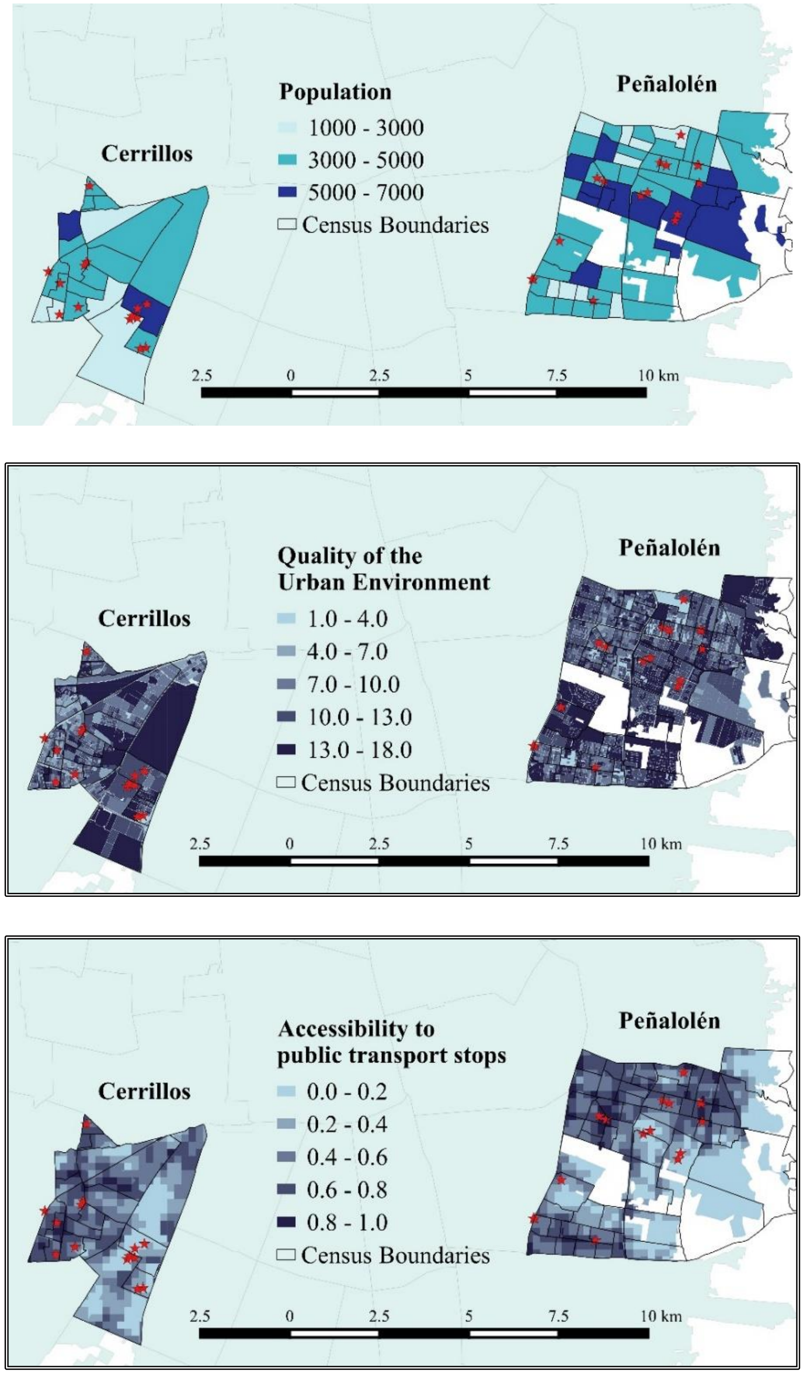

Figure 6-4 The context and urban conditions of focus group participants. On red, every location of the focus groups participants. The first picture shows the total population in each census boundary, the second picture shows the quality of urban environment and the third picture, the accessibility to public transport stops. (Source: Own elaboration)

Table 6-3 Descriptive statistics of quality of urban environment and accessibility to public transport indicators among participants in Peñalolén and Cerrillos. It is possible to see that there is a high variability within each municipality for both indicators (Source: Own elaboration, based on Tiznado-Aitken et al., 2018).

Indicator	**Descriptive statistics**	**Indicator value for Peñalolén**	**Indicator Value for Cerrillos**
Environment and Urban Quality Index (EUQI)	Average	11.19	9
	Standard deviation	5.15	3.48
	Minimum	3	3
	Maximum	17	14
Physical Accessibility Indicator (PAI)	Average	0.48	0.36
	Standard deviation	0.28	0.23
	Minimum	0.05	0.01
	Maximum	0.89	0.72

The profile of the average public transport user in this municipalities, according to the last Origin-Destination survey of 2012 (SECTRA, 2015), highlight some interesting trends. First, the modal share in both municipalities are the same: almost 1 out of 5 trips are made by public transport. However, 76.6% (Peñalolén) and 85.9% (Cerrillos) of those trips are made by the two lowest-income quintiles[2], reflecting the dependence of low-income population on public transport. Additionally, most of the trips are made by women and over 28% by people over 50 years. In fact, most trips in Cerrillos are not in a majority for work and study purposes: shopping, care, health, leisure, administrative and non-mandatory

[2] According to the Metropolitan Region income distribution (MDS, 2013a)

activities account for 54%. In Peñalolén, despite work and study account for 62.6% of the trips, shopping, leisure and other non-mandatory activities account for 27% of the public transport trips.

These statistics reflect a dependence on public transport for vulnerable population groups (medium and low-income, women and elderly) for both mandatory and non-mandatory trips, crucial for a more comprehensive analysis of social exclusion. These data and the previous work done in Santiago regarding the quality of urban environment and access to public transport stops will be useful to understand and complement better our analysis in the following sections.

6.6 Findings

A summary of the results is shown in Table 4. As we stated before, we related the concepts found in the content analysis of each focus group with accessibility components or barriers identified in the theoretical framework presented in Figure 1. We derived some new categories or macro categories of analysis, related to the convenience of transport modes and the overall experience of usual trips. Also, we divided some categories in order to be more accurate, as the comparison between Transantiago and Micros Amarillas. This allowed us to analyze the differences between Metro, buses and the evolution of the public transport system, as well as the economic dimension in the usual trips that inhibit or enhance accessibility within the city.

If we look at the concepts founded in the content analysis in Table 4, 3 out of 4 are related to the transport dimension and the coupling, gender, public transport space and public space barriers. Most of the concepts were linked with more than one dimension, showing the complementarity and interrelation between the opportunity and the barrier approach. Below we analyze more deeply these results. We highlighted the four main findings considering the key dimensions identified and the differences by gender, age, location and the primary transport mode used.

Table 6-4 Summary of qualitative findings in focus groups. We use CCAR, CPT, PCAR, PPT as a nomenclature for focus groups (CCAR: Cerrillos Car, CPT: Cerrillos Public Transport, PCAR: Peñalolén Car, PPT: Peñalolén Public Transport) (Source: Own elaboration)

Macro categories	Categories	Concepts	Accessibility: Components or barriers	CCAR	CPT	PCAR	PPT
Convenience	Price	High quality-price ratio	Economy	x	x	x	x
		Urban highways (car users)	Economy, coupling	x		x	
		Double payment for long trips (transfers)	Economy, coupling, context, geography				x
		Parking (car users)	Economy, coupling	x		x	
		Unfair due to fare evasion	Economy				x
	Use of other transport modes	Due to price	Economy	x		x	
		Due to speed and convenience	Transport, coupling, gender	x	x	x	x
		Due to security	Public transport space, gender		x		x

Table 6-4 (cont.) Summary of qualitative findings in focus groups.

Macro categories	Categories	Concepts	Accessibility: Components or barriers	CCAR	CPT	PCAR	PPT
Socially constructed narrative	**Buses**	Long waiting times	Transport, coupling, public transport space	x			
		Alternative to Metro	Transport, coupling				x
		Bus corridor improve service	Transport, coupling				x
		Uncertainty	Transport, coupling	x		x	x
		Uncomfortable	Public transport space, gender			x	
		Slow	Transport, coupling, gender		x		x
		Less crowded than Metro	Public transport space, gender		x		
		Unawareness of bus routes	Capability, context, technology			x	x
		Dirty	Public transport space			x	
	Metro	Limited access due to isolation	Geography, context	x	x		
		Operational failures	Transport, coupling		x		x
		Chaos	Public transport space			x	x
		Reliability	Transport, coupling	x	x	x	x
		Efficient	Transport, coupling, gender		x		
		Overcrowded	Public transport space, gender	x	x	x	x
		Limited service hours	Coupling, authority				x
		Network awareness	Transport, capability			x	x
		Fast	Transport, coupling, gender	x	x	x	x
		Safe	Public transport space, gender			x	
	Transantiago vs MA (+)	Intermodal stations	Transport, coupling		x		
		Contactless payment (Tarjeta BIP)	Technology, capability	x	x	x	x
		More transfers	Transport, coupling, public transport space	x	x	x	x
		Better bus drivers	Public transport space	x		x	
		Less accidents	Public transport space	x			
		Less pollution	Public space	x			

Table 6-4 (cont.) Summary of qualitative findings in focus groups.

Macro categories	Categories	Concepts	Accessibility: Components or barriers	CCAR	CPT	PCAR	PPT
Travel experience	Public transport level of service	Kindness and driving attitude	Public transport space	x		x	x
		Comfortable	Public transport space, gender	x	x	x	x
		Skipping bus stops	Transport, coupling				x
		Comfortable and inclusive design	Public transport space, capability	x	x	x	x
		Frequency	Transport, coupling	x	x	x	x
		Operating hours	Authority, coupling				x
		Places to charge payment card	Coupling, technology	x	x	x	
		Regularity	Transport, coupling	x	x	x	x
		Public transport resilience	Transport, coupling		x		x
		Security	Public transport space, gender		x	x	x
		Turnstiles	Public transport space, capability	x	x		x
	Urban environment	Isolation	Geography, context	x			
		Lack of green areas	Public space, geography	x	x		
		Beauty gap between municipalities	Public space	x	x	x	x
		Beauty gap within municipality	Public space			x	x
		Unfair and unworthy	Public space				x
		Insecure	Public space, gender	x	x	x	x
		Street and sidewalk poor conditions	Public and transport space			x	
	Usual trip	To/from work	Coupling	x	x	x	x
		Poor coexistence between transport modes	Public transport space			x	x
		Two tales: activity concentration vs counterflow	Land use	x	x	x	
		Trip chaining (familiar purposes)	Gender, roles and culture	x			
		Early departure to avoid congestion	Transport, land use			x	
		Multitasking	Economy, temporal	x	x	x	x
		Use in different time periods	Temporal	x	x	x	x

6.6.1. The 'socially constructed' narratives around public transport

Despite the fare and (some) operational integration, people perceived Transantiago as the bus system, while understanding Metro as an independent public transport mode. Overall, Metro system is perceived as reliable and fast for traveling but overcrowded. This scenario matches with the usual level of service of the Metro network in rush hour, which is attractive for time restrictions and coupling barriers since people need to get on time to mandatory activities as work or study.

Despite the bus perception not showing a clear agreement (the words mentioned to describe this transport mode does not fit exactly for everyone), almost all the concepts have a negative connotation and most of them are related to operational issues, also acting as coupling barriers. Even though people use public transport in different time periods, we found that they refer to the usual and most congested peak period to talk about their experience while traveling. That means, the worst-case scenario seems to dictate their overall reported perceptions for both Metro and buses (like Guiver (2007)'s study found for bus users) despite the fact many of the trips made by the participants are non-mandatory and likely to be made outside of peak-hour periods.

Usual public transport users add three elements to the social narrative of public transport. First, the bus is perceived as a slow mode, but mostly due to the congestion they must face. This outcome is supported by data in Santiago, which show that only 11% of the length of the bus network have priority on the streets, i.e., is covered by bus lanes or bus corridors (DTPM, 2017). Second, related to the former point, is that although the social narrative of the bus is associated with uncertainty and less familiar routes than those of Metro, public transport users in Peñalolén who had a bus corridor in one of the main roads crossing their municipality, expressed a high valuation for the system for speed, reliability and comfort, evaluating it as a valid alternative to Metro. Third, Metro is perceived as a vulnerable mode exposed to operational failures, which generates a significant “paralysis” of the city's mobility. For this reason, the participants mentioned the importance of a more redundant and robust transport system, suggesting the complementarity between buses and Metro, as we will detail later.

Regarding the evolution from Micros Amarillas (MA) to Transantiago, the main differences perceived by the participants were the transfers and the contactless payment system. The former is a negative element, related to less direct single routes which force people to make more transfers to reach destinations using Transantiago. The latter is a positive one; Micros Amarillas (MA) did not have a contactless payment using smart cards, forcing people and drivers to, for example, manage cash, rising risks of theft and delaying the alighting process. People from Cerrillos added the benefits of intermodal stations and less negative externalities generated by Transantiago, like pollution and accidents. The latter were one of the main reasons to change the system from MA to Transantiago, and the results are evident, with a current bus fleet 15 times less contaminant and the recently launched Euro VI buses 25 times less contaminant compared to MA (MMA, 2015).

6.6.2 The 'hidden' value of buses

Usual public transport users have a slightly more positive narrative and evaluation about the system than usual car users. We observed that their evaluation of Metro and buses was the same, and the gap compared with usual car users was bigger in the case of buses (4.6 vs 3.3) than Metro (4.6 vs 4.2)[3], whose difference is not statistically significant. Thus, the hidden value of buses shown in this section is mainly reported by actual public transport users. In fact, Transantiago's satisfaction studies reports that people evaluate better their usual bus service (4.7) than the overall system (4.3) (DTPM, 2014b), showing the importance of the user experience.

The overall perception in Cerrillos is that accessibility by public transport and the bus provision is limited. People refer to their municipality as an isolated one, where moving by public transport is an extremely bad experience, using transport, environmental and land use elements to describe how the geographical barriers affects their daily mobility experience. For example, despite one of the new Metro stations from Line 6 is placed in Cerrillos and it was inaugurated during 2017 before the focus groups, most participants in this municipality perceived limited access to Metro. Inadequate bus services and public transport stops, in addition to a low quality of the urban environment, hinder the inhabitants of Cerrillos from a better connection with a high-quality investment like Metro, key for daily mobility. Participants revealed the key role of buses given their capillarity function and underlying

[3] Buses represent a statistically significant difference (p-value < 0.05). Buses: p-value = 0.011 in the Wilcox rank sum test with continuity correction and p-value = 0.007 in the Welch Two Sample t-test.
Metro: p-value = 0.094 in the Wilcoxon rank sum test with continuity correction and p-value = 0.187 in the Welch Two Sample t-test.

connectivity with the Metro system, giving a proper recognition of the usefulness of buses. The situation is so critical that even informal alternatives appeared to solve this lack of bus services that connect with Metro.

"The problem is that most of the zones in our municipality does not have direct access to the Metro. There are no routes to get there, so there are little people of Cerrillos who benefits from the new station" [Paula, Female worker, usual public transport user, Cerrillos]

"There is a neighbor who has a van, who runs a kind of van. (...) He says ok, I have 10 people here, 10 people there and they have schedules, "I'll pick you up at 7, you 7:10, you 7:20", and he fill his van and leave them in the Metro station" [Paula, Female worker, usual car user, Cerrillos]

As we stated before, Metro is perceived as a vulnerable mode exposed to operational failures. When this situation occurs, buses in Santiago try to adequate and reinforce the supply in surface and made a similar route to Metro on the surface. Despite the efforts, buses are not usually very successful on this task, generating coupling issues for the users. For this reason, the participants mentioned the importance of a more integrated and redundant public transport network, suggesting that bus services on 'structural roads' of the city -with routes like those of Metro- should exist. This could be useful not only for operational failures, instead to give more alternatives to people to travel in any time period, reducing crowding and providing routes for different user preferences.

"I think the greatest solution is to improve the bus routes, because theoretically, there should be buses that made the same route as Metro, you know? As well as when Metro has a problem and they put these emergency buses that do the same route. It improves immediately. I think that is the idea, especially in Line 1 which is the most crowded one, having bus routes with stops in the exact same points" [Catalina, Female worker, usual public transport user, Cerrillos]

Thus, a better public transport system should consider alternatives to Metro and a proper integration between modes, understanding public transport as only one system. A proof of this is the Peñalolén case, where the provision of infrastructure dedicated to buses can significantly improve the level of service and the social perception of users. This leads to think that for some municipalities that do not have Metro or that want a greater resilience in the system, the on-the-streets bus priority could be a great solution from a technical point of view, especially considering the budget constraints that authorities face and the flexibility that buses could offer to the whole system. The most interesting thing about this is that users seems to agree with this technical solution, highlighting the benefits from bus priority like in Avenida Grecia[4].

- *"Sure, I leave the house, I have the bus stop there and I take it. (…). The 511, the 507, the 506, the 519 and others come here. Sometimes even I do not take the first bus to travel seated" [Gianina, Female worker, usual public transport user, Peñalolén]*

[4] One of the main roads in Peñalolén, which have bus priority and a bus corridor

- *"Avenida Grecia is the best avenue" [Janet, Female worker, usual public transport user, Peñalolén]*
- *"When I go to the center to do some paperwork, I also go to Grecia. Any micro (bus) that goes through Grecia is super-fast. Your delay is almost none"*
  [Igor, Male worker, usual public transport user, Peñalolén]

6.6.3 The dissimilar perception of transport environment: empathy and travel behavior

Many important elements in people's travel experience are related to the level of the service in public transport and were mentioned across all focus groups: frequency, reliability, comfort and transfers. The perception of all these elements were incorporated in accessibility indicators in our previous work (Tiznado-Aitken et al., 2016), except for the reliability between routes available to users, allowing us to validate the importance of these attributes in our selected contexts.

However, other attributes were also identified. The comfortable and inclusive design for buses were also mentioned in all focus groups. Factors such as handles to fasten, seat design and the bus layout considering the presence of turnstiles, low floor or ramps were constantly mentioned by the participants, highlighting the importance not only of coupling barriers and transport supply components, but also the individual or capacity barriers, since pregnant women, the elderly, people with children or those with reduced mobility are the most affected. Overall, even when the participants were not directly affected by this, they showed empathy for other users that must face these barriers in their everyday mobility.

Despite the general valuation of these attributes among participants, we observed some clear perception differences by age. In the focus groups, 1 out of 4 participants were over 40 years (46 years on average). Comparing this group with the rest, we observed that older people evaluated worst the public transport experience in our survey: buses (2.8 vs 4.2 out of 7) and their overall access by public transport (4.3 vs 5.7 out of 7)[5], with no significant differences for Metro. Moreover, older people not only referred to their personal travel experience, but also their children. Some of them prefer to pick up their children by car at night or advise them to take a taxi to overcome the lack of public transport alternatives or to avoid some routes or public spaces, especially in isolated places in Cerrillos.

"I cannot tell my daughter, who is 24 years old, "come back home alone at 11 o'clock". One day, she starts heading home at 9 o'clock (...) 9 o'clock is early, but she arrived here at 11 o'clock, "Mom, it's a wolf mouth" she told me, "Next time I'll stay here, and you pick me up." What would she do walking alone from beyond Indura (Landmark in Cerrillos)? Maybe she does not get home "[Sandra, Female worker, usual car user, Cerrillos]

"It's horrible, because to get to the Metro you do not have any alternative from here. From my house, it's like 20 minutes-walk or half an hour to be able to get to the Metro. It's horrible. Sometimes they (his children) call me and they tell me "dad, come pick me up at the subway station"" [Esteban, Male worker, usual car user, Cerrillos]

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[5] Both represent a statistically significant difference.
Buses: p-value = 0.02 in the Wilcoxon rank sum test with continuity correction and p-value = 0.036 in the Welch Two Sample t-test.
Overall access: p-value = 0.014 in the Wilcoxon rank sum test with continuity correction and p-value = 0.03 in the Welch Two Sample t-test.

Strong gender differences in accessibility barriers were observed too. We identified 3 key elements in the public transport level of service: speed, comfort and safety (Table 3). In general terms, for women the speed is not necessary the most important attribute and that is why some of them prefer the bus, which allow them to have a ‘friendlier’ trip, more relaxed and comfortable. The completely opposite situation was observed for men, who generally prefer traveling fast, without giving a high relevance to poorer safety and comfort conditions, usually represented by Metro services in rush hour.

“In general, I like more to travel in ‘micro’ (bus) than in Metro, but the problem is that there are more ‘tacos’ (high congestion). It is more uncertain the time you are going to arrive, but I have a very friendly route, it is not so crowded, so I prefer micros” [Paula, Female worker, usual public transport user, Cerrillos]

"I use the subway every day, especially in the morning. And there is a day that I take the bus, but I prefer not to take the bus because it takes a long time (...). It's because of the speed. Is just some time that you are crowded, but it is faster. That's why I made that choice" [Sebastián, Male worker, usual public transport user, Peñalolen]

Because women are usually more worried about safety and comfort, they change their travel patterns more than men, modifying transport routes, modes and times, even deciding not to travel (FIA Foundation, 2018). Security and safety are mentioned as one of the main inhibitors of the desired travel, being perceived by women not only in public transport space but also in the urban environment, an important component while access and egress public transport stops. These elements show some important gender and fear of public spaces barriers that women face in their day-to-day travel, revealing one of their main reasons to use car or other private alternatives.

"So, at that moment [stoned bus] I made the decision not to take that route anymore and actually I'm going to Melipilla taking the road to Melipilla or Plaza Maipú, but I do not stop by Lo Errázuriz. For those places, no, not anymore. I do not take I04 or I18 routes" [Bárbara, Female worker, usual public transport user, Cerrillos]

"I agree with you on the luminary at night issue. Personally, I do not feel insecure, but I do think that women are very influenced by the issue of security, that is, if you are walking just behind them, they start to walk faster, and that is because they are scared. In the municipality, people are scared" [Yerko, Male worker, usual public transport user, Cerrillos]

The main elements in the travel experience regarding the urban environment (see Table 3) are totally different when traveling around Santiago. Overall, participants noted that there is a significant disparity between the built environment standards of different municipalities. Better infrastructure and greater beauty are a reproduction of the socio-spatial disparities, evidencing a greater investment in the richer municipalities, as Rossetti et al. (2019) showed. The lack of green areas was consistently mentioned, which makes the environment an arid, dry and unattractive place to walk. This shows a relevant barrier not only for the use of public transport, but for walking and cycling. In fact, for short trips that should be carried out in sustainable transport modes according to distance, participants declared to prefer using the car due to poor environmental conditions and transport infrastructure.

This disparity was mentioned not only between municipalities, but also within them. In the case of Peñalolén, the participants said that well-maintained and safe environments are regularly in richer zones and other nearby ones are the total opposite. In addition, an overall poor road maintenance is perceived. Again, this reflects socio-spatial disparities, but probably from a different perspective since it seems that the municipality resources are not equitably distributed across urban space. These public space barriers are probably one of the most overlooked elements in the usual analysis of accessibility by public transport, but people (users and non-users) give it a high importance.

6.6.4 The accessibility narrative and the interrelation among barriers

According to the theoretical framework presented on Section 3, people referred more to barriers than opportunities. When people talked about their mobility experiences, they referred mostly to the worst every-day situations that hinder their accessibility, avoiding them to take full advantages of the available opportunities. For example, references to land use (distribution of opportunities) and opening hours were practically null, and the transport network elements were implicitly mentioned within the overall experience and perception while using public transport.

We observed a narrative that show interrelation between different accessibility barriers, where some strategies to overcome one dimension leads to difficulties in others. This is especially relevant for vulnerable populations. For example, for medium- and low-income people, coupling, public space and public transport space barriers could lead to a high use of private modes (cars, taxis or shared-cars), generating a car-dependence that could generate economic struggles, leading to some trade-off among dimensions. An example of this situation could be observed on some participants in Cerrillos, who state they use car for a 'need for access' due to both physical isolation and bad bus connectivity. They are 'forced' to use more expensive transport modes like cars and the consequent payment of tolls and parking, or uber/taxi to move by night or reach the Metro stations, trying to coordinate among family members to be more efficient.

"My husband studies at night, and sometimes he is late. If he does not reach the Lo Ovalle metro train before 11 pm, he runs out of micros (buses) to get here. Then he says, "my love, I'm not going to reach it", and there he starts looking for a taxi or asking for Uber, and that also makes travel more expensive" [Tamara, Female worker, usual car user, Cerrillos]

For the elderly, a non-inclusive and unsafe design or turnstiles in buses, classified as capacity or individual barriers, could lead to a worst travel experience, to prefer other transport modes or even to be immobile. Likewise, fear in public transport, with low-quality and insecure urban environments could lead even to be immobile or car-dependent, especially for women at night. Some of these women also face extra constraining factors in their travel pattern. For example, care trips are mainly carried out by them. There is a remarkable level of trip chaining in their travel pattern and trips with non-mandatory purposes (Sagaris & Tiznado-Aitken, 2018). This kind of behavior is almost never mentioned in the case of men, reflecting some gender, role and cultural barriers in the municipalities analyzed.

"I am alone with my two children. One of my children studies in Tobalaba with Alejandro Sepúlveda (address), and I have to arrive at 8 at that point. My daughter is near the house and I have to leave her at 8:30 in the kindergarden. I have to be stuck in the taco for half an hour for my daughter. Then I go to work at 9 (...) I almost never get on time" [Ángela, Female worker, usual car user, Peñalolen]

"In my case, well, we recently sold the car, so the main transport mode that I'm using now is public transport (...). I am going to leave my daughter every day at school. I take the bus, I14 there in Mirador (Landmark in Cerrillos). Also, I have to go 3 times a week to my work. I go to the city center by metro, micro or Uber" [Tamara, Female worker, usual car user, Cerrillos]

6.7 Conclusions: spatial, policy and practice implications

This qualitative research sought to further improve the characterization of accessibility according to users' travel experiences, as described by those attributes that inhibit or enhance access to opportunities within the city. The narrative that the participants made about public transport and their experience reflect spatial and contextual differences as well as individual constraints. Despite the findings cannot be generalized for overall Cerrillos and Peñalolén population, and even less for the whole metropolitan region of Santiago, some useful insights could be use with cautious.

Not all attributes can be or should pretend to be incorporated into quantitative accessibility measures. Qualitative and quantitative approaches should be complementary in order to describe and understand better the travel experience and the perceived accessibility. As we pointed out in the theoretical framework, most of the quantitative approaches look for a better description of opportunities and how to measure it in a bigger scale. The qualitative analysis, more focused on barriers and individual perceptions, allow to understand better the accessibility experience, identifying differences between different population groups and how different barriers impacts their daily mobility. This chapter not only enriches and validates our previous works on accessibility, but helping us to analyze and understand better accessibility for different users and contexts, as well as identifying key spatial, policy and practice implications.

Further to the already existing fare integration -which allows people to make longer trips using Metro and bus, paying only one ticket- people would benefit from a stronger operational integration between Metro and buses. Despite the communicational campaign that the current government has launched ‘replacing’ Transantiago, mainly for the negative brand of buses, people are currently benefited from both Metro and buses and need a better integration. As we revealed, people who use public transport value buses for a better coverage, to access Metro infrastructure and to expand their mobility alternatives, allowing a more robust network. Based on user perceptions, a higher investment and priority on-the-streets for buses would be highly valuated. This also could be translated into better accessibility indicators, including option values or substitutability (van Wee, 2016; van Wee et al., 2019) accounting for resilience, availability or redundancy in public transport routes, or even considering that some specific users could experience unawareness of bus alternatives, reducing their potential accessibility.

Significant spatial implications of our case study results can be derived. The isolation or severance in Cerrillos is a crucial problem, denying convenient accessibility through public transport to many users. To tackle this issue, an integral and intermodal accessibility vision would be highly beneficial. That means a proper bus provision and a better connection with the Cerrillos's Metro station by actives modes, considering access and egress trip-legs through a high-quality of urban space that allows users to experience a safe, friendly and attractive environment. Policies on that direction could improve the accessibility experience for current public transport users and could provide a real alternative for many people in this municipality that are car-dependent due to isolation, alleviating their coupling and economic barriers.

In Peñalolén, more equitable and just spatial planning would be important to benefit and compensate social disparities within the municipality. The bus corridor that goes through the municipality is highly valuated by users and could be replicated in other zones of Peñalolén where poor public transport connections exist. However, again the access and egress trip-legs play a key role since the participants stated that well-maintained and safe environments are regularly in richer zones and other nearby middle- and low-income ones are the total opposite. Governance issues emerge from this scenario, where the main aim should be providing a high-quality standard for public transport and actives modes across all the zones in Peñalolén, closing their gap in transport and urban standards.

Hence, a key element where more work should be done, both in academic and practice, is in a better recognition of the role of the urban and transport environment in the travel experience using public transport. Based on the perception of different users in focus groups, an indicator should consider the spatial context and qualitative findings. The weight of different elements (road safety, security, green areas, cleanliness, among others) should be derived from people's travel experiences in each municipality. For example, Tilahun and Li (2015) found that perceived unsecure environments could add up to 6 minutes in access. The inclusion of unsafe transport environments in both public transport stops and inside vehicles is still missing in the analysis and the decision-making, so more work on this line should be carried out, as the one of that Rossetti et al. (2019) proposed, using a methodology to collect data about built environment perceptions for a whole city.

Likewise, the accessibility analysis should be focused on more vulnerable groups that usually have to face lots of barriers or 'thickness' in Jirón (2013)'s words, in order to alleviate their everyday mobility and mitigate social disparities. In terms of policy, setting standards in a multidimensional accessibility analysis should be the emphasis to seek a more just and equitable scenario, benefitting and tackling the main barriers for women, low- and medium-income groups and the elderly. For example, the setting of comfortable and inclusive design seems to be a key factor, so defining goals in short and long term in the delivery of adequate public transport alternatives for those who suffer from these barriers should be priority.

Finally, in-depth understanding of the travel experiences of different population groups has rarely previously been directly translated into the development of quantitative measures of accessibility for the purposes of evaluation. As we stated before, not all the attributes can be included, but some of them could make the difference as input for practitioners. Our hypothesis is that differentiated maps by type of users which consider the perception and valuation of different key attributes in the travel experience could close the gap between usual quantitative measures and perceived accessibility. Future work could fill a gap that is still present in the literature and the challenge is how to take advantage these findings in order to make a more comprehensive accessibility analysis.

Acknowledgements

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7. ACCESSIBILITY FOR ALL? ANALYSIS OF THE CRITERIA TO DEFINE URBAN INTEGRATION AREAS IN CHILE

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7.1 Context

Accessibility to opportunities has been gaining relevance in academia and practice as the central objective of a transportation planning approach that seeks justice as the ultimate goal (Martens, 2017). To be equitable, accessibility has to fulfill different user needs, granting minimum conditions in order to reach opportunities that allow their economic and social development. Promoting the integration of the most vulnerable groups in society, providing them good transport conditions and accessibility to activities is essential, especially in Latin American cities characterized by socio-spatial segregation and social inequality (CEPAL, 2016; Deneulin and Sánchez-Ancochea, 2018)

At the beginning of July 2019, decree No. 56 was approved in Chile, which is a regulation of the Law ‘20,741’ on real estate ownership (Ley Chile, 2019). This regulation sets an article of the law in which the Ministry of Housing and Urban Planning (MINVU) can deliver urban planning standards benefits for “integrated projects” in certain places, after consulting the respective municipality (called “comunas” in Chile). The main aim of these regulatory benefits is to provide social housing in places where high land values are observed, allowing to increase the maximum capacity building in exchange for integration quotas into the project.

The regulation defines a set of conditions for the policy application: the project composition to be considered integrated, the urban planning rules on which benefits may be delivered, the procedure according to which these will be delivered, the different roles and responsibilities of the actors involved, among others. On the one hand, Ciudad con Todos (2019a) together with the Techo Chile Foundation have carried out simulations and models to assess the applicability of these benefits and the relationship between regulatory incentives and the social housing quotas that may be required.

On the other hand, the government has processed during 2019 a bill (PdL) of 'Social and Urban Integration', deepening the proposed normative incentive mechanism.. This PdL has already been approved by the Camara de Diputados (House of Representatives) and as a whole has been exposed to observations and criticisms from various actors and organizations (Bannen et al., 2019; Gasic, 2019; Centro de Políticas Públicas UC 2019; Larraín & Razmilic, 2019). Currently, this PdL is in the legislative discussion of the country's Senate.

An element that has not had enough attention in the debate, both in regulation and PdL discussions, are the accessibility criteria that a particular area must fulfill in order to be eligible to receive regulatory benefits. The regulation defines that these benefits may only be applied in specific polygons (called as "social integration polygons"), which should have proximity to transport infrastructure and urban realm (Decree No. 56, Article 6.6.2). These accessibility criteria are fundamental, as one of the fundamental objectives of this policy is to substantially improve the social housing location to facilitate their integration and access to urban opportunities. The national and international literature on accessibility allows approaching the discussion from a critical perspective, analyzing those indicators or accessibility conditions that social housing should possess.

Thus, the purpose of this work is to conduct a critical analysis of the main proposals on the accessibility criteria that potential areas, where densification and social integration in Chile will be promoted, should have. To do this, we describe the conditions established in article 6.6.2, decree No. 56, and the criteria proposed by other relevant actors in the public discussion. Then, a critical analysis will be carried out on the advantages and drawbacks of each of them, based on a more robust and comprehensive definition of accessibility to urban transport and opportunities from national and international literature. Finally, we proposed a series of recommendations to guide public policy around the location of social housing and possible future modifications to the regulation in question.

7.2 Proposals of accessibility criteria

Besides the decree No. 56, other actors have also developed proposals on the conditions that the areas should have to be eligible for densification with social integration. First, there is the Ciudad con Todos (2019b) project, born in a collaboration between the UC Public Policy Center and real estate developers. During 2019, it's objective was to provide evidence, diagnoses, and proposals on "balanced densification", preparing a report where they define

Zones of Good Accessibility (ZBA), such as those territories suitable for densification and, therefore, where social integration could be promoted.

An alternative proposal comes from the National Urban Development Council (CNDU), a state advisory that proposes urban reforms aligned with the National Urban Development Policy. During 2019, the CNDU published a document with proposals for social integration in Chilean cities, where they recommend to establish Social Integration Zones in consolidated urban areas that would operate very similar to the social integration polygons established in Law '20,741'. The CNDU also proposed criteria to define these areas, linked with both their socioeconomic composition and their accessibility to services and urban opportunities.

To analyze each proposal, we classify them according to the main conditions that determine their accessibility and densification dimensions. We consider:

(i) Accessibility to public transport: refers to the proximity to public transport and the spatial coverage through it.

(ii) Accessibility to opportunities: refers to the proximity and access to urban equipment and opportunities, reachable through walking, public transport, or other transport modes.

(iii) Load capacity: refers to a relationship between the supply (urban equipment and services) and the potential demand for such opportunities offered. In other words, the capacity of a particular territory to effectively received people.

Considering this categorization, the criteria proposed by the decree No. 56, the CNDU and Ciudad con Todos were analyzed in Table 7-1.

Table 7-1 Proposals and criteria for urban integration zones (Source: Own elaboration, based on CNDU (2019), Ley Chile (2019) y Ciudad con Todos (2019c).

	Decree N°56	**CNDU**	**Ciudad con todos (ZBA)**
Accessibility to public transport	Any of the following conditions: 1. Stops for public transport services segregated from vehicular traffic (constructed, in execution or with an assigned budget) within 700 meters 2. Main roads with a significant public transport offer within 500 meters 3. A public transport stop, taxibuses or collective taxis within 500 meters. If this criterion is applied, you must fulfill the criteria for accessibility to opportunities.		Any of the following conditions: 1. Bus stops within 300 meters 2. Metro or intermodal stations within 600 meters
Accessibility to opportunities	Only applicable if condition #3 of accessibility to public transport is used. In that case, the criterion is a maximum distance of 500 meters to at least 4 facilities or public spaces, such as: 1. Educational establishment (primary or secondary) 2. Public health establishment 3. Commercial establishment 4. Public service	1. Primary education: within 500 meters (existing or approved financing) 2. Primary Health: within 1500 meters (existing or approved financing)	1. Primary education: within 500 meters 2. Health: within 1500 meters 3. Green areas: any of the following conditions. - Less than 500 meters for small green areas - Less than 5000 meters for parks (more than one ha)

Table 7-1 (cont.) Proposals and criteria for urban integration zones

	Decree N°56	**CNDU**	**Ciudad con todos (ZBA)**
Accessibility to opportunities	5. Sports or culture equipment (free or affordable cost) 6. Park or green area exceeding 5,000 square meters It will be admitted that one of the 6 maximum distances referred above can exceed 500 meters, but always less than 1000 meters. Facilities 1, 2, 5 and 6 could only have permits, be executed or with an assigned budget.	3. Services or commerce: less than 500 meters (existing or under construction, density = 600m2 / ha) 4. Public small green areas or parks: within 500 meters (existing or approved financing) 5. Work hubs and Technical and Higher Education Centers: less than 30 minutes by public transport	
Load capacity	There are no specific criteria. A report on urban potential should justify the number of inhabitants by each sector.	1. Public transport: sufficient standard for potential demand 2. Primary education: available enrollment must exceed the potential demand. 3. Primary health: idle capacity (medical work days/1000 inhab) to the potential demand. 4. Public small green areas and parks: max of m2/h considering the potential demand.	1. Green areas: max 3.43 m2 per inhab., considering an area of influence of 500m for small areas and 5000m for parks (+1 ha). 2. Primary education: maximum 0.75 enrollments per inhabitant for an area of influence of 400m. 3. Primary health: maximum 0.5 quotas in the establishments per inhabitant for an area of influence of 1500 meters.

7.3 Critical analysis of the standards for urban integration zones

To observe the advantages and drawbacks of the proposed criteria for densification and social integration, we analyze the dimensions mentioned above using 3 subsections that synthesize our main observations.

7.3.1 Public transport and urban opportunities as excluding dimensions

There is a tendency of the proposals to consider the dimensions of accessibility to public transport and accessibility to urban opportunities as exclusionary dimensions. This is shown in decree No. 56, where criteria are formulated for both dimensions, but using an independent approach. This decree proposes not applying the criteria for access to opportunities when there is access to high-frequency or priority for public transport, and only minimum conditions for public transport are requested if those related to urban opportunities apply. On the other hand, the CNDU proposal simply chooses equipment standards, ignoring those associated with public transport.

One possible reason for these standards is the high value of accessibility to urban public goods, assuming that these could be reached interchangeably via “walkable” distances (territorial proximity) or via public transport. Therefore, it would be sufficient to accomplish one of these two conditions to “cover” accessibility to urban opportunities. However, this analysis has some shortcomings:

(i) Walkable accessibility to opportunities is not a substitute for accessibility to opportunities that can be accessed via public transport. This is especially valid for strongly segregated cities such as Santiago, where high-quality opportunities are far from being homogeneously distributed in the city. Thus, public transport is a mobility option that serves several purposes. Among them, allowing participation in society and avoid social exclusion (Lucas, 2012), such as visiting family and friends, entertainment places such as cinemas, bars, and restaurants, or cultural facilities. But also, compulsory travel purposes matter, where the job trips are the most recurring example. In Santiago, where most of the job opportunities are concentrated in specific places in the city (see Figure 7-1), having adequate access to public transport is essential to convert available opportunities in effective participation, especially for those who depend on this mode (low-income and and people with reduced mobility, for example).

(ii) Accessibility to public transport is not a substitute for walkable accessibility to urban facilities. There are areas with relatively good connectivity to public transport that lack walkable urban opportunities. Since walking is part of our nature, if the space around our activities invites us to walk, our quality of life improves substantially. For example, if we analyze green areas in terms of square meters per inhabitant (Figure 7-2), we observe that pericentral communes such as San Joaquin or Macul have areas with low access to green areas, although they have a good public transport provision (Figure 7-3). Thus, its inhabitants have good accessibility to the city by public transport but lack an attractive walkable environment that provides opportunities to fulfill some of their needs.

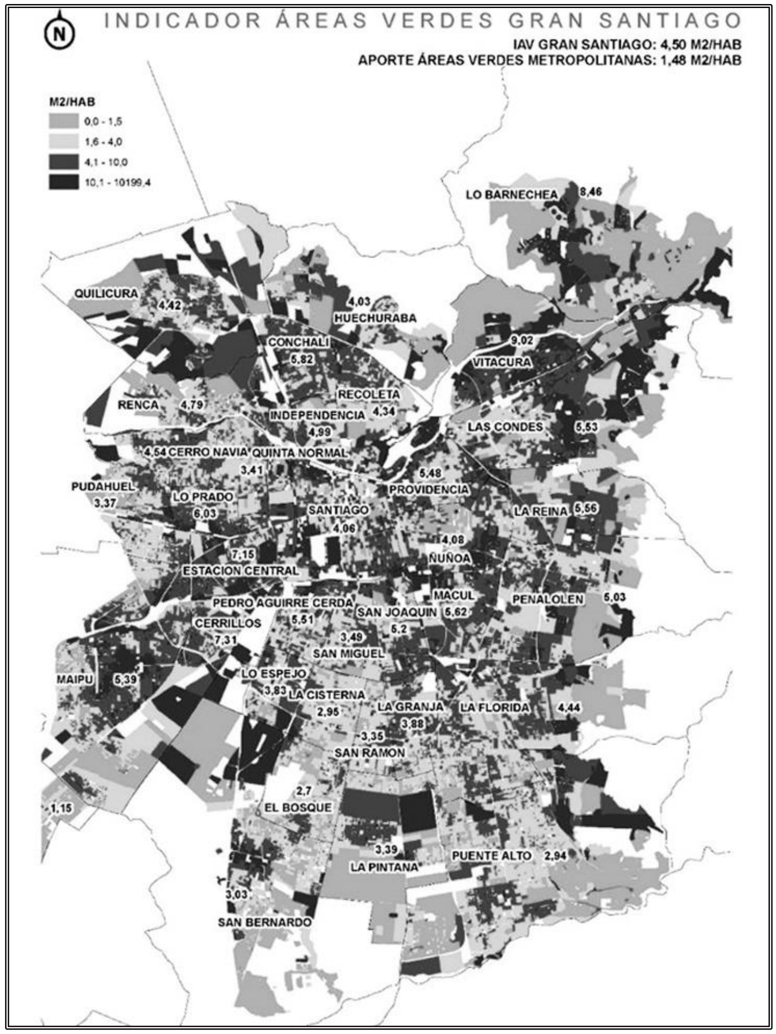


Figure 7-1 Square meters of green areas per inhabitant (Source: CIT-UAI, 2018)

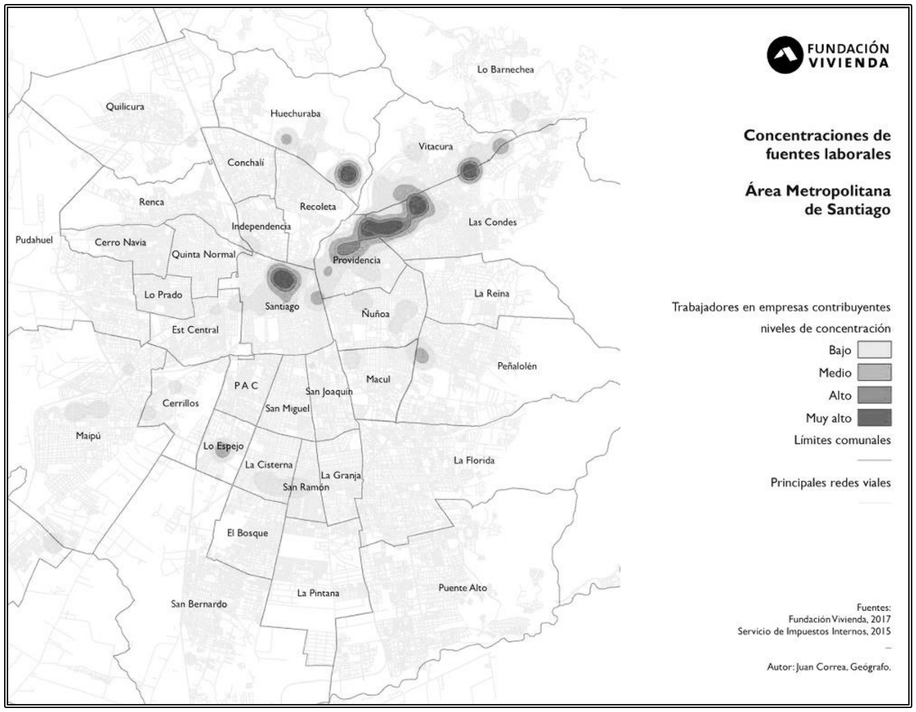


Figure 7-2 Concentration of workers in contributing companies. In darker colors, better access to green areas (Source: Correa, 2019)

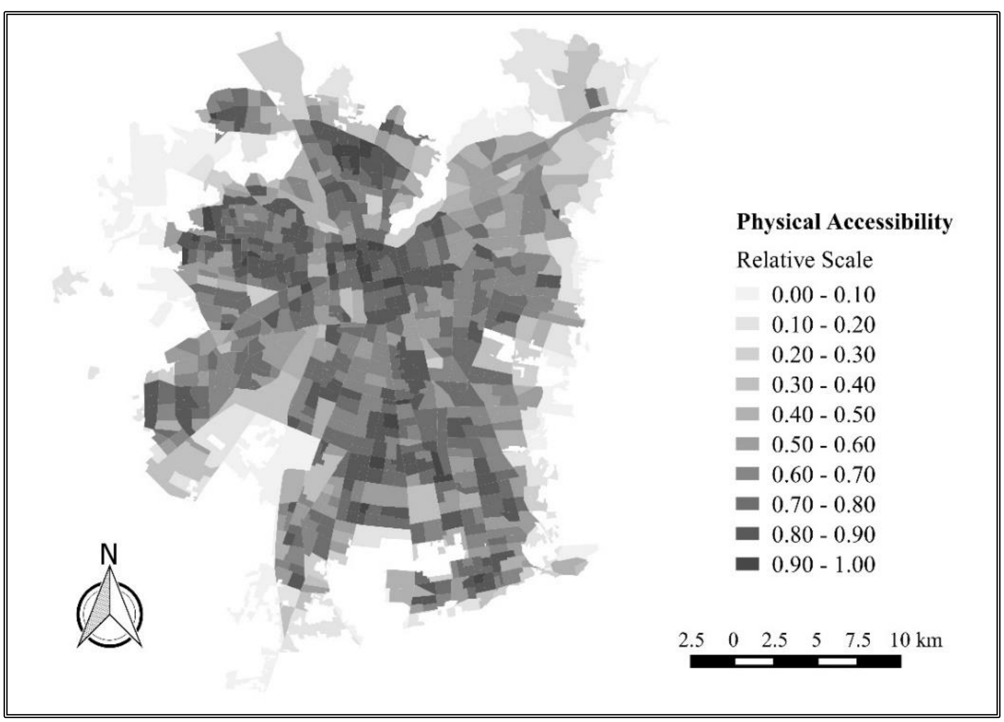


Figure 7-3 Access to public transport stops in Santiago. In darker colors, better access to public transport stops (Source: Tiznado-Aitken et al., 2018)

7.3.2 Accessibility to public transport: deficient criteria

If we observe the accessibility to public transport criteria, a single type of standard is recognized in all the proposals: territorial proximity to public transport stops, which translates into a “walkable” distance. The only additional component - present in Decree No. 56 - is to increase the distance threshold allowed according to the importance of the public transport stop (for example, a Metro station has an area of influence greater than a bus stop).

This approach to accessibility is quite limited, since it does not incorporate other fundamental variables of the travel experience by public transport (Lucas et al., 2016; Martens, 2017), such as the quality of the walking environment (Tiznado-Aitken et al., 2018), the waiting time, comfort inside the vehicle, the number of transfers (Currie, 2004; Tiznado-Aitken et al., under review), congestion, travel time reliability and operating hours for different services (Weber and Kwan, 2002; Delafontaine et al ., 2011; Neutens et al., 2012; Fransen et al., 2015).

As an example, let's look at the transport dimension criteria that defines Ciudad con Todos through the ZBA. According to the Transantiago operation program (DTPM, 2019a), 30% of the bus stops have only one service (DTPM, 2019a). Of these, 115 bus stops cover a 300 meters area of influence that would accomplish the criteria defined by ZBA. However, the public transport supply provided in these areas would be far from sufficient. Of these 115 zones, 24 can be considered relatively central in the city (Figure 7-4)

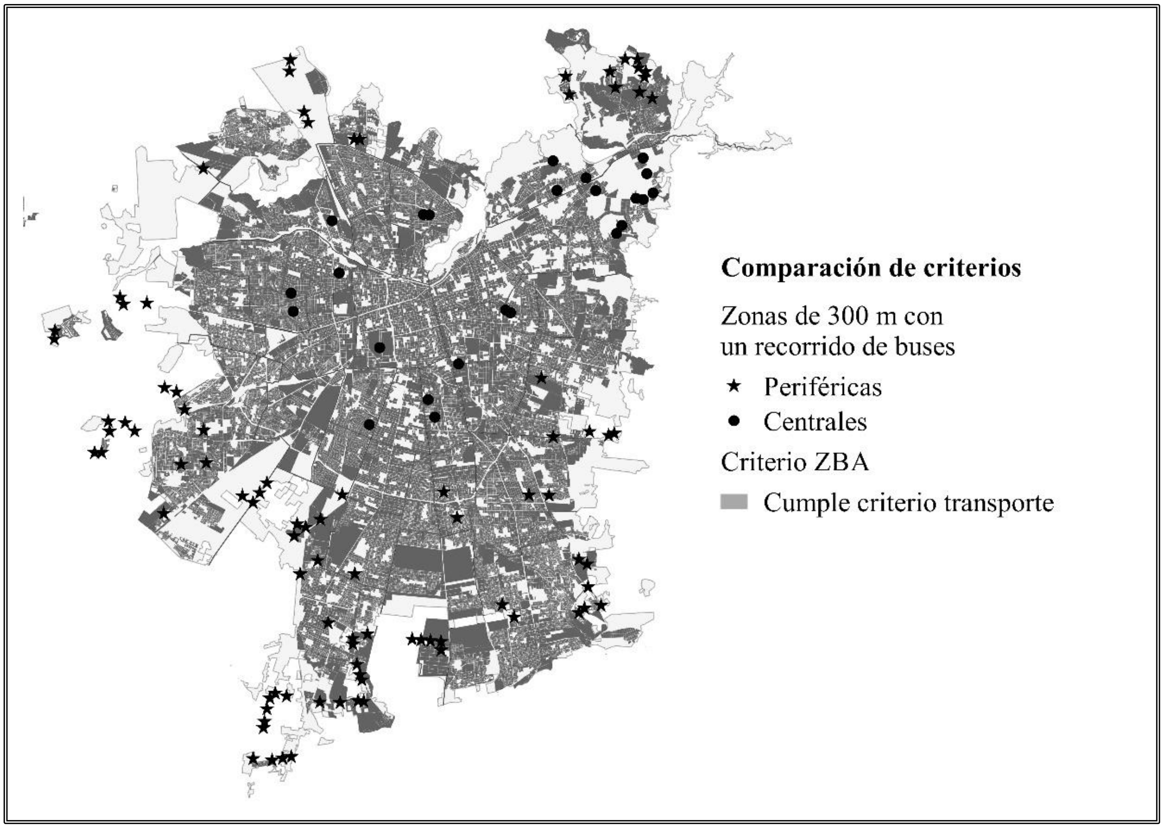


Figure 7-4 ZBA transport criteria and public transport stops that serve areas of 300 meters with a single route (Source: Own elaboration, based on DTPM (2019a) and Ciudad con Todos (2019b))

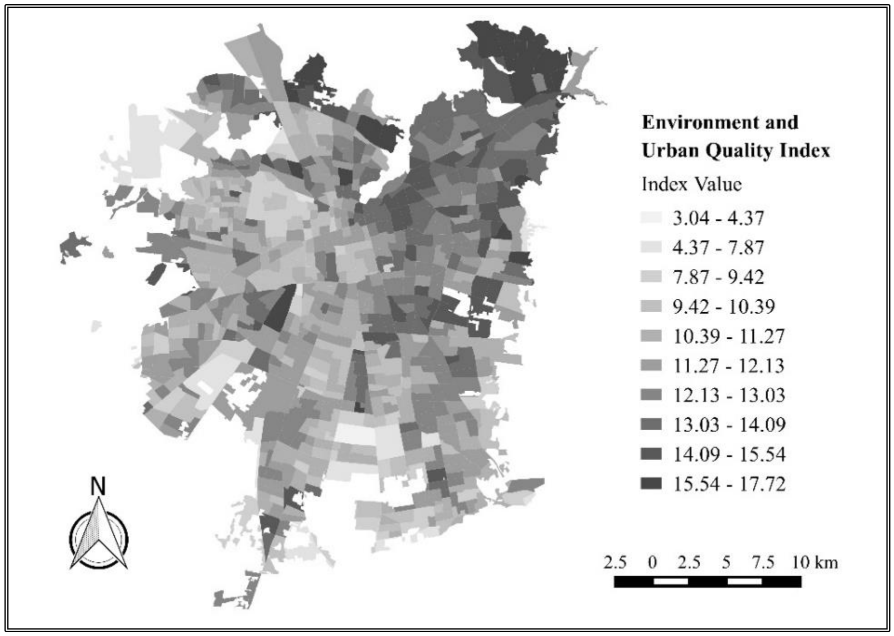
Let's analyze some problematic areas under the ZBA criteria:

(i) In the northeastern sector of Ñuñoa, stops PD1034 and PD1035 have only one route in operation (D09). This route usually has a frequency of one bus every 10 minutes. The nearest Metro stations are Chile España and Ñuñoa, although far from the defined area of influence.

(ii) In the central-western sector of San Joaquin, stops PH509 and PH775 have a single service operating (H05 and H09, respectively). These routes have an even worse frequency than the previous case: a bus every 15 minutes. Although the H09 route goes through the Carlos Valdovinos Metro station, it takes 23 minutes to reach it. That is, a user should plan around 30 minutes just to reach a Metro station.

(iii) In the Lo Prado sector, stops PJ756 and PJ1037 have a single route (J06) with a frequency equivalent to one bus every 10 or 12 minutes. Despite arriving at Metro Pajaritos, this route takes 16 and 10 minutes from each stop, respectively. That is, similar to the previous case, it takes approximately 20 to 30 minutes just to access the Metro network.

There are multiple points (Figure 7-4), that can fulfill all the criteria proposed by the government, the CNDU and Ciudad con Todos, but that do not guarantee good accessibility to public transport, and therefore, to the opportunities that the city offers. Furthermore, they do not have a minimum quality of the urban walking environment (Cheng & Chen, 2015). Consider elements as infrastructure, beauty, furniture, safety, and cleanliness (Figure 7-5) are essential in the travel experience, and therefore, allows proper social integration of vulnerable groups to areas that offer high-quality access to opportunities. There is segregation in terms of urban quality that is consistent with the socio-economic condition in the city, that is, with better standards in the north-eastern sector.



(a)

(b)

Figure 7-5 (a) Quality of the urban environment, considering elements of safety, cleanliness, infrastructure, security, and urban furniture (Source: Tiznado-Aitken et al., 2018). Perception of beautiful (b, on the left) and safe environments (c, on the right) in Santiago de Chile. In the 3 figures, darker colors mean better standards (Source: Prepared by the author based on Rossetti et al., 2019).

7.3.3 Accessibility to opportunities: a limited vision of transport, load capacity and quality of opportunities

As the accessibility to public transport, all proposals use a “maximum walking distance” as a criterion that determines accessibility to “homogeneous” facilities. That means the urban opportunity will be considered of the same quality and would be available or not (as a discrete variable) as long as the distance to its location does not exceed a certain threshold.

A first drawback is, again, to homologate accessibility only to walking distance. Urban parks, health facilities, or education centers could also be linked with reasonable accessibility by public transport. Is it more accessible a green area located 500 meters away in an unsafe environment or a green area accessible in 15 minutes by public transport? The CNDU proposes some improvements in this regard, establishing public transport travel time standards for workplaces and higher education.

A second shortcoming is linked to the quality of urban facilities into the proposals, which is highly problematic in that accessibility is strongly conditioned by this dimension (Vecchio et al., 2020). Indeed, having schools of excellence available is not the same as having schools with inadequate quality and infrastructure. Thus, advancing criteria that allow classifying opportunities based on their quality and adequate supply is essential.

Finally, in order to analyze the load capacity of a specific area, it is proposed to consider three load dimensions: (i) urban population, (ii) public transport, and (iii) urban opportunities. Each one is important to define if there is adequate capacity for the eventual increase in population.

The urban population dimension relates to the appropriate density that a neighborhood could receive, given its geographical and urban conditions. Decree No. 56 is the only proposal that contributes to this regard, demanding an urban potential report that justifies the adequate densification of the proposed area. This point is crucial because there are several areas that, despite having the available capacity for public transport and facilities, have heritage neighborhoods or buildings, risk areas, or other conditions that limit their eventual densification. Examples are the central or pericentral heritage neighborhoods (Brazil, Lastarria, Yungay, among others) that achieve decree's conditions, but where it is not feasible to densify.

When we analyze load capacity restrictions of public transport, we observe that only the CNDU proposal incorporates some criteria. The absence of this standard in government regulations is worrying since there are public transport infrastructure and services that are currently operating at maximum capacity or overcrowded. Some bus or Metro routes have the ability to increase their frequency and satisfy their demand, but other public transport services cannot do so or have infrastructure restrictions, which limits an increase in capacity. For example, different areas fulfill Decree No. 56 near Line 1 and 4 of the Metro but do not consider that Line 1 to the east and Line 4 to the north at morning-peak operates at maximum capacities, so they offer a level of service marked by overcrowding (see Table 7-2).

Table 7-2 Passenger density per square meter on trains that goes through the “critical” station of each line of the Metro system during morning peak hours (7 to 9 hours) (Source: Own elaboration based on Metro S.A. (2015a, 2015b, 2015c))

Line	**Stations**	**Average passenger density (pax/m^2)**
1	Los Héroes – La Moneda	5.95
2	Rondizzonni – Parque O’Higgins	5.64
4	Los Presidentes - Grecia	6.31
4A	Santa Julia – Vicuña Mackenna	5.04
5	Santa Isabel – Parque Bustamante	5.1

The proposals of the CNDU and Ciudad con Todos incorporates some criteria about the load of urban opportunities available in each area. Its absence in the Decree N°56 is problematic, because it assumed that schools, health facilities, and green areas within walking distances are accessible. However, to be effective, it is essential that they have a sufficient capacity to receive new people.

Let's analyze the ZBA proposal. It defines an isochron of 500 meters and an accessibility standard of 0.75 education vacancies per inhabitant. These criteria produce the map seen in Figure 7-6. This scenario ignores the fact that the potential demand for education can come from all city zones, where public transport and competition for those opportunities play a crucial role. Tiznado-Aitken et al. (under review) compare potential accessibility measures (Hansen, 1959), considering only the educational supply and the travel times to them, versus competitive accessibility measures (Shen, 1998), which consider both the supply and demand for educational opportunities on a certain quality standard. Besides, the latter incorporates the perception of the public transport level of service, such as waiting times, comfort, and number of transfers (Figures 7-7a and 7-7b).

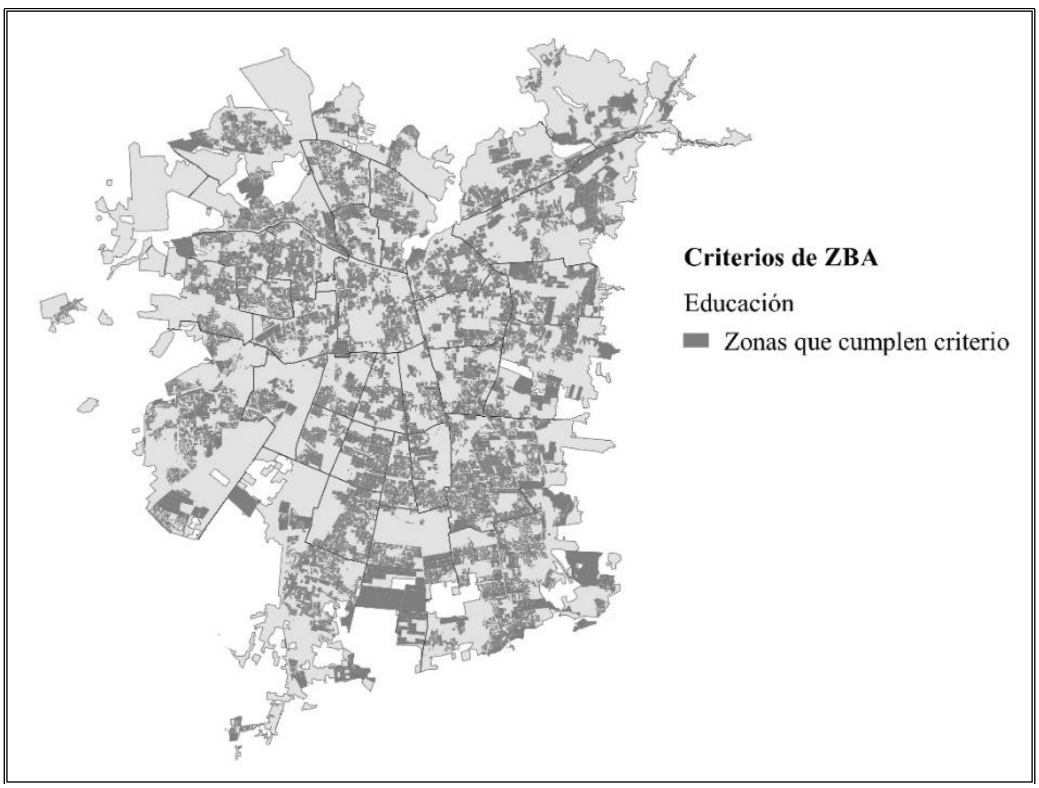
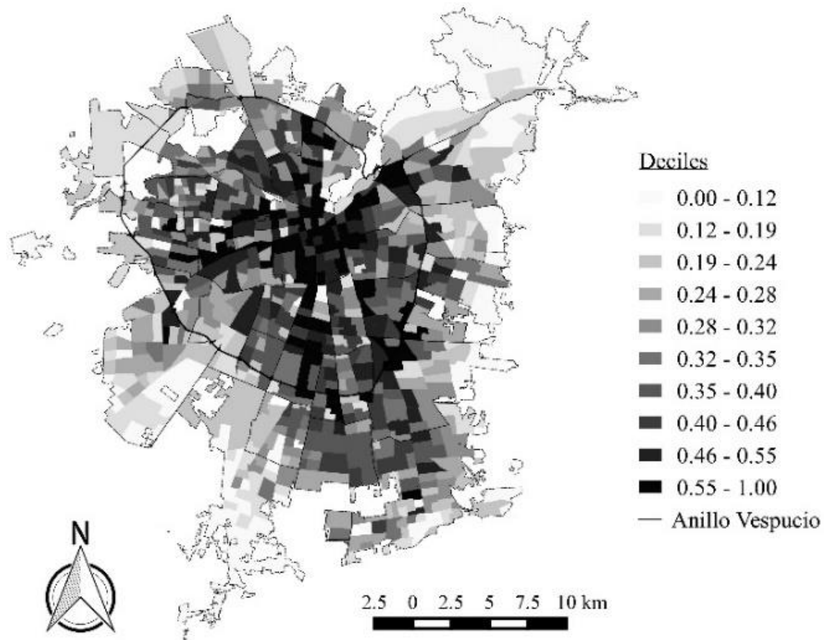
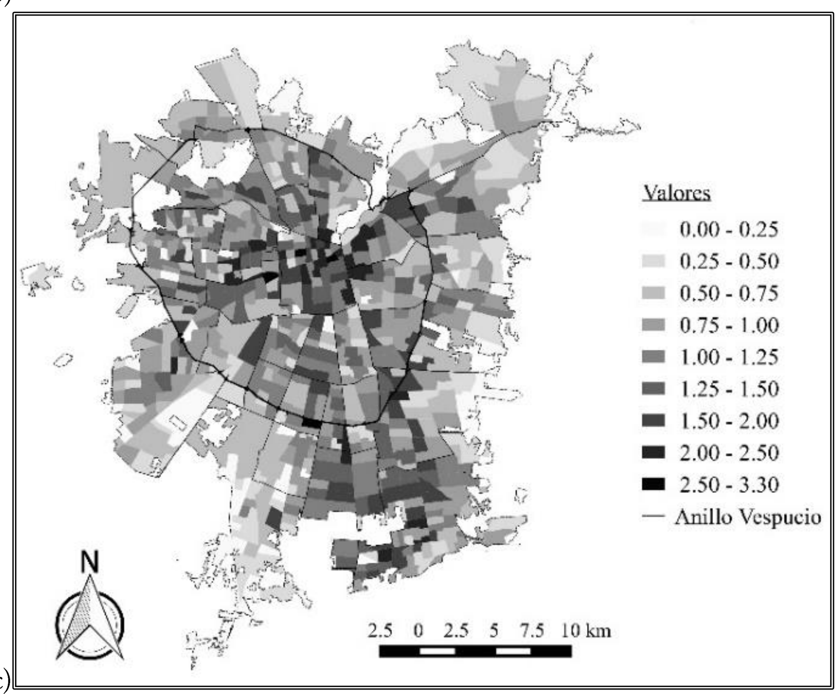


Figure 7-6 Areas of Santiago that accomplish the ZBA criteria for education (Source: Own elaboration based on Ciudad con Todos (2019b))



(b)



(c)

Figure 7-7 Above (a), accessibility to educational opportunities considering only the supply and total travel times by public transport. At the bottom (b), accessibility to educational opportunities considering supply and demand, as well as the perception of the level of public transport service (Source: Tiznado-Aitken et al., under review).

The spatial patterns are different if we incorporate competition (Figures 7-7a and 7-7b), which probably is closer to reality than just considering walking distances and the educational supply. Thus, the methodology used by the ZBAs is not adequate, since the potential demand for services is greater than the area of influence determined by geographical distance. Although the criteria may not be necessary for green areas (square meters per inhabitant seems to be adequate), this could be critical for health and education opportunities. In that sense, the proposal made by the CNDU, considering the current idle capacity and potential demand, best approximates real post-densification demand in these areas.

7.4 Guidelines and proposals to establish accessibility criteria

To approach an integral conception of accessibility, where walking distances are considered, but also elements of the public transport level of service, travel experience, and distribution and quality of urban facilities, it is proposed to establish minimum criteria in four particular dimensions, which are detailed below.

7.4.1 Access to public transport

(a) Physical accessibility: the maximum distance to public transport stops is not accurate to define whether or not that stops are walkable. The problem, instead of being approached as continuous, is treated as a binary one: in this case, a stop at 300 meters is considered accessible and therefore fulfills the standard, but at 301 meters, it is considered inaccessible. Alternatively, it is proposed that accessibility should decrease as the distance increases using a mathematical function. Tiznado-Aitken et al. (2018) calibrated an impedance function according to walking times to public transport for 35 thousand areas of Santiago (see Figure 7-3). A proposal could define a minimum standard, which would imply that people have a minimum of added impedance from each location.

(b) Quality of the walking environment: there is a vast body of research that shows how urban space and the built environment affect the modal share of public transport. For example, the absence of a pedestrian-friendly environment and the lack of mixed land use influences car use instead of walking and public transport (Tilahun & Li, 2015). Tiznado-Aitken et al. (2018) created an urban quality indicator for walking that integrates safety, environment, cleanliness, and infrastructure, and applied it to Santiago (see Figure 7-5a). In that sense, a proposal could be to establish a minimum quality standard for the walkable environment, such as the presence of good sidewalks, the presence of luminaire, and urban trees. This would prevent the potential areas for social integration from being located in zones where, despite having good physical accessibility, lacks elements of security, beauty, cleanliness, and infrastructure, affecting the adequate accessibility to public transport.

7.4.2 Coverage and the quality of public transport

(a) Travel time thresholds: the amount of opportunities that someone can access using public transport is also an important variable. Isochronous measures (Forbes, 1964) allow us to know the number of opportunities that people are able to reach from an area at different thresholds (which can be, for example, 15, 30, 45 and 60 minutes), incorporating access and waiting times. A threshold of access time to services that potential areas for social integration must reach could be defined. For example: if I do not have primary care within a certain distance, then I must be able to access X opportunities in less than Y minutes by public transport (see Table 7-3 for some examples).

Table 7-3 Accessibility criteria for three essential urban opportunities (Source: Own elaboration)

Accessibility to opportunities	**Decree N° 56 criteria [meters]**	**Possible criteria [minutes by walking or public transport]**
Primary education	Max 500	Max 15
Primary health-care	Max 1500	Max 20
Green areas	Small green areas: Max 500 Parks: Max 5000	Max 10 Max 30

(b) Level of service: the level of service experienced by the user is also central to accessibility through public transport. The PTAL model incorporates the number of routes that goes through public transport stops and their respective frequencies to include elements of waiting times, coverage, and reliability, establishing different levels of accessibility. Shirahige and Correa (2015) applied it to Santiago according to census blocks (see Figure 7-8), so it could also be used together with some minimum standard.

Furthermore, Tiznado-Aitken et al. (under review) created an indicator that incorporates waiting time, travel time, transfers, and comfort, where each component has a different weight in the overall perception of the public transport level of service. Based on the origins and destinations of public transport trips, they estimated an indicator for different areas of

Santiago, based on the "effective" time and the "perceived" time (see Figures 7-9a and 7-9b). Minimum public transport level of service could be defined, for which both aforementioned measures are useful. This way, it is ensured that potential areas for social integration have appropriate frequency and do not exceed certain overcrowding and transfer limits.

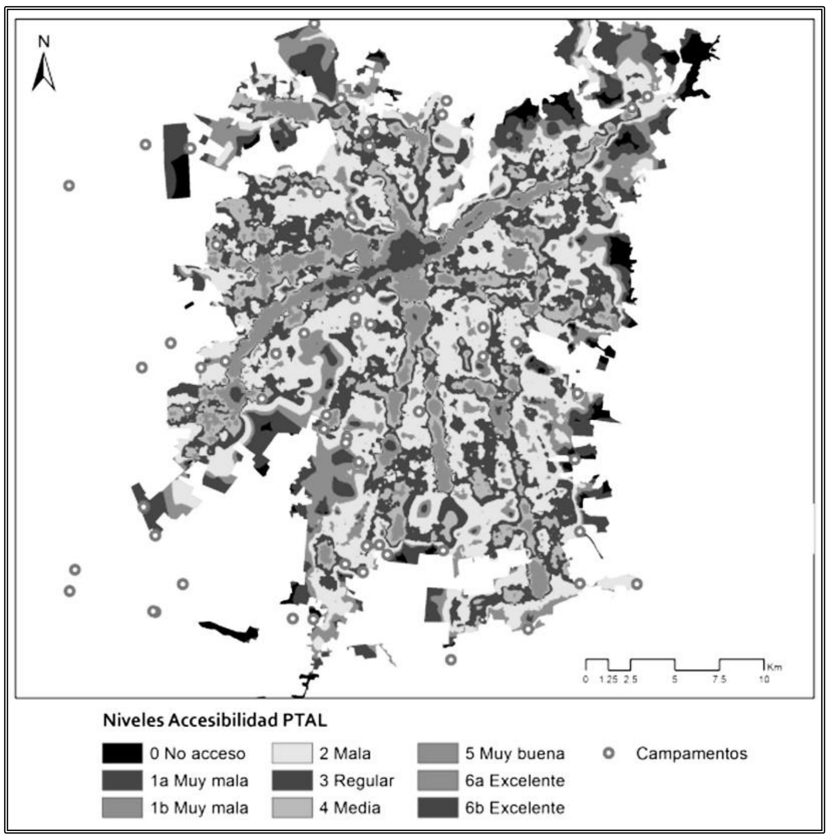


Figure 7-8 Above (a), PTAL Model for Santiago (Source: Shirahige and Correa)

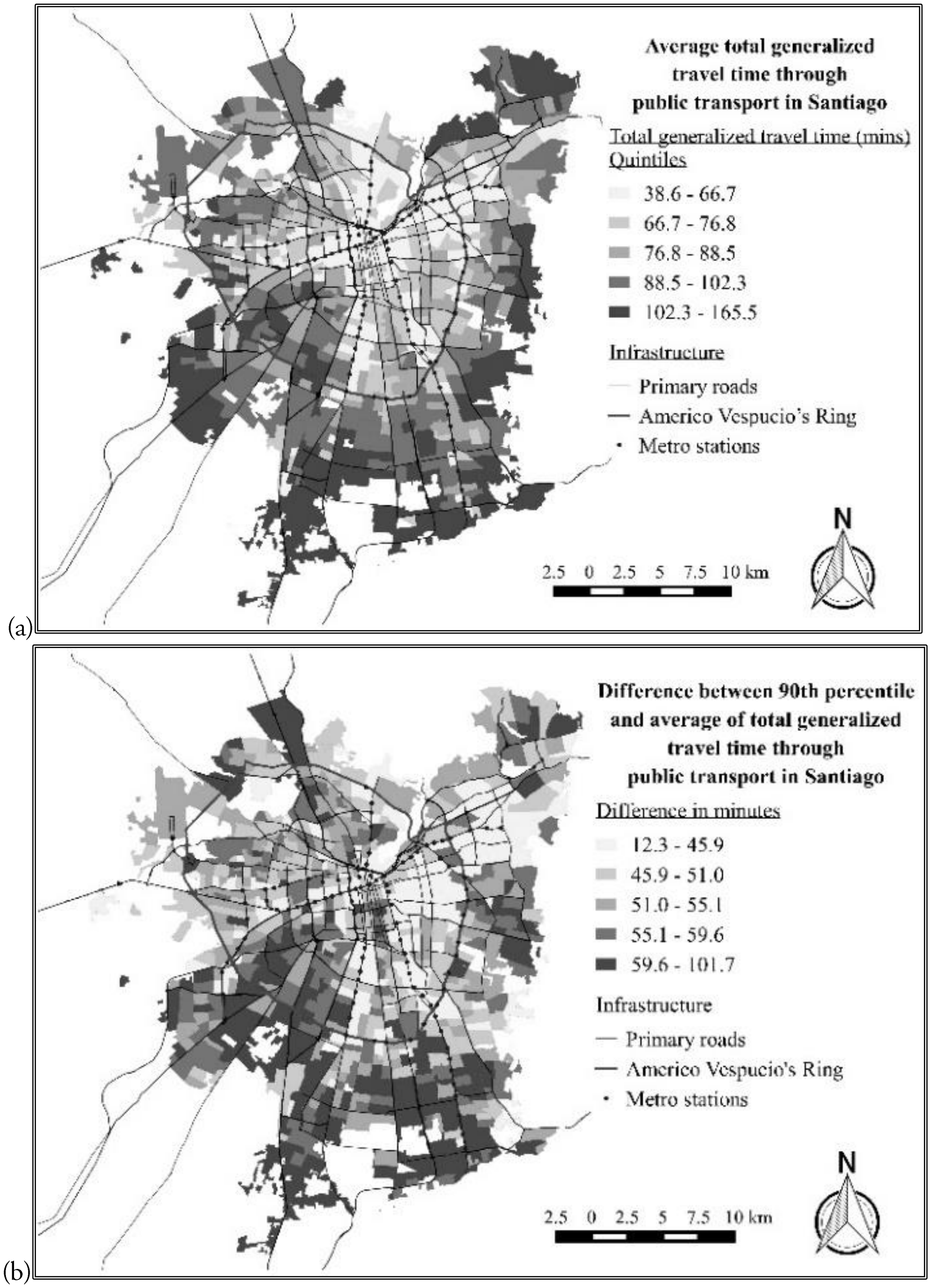


Figure 7-9 Above (a), a level of service indicator for different areas of Santiago, from the 'effective' travel time. At the bottom (b), the difference between the 'perceived' travel time and the ‘effective’ travel time (Source: Tiznado-Aitken et al., under review).

7.4.3 Accessibility to high-quality urban opportunities

Establishing reasonable access and quality standards for different urban facilities is essential. To do this, we may use data available as the quality of schools, the quality of health-care facilities considering surface, professionals and infrastructure, maintenance and continuity of green areas, among others. An application of these elements to three key urban opportunities within the city can be found in Table 7-4.

Table 7-4 Quality criteria for three essential urban opportunities (Source: Own elaboration)

Quality of urban opportunities	**Possible criteria**
Education	- Minimum performance and quality according to the National Education Agency - Infrastructure - Professionals available for each student
Health-care	- Number of professionals - Variety of specialties - Infrastructure
Green areas	- Effective square meters - Maintenance of green areas - Street furniture / Urban realm

7.4.4 Competition for urban opportunities and load capacity

Potential areas for social integration must pursue load capacity. For this, a first approach is to prevent those areas from being located in risky or heritage neighborhoods, defined by the actual planning instruments (communal or metropolitan).

Furthermore, it is suggested to consider the public transport load, excluding those areas that will stress infrastructure that already exceeds its maximum capacity. As we show in Table 7-2, specific Metro stations are operating on extreme overcrowding levels. Based on this, we can define an overcrowding standard (for example, 4 passengers per square meter) and consider that these transport services are not available to calculate accessibility levels. Travel by bus can be assessed similarly. Some routes may increase their frequency more easily or operate under priority (bus-lanes or segregated corridors) to accomplish the defined standard, but others may not accept new demand given the corresponding increase in passenger density.

Finally, it is suggested that, in order to analyze the urban opportunities load, both supply and demand for services should be considered according to their accessibility by public transport. As we explained in Figures 7-9a and 7-9b, the spatial patterns are very different when considering these elements together. This allows a more realistic estimation of the opportunities available and competition for them within the city.

7.5 Final remarks

Social and urban integration has become one of the main priorities of urban policies in recent years. These efforts are essential as they improve opportunities and access to urban public goods, especially for the most vulnerable population groups, favoring social diversity across the territory.

The urban incentives to promote social integration is one of the mechanisms that have been proposed in Chile. Even when it has been questioned for its centralist nature or its low effectiveness, it requires that its application fulfill adequate conditions of accessibility to transport and urban opportunities. Accessibility is, therefore, a key concept for this urban policy and it seems crucial to incorporate a more robust definition, with a broader conception and better indicators.

The current accessibility standards, proposed by both the government and other actors, appear to be insufficient, lacking a broader understanding of accessibility. The criteria analyzed consider accessibility to public transport and urban opportunities as exclusive dimensions and only from the territorial proximity or walking distance perspective. The proposed criteria do not adequately contemplate load capacity, considering only areas of influence and ignoring the public transport capacity, which can operate under significant levels of overcrowding.

In this work, we contribute to the analysis, proposing some guidelines that can help to formulate better criteria and standards when defining areas for densification with social housing quotas. The next steps of this research should focus on formulating and defining these standards, modeling and evaluating which areas of Chilean cities meet the integration criteria. We hope that a broader and more comprehensive conception of accessibility will allow us to have really integrated cities in Chile, achieving social diversity in our territory.

Acknowledgements

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8. DISTANCE-BASED PUBLIC TRANSPORT FARE SCHEME: ACCESSIBILITY, URBAN FORM AND EQUITY IMPLICATIONS IN SANTIAGO DE CHILE

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8.1 Introduction

Latin-American cities show deep socio-spatial inequalities and urban segregation. Despite remarkable progress towards alleviating lower income inequality and poverty (Lustig et al., 2012; Székely & Mendoza, 2015), social inequality has proved to be a much more complex phenomenon. Under the context of rapid urban change and globalization in Latin American cities over the last three decades, spatial segregation has always been present, both socio-demographically and functionally (Thibert and Osorio, 2014). Issues of territory, gender, race, ethnicity, and age are key exclusion dimensions (CEPAL, 2016), impeding equitable progress (Deneulin & Sanchez-Ancochea, 2018). In a region whose population is mainly urban (World Bank, 2018), Latin American cities show complex travel patterns given the (usually peripheral) location of low-income inhabitants, their accessibility to key opportunities, and low-quality transport systems (Hidalgo & Huizenga, 2013; Rodriguez, 2008).

This unequal scenario raises key challenges regarding accessibility and affordability of transport and housing, especially for the most vulnerable populations, which usually experience the consequences of spatial mismatch. In big cities like Santiago de Chile, an equitable public transport provision is highly desirable, especially as 60% of the households do not own a car and depend on public transport for daily mobility (SECTRA, 2015). Moreover, Santiago shows a somewhat monocentric structure and has been expanding towards the wealthiest neighborhoods for the last 40 years, which could be exacerbating the difficulty of accessing opportunities for some socio-economic segments of the population (Suazo-Vecino et al., 2020).

Metro and buses are the modes making up the public transport system in Santiago. Users can ride both transport modes paying only one fare, which is fixed all day for buses and period-based for Metro. In this chapter, this public transport flat fare scheme is analysed through the lens of accessibility, affordability, and equity. The implication of a distance-based charge in the public transport system is compared with the flat fare scheme for accessibility levels in the current land use scenario and for equity outcomes to identify whether either fare scheme could be a progressive policy, benefitting low- and medium-income populations in the city, providing them more affordable access to opportunities.

Two metrics are used to analyze the effect of the fare schemes. First, the fare increment or reduction for each public transport trip from the flat fare to distance-based scheme is estimated, using an extensive trip database obtained from smart card records that include origins, destinations, and routes distances for 2.9 million trips performed during April 2019. Then, the results at a municipality level in Santiago are aggregated. Second, the effect on accessibility considering a generalized travel cost accounting for travel time, waiting time, walking time, and fare is estimated. For both metrics the impact on each socio-economic quintile given the socio-demographic composition of each municipality is estimated. Based on these results accessibility, affordability, and equity outcomes of the fare schemes under the current land use pattern are analyzed, and the implications of a future land use scenario where activity sub-centers (decentralizing opportunities) are developed in Santiago are discussed.

This chapter is structured as follows. Section 2 provides a literature review on the main socio-spatial inequalities reported for urban development in Latin America, especially for public transport implications on urban form, accessibility, and equity issues. Section 3 describes the case study in Santiago, its public transport system and its fare system. The methodology is described in Section 4, while Section 5 shows the main findings obtained. Finally, Section 6 discusses the implications of the results and the main conclusions.

8.2. Accessibility, affordability, urban form, and equity: a brief review focusing on Latin American settings

Urban form strongly affects citizens' affordability. This concept alludes to financial stress faced by households to cover housing and transport expenditures, influencing the opportunities they can access. It is possible to define an 'affordability threshold' to identify households that struggle with these expenditures, which usually shows an inverse relationship: the higher the cost of housing, the lower the cost of transport, and vice-versa (Mattingly & Morrissey, 2014; Glaeser, 2008). For example, as several contexts demonstrate, people living in the urban periphery, where land values and housing is typically cheaper, have higher transport expenditures than more centrally located expensive housing because of distance and poor public transport connections, which, in turn, leads to a dependency on cars (Banister, 1994; Currie & Senbergs, 2007).

There has been an on-going concern about the impacts of urban form, especially in the US and Europe (Dieleman & Wegener, 2004). Most European metropolitan areas with high relative densities and more centralized land-use patterns present low levels of car use whereas low-density urban forms, as in some US cities, tend to have higher transport costs since travel distances increase, and access to services through public transport decreases (Newman & Kenworthy, 1989; Horner, 2002; Giuliano & Narayan, 2003; Low et al., 2005). These low-density urban forms could bring consequences as urban sprawl, with city center disinvestment and decline, car dependence, a growing number of vehicle-kilometers traveled (VKT) and a loss of open space (Ewing et al., 2002).

van de Coevering & Schwanen (2006) states that cities should adopt a vision for city development tailored to their specific regional contexts. In the Latin American case, cities are highly unequal and segregated. Residential segregation reproduces socio-economic inequalities and isolates the poor (Rodríguez & Arriagada, 2004), so the inhabitants' location, activity distribution, and transport provision play a key role. In this context, urban mobility can be considered both a cause and an effect of such structural imbalances. In an exhaustive review of socially-oriented accessibility assessments in Latin American cities, Vecchio et al. (2020) highlight noticeable accessibility gaps between socio-economic groups, and that the public transport projects devoted to reducing this gap have been still insufficient.

Rodriguez (2008) points out that the Latin American metropolitan cities show many trips joining poor communes (usually periphery) and business centers (central and high-income communes). Given these mobility patterns, the most relevant transport policies for segregation control are those that improve public transport services (Sabatini, 2003). Better transport services allow for better accessibility to the city, making residential segregation less harmful. This way, providing public transport and a better distribution of key opportunities would be helpful to overcome spatial mismatch, especially in cities like Santiago where a high concentration of activities and services is placed in the wealthiest sectors of the city (Suazo-Vecino et al., 2020).

Rodriguez (2008) and Sabatini et al. (2001) both show that transport inequalities in Santiago are evident in terms of travel time and monetary cost. Low-income people rely on walking and public transport: the two lowest quintiles made 65% of their trips by these two modes according to the origin-destination survey of 2012 (SECTRA, 2015), and the economic impact of using public transport in daily life can be huge, with vulnerable populations spending around 30% of their monthly income (Iglesias et al., 2019). Recent trends in urban growth in Santiago have produced several gated communities, located in peripheral areas, and targeted at mid and mid-low-income households who are car owners. These households end up experiencing financial stress and reduced time budgets due to an even larger spatial mismatch, which, in addition to the lack of adequate public transport services, makes them car-dependent (Cáceres-Seguel, 2015, 2017; Gainza and Livert, 2013). These accessibility and affordability concerns make social integration across the space almost impossible (Hidalgo, 2007; Rivera, 2012), highlighting the importance of creating a good public transport fare scheme.

A public transport fare system is defined by a collection method linked with form, time and place of payment, a certain fare level, and a fare structure or scheme (Batarce & Mulley, 2016). The latter has been the object of several studies, focusing mainly on optimization problems to maximize profitability considering dimensions as fare schemes, elastic demand, and profitability (Lam & Zhou, 2000; Chien & Tsai, 2007; Tsai et al., 2008; Huang et al., 2016). Nevertheless, the literature linking fare structures and equity implications is not extensive and has not been thoroughly addressed in Latin American settings.

Different fare schemes (Table 8-1) have different effects on vulnerable groups. Usually, flat fares are shown to be inadequate in pursuing equity due to cross-subsidization from long-distance travelers to short trip ones (Nuworsoo et al. 2009; Cheng et al., 2015; Batarce & Mulley, 2016; Bandegani & Akbarzadeh, 2016). Like Cervero (1981)'s findings, Brown (2018) concludes that non-capped distance-based fares plus a time-based fare considering peak and off-peak periods is the most equitable fare structure. Farber et al. (2014) show that in Utah, distance-based fares have good results too. Still, the heterogeneous population distribution must be included in the analysis, especially for spatial mismatch issues and those living in peripheral areas. Likewise, Rubensson et al. (2019) in Stockholm found progressiveness in distance-based fares, but they note that geography is a crucial dimension since flat fares could benefit more peripheral areas.

Table 8-1 Public transport fare schemes (Source: Own elaboration based on Cervero (1981), Bandegani & Akbarzadeh (2016) and Brown (2018))

Fare schemes	Description	Example
Flat	Same fare for all users	Metro system in Lima, Perú
Trip-based	The average fare depends on the number of trips. Usually are known as travel passes.	SUBTE in Buenos Aires, Argentina
Distance-based	The fare depends on exact distance travel or approximate distances through fare zones	London Underground, UK (zones) and Metro system in Tokio, Japan and Valparaíso, Chile (distance)
Period-based	The fare depends on (i) time of day, charging differently in peak and off-peak hours or (ii) trip duration	Metro/Train services in Sydney, Australia
Mode-based	The fare depends on the transport mode, which offers different services	Transmilenio and SITP (bus systems), Bogotá, Colombia
Rider-based	The fare depends on the rider group. For example, the elderly, students, or low-income population.	Transantiago (bus and Metro system) in Santiago, Chile

Brown (2018) identifies three main paths to analyze fare equity in the literature: percentage differences in the costs paid by users, absolute gains for different income groups, and the fare recovery, defined as the operating costs that a particular trip covers through its fare. Inspired by Brown’s work, fare equity in Santiago is analysed using two main metrics, as described in the next section.

8.3. Case study setting: Santiago, Chile

Chile is divided into 16 regions. The largest one, the Metropolitan Region (RM), is composed of 6 provinces, with Santiago being, the most important one, and also Chile's capital. Greater Santiago is the main urban center in the RM, with an urban extent of 640 km2, divided into 34 municipalities, and with a population of 6.12 million inhabitants (INE, 2017). As described above Santiago is a highly segregated city with a very uneven distribution of transport-related benefits across different population segments. Iglesias et al. (2019) show that the wealthiest quintiles receive 2.5 times more investment in both transport and service infrastructure compared to the most deprived quintile. Given this context, the provision of an efficient and equitable public transport system that gives the possibility to access opportunities at an affordable fare remains a primary challenge.

In 2007, Santiago drastically changed its public transport system. Previously, the city had a deregulated, competition-based, semi-informal, and polluting bus system called "Micros Amarillas" (yellow buses). Buses operated along with the Metro system which was much more efficient but barely accessible for lower-income population since buses and Metro had independent and non-integrated fares. The system evolved in 2007 to a modern and integrated-fare public transport system called Transantiago, comprising both Metro and buses. In this system, the user pays only one period-based flat fare to use both buses and MetroIf a trip uses buses and Metro, the user pays the most expensive fare, and the flat fare changes with different time periods (see Table 8-2).

Table 8-2 Transantiago fare (Costs for April 2019, using the average US dollar (USD) value = 667.4 chilean pesos (CLP)) (Source: Own elaboration, based on EMOL (2019)).

Public transport fare	Time period	Fare (USD)
Bus-only trips	All-day	1.05
Trips involving a Metro leg	Off-peak hour (06:00 - 06:59 and 20:45 - 23:00)	1.00
	Flat hour (09:00 - 17:59 and 20:00 - 20:44, All weekends and holidays)	1.08
	Peak hour (07:00 - 08:59 and 18:00 - 19:59)	1.20

Since its launch, the system has grown significantly: the Metro network grew from 85 to 140 kilometers between 2007 and 2019, becoming the largest in Latin America. In the same period, the number of bus services grew from 276 to 382 routes, reaching 3,000 km coverage approximately (see Figure 8-1). According to the last origin-destination survey in 2012 (SECTRA, 2015), 26% of the trips in Santiago are made by public transport: 52% of them being bus only, 22% Metro only, and 26% involving bus-Metro combinations. There is a remarkable variation in the number of trip-legs involving these public transport trips. Since it is often necessary to travel long distances, users must make several transfers to reach their final destination. Those who have the privilege of working or studying in municipalities close to their residential location are more likely to experience single-leg trips. Fewer trip-legs are linked with higher average incomes (Table 8-3).

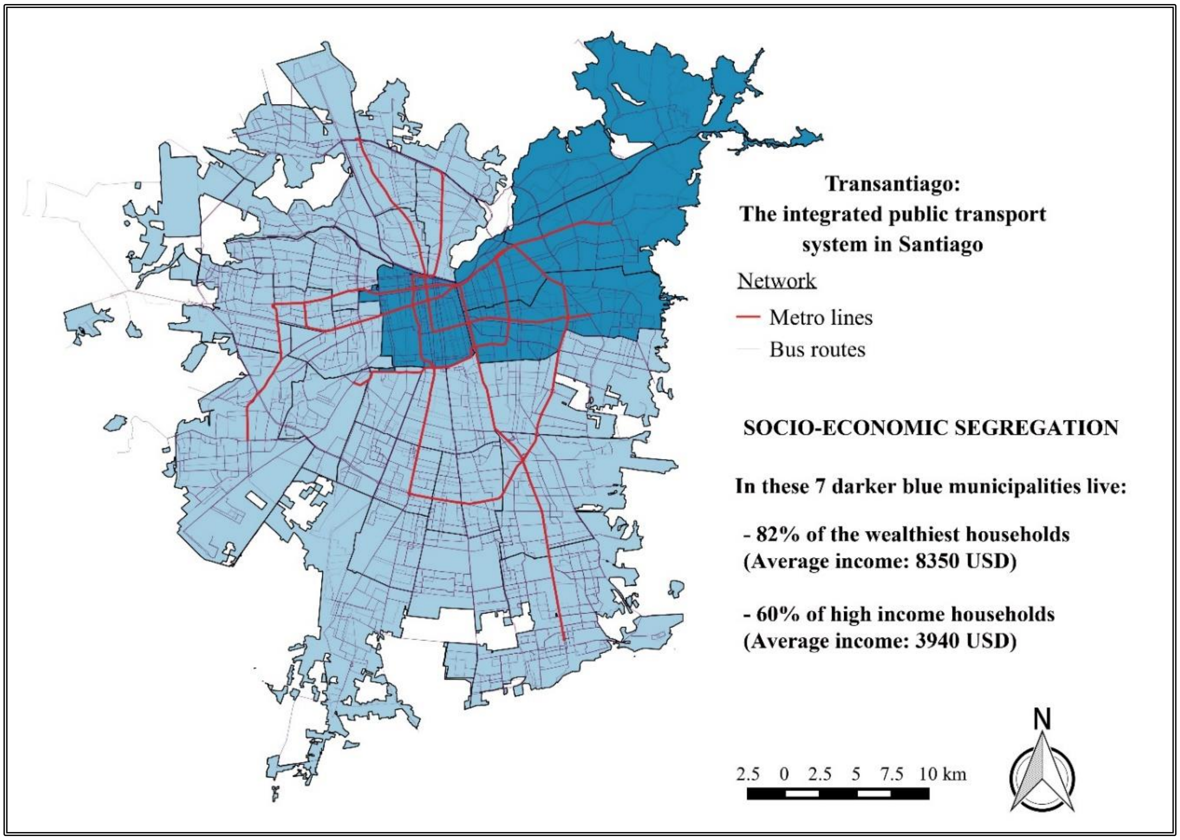

Figure 8-1 Transantiago and socio-economic segregation in Greater Santiago (Source: Own elaboration, based on Tiznado-Aitken et al. (under review))

Table 8-3 Trip stages in Transantiago trips sample of the Origin Destination Survey (2012). USD = 486.5 CLP (2012)(Source: Own elaboration, based on SECTRA (2015))

Trip legs	**Total trips**	**% of total trips**	**Average income (CLP)**
1	6.147.152	57.8%	$334.658
2	3.784.139	35.6%	$332.309
3	678.310	6.4%	$304.887
4	16.486	0.2%	$257.908

These factors indicate that a distance-based fare should be regressive. In theory, a flat fare implies a cross-subsidy of short-trips in favor of long-distance trips, benefitting low-income workers that have to locate in the periphery (Morandé & Doña, 2007). Preliminary analysis using the last Origin-Destination Survey of 2012 in Santiago shows that a flat fare benefits middle-income people and pericentral zones, reducing the fare they would pay in a distance-based fare scheme (Pineda, 2018). This chapter aims to undertake a more sophisticated analysis using an extensive smart-card database, to identify and quantify winners and losers under a distance-based fare scheme, as compared to a flat fare scheme, and to measure the impact on generalized travel costs, which affects accessibility levels within the city.

8.4 Methods

In the following sub-sections, the data used, and the methods employed to calculate the variables analysed are presented in turn.

8.4.1 Who benefits from a distance-based fare scheme?

To estimate the fare increase or decrease for each public transport trip, the database obtained from an extensive Automated Fare Collection (AFC) database from the public transport system in Santiago is used. The data is retrieved from smartcard records of the time and place of each validation in both buses and Metro stations. Since there is no card validation when people alight from any public transport service in Santiago, the methodology proposed by Munizaga and Palma (2012) is used to estimate the time and station in which each trip stage ends and connecting sequential trip stages belonging to the same trip. From the destination estimation, routes distances are inferred.

The information from three days of one week in April 2019 is used, filtering morning trips between 06:00 and 10:00, corresponding to 2.9 million trips. The total revenues obtained for all the trips analyzed is estimated. For this purpose, given the inability to distinguish between users, the analysis did not consider the elderly and students who pay a discount fare (230 CLP all day for using buses and Metro for students, and only for Metro use for the elderly), i.e., it is assumed that all users pay the full fare of the corresponding time period. Furthermore, only the trips paid and, therefore, observed in the database are considered. The system has a relatively stable fare evasion between 24% and 35% since 2014 (MTT, 2019), mainly by users that make short trips using only bus and from lower-income households (Guarda et al., 2015; Gallegos et al., 2015).

Using route distances, the new distance-based fare that would be required to collect the same total revenue as in the flat fare scheme is estimated. Thus, the unit distance charge is calculated by dividing total revenue by the total distance travelled across all trips. The impact of this policy on each socio-economic quintile is estimated, given the socio-demographic composition of each municipality (MDS, 2015) and average income according to Unemployment Insurance 2017 (MDS, 2019). The results are shown in the next section.

8.4.2 How much does a distance-based fare affect the perceived accessibility levels?

The effect on accessibility is estimated using a similar methodology to that proposed by Tiznado-Aitken et al. (under review), which accounts for several of the attributes that drive the level of service received by the user. An average total generalized travel cost across all trips generated at each municipality is computed, monetizing travel time, waiting time, and walking times (see Table 8-4) and considering the monetary cost for the current fare scheme and the distance-based fare scheme.

Table 8-4 Social value of time defined by MDS (2018) for in-vehicle time, waiting time and walking time (Source: Own elaboration, using average US dollar (USD) value = 615.22 chilean pesos (CLP))

Social value of time	Dollars per hour per passenger
In-vehicle time	2.87
Waiting time	5.74
Walking time	8.6

To do this both AFC data and Automated Vehicle Location (AVL) data are used. Besides the data described above for buses, Global Positioning System (GPS) information every 30 seconds is obtained, estimating the exact arrival time at each stop. For Metro, the trains' schedules are inferred from arrival and departure times for every train at every network station. Using these data, it was possible to estimate waiting times and in-vehicle times after the user arrives at the public transport stop. To compute walking times to public transport stops, OpenTripPlanner was used dividing the city into a grid of cells of 200x200 meters. The results were aggregated at the “Transantiago-Zoning” level, consisting of 804 traffic analysis zones defined by the Public Transport Agency (DTPM). The results are shown in the next section.

The impact of this policy on each socio-economic quintile is estimated, given the socio-demographic composition of each municipality (MDS, 2015) and average income according to Unemployment Insurance 2017 (MDS, 2019).

8.4. Findings

When analyzing public transport trip distances, disaggregated by municipality, significant but predictable differences are observed which are explained by Santiago's spatial distribution of residential density, income, and employment opportunities (Figure 8-2 and Figure 4-1 for all the municipalities and its spatial location). On the one hand, residents of Puente Alto and La Pintana, southern peripheral municipalities, have to travel on average almost three times the distance than Providencia and Santiago's residents, usually to central municipalities that concentrate a high density of opportunities and services. On the other hand, a significant distance variability is observed within trips originating in each municipality. The 5% shortest trips originating from every municipality are relatively similar, between 1 and 2.5 kilometers. However, their longest trips are very different. For example, the trip associated with the 5% longest trips in Providencia is shorter than the average trip originating in Puente Alto, where 5% of the trips are longer than 29 kilometers. Such long distances should be a concern since the time period analysed (6 to 10 AM) reflects that a large portion of residents from peripheral zones commute extremely long distances to satisfy their mandatory activities (usually work or study). Meanwhile, for example, residents from Providencia (a high-income and central municipality) commute much shorter distances, explaining the high modal share of walking and bicycle trips (SECTRA, 2015).

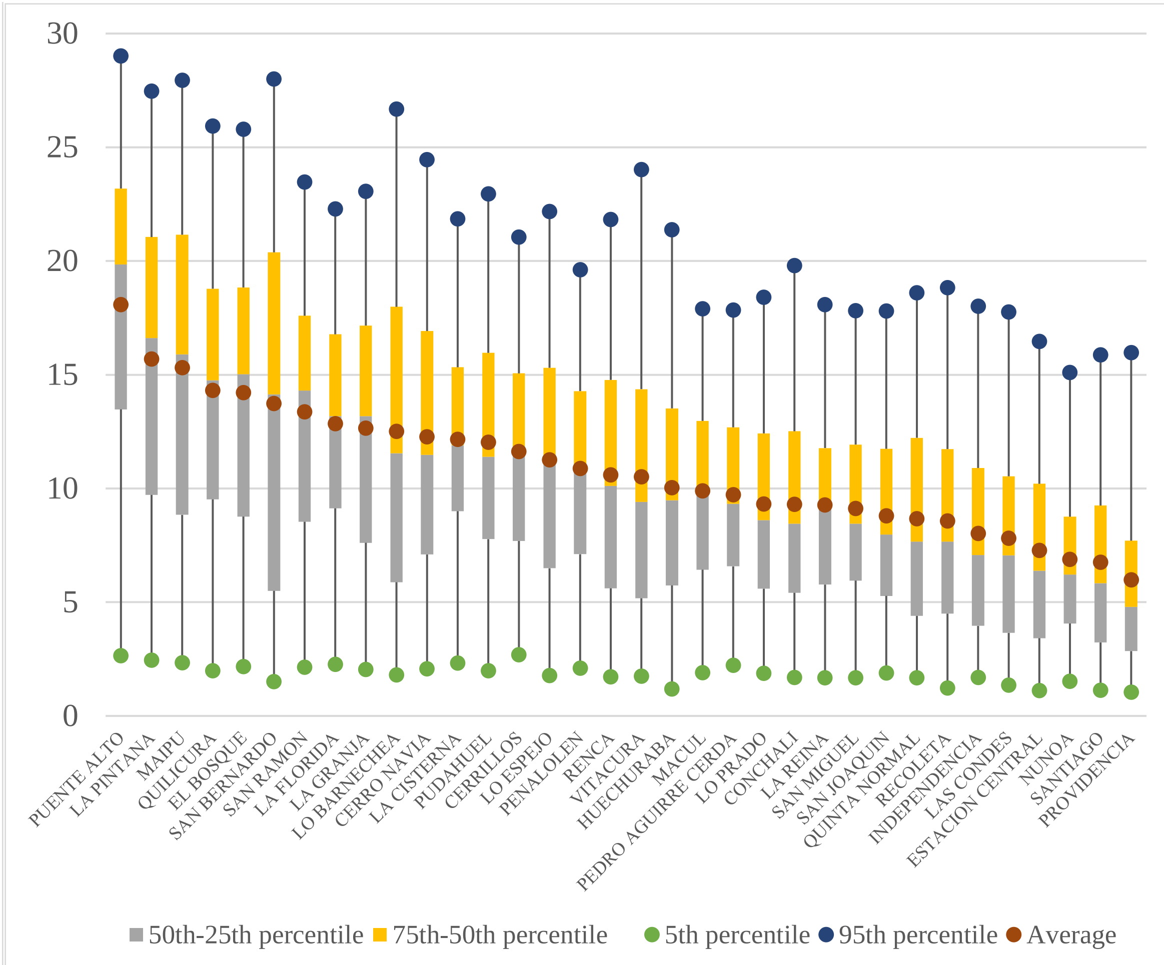

Figure 8-2 Route distances through public transport by municipality (Source: Own elaboration, based on DTPM (2019b)).

Such disparity across municipalities reveals that a distance-based fare scheme would likely treat residents from different municipalities very differently. To quantify these differences, the distance-based scheme is compared with the current fixed fare scheme used by Transantiago, computing the total amount to be paid by all trips emanating from each municipality in both fare schemes. Figure 8-3 presents the average percentual fare variation in each municipality. Unsurprisingly, seven peripheral zones of the city (shown in dark in the Figure), located mainly in the south are the most disadvantaged, paying an average of

57% extra per each public transport trip. In contrast, the municipalities in the area expanding from downtown to the northeast where most activities are concentrated (depicted in white in the Figure) would benefit, allowing their residents to save on average 25% of the fares they currently pay. The remaining outer zones situated in the north and several pericentral zones located in between these two regions show mixed results, from -10% to 35% fare variation.

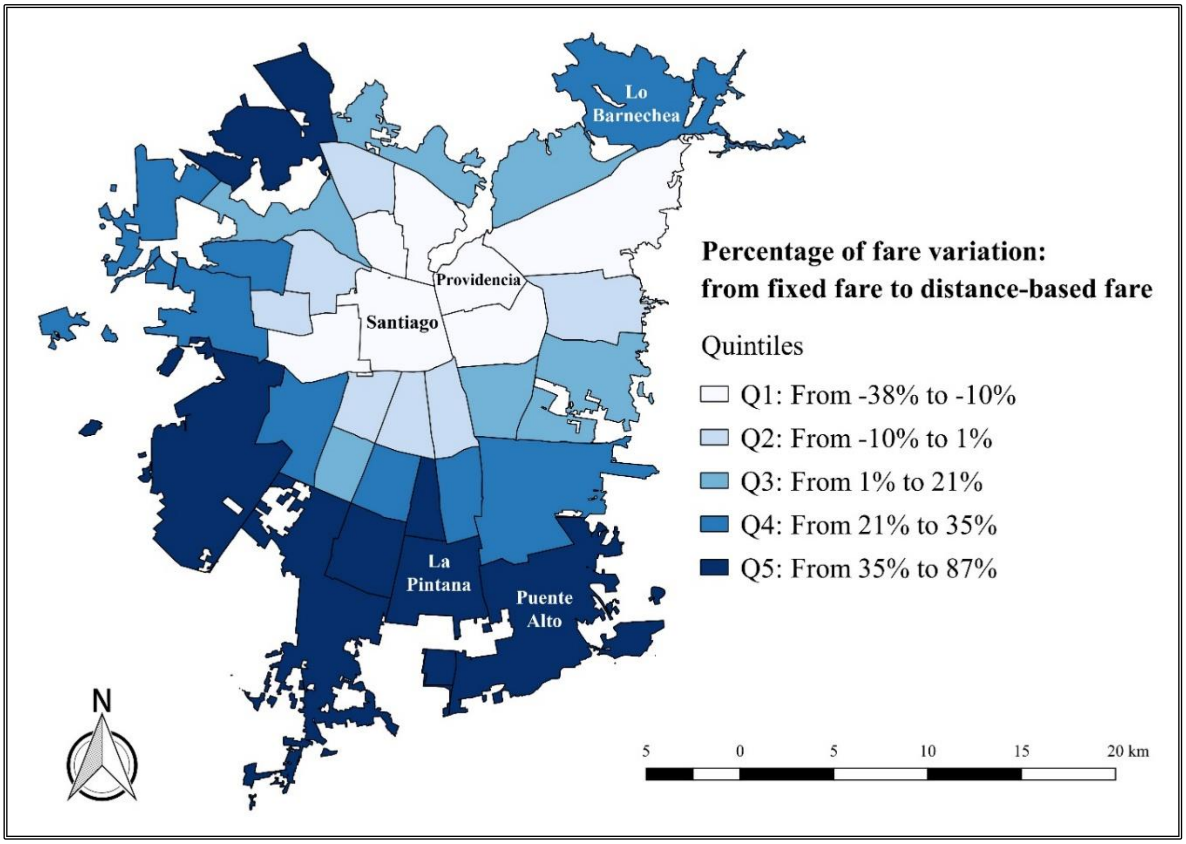

Figure 8-3 Percentage of fare variation by municipality (Source: Own elaboration, based on DTPM (2019b))

As shown in Figure 8-4, on average, residents from 21 of the 34 municipalities would pay more with the distance-based scheme than in the current fixed fare. The Figure also shows that despite the high variability of trip distances, one-third of those 21 municipalities have more than 70% of their trips paying more than in the current fare scheme. Six municipalities show a relatively even distribution among 'winners' and 'losers' of the scheme change, with no clear spatial pattern. Nevertheless, the aggregate effect on these municipalities is an increment of 7.5% of the average fare per trip.

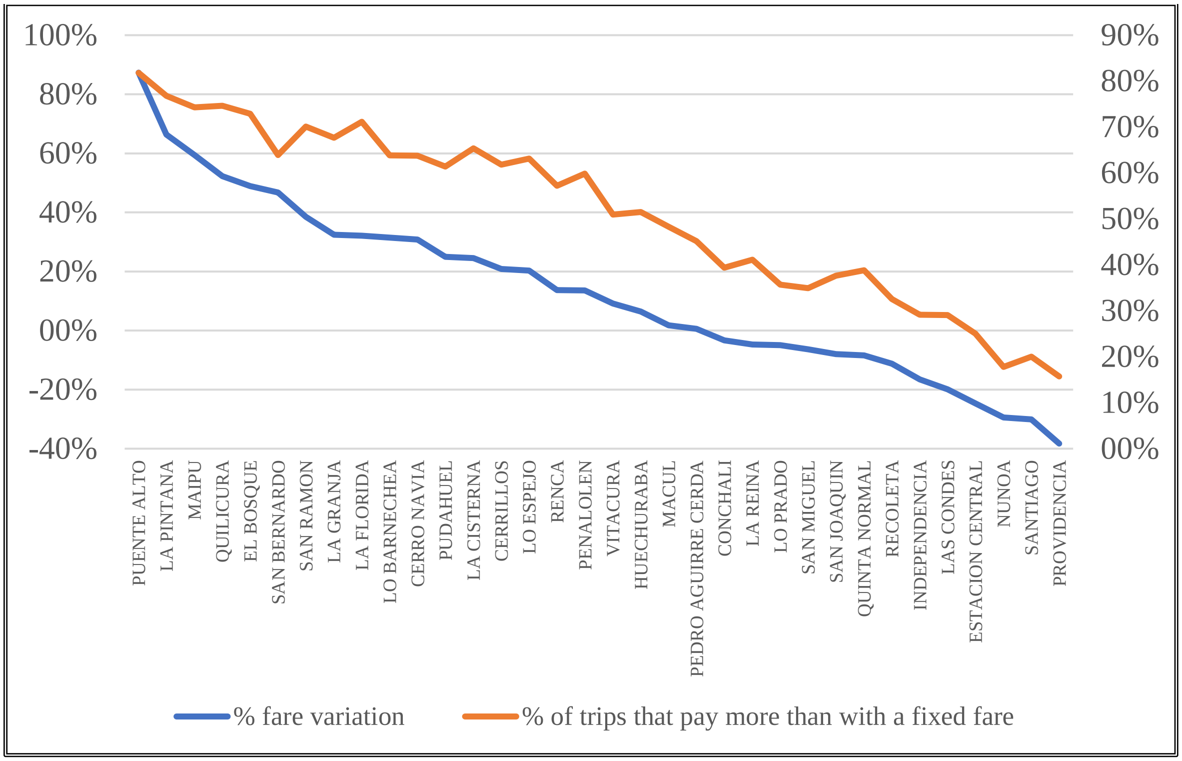

Figure 8-4 Fare variation along with the percentage of 'losers' with the distance-based scheme (Source: Own elaboration, based on DTPM (2019b))

An important issue, moving beyond the geographical dimension, is to analyze the affordability effects of a distance-based fare scheme. To study the socio-economic composition of the municipalities affected, the percentual fare variation is plotted along with the percentage of the population belonging to the two lowest income quintiles per municipality (Figure 8-5), and ii) the average household income per municipality (Figure 8-6). This way, it can be shown if the cross-subsidy between short trips and long trips would contribute to a more equitable scenario where the most deprived populations would have less economic stress related to transport expenditures.

The results in Figure 8-5 show 15 of the 34 municipalities have over 50% of their population in the two lowest income quintiles. In only 3 municipalities, the residents would, on average, benefit from a distance-based fare scheme, saving 6.5% of their current expenditure. The remaining 12 municipalities would be disadvantaged by the distance-based fare scheme, with expenditure increasing on average, by around 30%.

Households belonging to municipalities with a low-income majority (i.e., households in the two first quintiles representing more than 50% of the population) earn, on average, 1,056 USD per month. In contrast, households in the remaining 19 municipalities make, on average, 50% more (1,580 USD). The distance-based fare scheme would hit the affordability of residents quite differently. For example, La Pintana households make, on average, 866 USD per month. One of its residents traveling 50 times per month at the distance-based fare would spend over 10% of the household income on these trips. However, 50 trips from a resident from Lo Barnechea municipality, which on average, earns 2,321 USD per month, would spend just over 3% of the income. The different affordability impacts on residents from different municipalities could be even more significant if more complex household structures are considered.

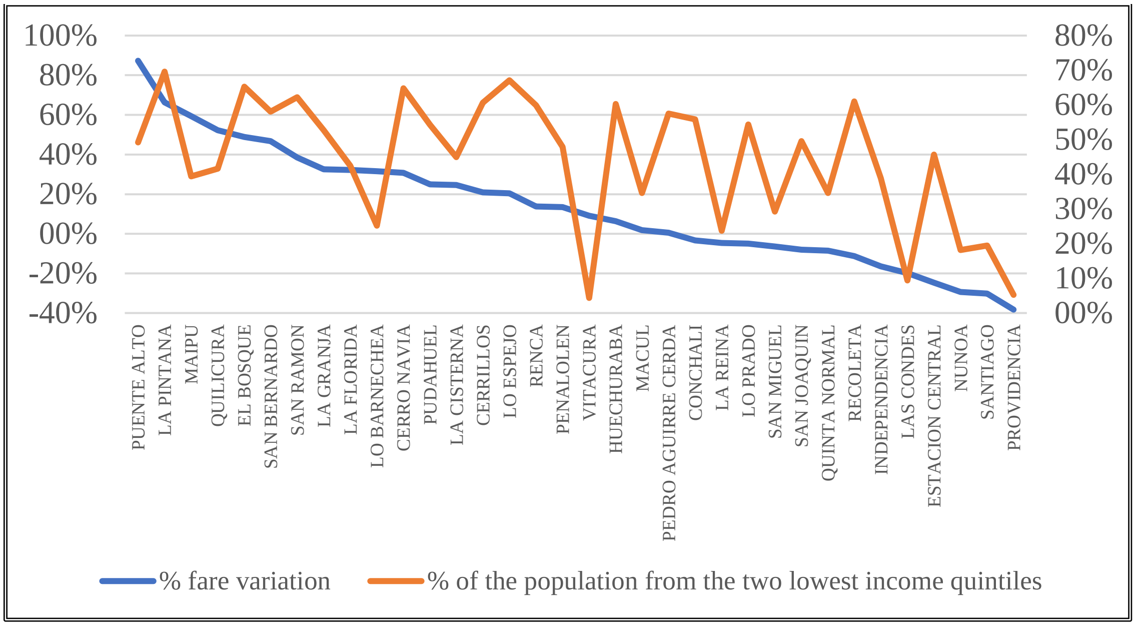

Figure 8-5 Fare variation along with the percentage of the population of each municipality that belongs to the 2 lowest income quintiles of the city (Source: Own elaboration, based on DTPM(2019) and MDS (2015))

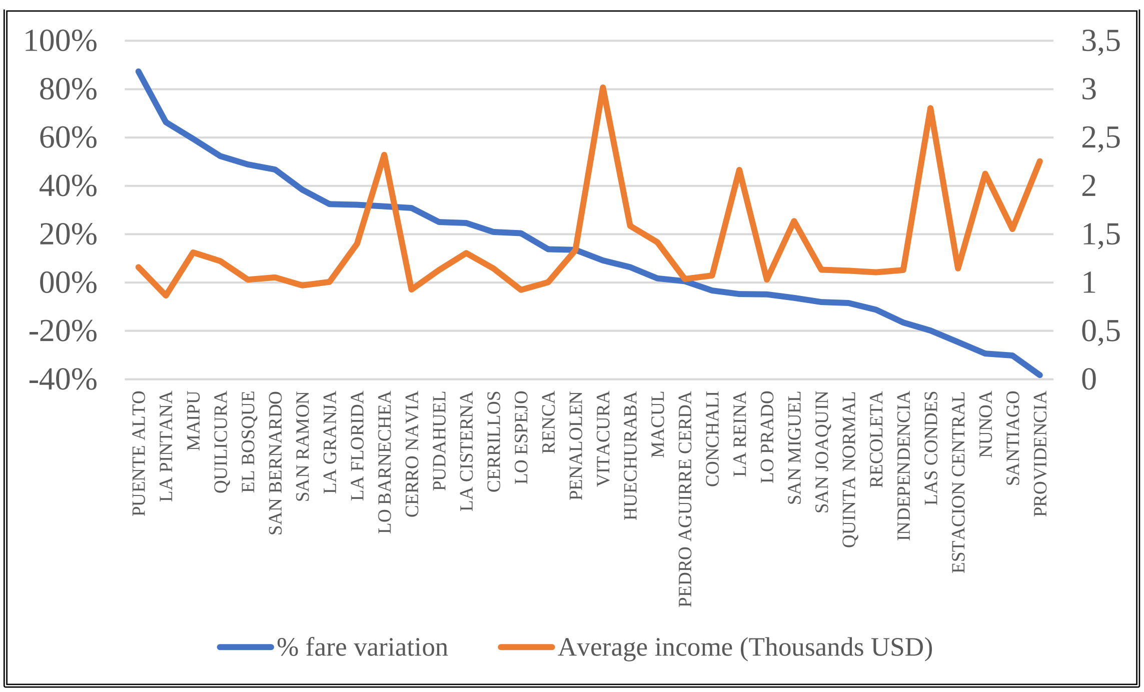

Figure 8-6 Fare variation along with the average income by municipality (Source: Own elaboration, based on DTPM (2019b) and MDS (2019))

Finally, it must be recognized that the fare is just one element affecting the level of service experienced by a public transport user. All the attributes affecting the level of service are usually aggregated into a single indicator identified as the generalized travel cost. In this chapter, a generalized travel cost considering in-vehicle, waiting, and walking times and fares (with each of the two fare scenarios: fixed and distance-based) is considered. As Figure 8-7 shows, the distance-based fare exacerbates the current accessibility problems in the city. As expected, residents from peripheral zones would experience higher generalized travel costs and, therefore, lower accessibility levels. It is observed that the fare increase or decrease creates an impact of between +25% and -15% of the generalized travel cost at the municipality level (Figure 8-8).

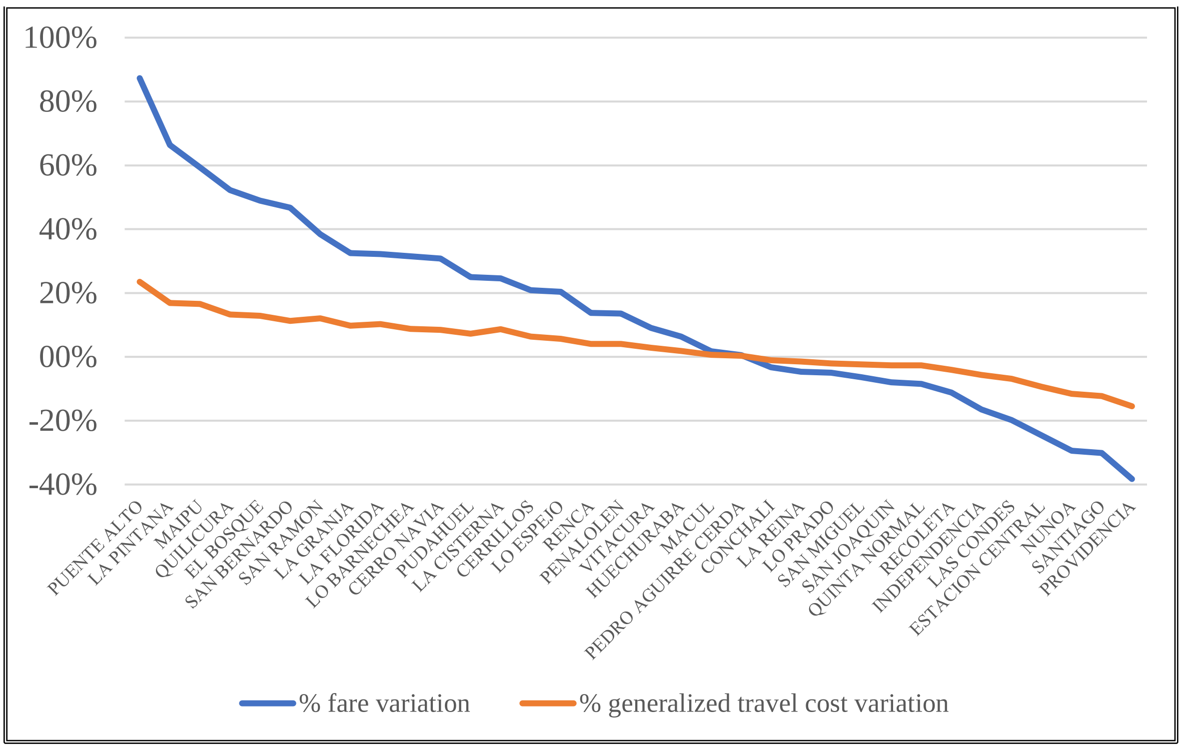

Figure 8-7 Percentage of fare variation and its effect on generalized travel costs (Source: own elaboration, based on DTPM (2019b))

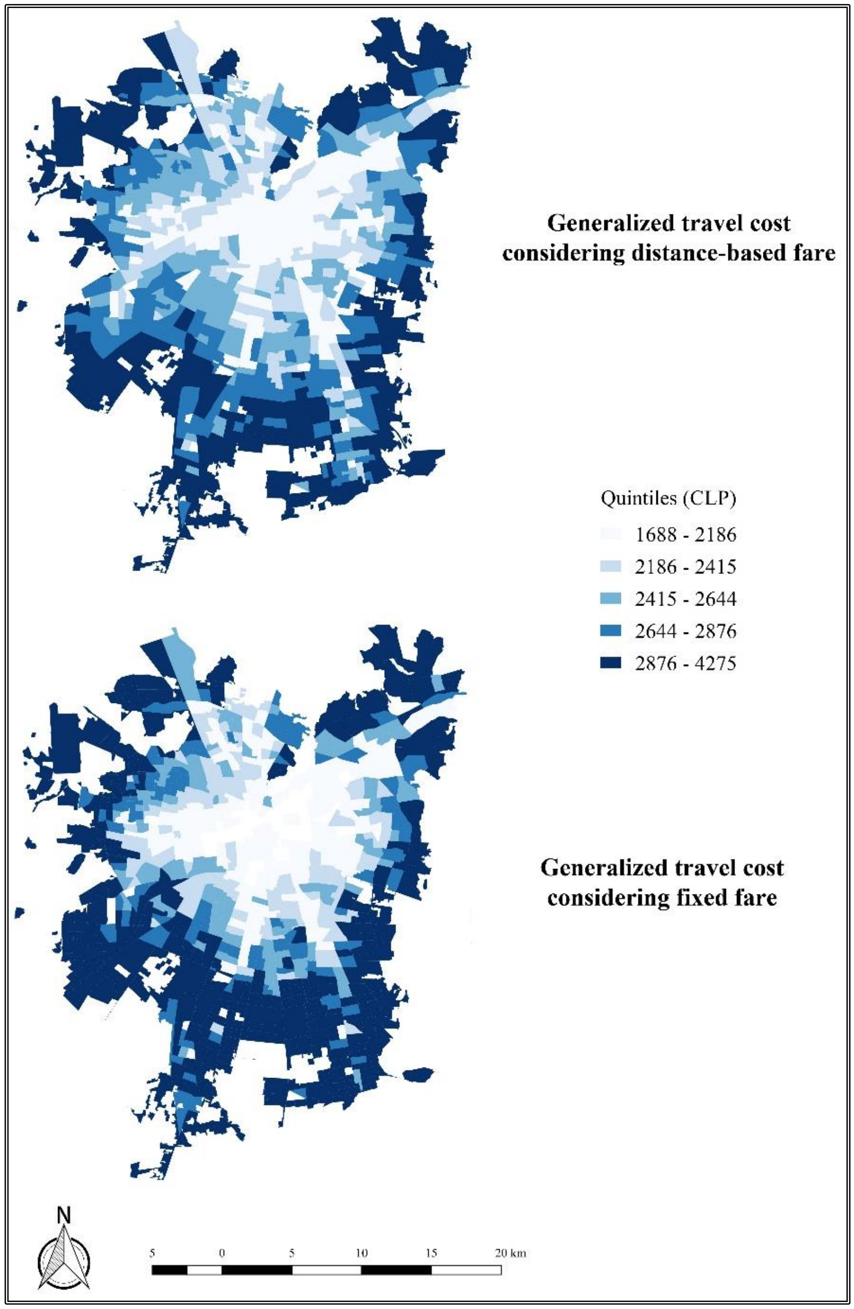

Figure 8-8 Generalized travel cost considering the two analyzed fare schemes (Source: Own elaboration, based on DTPM (2019b))

8.5. Discussion and further research

Accessibility and affordability are critical dimensions for socially sustainable development. In Latin American cities, characterized by urban segregation and social inequalities, public policies oriented to counterbalance transport-related inequalities and provide a better quality of life, especially for the most deprived populations, are highly desirable. This chapter analysed if the current public transport fare scheme in Santiago, which is fixed for given time periods and mode combinations, is desirable over a distance-based fare scheme. The analysis focused on equitable outcomes, analyzing how a distance-based fare scheme would affect accessibility and affordability to urban opportunities for low-income populations.

The results show that the current fare scheme in Transantiago is preferable over a distance-based scheme. In Santiago, those living in the central zones tend to make significantly shorter trips than those living in the periphery and, on average, tend to have higher income levels. This scenario is coherent with the observed trend of central areas presenting a more mixed land use allowing its residents to perform key activities at a convenient distance. Medium-high and high-income people dominate most of these zones. By paying a flat fare, they cross-subsidize the more extended trips made by medium-low and low-income people living in pericentral and peripheral areas of the city. It is essential to recognize that these results would not apply to many cities with a different land use structure or income distribution spatial pattern. In effect, if wealthy neighborhoods are mostly in the periphery, the distance-based fare scheme may show a more progressive effect, as indicated by the literature.

The findings question the urban development of Santiago over the last four decades, which lacks integrated transport and land use planning policies. In the ’80s, during the dictatorial period in Chile, most of the low-income settlements – by then located in central and well-provided areas – were displaced to the periphery (Morales & Rojas, 1986; Tapia, 2011), which nowadays implies long commuting to reach job and educational opportunities. Real estate developments need to focus on spreading key opportunities (including jobs) to each municipality to improve accessibility. Likewise, land use incentives for the private sector could change the current pattern of Santiago, homogenizing the opportunity distribution across space. If the city were to develop in such a polycentric fashion, a distance-based fare structure would become more attractive.

However, such an urban policy requires a long-term vision to promote more sustainable development, considering economic impacts, environmental effects, and social inclusion. Given the climate and social emergency that most of Latin American cities face, reducing distances and promoting an ecology of modes where the sustainable trio (public transport, walking, and bicycle) have priority (Sagaris et al., 2017), could reduce trip distances, vehicle-kilometers traveled and car use.

Two directions for future research are proposed. First, understanding how accessibility conditions could be improved by simultaneously providing better public transport connections and encouraging local opportunities in every municipality. This may require evaluating the impact of new transport projects and considering their effects in terms of seeking a more even distribution of opportunities across the city. Developing such indicators could help to promote a more equitable city, complementing the social cost-benefit analysis that every project in Chile must go through. Second, exploring new fare schemes that could enhance affordability conditions for the most vulnerable groups. A more comprehensive assessment of subsidies focused on low-income people and the elderly could be performed. Furthermore, new ways to finance public transport as local taxes or parking charges (see Ubbels et al. 2017 for an overview of different case-studies), especially considering the high rates of fare evasion in the Santiago system would be especially interesting to study.

9. FREEDOM TO CHOOSE? HOUSING AND TRANSPORT AFFORDABILITY ISSUES IN SANTIAGO DE CHILE

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9.1 Introduction

Two key dimensions of the Sustainable Development Goals (SDG) set by the United Nations (2018) are “No poverty” (SDG #1) and “Sustainable cities and communities” (SDG #11). Among other actions, providing affordable housing, improving access to transport and basic services, improving income distribution and enhancing public transport can help achieving these goals. These objectives are especially important for developing regions like South America in which social segregation and inequality are particularly high.

Latin American and Caribbean cities face important housing issues, associated to low income, lack of financial markets, low supply and high prices, leading to informal housing and lack of basic services as water and sanitary services (IADB, 2012). In Santiago, Chile, Espinoza & Urzúa (2018) shows that sales prices have almost doubled in the period 2009-2017 and that the rent prices have increased by about 50% in the same period.

Similar problems are observed in the transport sector. Average transport expenditures per household in the region could vary between 7.7% and 17.1% of the average household income. Despite subsidies being widespread to increase affordability, especially among low-income households, their distributive impacts need to be improved (IADB, 2019). In Santiago, Chile, if we consider the transport user costs under the current modal share and a potential mobility (40 trips per month), the two lowest quintiles spend 28% or more of their average monthly income (Iglesias et al., 2019).

Despite the growing literature on housing and transportation affordability studies, little attention has been given to the Latin American context (Guerra et al., 2018). Moreover, most studies on this subject perform analyses based on aggregate data for income and costs, ignoring distributional considerations (Dokko, 2018) and potentially under-estimating the simultaneous impact of transport and housing costs on lower income family budgets. Our work seeks to contribute to filling those gaps by understanding and measuring housing and transport affordability using different types of households in Santiago de Chile as a case study. Combining income, housing, transport and census data, we estimate housing and transportation distribution costs using spatial clusters and probability functions, analyzing the “degree of choice” that low-income people could make given their budget constraints.

The article is structured as follows: in Section 2 we provide a literature review on housing and transport affordability and identify the research gap with more detail. In Section 3 we explain the data and methods used for the analysis and Section 4 presents the results for our case study in Santiago de Chile. Then, in Section 5 we discuss the main findings and finally, we analyze key impacts of our results in terms of policy and practice, identifying paths to move forward.

9.2 Literature review

9.2.1 Housing and transportation affordability

Affordability has been extensively studied and measured by the literature concerning the financial stress that housing or transportation costs generate. The latter has been analyzed in a variety of contexts like Africa (Boamah, 2010; Venter, 2011), Latin America (Guerra et al., 2018; Acolin & Green, 2017), Oceania (Beer et al., 2007; Mattingly & Morrissey, 2014), Asia (Isalou et al., 2014; Dewita et al., 2018) North America (Luckey, 2018; Salon et al., 2016) and Europe (Coulombel, 2018; Cao & Hickman, 2018). The housing costs are usually analyzed by the ratio between the average housing costs in a certain area and the household income (Suhaida et al., 2011; Jewkes et al., 2010; Stone, 2006). Afterwards, an 'affordability threshold' is defined to identify households that struggle with this expenditure, which usually is 30% of household income allocated to housing costs (Hulchanski, 1995; Nepal et al., 2010).

It is important to stress that the aforementioned approach, although straightforward, has some shortcomings. Some of them include considering the concept of affordability as dichotomic instead of continuous (Robinson et al., 2006), using aggregate income and cost data and, therefore, missing relevant distributional considerations (Dokko, 2018) and overlooking housing characteristics such as size, presence of children and financial circumstances (Luckey, 2018) or the inability to differentiate between different housing qualities (Bogdon and Can, 1997; Stone, 2006). More complex analyses have been proposed to overcome some of the former mentioned limitations. For example, the use of the residual income approach (Stone, 2006), which considers the available income for housing costs after a minimum or essential consumption (Luckey, 2018). Likewise, considering housing adequacy (over-crowding and living instability) and amenities (Cai & Lu, 2015) or including affordable housing supply for different socio-economic groups (Meen, 2018) could enrich the analysis.

Like housing affordability measures, studies focused on transport usually address affordability through the ratio between transportation expenses and household income after taxes or the ratio between transportation expenses and total household expenses. Based on findings from previous studies, different spatial patterns emerge from the application of both housing and transportation indicators and no clear linkages could be made between a lower-income share expended in transport and higher wellbeing (Fan & Huang, 2011). Contextual factors, such as sociodemographic characteristics, household composition and the built environment, play a key role in better understanding transport expenditures. In fact, recent works suggest that good transit-accessibility alone is probably not enough to reduce transportation expenditures and that cost reduction of moving to more accessible neighborhoods could be overstated because more trips can be made and car trips could be cheaper (Smart and Klein, 2017; Guerra, 2018).

Falavigna & Hernandez (2016) make a key distinction between the use of observed mobility and potential mobility in affordability studies. Public transport fare or car-related costs can constitute an important barrier for lower-income households, depriving them of trips that they wish to perform or forcing them to use non-motorized modes (Badami et al., 2004; Cropper, 2007; Fan & Huang, 2011; Diaz Olvera et al., 2013). Thus, defining a potential mobility (i.e., a fixed number of trips and distance traveled) (Carruthers et al., 2005) can be a better path to compare between cities and socioeconomic groups (Gómez-Lobo, 2011).

Despite the methodological debates and the usefulness of housing or transportation affordability measures, a more holistic analysis is required in order to explore the relationships between the two. Urban economic models allow us to conclude that there is a clear trade-off between transport costs (money and time spent) and location (Alonso, 1960; Glaeser, 2008). This kind of analysis shows that diffuse and low-density urban form, ceteris paribus, tends to increase transport costs by decreasing accessibility to services and increasing travel distances, forcing a higher car use (Newman & Kenworthy, 1989; Horner, 2002; Low et al., 2005).

Thus, in recent years, several studies have been developed worldwide to explore the joint effect of housing and transportation costs (Guerra et al., 2018; Dewita et al., 2018;

Coulombel, 2018), especially in American (Salon et al., 2016; Smart & Klein, 2017; Luckey, 2018) and Australian cities (Li et al., 2018; Mattingly & Morrissey, 2014; Saberi et al., 2017; Vidyattama et al., 2013). Notwithstanding clear contextual differences, all these studies show similar patterns: housing is more expensive close to the central business district (CBD) and cheaper in outer zones. The latter affirmed, however, if transport costs are considered, people living in the urban periphery have higher transport expenditures because of poor public transport connections; which, in turn leads to a dependency on cars (sometimes termed forced car ownership or FCO (Banister, 1994; Currie & Senbergs, 2007)).

This phenomenon has received growing attention in the last years especially across the UK, revealing how vulnerable are households to fuel prices rise and the consequences of the car-related economic stress in daily mobility. Cutting other expenses, adjusting the number of trips to the minimum or going into debt are some of the consequences of the aforementioned phenomena. The latter is especially true for low- and medium-income households, as well as households with children and employed adults in middle age groups that deal with multitasking (Mattioli, 2017; Chevallier et al., 2018; Walks, 2018; Curl et al., 2018; Mattioli et al., 2018a; Mattioli et al., 2018b; Cao & Hickman, 2018).

The literature on housing and transport affordability has been focused on identifying spatial patterns and gaps between socioeconomic groups. These studies usually propose different policies to alleviate the income share allocated to housing and transportation costs for most vulnerable households' types, which usually compresses low-income households and families with children. Recent efforts have been developed to characterize and analyze the elements that contribute to transport poverty and its dynamics (Martens, 2013; Martens & Bastianssen, 2014; Grieco, 2015, Lucas et al., 2016). Following this research topic, our article provides evidence on a different (Latin American) context by proposing a novel methodology to understand and analyze HTA for different household types in Santiago de Chile, focusing on the choices that low-income and vulnerable household could make in this urban segregated space.

9.3 Data and methods

Our main aim is analyzing HTA for different household types in Santiago de Chile, focusing especially on the "degree of choice" for those on low-income. To do this, we can split our methodology into 3 main steps: first, analyze spatial patterns of both housing and transportation costs, using origin-destination data per municipality and average prices per square meter. Second, we divide the housing data into spatial clusters, in order to estimate costs distributions for housing and transport. Third, we estimate the probability to locate and use a certain transport mode in each cluster for every household type.

For each step, we use different sources of data. A summary of the process, considering methods, analysis and data used is shown in Figure 9-1. Below we deepen the data and methods used to fulfill the chapter aims.

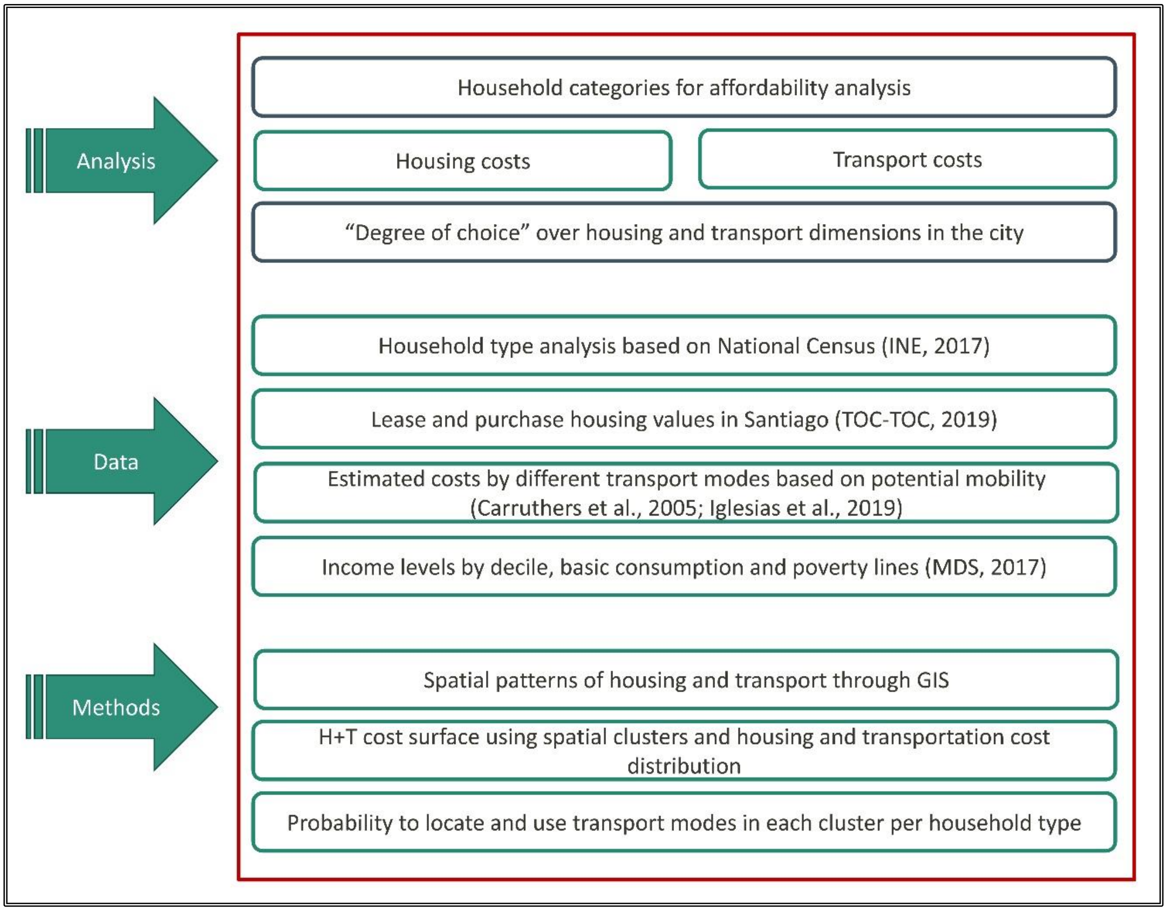


Figure 9-1 Summary of the analysis, data and methods deployed in our article (Source: Own elaboration)

9.3.1. Household categories

According to the last Chilean National Census (INE, 2017), around 80% of the households are comprised by a maximum of four people. Table 9-1 shows the distribution of households by type and number of bedrooms for sleep-only purposes. If we analyze household types up to four members, most of them live in a house with no more than three bedrooms (grey cells).

Table 9-1 Household types, members and rooms for sleep-only purposes (Source: Own elaboration based on INE, 2017)

		Rooms for sleep only						
Household Type (National Census, 2017)	**Members**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
One-person household	1	1.3%	50.8%	32.1%	12.9%	2.0%	0.5%	0.4%
Single parent nuclear household	2	0.3%	11.1%	63.4%	21.3%	3.1%	0.6%	0.2%
Single parent nuclear household	3	0.2%	5.9%	31.5%	54.2%	6.8%	1.1%	0.3%
Single parent nuclear household	4	0.2%	4.6%	24.9%	43.9%	22.9%	3.0%	0.5%
Two-parent nuclear household without children	2	0.6%	42.0%	38.1%	15.9%	2.7%	0.5%	0.3%
Biparental nuclear household with children	3	0.3%	9.7%	55.9%	29.0%	4.2%	0.7%	0.2%
Biparental nuclear household with children	4	0.1%	3.8%	30.0%	55.5%	9.2%	1.1%	0.3%

Thus, we define six households' types for the analysis according to sociodemographic composition. These are: single, retired, couple, single parent with one child, couple with one child and couple with two children. Moreover, we focus our study in five different dwelling layouts: one room and one bathroom, two rooms and one bathroom, two rooms and two bathrooms, three rooms and two bathrooms and three rooms and three bathrooms. Using the former configurations, we were able to analyze the cost distribution for different household types.

9.3.2 Housing costs

We use rent and purchase values for new and used housing in Santiago de Chile between 2014 and 2018 (TOC-TOC, 2019). After a data cleaning process to remove outliers and records with missing information, we kept around 90% of our data. The surface range is from 17 to 150 square meters constructed (up to 300 for the land space) and up to 7640 UF. For each rent record, the location, surface (square meters) and number of bedrooms and bathrooms is known. The same data is known for each purchase, with the exception of the number of bedrooms and bathrooms, which is imputed based on surface using the rent database values.

Our analysis is based on monthly expenditures for every household type in each municipality. For rent values, the analysis is straightforward given our data. For purchase values, we consider all transaction costs using a 10% immediate payment and a mortgage loan for 90% of the house cost, which is the most common loan bound delivered by all banks in Chile. We assumed that this mortgage loan would be paid in 20 years with a fixed interest rate, according to standard mortgage conditions in our setting. For all the analyses we use a unit measure called "Unidad de Fomento" (UF), which is a resettable financial unit that is adjusted monthly according to inflation. Using this data, we were able to create a 'cost distribution' for each location based on household categories using size and amenities.

Besides the calculation of average costs as a first approach, we cluster the data to analyze housing cost distribution using purchase values per square meter. We used a k-means algorithm to estimate 5 different clusters, considering between 13’000 and 66’000 records per cluster. For each cluster, we fit a probability distribution using Easy Fit software (Mathwave, 2004). This way, we classify each dwelling purchase record (price per square meter) in cluster k as H_k. Then, for a certain household type j, H_{kj} corresponds to the price of a dwelling of certain square meters in cluster k that fits with each household type j needs (see Table 9-2).

Table 9-2 Basic statistics. Apartments in the rent data base (Source: Own elaboration, based on TOC-TOC (2019))

	Square meters			
Household Characteristics	**Minimum**	**Maximum**	**Average**	**Fitted Probability Distribution**
1 room, 1 bathroom	31.73	51.66	41.35	Burr (k=0.68217, α=8.8206, β=37.077)
2 rooms, 1 bathroom	43.71	71.02	53.11	Frechet (α=5.7881, β=46.263)
2 rooms, 2 bathrooms	52.31	90.75	74.22	Dagum (k=0.68838, α=5.0772, β=48.235, ϒ=28.462)
3 rooms, 2 bathrooms	67.34	127.84	106.35	Erlang (m=4, β=15.052, ϒ=45.153)
3 rooms, 3 bathrooms	78.00	150.22	141.82	Burr (k=0.73017, α=7.9078, β=127.59)

9.3.3 Transport costs

For transport costs, we follow a similar methodology to the one proposed by Iglesias et al. (2019). In each location we analyze potential mobility thorugh different transport modes, understood as a fixed number of trips to a fairly comparison between socioeconomic groups, following Carruthers et al. (2005). We used 50 trips based on an average distance for each transport mode from origin-destination data (SECTRA, 2015). The transport modes we considered are car, shared taxi, bicycle, walking and public transport.

To estimate car costs, we were inspired by Salinas et al. (2016), which disaggregate them into operation and maintenance cost. We include fuel consumption, insurance and permits, maintenance, parking and highway costs. For shared taxis, we estimated the fare using a distance-based scheme obtained from reported fares (Domarchi et al., 2019). Despite their high variability, we use the average value to capture low and high fares present on different contexts. For public transport, we use the highest fare (Metro system at rush hour) charged for adults, students and the elderly (Metro S.A., 2019). For bicycle costs, we use an upper bound corresponding to the monthly subscription of the main bike-sharing system in Santiago (Bike Santiago, 2019). It is considered an upper bound since the cost of owning a bike should be lower.

As in the case of housing, we calculate average costs in every municipality and study the main spatial trends in terms of car use and sustainable transport use. Then, for every municipality, we computed the monthly transportation costs for every household type creating a sample of 5000 trips that replicates the current modal share of every municipality for fixed trips (work and education) (SECTRA, 2015). In these cases, the lower bound of the transport cost for a household member corresponds to the case when the person walks to the destination, while the upper bound corresponds to using a car. By using the modal share reported in each municipality to households in each cluster k previously defined, we associate a probability to each possible cost for each household type j (T_{kj}).

9.3.4 Income and consumption

To analyze the impact of housing and transportation costs for different households, an estimation of income for different socioeconomic groups is required. The Supplementary Income Survey (INE, 2017) provides the average and median household income, and the per-capita income for each income decile (Table 9-3). Moreover, we used the basic consumption basket and poverty lines defined by the Ministry of Social Development (MDS, 2017) (Table 9-4) to calculate the available income for each household.

Table 9-3 Average, median and per cápita household income divided into deciles (Source: Own elaboration based on INE, 2017b)

Income decile	Per capita income	Average household income	Median household income
1	3.04	12.13	11.68
2	5.20	19.59	18.06
3	6.74	23.92	22.00
4	8.25	27.21	25.21
5	9.88	30.46	29.15
6	11.79	35.24	34.19
7	14.27	38.96	31.80
8	18.08	46.39	39.52
9	24.63	61.23	53.82
10	52.43	123.99	97.81

Table 9-4 Basic consumption basket and poverty lines (Source: Own elaboration based on MDS, 2017)

	UF per person
Basic consumption basket	1.53
Poverty line	5.89
Extreme poverty line	3.93

Using all the data and estimations from the previous subsections, the probability of a certain household type j with an income i (after basic consumption) to live in a certain type of dwelling and using a particular transport pattern according to spatial cluster k can be estimated as follows:

$$P_{|i,k,j,x}\left(H_{xkj} \cap T_{kj}\right) = P\left(H_{kj}\right) \cdot P\left(T_{kj}\right) \tag{9.1}$$

where

T_{kj}: Transport cost probability in spatial cluster k

H_{kj}: Dwelling cost probability for x square meters in spatial cluster k t for household type j

9.4 Case study: Santiago de Chile

Chile has the second highest Gini coefficient (0.454) of all OECD countries (OECD, 2015), which discloses high inequality levels. The advances in the last fifteen years has been insufficient to reduce the large income gaps between existing social strata. In fact, the general population's perception is that social distances have increased in recent years (PNUD, 2016).

Santiago, the capital of Chile and its largest Metropolitan region, it is probably the 'iconic' inequity example of the country. It has a population of over 6.5 million people within an area of approximately 640 km2. The high-income population lives almost exclusively in the northeastern area (see the seven municipalities in blue in Figure 9-2) which has also increasing its share of productive activities, commerce and activities (Suazo-Vecino et al., 2020). In fact, the richest quintile benefits from 2.5 times more 'non-housing' real estate investment in their municipalities than the poorest quintile (Iglesias et al., 2019). Likewise, huge material differences can be found between the affluent and lower-income neighborhoods (see for example Tiznado-Aitken et al., 2018 and Rossetti et al., 2019).

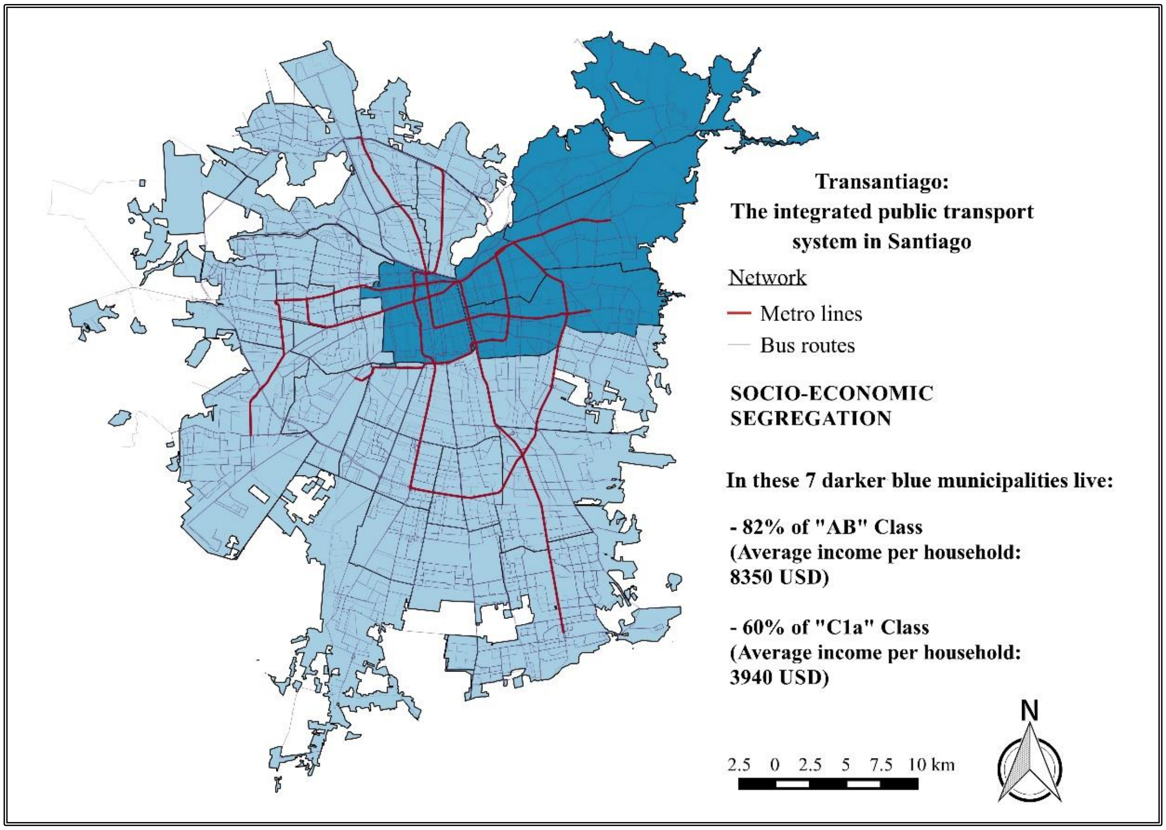


Figure 9-2 Transantiago and socio-economic segregation in Greater Santiago (Source: Own elaboration, using DTPM (2019b) and AIM (2016) data)

This uneven urban development can be explained by several public policies implemented in the past (PNUD, 2016). Since 1980, low-income informal settlements and social housing were displaced from central and high-income areas towards the periphery (Molina, 1986; Morales & Rojas, 1986; Tapia, 2011). This scenario strengthening urban segregation over the years, forcing long commutes for the low-income population to reach business centers, where job opportunities accumulate (Sabatini et al., 2001; Rodriguez, 2008). Thus, this development produces inequalities regarding access to transport (Shirahige & Correa, 2015) and basic services such as employment and education (Asahi, 2014). If we add that 60% of the households in Santiago does not own a car (SECTRA, 2015), and recognize that most of them are located in 20% of the municipalities where 2 out of 3 households have a car, many inhabitants of low income areas of Santiago are captive to the public transport system (Transantiago, see Figure 9-2) to satisfy several basic needs.

Given this context, our aim is to analyze how different household types could choose housing and transportation options in a highly segregated context like Santiago, considering different mobility alternatives and price fluctuations in space. Below we analyze the main findings.

9.5 Findings and discussion

Unsurprisingly, the more expensive places to live in Santiago were concentrated around the north-east sector of the city. In this area, the high housing prices respond to the attractiveness and convenience that those places offer to any household: high quality of urban environment, good access to public transport and a great accessibility to economic activities and basic services (Tiznado-Aitken et al, 2018; Rossetti et al., 2019; Suazo-Vecino et al., 2020).

A less marked difference between the high-income zone and central, pericentral and peripheral locations was observed in the rent values compared to purchase values (Figure 9-3). The most likely explanation for this is that the database that we used (TOC-TOC, 2019) has a bias towards properties in the eastern sector, and therefore, of greater value. Thus, the estimation for properties of peripheral sectors could be overestimated. A more realistic estimation could be observed in the case of purchased houses, where the gap between the minimum and maximum values could reach up to five times. Given this scenario, among other reasons, in Santiago rent is rising as a main option nowadays. In fact, the price housing index has been rising since 2002 as well as the PIB per capita, but the former decoupling from PIB per capita since 2012 (Simian, 2018).

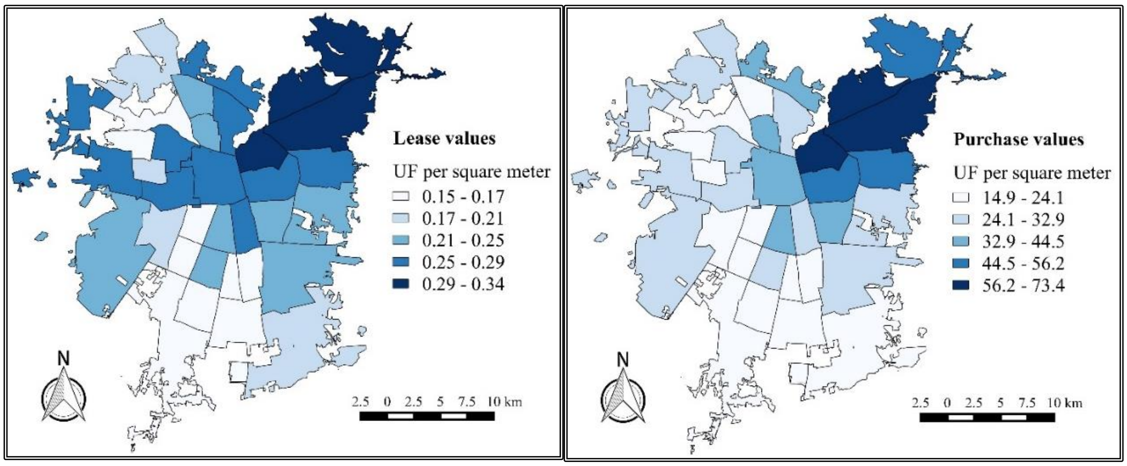
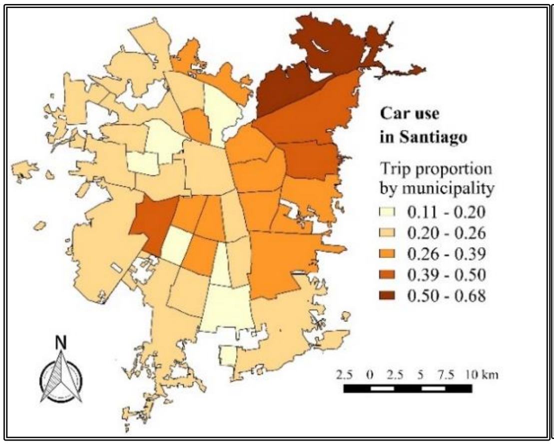


Figure 9-3 Average rent and purchase values in Santiago (Source: Own elaboration based on TOC-TOC, 2019)

Given the high socioeconomic segregation in the city, transport costs show an inverse pattern (Figure 9-4). The use of the car in Santiago is mainly concentrated in high-income households, that usually possesses more than one car (SECTRA, 2015) and could afford them considering operation, maintenance, parking and urban highway payments. Sustainable transport use is quite remarkable in central, pericentral and peripheral areas. This sustainable behavior hides that many inhabitants in these areas are captive of these modes, which provide a lower accessibility than the car. This is particularly worrying for the many in Santiago with high dependency on walking (Sagaris & Tiznado-Aitken, 2018).



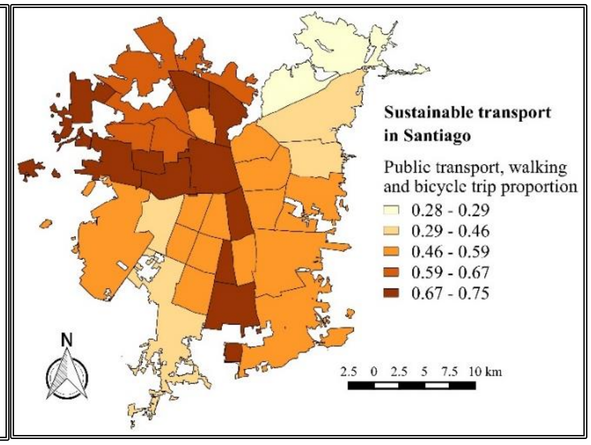


Figure 9-4 Car and sustainable transport use in Santiago (Source: Own elaboration based on SECTRA, 2015)

Although quite informative, the average price indicators used in ths work hide their distribution which play a key role in understanding affordability of the poorest and the magnitude of urban inequalities. In low-income municipalities, the variance is lower than in high-income municipalities, as we can see in Figure 9-5. However, outliers are observed in every zone. In order to analyze how affordable certain places are for different households, we had to include the price distribution into the analysis, computing the probability to live in an area and the probability to use each transport mode.

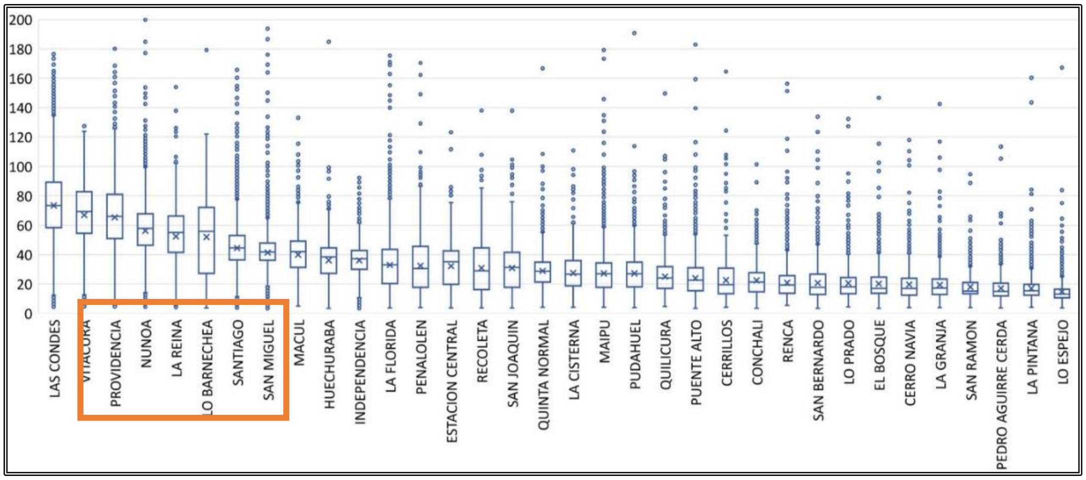


Figure 9-5 Transactions costs in Santiago (Source: Own elaboration, TOC-TOC, 2019)

Following the methodology described in section 3, we created 5 clusters of zones (Figure 9-6). Given the high segregation in Santiago, and to focus our attention in the most vulnerable households, we analyzed clusters 1 and 2 (with up to 27 UF per square meter on average). We studied the probability to purchase in each area, ignoring the time needed to save the funds required to pay for the 10% immediate payment and considering instead only the monthly payment for the mortgage loan for the 90% of the house cost. Moreover, we considered the mobility costs using a certain (combinations of) transport modes. We considered the six household types for the five lowest income deciles in Santiago.

The scenario for households from the two lowest deciles in Santiago was quite dramatic. For any household type, the housing and transportation costs represented more than 60% of their income. Take for example a two-resident household, composed by a couple or a mother/father with a child. This household could afford up to 50% of the housing supply in Cluster 1 (sky-blue color in Figure 9-6) and spend up to 1.4 UF in transport costs, equivalent to use public transport for most of their trips whole walking to few of them to reduce their monthly costs. For this household to be able to afford 50% of housing options in Cluster 2 (blue color in Figure 9-6), they would need to devote up to 83% of their monthly income.

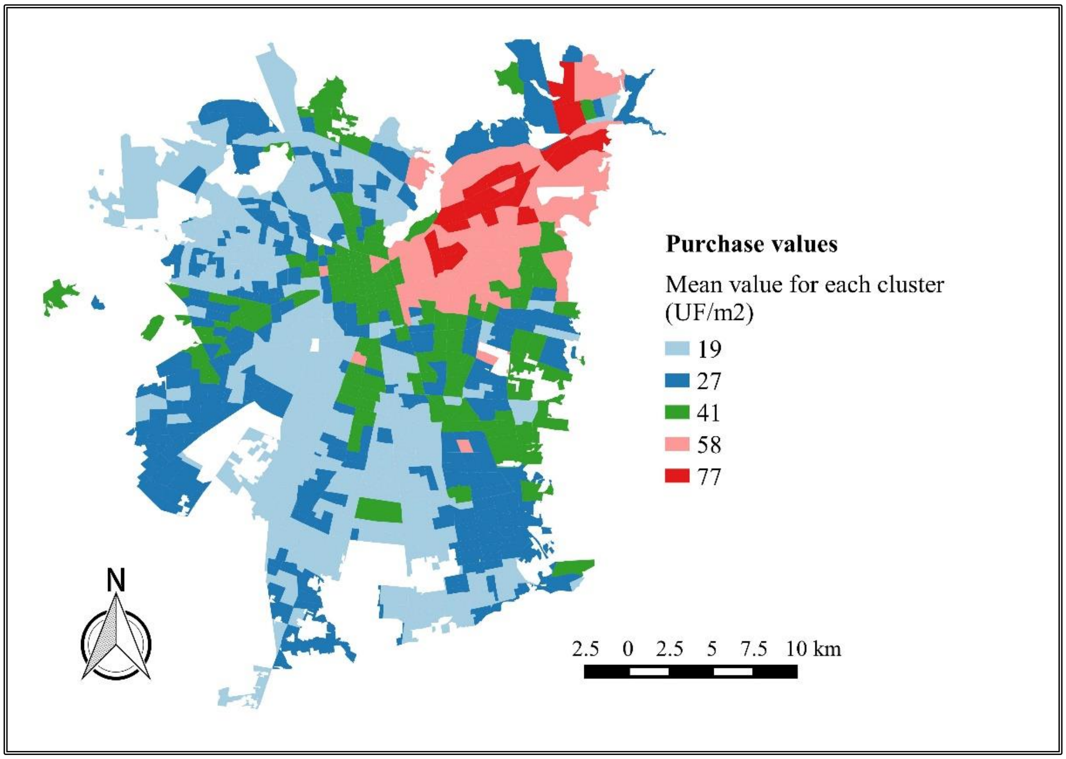


Figure 9-6 Housing clusters and its mean purchase value in Santiago (Source: Own elaboration based on TOC-TOC, 2019)

For a household composed by a couple of parents and two children, the situation is almost the same. This type of family would spend between 30% and 40% of their income if they belong to the fourth or fifth decile, under the same conditions as the previous example (afford up to 50% of the housing supply and using public transport and walking as mode options). For the three lowest income deciles, the funds destinated to housing and transport costs would exceed their income, making this location-mode combination unfeasible.

These figures reveal the difficulties faced by the two lowest deciles in Santiago to locate their homes in “standard” conditions, i.e., in uncrowded formal housing. This means that these socioeconomic groups are forced to “choose” informal housing or living under crowded conditions, sharing little space among them. In Chile, a household is considered to be in an overcrowding situation when the number of people per bedroom exceeds 2.5 or in the case that the home does not have a bedroom for exclusive use. More than 10% of households live under these conditions (INE, 2017) and immigrants are one of the main groups falling in this category. 350,000 units is the housing deficit estimated considering current overcrowding and housing quality conditions (Fundación Vivienda, 2018), revealing one of the key social conflicts in the Chile’s capital.

For retired people, the situation could be even worse. At December 2018, 50% of the 684,000 retirees who received an old-age pension by age (the most massive pension modality) earned less than 5.5 UF per month. Even for the least transport expenditure life condition observed in Santiago (like municipality Pedro Aguirre Cerda, where almost 60% of trips are by walking with zero cost), retired people would spend 23% of their income just in mobility costs. Thus, living alone under these conditions is simply infeasible, so family members must sustain them economically, taking care of their well-being.

If we define an affordability threshold for housing and transportation costs, the big impact that these two essential dimensions have in poorest household’s economy become apparent. Setting a maximum of 40% of their income devoted to housing and transport costs for all the six household types, the two lowest deciles do not have a feasible option. The only household type that fits with this condition is a family with 2 children living in a two-room and two-bathroom apartment, being able to afford among 50% of the total housing supply available and a percentile 25th of the transport costs linked to Cluster 1.

9.6 Final remarks and future work

Housing and transport affordability (H+TA) analysis have been receiving increasing attention among academics and practitioners around the world. Most of the work done focuses on thresholds to define unaffordable H+TA considering average values for a given spatial distribution. A large body of literature has been devoted to Global North settings, giving Latin American cities little attention. This is somewhat disturbing since these cities are among those facing highest inequality, poverty and urban segregation indicators.

Our work contributes to filling these gaps by understanding and measuring housing and transport affordability using different types of households in Santiago de Chile as a case study. The high costs linked to housing and transportation for different low- and medium-income households severely limits the choices that people can have in the city. Small homes in central locations with high accessibility and urban standards are out of reach for all the aforementioned families, leaving only peripheral and poor-connected areas available for them, and still spending a high share of their income.

The methodology we present in this chapter may be useful to evaluate several policies. For example, to explore the effect of a reduced public transport fare in specific groups; e.g. the elderly. Nowadays, only the Metro system has a reduced fare for this group, but buses still cost a full fare. Since public transport fares are integrated, most elderly end up paying the full fare for their trips. Likewise, a public transport subsidy focalized on the two lowest quintiles, the most vulnerable ones according to our analysis, could have a positive effect in reducing the income share they must devote to housing and transportation costs.

Several subsidies could be evaluated using our methodology. For example, the Ministry of Housing and Urbanism (MINVU in Spanish) offers subsidies for different price-range houses to promote purchasing. Our estimations do not consider these subsidies and as a next step we plan to evaluate their effect in avoiding the inequities faced by these households. Similarly, the methodology could be used to study the impact of some proposals as the road pricing affecting mostly the high-income sector (Steer Davies Gleave, 2011). It is claimed that this could raise between US$480 million and US$870 million annually that could be redistributed in order to alleviate the transport costs for the most disadvantaged households in Santiago.

Our future work seeks to include the time dimension in this analysis. Affordable housing and transport studies usually approach the income dimension of poverty only, ignoring the time poverty aspects associated with people's activity and mobility, which are also highly dependent on location and transport "choices". Despite the vast literature on poverty, a limited number of researchers have started to investigate the uses, causes, and potential consequences of time poverty (Williams et al., 2015).

According to Encalada (2015), if we consider the population between 18 and 65 years in Santiago, 26% work and travel to/from work at least 12 hours a day and 32% have less than 2 hours of free time a day. Moreover, the time distribution among socioeconomic quintiles and the household members show deep inequalities. For example, analyzed by gender, women spend less time in leisure, social life, paid work and studies, and spend more time in unpaid work.

These imbalances are another inequality dimension that is conditioned by housing and transport affordability, since time and income are strongly linked. Therefore, the impact of urban configuration on time and consumption dimensions, which in turn are affected by HTA, has not been directly analyzed in literature.

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10. CONCLUSIONS

Countries worldwide launched new commitments to a set of Sustainable Development Goals (SDG) as the focus for human development until 2030. The SDG underlines the relevance of several social issues, among them the sustainable development of cities and communities (SDG #11), as well as ending poverty (SDG #1). These objectives are essential for developing regions like South America, in which social segregation and inequality are particularly high.

This dissertation aims to study accessibility and affordability issues derived from the interaction between the transport and land-use systems, and how these issues contribute to the reduction, production, or maintenance of transport-related inequity and poverty in cities. Santiago de Chile is used as a case study, which has grown without integrated land use and transport planning during the last four decades. This scenario generated severe urban segregation that has brought inequalities and poverty conditions regarding accessibility to key urban opportunities, affordable housing and transport, and the quality of urban space and the mobility-related built environment.

Activity concentration around high-income municipalities in Santiago makes these zones more and more attractive for new activities, services, and high-quality real estate developments, as Suazo et al. (2020) show. They also provide convenient locations for the commutes of those deciding where to install them. Fragmented governance and deeply segregated residential locations in Santiago feed this loop: affluent municipalities approve new trip-attractor opportunities to be located in their area, benefiting affluent people from shorter travel times, high-quality urban environment, and a better level of service. This group then consider locating their residences further east where land can be found at relatively lower prices, feeding the loop of attracting future activities towards them. This negative loop of segregation and opportunity concentration in the affluent sectors of the city stresses accessibility and affordability conditions for low-income people that are forced to live far from these areas and who are quite likely to be captive public transport users with an inadequate level of service.

Overall, this research quantifies and makes visible the inequity gap affecting the most vulnerable groups of the population, i.e., low-income people, women, elders, families with children, and those located far from the activity centers. This inequity is multidimensional, including access to public transport, quality of the urban space and mobility-related urban environment, accessibility to opportunities, the level of service experienced using public transport, and choosing housing and transport modes. Thus, it is possible to conclude that there are population groups in Santiago who are systematically disadvantaged regarding mobility, accessibility, and affordability, which have been previously identified as principal factors of what has been called transport poverty.

This dissertation contributes methodologically to expand the concept and operationalization of accessibility. First, the quality of the urban environment while walking to public transport stops is considered into accessibility analysis, allowing to measure equity and justice issues affecting 12 out of the 34 municipalities in Santiago. Second, incorporating the user's perception of attributes that impact the level of service on his/her trip is proposed, concluding that perception of walking times, waiting times, crowding conditions, and the number of transfers increase accessibility inequity in Santiago. Third, competition over destinations is considered for accessibility indicators, whose results allow a more realistic assessment compared with traditional potential (or supply-only) measures. Fourth, disaggregate stop-to-stop data of actual trips and the level of service that each user experienced is used, leaving aside GTFS-based platforms that usually consider non-realistic public transport operational plans. All these contributions show an even more unequal accessibility scenario, reflecting new dimensions of inequity that deepen the disadvantages experienced by low-income and peripherally located people.

Furthermore, a mixed-method strategy is adopted for accessibility analysis, proposing a new theoretical framework to enhance accessibility and travel experience analysis through qualitative data, complementing the previous quantitative work. This framework and content analysis developed highlight barriers linked to a disparate perception of the built environment around transport infrastructure, which creates a 'socially constructed' narrative for traveling in buses and Metro. These results suggest that standards (or minimum thresholds) in a multidimensional accessibility analysis should be set to seek a more just and equitable scenario, benefitting and tackling the main barriers for women, low- and medium-income groups, and the elderly.

This thesis also contributes to policy discussions and formulations on the intersections between accessibility and affordability. The accessibility contributions mentioned above and trade-offs between transport and housing affordability dimensions are applied to four main topics. First, to the educational case, measuring through perceived and competition-based public transport accessibility measures that around 20% of the zones in Santiago have at least a 50% deficit of higher-quality public education, and 71% of them are in peripheral areas. Second, to the fare scheme of the Transantiago public transport system, concluding that the current flat fare scheme is a progressive policy, preferable over the proposed distance-based fare scheme in terms of accessibility levels and equity outcomes. Finally, the freedom of choices regarding transport and housing are analyzed, providing useful inputs for policy evaluations as housing subsidies, transport fares, or road pricing, in order to alleviate the monetary costs of location and mobility.

Three clear recommendations for policy and practice can be derived considering the SDGs highlighted at the beginning of this work. First, a wider understanding of the urban inequality and poverty dimensions, including the quality of the urban environment, the demand for urban opportunities and the public transport level of service. This is essential to improve the current inadequate criteria for the urban areas that could receive socially integrated housing projects in Chile. Second, authorities should provide affordable, accessible and safe opportunities to all. Many of Santiago's residents do not have access or don't have the economic resources to use a car. Policymakers and planners should encourage a fairer distribution of urban space, giving priority to sustainable alternatives as walking, cycling, and public transport. This could provide a clear vision of the city we want to promote and the role of sustainable development on it. Third, a mechanism that allows balancing the economic resources received by the municipalities should be promoted. Considering that most local interventions rely on municipality authorities, which have very different resources in the city, a system that favors the communities with lower incomes and greater needs is necessary to avoid deepening the structural inequalities of the city.

This dissertation is especially relevant given the recent events of October 2019 in Santiago, in which a (relatively small) increment in the public transport fare triggered a deep social crisis derived from severe inequities in several dimensions of daily life. One of the main questions that arise from these events is how to design public policies that counter these harmful effects on the vulnerable groups in Santiago. This dissertation highlights the relevance of the formulation of comprehensive and intersectoral public policies, integrating housing, land use, and transport to reduce the inequality gap and poverty in our cities. Indeed, this research tackles some of the challenges that policymakers currently face (or should be facing, at least), providing paths and recommendations to achieve a more equitable distribution of both benefits and costs derived from interventions to the transport and land-use systems.

Understanding the impact of accessibility and affordability on the people's quality of life is the main guideline of this research. Engaging academia with people's needs and public policies is essential to offset the inequities and poverty conditions that this research shows. The recent social outburst makes clear that most people demand a more friendly, inclusive, and equitable society, which should be reflected in a city where the dignity of its dwellers is guaranteed, making it a place worth living in. Our long-term planning processes can no longer ignore them.

11. FUTURE RESEARCH

One of the main challenges of researchers living and investigating Global South settings is to contribute from our reality to an ecology of knowledge and cultural diversity (De Sousa Santos et al., 2008), in an epistemology mainly defined by research located or carried out by researchers from Global North. Considering this context, four topics for future research are identified, filling gaps observed in the literature worldwide and our specific cities.

11.1 Advances in accessibility assessments in Latin American settings

Accessibility evaluations aimed at studying elements of transport and equity in Latin America show a growing but still limited literature (Vecchio et al., 2020). Their geographic scope is still restricted to the main countries and metropolises. In the Chilean case, more than 70% of the works are devoted to Santiago, while issues and challenges of accessibility, affordability, and equity are significant also for small regions, peri-urban settings, and rural areas. Therefore, more work should be devoted to these settings, fostering the adoption of easy accessibility tools where no work has been developed, nor relevant data is attainable and consolidated.

The refinement of accessibility-based analyses where more work has been developed is another crucial challenge. More work should be devoted to active transport and accessibility comparisons between transport modes, given the primary focus on public transport evaluations. Likewise, including the competition for opportunities in the proposed indicators is essential, as our previous work shows. Rather than focusing only on mandatory activities and rush-hours, the levels of accessibility to non-compulsory activities through different periods of the day should be considered. Finally, a higher sensitivity to age, gender, and ethnicity-based differences should complement the current prevailing attention to economic inequalities between population groups. These dimensions have been barely considered in a broader and more robust conceptualization of transport justice, as Sagaris et al. (2020) point out in their experience of the first Fair Transport Balance in Santiago and Temuco-Padre Las Casas in the Chilean context.

11.2 Time poverty as a commonly neglected dimension in mobility-related studies

Despite the vast literature on understanding and measuring poverty, a still limited number of researchers have begun to study the causes and possible consequences of time poverty (Williams et al., 2015). Recent contributions have emerged to characterize and analyze the dimensions that contribute to transport poverty and the impacts of its dynamics (Martens, 2013; Martens & Bastianssen, 2014; Grieco, 2015, Lucas et al., 2016; Titheridge et al. 2014). However, these papers focus on mobility, accessibility, affordability, and externalities such as congestion, accidents, or pollution, and none explicitly address time poverty issues.

Zacharias et al. (2012) and Encalada (2015) have preliminarily explored this topic for the case of Santiago, Chile, analyzing both socioeconomic and gender gaps, and monetizing time poverty. However, the impact that transport and land use dynamics have on time and consumption poverty has not been directly analyzed in the literature. Likewise, how care tasks (i.e., food provision, paperwork, shopping, education, and health activities) carried out within-household and out-of-household affects people's available time is an interesting topic to tackle. The relation between mobility, care tasks, and time poverty has not been attempted in the literature either and could provide new insights expanding the transport poverty concept.

11.3. Mobility-related inequalities in Chile: exploring transport poverty in several cities

As stated in this thesis, one of the main challenges of the transport justice discussion is how the benefits and costs derived from mobility practices are (and should be) distributed. In order to contribute to this topic, the work of Vasconcellos (2005) and particularly the study by Iglesias et al. (2019) analyze mobility-related inequities in terms of mobility, transport and services infrastructure, monetary costs, accidents, pollution, and energy consumption in Santiago.

Study the evolution of this diagnostic for Santiago across different Origin-Destination Surveys is proposed in order to assess the impact of various urban (both transport and land use) policies implemented in that period. Similarly, replicate and enrich the analysis for other cities in Chile that have destination origin surveys (12 cities since 2010) is proposed, in order to establish comparisons and propose transport policies with sustainability goals to be achieved in different contexts of the country.

11.4 Emerging transport justice discussions: Equity and urban justice standards

An emerging discussion around Martens' book (2017) has been carried out recently (Vanoutrive & Cooper, 2019; Martens, 2020; Vanoutrive & Cooper, 2020). One of the main critiques lies in the 'paternalism' of the theories discussing fair mobility. They also question how to define and differentiate between insufficient and sufficient accessibility levels.

Likewise, the literature has shown the need to establish standards that allow clear goals to be established to ensure a fair city. The quality of the urban and built environment (Tiznado-Aitken et al., 2018), accessibility levels to key destinations (Pereira et al., 2017), public transport (Lucas, 2012), dimensions of fair transport (Beiler & Mohammed, 2016) or general benefits derived from transport (Martens et al., 2012) are just some examples. The question that arises is how to define these standards.

Theoretically, sufficiency standards can be established, but how to define them requires complex democratic processes to carry them out in practice (Martens, 2017). Therefore, future research should address the issue of the (dis)advantages of establishing criteria based on common arbitrary standards of the literature, standards based on expert or institution criteria (in this case, paternalistic criteria) or thresholds based on citizen participation processes, analyzing how they differ between them in real-world terms.

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APPENDIXES

APPENDIX I: FOCUS GROUP: QUESTIONNAIRE (ORIGINAL – SPANISH)

ESCUELA DE INGENIERÍA
FACULTAD DE INGENIERÍA

Folio

Encuesta Accesibilidad y Transporte

DATOS GENERALES DE LA ENCUESTA *(No completar)*

Fecha / del 2017

Comuna: Peñalolén / Cerrillos

Modo: Transporte Público / Automóvil

I. DATOS BÁSICOS

Edad

Ocupación

Género: Femenino / Masculino

¿Dónde vive? *(intersección, punto de interés cercano o dirección exacta)*

¿Cuántas personas viven en su hogar? *(indicar número, incluyendo a Ud.)*

Además de Ud. ¿Quiénes viven en su hogar? (ej. esposo(a), pareja, hijos, padre, madre)

¿Cuál es el ingreso aproximado de su hogar?

$150.000 o menos
$150.001 a $250.000
$250.001 a $400.000
$400.001 a $600.000
$600.001 a $800.000
$800.001 a $1.000.000
$1.000.001 a $1.500.000
$1.500.001 a $2.000.000
$2.000.001 a 3.000.000
Más de $3.000.000
No sabe/No responde

II. DATOS DE MOVILIDAD

¿Qué modos (medios) de transporte utiliza en su vida diaria?

	No usa	Menos de 1 vez a la semana	1 a 2 días a la semana	3-4 días a la semana	5 días a la semana	6 a 7 días a la semana
Metro						
Bus (micro)						
Automóvil Particular						
Bicicleta						
Colectivo						
Taxi						
Otro *(¿Cuál?)* ___________						
Otro *(¿Cuál?)* ___________						

Folio

II. DATOS DE MOVILIDAD *(continuación)*

¿Cuántos automóviles tiene en su hogar? *(Si no tiene indicar cero «0»)*

¿Por qué comunas de la ciudad se moviliza regularmente? *(indicar todas las que transita, incluyendo las que cruza en su trayecto)*

III. VIAJE MÁS FRECUENTE

¿Cuál es su destino más frecuente de sus viajes fuera de su hogar? *(intersección, punto de interés cercano o dirección exacta)*

¿En qué modo (medio) de transporte lo realiza? *(Marque todos los que usa)*

Metro ☐ Bus (Micro) ☐ Automóvil ☐ Bicicleta ☐ Colectivo ☐ Otro ☐ ⇨ ¿Cual?

¿Con qué motivo?

Trabajo ☐ Estudios ☐ Dejar a alguien ☐
Compras ☐ Trámites ☐ Otra cosa ☐ ⇨ ¿Cual?

¿En qué horario? Mañana ☐ Tarde ☐ Noche ☐ Madrugada ☐

¿A qué hora sale de su hogar?	**¿A qué hora llega regularmente a su destino?**	**¿Cuántos transbordos realiza?** *(si no realiza poner "0")*
:	:	

¿Cuán cómodo es su viaje habitual?

Muy incómodo ☐ Incómodo ☐ Cómodo ☐ Muy cómodo ☐

IV. EVALUACIÓN Y PERCEPCIÓN

En una escala de 1 a 7 (como en el colegio...)

¿Con qué facilidad puede acceder a sus actividades diarias? (trabajo/estudios, compras, recreación)

¿Cómo evaluaría el sistema de buses (micros) de Santiago?

¿Cómo evaluaría el sistema de Metro de Santiago?

Si usted tuviera que comparar a las «micros amarillas» con Transantiago, diría que el sistema actual es:

Mucho peor que las micros amarillas ☐
Peor que las micros amarillas ☐
Igual que las micros amarillas ☐
Mejor que las micros amarillas ☐
Mucho mejor que las micros amarillas ☐

Desde que existe Transantiago, ¿usted cree que el sistema ha mejorado o ha empeorado?

Ha empeorado mucho ☐
Ha empeorado ☐
No ha cambiado ☐
Ha mejorado ☐
Ha mejorado mucho ☐

APPENDIX II: FOCUS GROUPS: GUIDELINE (ORIGINAL – SPANISH)

<table>
<tr><th colspan="3">OBJETIVO GENERAL</th></tr>
<tr><td colspan="3">Explorar la complejidad detrás de las percepciones, experiencias y construcciones/representaciones sociales asociadas al fenómeno de accesibilidad y el transporte público en el contexto urbano.</td></tr>
<tr><th colspan="3">INTRODUCCIÓN A LOS PARTICIPANTES</th></tr>
<tr><td colspan="3">Bienvenida: Buenas tardes y bienvenidos a esta reunión. Les agradecemos el tiempo que se han tomado en venir.

Presentación de moderador y estudio: Mi nombre es ____ y me acompaña______, estamos realizando un estudio para la Universidad Católica de Chile.

Explicación de por qué se invitó a los participantes: Ustedes fueron seleccionados debido a que todos son usuarios de (automóvil/transporte público) y viven en la comuna de (Cerrillos/Peñalolén).

Revisión del tema a tratar: Nos interesa conversar sobre sus opiniones respecto al transporte en la ciudad de Santiago y sobre el entorno de su comuna y de la ciudad. Es importante señalarles que no hay respuestas equivocadas, simplemente opiniones diferentes. Siéntanse totalmente libres de expresar sus puntos de vista, pues nos interesan tanto las opiniones positivas como negativas.

Descripción de la actividad: Antes de comenzar, permítanme que les señale algunas normas generales. Lo que Uds. digan aquí es totalmente confidencial, es decir, sus nombres no serán revelados (de hecho, sólo anotaremos su nombre de pila, no les preguntaremos su apellido ni donde viven).
Vamos a grabar la conversación porque no queremos olvidar ninguno de sus comentarios, pero esta grabación será oída sólo por nosotros, porque en base a esta conversación debemos preparar un informe escrito. Les pedimos que hablen de a uno, porque si hay varias personas hablando al mismo tiempo, no se escuchará bien.

Nuestra conversación durará aproximadamente una hora.</td></tr>
<tr><th>Ámbito</th><th>Pregunta Principal</th><th>Preguntas secundarias o explicativas</th></tr>
<tr><td>Presentación de los participantes</td><td>Les pedimos por favor que nos digan su nombre y actividad principal.</td><td></td></tr>
</table>

Viaje habitual	Describa su viaje más común *(hacia el trabajo, lugar de estudios, compras, dejar a alguien, etc.)*	*Que lo describa desde la experiencia propia, relato donde se mencione todo lo relevante, incluyendo la calidad de los espacios por los que se moviliza* ¿Qué tipo de actividad van a realizar? ¿Qué tan seguido usan este servicio? ¿Qué actividades realizan durante el viaje (leer, dormir, jugar, hablar por teléfono, etc.)? ¿En qué horarios lo utilizan? ¿Combinan esos viajes con otros medios de transporte? (colectivo, bus, etc.). ¿Cómo es la calidad de ese viaje?
Dificultades de acceso	¿Cuáles son las principales dificultades que posee usted para realizar sus viajes habituales? ¿Qué tan importante es el ítem transporte en el presupuesto de su hogar (para todos los modos)?	¿Cómo se podrían resolver esas dificultades? ¿Es una fuente importante de gastos? ¿Le parece caro el pasaje / la bencina / el tag, entre otros? Si pueden hablar de montos o porcentajes, mejor
Entorno urbano	¿Cómo es el espacio por el que transita (cuando hace su viaje habitual?) ¿Cómo les gustaría que fueran los espacios por los que regularmente transita (cuando hace su viaje habitual)?	¿Qué cambiarían? ¿Por qué?
	¿Qué opinión tiene de su comuna y en particular por los sectores donde transita?	¿Es bonito, seguro, limpio? ¿Por qué? ¿Es agradable su experiencia al transitar por este entorno?

Transporte público	¿Qué debiera tener o cómo debiera ser un buen sistema de transporte público?	¿Qué cambiarían? ¿Por qué?
Construcciones sociales	¿Qué medios (modos) de transporte componen Transantiago? *Para clarificar, Transantiago está compuesto de buses y Metro.*	
	Si menciono la palabra Metro, ¿qué es lo primero que viene a su cabeza? Si menciono la palabra Transantiago, ¿qué es lo primero que viene a su cabeza?	¿Por qué?
	¿Cuán importante es para usted el transporte público de Santiago? *(Para los habitantes de Cerrillos)* ¿Cuán importante es para Ud. la llegada del Metro a su comuna?	¿Por qué?
	(Para los automovilistas) ¿Utiliza transporte público? ¿Cómo se siente cada vez que se moviliza por la ciudad en transporte público?	*Sensaciones: Por ejemplo, ansiedad, tranquilidad, temor, agresividad, confianza, entre otros*
Valoración de atributos	¿Qué es lo negativo de Transantiago? ¿Existen experiencias o aspectos del sistema hacen que no quiera utilizarlo más? ¿Cuáles?	¿Qué es lo negativo de los buses? ¿Qué es lo negativo de Metro?
	¿Considera que hay algún aspecto positivo de Transantiago? ¿Cuál?	¿Existe algún elemento que haga que sienta orgullo del sistema?
CIERRE DE LA ACTIVIDAD		
Hoy hemos conversado sobre transporte y el entorno urbano en la ciudad de Santiago. Quisiéramos saber si alguno de Uds. quisiera mencionar alguna otra cosa que no se haya dicho sobre estos temas. Queremos agradecer su participación en esta instancia y quedamos disponibles en caso que tuvieran alguna consulta particular.		

APPENDIX III: FOCUS GROUPS: TRANSCRIPTS AND ANALYSIS (ORIGINAL – SPANISH)

Link to full transcripts: https://bit.ly/38SLmDF

FOCUS GROUPS ANALYSIS

FOCUS GROUP CERRILLOS – AUTO

1. VIAJE HABITUAL

- Problemas de transporte público. En general se ocupa de forma intensiva el automóvil, durante toda la semana, en distintos horarios

Carolina: "A las partes donde me muevo me es muy complicado salir en locomoción por el horario de regreso. Estamos muy limitados por los colectivos, la locomoción pública, entonces paso igual arriba del auto de lunes a lunes"

- Facilita la realización de muchas actividades: trabajo, ir a dejar hijos, visitar amigos y familiares, actividades de hijos

Sandra: "Ocupo el auto, pero, porque tengo allá familiares, los amigos, las actividades de la u de mis hijos, todas esas cosas, entonces, en realidad, es muy poco lo que hago yo aquí, dentro de la comuna"

Valeria: "Yo también, de lunes a lunes, porque de lunes a viernes ir a dejar a los niños al jardín, después yo al trabajo, después de vuelta al jardín y a la casa, y los fines de semana están las actividades de los niños, que el futbol, las clases de danza, pero afortunadamente, dentro de la comuna, dentro del sector incluso.”

- **Se utiliza el auto en base a dinámicas familiares o conveniencia personal**

Tamara 2: “En mi caso, igual, o sea, trabajo de forma independiente, me muevo en auto o en bicicleta, que es cuando, me queda acá dentro de la comuna, y el traslado a la universidad, auto, hasta el sábado, auto, y cuando hacemos cambio con mi esposo, transporte público”

Tamara: “Yo en mi caso, bueno, hace poco vendimos el auto, así que en lo único que me ando transportando ahora es en micro, más que nada, y en bicicleta. Voy a dejar a mi hija todos los días al colegio, tomo la micro, la I14 ahí en Mirador, y dejo a mi hija en el colegio, y después tengo que ir 3 veces a la semana, voy al centro, a mi trabajo, en metro o en micro, o Uber”

2. COMBINAR VIAJES

- **Viajes al centro: estacionamiento, tema importante por disponibilidad y precio**

Carolina: “Yo visito muchos clientes, tengo un estacionamiento que arriendo en Providencia, y el auto lo dejo ahí. Cuando tengo que visitar algún lugar uso Uber, el metro, taxi o micro. Cuando tengo que llegar a ver a los clientes, desde ese estacionamiento me muevo a las distintas comunas, porque por donde voy o no hay estacionamiento, o es muy difícil, o es muy caro, entonces prefiero dejar el auto ahí, y moverme en otro medio de transporte”

Valeria: “En lo personal, cuando son los fines de semana, o compras de la vega, o cosas así, claro, le pido el estacionamiento derechamente a mi hermano, porque es carísimo estacionarse en el centro de Santiago. Entonces siempre me acomodo, y ahí ese es como el punto neurálgico, y de ahí nos vamos, nos iremos en metro, de alguna forma llegaremos, si es que es por Providencia o el centro, siempre dejamos ahí el auto, porque es muy caro estacionar ahí”

- **Más comodidad, más rápido combinar con otros modos**

Jovy: “Yo en mi caso, si, cuando tengo reuniones, por ejemplo, en el centro de Santiago, coordino con una persona que me puede prestar su estacionamiento en el centro sur, y de ahí moverme caminando o en metro, porque me complica mucho estacionarme y llegar a ese punto a tiempo en vehículo”

Tamara 2: “En mi caso es lo mismo, nosotros 3 estacionamientos donde llegar, que puede ser el estacionamiento del trabajo de mi esposo, que cuando vamos por ahí, por ejemplo, todo lo que es Estación Central, llegamos al estacionamiento y de ahí nos movemos en bus, o caminando, o lo que sea más rápido. Cuando voy a la universidad, lo dejo en el estacionamiento de la casa de una tía que vive en Providencia, y de ahí me voy caminando a la universidad, por lo mismo, por el costo, es muy caro, y cuando voy al centro centro, ahumada, todo ese sector, ocupo el estacionamiento de mi hermano, porque también es caro y son difíciles los accesos, siempre, entonces trato de ir moviéndome siempre”

3. CALIDAD DE LOS VIAJES

- **Agotador. No se cumple objetivo de la autopista: siempre hay taco**

Carolina: “Es agotador, a mí personalmente, la costanera norte, es agotador, o sea, a la hora que yo la tomo es agotador, la costanera siempre tiene taco”

Jovy: “Siempre hay tacos, hay accidentes, porque vas estresado, porque además vas contra el tiempo, porque tenemos que cumplir reuniones y para el horario de llegada, vas con esa presión, aparte que no es muy agradable estar en un taco dentro de un túnel”

- **Estresante, hay presión por llegar, lluvia también genera problemas**

Claudia: “Es lento, es cansador, llego con dolor de cabeza, uno va con el aire, como decían ustedes, con el aire acondicionado, pero igual uno llega así, agotada, es un cansancio acá, desagradable”

Esteban: “Horrenda, espeluznante, yo creo que la palabra es espeluznante”

- **Ir en contra del sentido del tráfico: experiencia agradable**

Valeria: “Yo tengo la suerte que estoy en San Bernardo, llego a mi pega en 15 minutos. Estoy feliz, después de vuelta, también. O sea, voy en sentido contrario a lo que sea el choclón, entonces, rico, voy cómodo, nada que decir”

- **Permite distracción: noticias, música, hablar por teléfono**

Jovy: “Yo escucho música y también hablo harto por teléfono con el manos libres, porque voy a dejar cosas, o recibo llamados, entonces voy con eso conectado, no siempre, pero igual es frecuente en mis trayectos”

4. RELACIÓN CON EL AUTOMÓVIL

- Precio que se paga es una estafa (por autopistas).

Efecto del uso del automóvil en la economía. 20 mil pesos a la semana en promedio más 50 mil de tag en algunos casos. Precio elevado por estacionamientos. Uso alternativo de esos recursos.

Jovy: “Yo hace meses opté por salir con más tiempo, y estoy usando mucho más la caletera, porque en mi trayecto hay al menos 2 pórticos que cuestan $890 pesos, y es realmente una estafa, yo me siento estafada, porque no voy ni siquiera a 50 por hora”

Esteban: “mira, yo por ejemplo, mi auto es económico, es un city car, y yo creo que ocupo 20 mil semanales en bencina, sin contar la locomoción de los chicos míos, eso es lo que gasto yo para ir a trabajar, y el tag debe ser por ahí, entre 40 y 50 más o menos”

Melissa: “A mí me sale mejor que me dejen en un metro, que mi marido siga directo, porque si yo voy en el auto, a mi el puro estacionamiento en el día me sale 12 mil pesos, más la bencina en la semana, imagínate, 5 días, son 60 mil pesos que me echaría en puro estacionamiento”

- Auto como una necesidad de movilidad y acceso

Esteban: El auto en esta comuna no es un lujo, es una necesidad, claro.

Varios: No, es una necesidad, claro.

Jovy: “Inclusive es más complicado estar cerca que estar lejos, porque al centro por último tienes más acciones, e inclusive también el fin de semana las frecuencias son pésimas, yo intento moverme a pie, me encantaría tener más la opción, y me pongo a esperar colectivos, me pongo a esperar la micro, y me tengo que devolver a buscar el auto"

Janis: "Esa es la otra, porque si tienes que ir a otra comuna, por muy al lado que quede, igual tienes que tomar muchas locomociones, y es muy complicado"

Claudia: "Hace tiempo atrás, cuando mandé que arreglaran el auto, y yo trabajo a 15 minutos de acá, pero no tenía como llegar a mi trabajo, me tupí entera (…) de verdad, 3 locomociones, después de vuelta (…) yo sin auto, la verdad que indistintamente de los tacos, yo no podría moverme"

- **Comparación de viajes en auto vs transporte público**

Esteban: "Mira, el otro día yo hice el ejercicio de salir de mi casa caminando, por acá por la biblioteca, por en ese entonces estaba cerrado el edificio, y me demoré 20, 25 minutos en llegar a camino a Melipilla, tomé la micro, la tomé al tiro porque esas pasan cada 2 minutos, de partida, tiene un costo, porque esa la tienes que pagar en plata, me costó 700 pesos, de ahí me demoré 20 minutos más en llegar al metro, pagué el pasaje del metro y me demoré 20 minutos más en llegar a Los Leones, de ahí al metro Pedro de Valdivia, me demoré la misma hora y diez, pero con más costes entre medio"

Sandra: "Cualquier trayecto que tú hagas, por lo menos a mi me pasó, que todas las actividades que tú hagas fuera de la comuna, siempre son 2 horas, 2 horas y media. Ahora, si te vas en micro, son más, eso es como lo mejor de usar auto"

5. EFECTO BARRERA Y SEGREGACIÓN

Incomodidad. No es directo, no es accesible ni seguro. No permite una circulación libre.

- Lugar poco conectado, encerrado. Todo lejos, mal nivel de servicio. Poco directo.

Sandra: “Tengo 2 hijos universitarios y la mayor que trabaja, todos se mueven en metro, micro, y hacen 5, 6 trasbordos todos los días, porque empiezan, una micro acá, el metro, que el trasbordo, al final, 2 horas fácil”

Jovy: “Es complicado igual vivir en esta zona y trasladarse sin vehículo particular”

Tamara 2: “Es que en este sector estamos aislados”

Varios: “Si, porque aquí es super encerrado”

Esteban: “Me llaman y me dicen papá, ven a buscarme al metro, yo voy por camino a Melipilla en auto, y después me tengo que dar una vuelta brutal, y como si esa estupidez fuera poca, porque me agarro unos tacos tremendos ahí en Departamental con camino a Melipilla, para poder meterme a la villa, donde vivimos todos, tengo que ir a dar una vuelta en camino a Lonquén, 2 kilómetros y medio más allá a una bomba de bencina, y devolverme por el costado del mall y meterme por esta calle, para no ir a dar la vuelta al mall Plaza Oeste”

Claudia: “De hecho, son 7 kilómetros los que hay que hacer, ida y vuelta”

- **Opción de irse de la comuna es atractiva. Coarta oportunidades.**

Sandra: “nosotros, que ya estamos pensando en ya el próximo año, cada vez que alguien nos dice, oye si pudiéramos irnos, nos vamos mañana, porque es, y a quien le preguntes tú, es lo mismo”

Sandra: “Y el tema del transporte coarta un montón de otras cosas, porque, hay trabajos donde uno no ha podido ni postular, porque si te queda a 2 cuadras de la clínica Tabancura, y tienes que entrar a las 8 y media, tu sabes que no, mejor ni vas a la entrevista de trabajo, porque tú dices, cómo lo voy a hacer, o sea, así no, me tendría que ir a las 5 de la mañana de aquí, y no puedo, o me tendría que ir a vivir con alguien por ahí, que alguien me arrendase una pieza, o sea, es eso lo cuático que nosotros vivimos”.

- **Sector fantasma**

Esteban: “Este sector, o sea, desde el punto de vista vial, de conectividad y locomoción, es una estupidez, no pensé que existía algo tan brutal como esto”

Esteban: Esta comuna está como en abandono.

Sandra: Yo creo que más que la comuna, el sector, este triángulo, porque si tu lo ves, nosotros estamos tan abandonados que si tú ves, todavía ni siquiera salimos en el mapa, en el mapcity, ni siquiera.

Valeria: Si, cuando tu quieres geo referenciar…

Sandra: Si, cuando te dice dame tú, el Uber cuesta, de pronto, porque no te encuentra.

Esteban: “Somos como tierra de nadie, me entiende, este sector, en resumen, mira, este sector está mal iluminado, inseguro, sucio, porque, ¿han visto en la carretera la cantidad de mugre que hay?”

6. ENTORNO URBANO

- Inseguridad. Relación con el tema de poca conectividad.

Janis: Es muy complicado el acceso también caminando, porque es demasiado solo.

Tamara 2: Si, por eso te digo, mi hija se demoraría, son 3 cuadras, se demoraría 5 minutos.

Janis: Si es por la inseguridad que sentimos igual frente a eso, es terrible la situación.

Tamara 2: Son muchas cosas, aquí mismo, la otra vez, un guardia vio también como asaltaban a una chica que conozco, y resulta que la chica me dice, oye, es que el guardia tampoco podía meterse, y le quitaron cartera, celular, todo, ahí.

Sandra: Hace 3 semanas asaltaron aquí, en la esquina de la biblioteca a una chica que venía ahí al colegio.

Esteban: A un vecino nuestro, cuando todavía esa pasada era de tierra y estaba abierta, y uno con el riesgo que conllevaba pasar, lo usaba igual porque era eso o venir a darse 40 minutos de vuelta.

Carolina: "La seguridad, que haya más seguridad por el entorno"

Jovy: "Mira, por acá igual pasan carabineros, y tenemos el contacto directo con ellos, pero como el acceso es complicado, el tipo ya te robó, se fue, te pegó, y ahí recién, carabineros llegó"

Claudia: "Lo que pasa también es que el acceso de carabineros también está a tras mano, porque tenemos acá, nuestro plan cuadrante pertenece a este lado, entonces en llegar"

- **Seco, poco amigable**

Janis: “Muy seco, en esta época es super seco, no hay ni árboles, entonces, de repente eso es lo otro, si van a tomar locomoción colectiva tienes que esperar mucho tiempo, y te freís po”

Tamara: “Y si optas por caminar, te tienes que ir por todo el sol”

- **Sitios eriazos**

Sandra: “Hay muchos sitios que están pelados y se ocupan para poner caballos, para echar basura, entonces, al final tu vienes llegando a tu casa y lo único que encuentras es peladero”

Esteban: “Somos como tierra de nadie, me entiende, este sector, en resumen, mira, este sector está mal iluminado, inseguro, sucio”

Jovy: “Hay paradas de micros, que son sitios eriazos grandes, con barro”

- **Diferencias con otras comunas. Más recursos. Hay potencial pero que debe aprovecharse con medidas sencillas de conectividad y servicio. Equidad territorial**

Ciclovías: concentración de calidad en comunas de altos ingresos a pesar de que sectores mas vulnerables las ocupan intensamente

Esteban: “La diferencia se nota, o sea, yo cuando vengo en las tardes, vengo de Providencia, Ñuñoa, Macul, Lo Espejo, Cerrillos, y se nota con la limpieza, la iluminación, la belleza…”

Varios: Se nota el cambio.

Sandra: “Es que eso también, esta es una comuna pequeña, pero tiene harto potencial, yo eso te decía, tenemos los parques, tenemos la piscina, tenemos hartas cosas, y cuando yo, una vez, citamos al Alcalde y almorzamos en la casa, le decíamos, a veces son pequeños cambios que no son tan complejos de hacer, pero en realidad, pucha que nos solucionarían los problemas"

Valeria: "Es que sabí lo que pasa, que a mí me da mucha rabia cuando, por ejemplo, hablemos de ciclovías. Las mejores ciclovías, Pocuro y todo, cuando siendo que las comunas de La Pintana, La Granja, los maestros van a trabajar en bicicleta, y para ellos no consideran eso, o sea, yo por ejemplo, en la fábrica trabajaba un maestro que venía desde Peñalolén a La Granja en bicicleta, y cuando abrieron la autopista, venía en la autopista, lo sacaron muchas veces, expulsado, y le tenemos sacada la foto, lo vamos a llevar detenido, y el hombre pero feliz, muchos maestros que tenían sus bicicletas y que llegaban a La Cisterna en bicicleta, cuando nos cambiamos a Carlos Pino, por el tema de los accesos, adiós bicicletas, y viéndose como se van, viendo el tema del auto, porque tampoco, en el barrio industrial que está por aquí, camino La Vara, tampoco hay mucha locomoción, entonces, ¿de qué estamos hablando? Lindas las bicicletas, para qué se yo, los que vayan a un estudio de abogados, precioso, con pasto, pero, oye, para todo Santiago. Acá la harían de oro, pero por favor, ciclovías decentes."

7. RELACIÓN CON EL TRANSPORTE PÚBLICO

- **Problema principal: accesos y conectividad. Recorridos que acerquen a Metro.**

Sandra: "Y el problema, a nosotros nos pasó varias veces, que a veces los chicos iban a, la única micro en el invierno se había ido a paro, y se quedaron sin locomoción, 2 días sin ir al colegio porque no había cómo salir, en ese minuto no había, y no había como mandarlos al colegio"

Esteban: “O sea, poniendo más locomoción y habilitando más accesos, en buenas condiciones, yo creo que pasaría por ahí”

Janis: “Yo creo que hay que hacer un estudio para ver cuál sería la mejor forma de, valga la redundancia, mejorar los accesos y también el tema de la locomoción, como dice el caballero”

- **El Metro no es solución (nueva estación Cerrillos).**

Lo Ovalle o La Cisterna siguen siendo opciones por conectividad. En tierra de nadie, no hay conexión con buses, a trasmano

Sandra: “Esperamos durante 7 años, por lo menos los que vivimos aquí, en las villas de atrás, 7 años en la puerta esperando que abrieran el metro y no nos sirvió. Nosotros estamos tan cerca y no nos sirve. Mi hija sale a las 7 de la mañana, tiene que llegar ahí a Vitacura, y no tiene por donde salir, entonces qué tengo que hacer, contratar un Uber solamente para hiciera este tramo de 10 minutos al metro, nada más, porque no tenemos locomoción”

Esteban: “El metro nuevo, que es maravilloso, que supuestamente nos iba a solucionar la vida, no es tan así, porque aquí estamos nosotros, en tierra de nadie, es como de nunca jamás, me cachai? Es horrible, porque para llegar al metro no tienes como llegar de aquí a camino a Melipilla, de mi casa caminando, es como 20 minutos, media hora, para poder llegar recién a tomar el metro”

Esteban: “Este sector, o sea, desde el punto de vista vial, de conectividad y locomoción, es una estupidez, no pensé que existía algo tan brutal como esto”

Janis: Y lo otro es que el metro no mejoró mucho, porque igual es difícil llegar a el.

Esteban: Es que de aquí a allá es complicado llegar.

Valeria: Da la sensación que quedó corto, de que faltó, otra estación.

Sandra: Podrían haber construido otra estación aquí en Lo Errazuriz.

- Espacio para transporte informal (transfer). Micros o servicios puntuales. Ayuda entre vecinos. Opciones para superar barrera de conectividad

Tamara 2: "lo que hace, dice ya, yo agendo a 10 personas, las 10 personas y tienen horarios, a ti te paso a buscar a las 7, a ti a las 7:10, a ti a las 7:20, y llena su van y los va a dejar acá al metro"

Tamara: "Aquí lo tengo, no, es una micro, mira dice "vecinos, les informamos del bus de acercamiento dispuesto por el mal Plaza Oeste, el cual acerca a los vecinos a la estación Cerrillos del metro de Santiago". Hay una parada aquí en Lalo Parra"

Tamara 2: Que, por ejemplo, mi esposo igual ha hecho lo mismo, coordinarse con el vecino de al lado, dice bueno, ocupemos un auto, ya, mañana a qué hora vas tú, a qué hora vas tú, vámonos todos juntos y los dejo en el metro y yo sigo. Entonces es como tratar de arreglarlo.

- Características de un buen transporte público

Primero la existencia. Un mínimo, de recorridos y frecuencia, en todos los horarios. Frecuencia entre 12 y las 3, horario valle, no hay nada.

Esteban: "Acá hay una sola micro"

Valeria: "No puedes llamar transporte si solo pasa una micro, y esa micro te deja en el metro Lo Ovalle, y que pasa cada media hora, si es que, con suerte, si no es a esa hora entre las 12 y las 3, que no pasan micros a esa hora"

- **Lo más negativo de Transantiago**

Frecuencias

Trasbordos

Diseño de buses

Torniquetes

Conductores

Costo no se condice con calidad de servicio

- **Aspectos positivos de Transantiago. Muchos no ven nada positivo.**

Saber los horarios con aplicaciones

Acceso para movilidad reducida, que no lo tenían las micros amarillas

Buses nuevos, más bonitos, con aire, con wifi

- **Comparación Transantiago y Micros Amarillos**

Micros amarillas: contaminación, accidentes, choferes. Pero era directo, menos trasbordos

Cosas positivas: micros nuevas, pago con tarjeta, pero trasbordos

Escolares: hoy algunas no paran, antes podías irte por menos

Carga de bip: pocos puntos, antes con efectivo era distinto

8. CONSTRUCCIONES SOCIALES

- **Transantiago: Principalmente es considerado como Metro. Otros consideran que es sistema mixto, con micros (minoría).**

- **Metro: asociado principalmente con hacinamiento. Luego, con rapidez y confiabilidad.**

Valeria: Apretados.

Claudia: Esa sensación de andar apretado así.

Esteban: Colapso.

Janis: Agobio.

- **Micros: asociado con problemas de frecuencia y confiabilidad.**

Varios: Atraso, espera.

Esteban: Lo mismo pero más lento. Es que mira, el metro es malo, pero tiene los horarios acotados, tú sabes que en 20 minutos más vas a llegar. La micro, es malo y no sabes cuánto te vas a demorar.

- **Importancia del transporte público en la ciudad. Asociado a calidad de vida.**

Unico modo de transporte para una proporción importante. Elemento de descontaminación y menor congestión

Tamara 2: “Es importante, porque hay gran porcentaje de personas que no tiene vehículo y es su único medio de transporte, entonces, ponte tú, yo lo veo en mi hermana, mi hermana toma transporte público todos los días y todos los días, entre comillas, también se queja, entonces, pero si ella no tiene auto, o sea, no tiene transporte público, ¿cómo llega a su trabajo?”

- **Sentimiento al momento de andar en transporte público**

Angustia y estrés. Consecuencias en el trabajo.

Horarios, no poder cumplir en el trabajo (horarios, carga emocional). Especialmente para mujeres

Poca conectividad afecta oportunidades a las que se accede. Diferencia muy grande con comunas como Santiago o Ñuñoa

Caótico

- **Tema de género. Para las mujeres es más complejo, por ser madres y sus actividades.**

Sandra: “Ahora, si tu a eso le agregas que somos mujeres, yo, el año pasado, a mi hija, nosotros la tuvimos con crisis de pánico, y era solamente por el tema del transporte”

Tamara 2: “No, al final no te creen, y es una cuestión que tu, yo, listo dejaba mi guagua, me iba a mi escritorio, y lo único que hacía era llorar, llorar, llorar, llorar, llorar, y trabajai mal, trabajai mal, porque ya el estrés de la mañana, que mi jefe me va a retar, que el chofer venía enojado, que no te abre la puerta, que te empujaron, que te dijeron quizás qué tontera, y después tu decí, chuta, me toca lo mismo a la tarde, y con guagua mas encima.”

Melissa: “Yo un día tuve que hablar con mi jefa y decirle, ¿sabe qué?, yo ya no puedo venir, yo, a mi me gusta mi trabajo, pero ya no me puedo venir, llega un punto en que me siento estresada y colapsada por venir a trabajar. Y si venía en auto, yo te digo, podía estar más de media hora parada en el cruce de Panamericana por San Pablo, entonces ¿qué hacía?”

FOCUS GROUP PEÑALOLÉN – AUTO

1. VIAJE HABITUAL

- Uso regular durante la mañana. Distintos lugares de trabajo

Lorena: “Yo trabajo lunes, martes y jueves en un lugar, miércoles en otro lugar y viernes particular. Veo atención particular. Entonces yo me muevo más”

Jorge: “Yo trabajo de lunes a viernes en un lado y sábado y domingo, particular”

George: “Muy pocas veces los sábados, pero de lunes a viernes igual, en varias obras, varias comunas”

- Congestión en todos lados. Conejeo no permite evitarlos. Importancia de salir con tiempo de la casa para evitarla.

Katiuska: “Me voy aproximadamente como a las 8:30 y llego aproximadamente como a las 9:30. Llego antes de las 10. Pero, siempre tengo ese lapsus de hora porque a veces en la carretera no sabes lo que te espera, entonces me voy antes”

George: “Yo por lo menos, me ha dado con la idea de que tengo que ir a una hora y a esa trato de llegar temprano. Salir antes de las 7 para llegar a una comuna más o menos lejana. Sino, los tacos después de las son...”

Felipe: “Yo siento que vivo en un taco. Siento que en esta ciudad, en realidad, está lleno de tacos por todos lados”

- **Concentración de actividades. Congestión por sentido de los viajes**

Lorena: “Porque como yo voy hacia El Bosque, hacia Puente Alto, yo me demoro en llegar, te hablo de Gran Avenida comuna El Bosque, me demoro 30 minutos en llegar. Por la autopista. Pero, voy contra. O sea, yo miro la autopista al otro lado y es horroroso”

Ángela: “Yo trabajo acá en Peñalolén así que no me muevo mucho en taco. Me agarro solamente en Tobalaba”

George: “Claro, en la mañana va todo para Santiago”

- **Actitud de las personas. Existe poca empatía y tolerancia al manejar. Todo el mundo anda apurado**

Felipe: “Yo creo que también la gente maneja de forma muy ofensiva. Entonces, al final, no solamente se hace complicado el tema del taco, sino que también se hace complicado el tema del respeto por la otra persona”

George: “Es un tema de empatía con el otro. Uno puede dejar que alguien pase y ¿cuánto vay a perder?”

Ángela: “Yo manejo moto, entonces me quedé esperando a que entrara alguien a la pista y la gente de atrás se volvió loca. Es una cuestión de que tampoco te dejan ser buena onda. Todo el mundo te presiona”

2. COMPARACIÓN CON EL TRANSPORTE PÚBLICO

- Comodidad del automóvil

Ángela: “A pesar de tener taco y todo es mucho más cómodo para ellos (mis hijos) estar en un auto que en micro o en metro”

Katiuska: “Yo priorizo, más que el tiempo, la comodidad”

- Seguridad

George: “Subirse en micro acá, yo me he subido y es de locos. Para mí es más rápida a lo mejor llegar al metro, pero subirse a un bus... El tipo va, no sé, a unos 90 o 100 bajando, yo creo, fácil. Y vay con un niño, la micro va saltando”

Jorge A: “Es que estás más expuesto”.

Ángela: “En el transporte público he perdido un montón de celulares, me han quitado las cadenas”.

George: “En el metro, ir apretado, los carterazos (…)”.

3. EXPERIENCIA DE VIAJE

- Depende del horario de viaje

Jorge A: “Es mucha la diferencia entre manejar en hora pick y manejar en otra donde no hay tantos autos. Yo me muevo también a la hora de almuerzo. No puedo decir que es un agrado manejar, pero, o sea, es demasiada la diferencia”

Katiuska: “Yo a veces hago turnos de noche, pero muy pocas veces. Hago los turnos de viernes en la noche, hasta el sábado. Y es una delicia”

- Convivencia vial

Felipe: “Yo creo que ya estamos programados para ser pesados manejando. Entonces, me encantaría de repente que hubiese algún tipo de campaña para que la gente reflexionara”

Ángela: “Es que eso es cultural”

Katiuska: “Es cultura”

Lorena: “Yo creo que eso tiene que ver con educación. Porque nosotros no tenemos educación vial”

Jorge: “¿Sabes lo que pasa? Es que falta voluntad. De repente uno maneja y trata de ser voluntarioso o bondadoso con la otra persona”

- Estrés

Katiuska: “Yo creo que es un tema de que la gente está cansada. Yo creo que está cansada en el sentido de que hay muchas personas que cruzan Santiago, que pierden dos horas de su vida, que podrían estar en la casa, quizás, con los niños, o quizás simplemente viendo tele y descansando”

- Permite realizar otras actividades

Lorena: “Teléfono, yo hablo harto por teléfono. Es como mi instante de hablar”

Jorge: “Escuchar radio, noticias”

Katiuska: “Yo pongo compacts”

4. PRECIO

- Combinación de viajes por conveniencia

Jorge: “De repente ir en auto a trabajar al centro sale más caro que lo gana más en el día uno, entonces conviene más dejarlo por ahí donde un familiar un pariente más cerca y de ahí tomar una micro o el metro”

Rodrigo: Sí, yo lo hago seguido porque tengo una reunión, por ejemplo. Me voy en auto al trabajo y después tengo una reunión en el centro o en Providencia y dejar el auto en Providencia, te pegan un palo (…) Entonces ahí uno toma un Uber o un taxi. Como que te acercas al metro y ahí te tomas el metro”

- Gasto importante, pero se privilegia el tiempo y la comodidad.

George: “Yo saco la cuenta más o menos son como 30 mil pesos a la semana en combustible, más o menos lo que gasta el vehículo”

Katiuska: “Yo en tag ocupo como 38”

Felipe: “Estacionamientos”

George: “Si po, en algunos sectores, estacionamientos. Yo ahora estoy yendo a Chicureo y para cruzar ahí el primer peaje no más para entrar a Chicureo son $900 para allá y $900 para acá. Igual soy cómodo. Trato de tomar todas... es un tema de ahorrar tiempo, porque me meto en la caletera por ahorrarme dos lucas diarias y pierdo dos horas en el día a lo mejor”

Lorena: “Sí. Prefiero pagar eso para poder llegar más rápido”

- **A veces se paga y hay taco. Costanera Norte por ejemplo.**

Felipe: “Y lo otro es que pagai y hay taco. O sea, vay a pagar eso con un taco”

George: “De verdad que da rabia pasar por esos pórticos tan caros y, no sé, ir a 60 que es lo que alcanzai a estar...”

Lorena: “Menos”

Felipe: “En la costanera norte, también siempre de vuelta, hacia el oriente siempre hay taco. Y la costanera es cara, po.”

5. POSIBLES SOLUCIONES

- **Planificación**

Rodrigo: “Ahora, creo que (el problema) va a un tema un poco más macro. Un tema un poco más de planificación. Planificación comunal, de ciudad y de metro, del Gobierno. (…). Los planos reguladores. No sé si han visto en Ñuñoa, es absolutamente colapsado en ciertas horas, porque está edificio, tras edificio, tras edificio, tras edificio.”

- **Descentralización de trabajos y actividades**

Lorena: “Entonces, también los trabajos están súper centralizados. Como que todo el mundo trabaja en Providencia, todo el mundo trabaja en Santiago Centro, nadie trabaja en Puente Alto. Salvo que yo lo veo”

- **Distribución de horarios de entrada de niños, colegios, universidades y trabajos**

Lorena: “Porque todos entran a las 8 y salen a las 6. Yo creo que mejor entrar a las 10, salir a las 7. A lo mejor hay gente que optaría por los colegios”

George: “Los colegios también que son justo a las 8. Los niños podrían entrar a las 9 yo creo. 9:30 incluso yo creo que es bueno”

Felipe: “Los universitarios deberían entrar más tarde”

- **Trabajo a distancia**

Felipe: “Oye y en las pegas si uno también, por qué entrar a las 8 o a las 9 si cada vez hay más posibilidades de moverte con tecnologías, poder trabajar desde tu casa o qué se yo”

- **Compartir el auto**

Felipe: “Me acuerdo de que en la costanera se propuso que los autos que anduvieran con más personas, podían ocupar ciertas vías que eran más despejadas. Y al final no pasó nada, o sea, al final esa medida no funcionó porque en realidad la gente prefería andar sola en el auto”

6. ENTORNO URBANO

- Realidad dispar entre comunas. Áreas verdes son elemento clave, una visión de la comuna y no proyectos aislados

George: "Eso va cambiando según la comuna y se nota. Yo cuando viajo a San Bernardo, El Bosque o cuando voy a La Dehesa o a Chicureo, se nota en los entornos. O a Ñuñoa, cruzar por Estación Central. Estación Central es otra cosa también. Son comunas diferentes. Hay comunas que son industriales y acá mismo, uno cruza La Reina por acá entremedio y tiene un sector industrial igual, que es bastante para mí feo"

Katiuska: "Uno encuentra que se ve todo más bonito con el área verde. Entonces, de pronto, no es un sector tan bueno, pero ya con área verde cuidado, ya tú ves verde, que hay como una preocupación, una placita bonita, qué se yo. Ya te cambia la percepción del lugar"

Rodrigo: "Si tú vay a Vitacura, por ejemplo, y tú ves los parques, Parque Bicentenario, etcétera, ves una preocupación que viene desde la alcaldía de mantener un entorno verde, de tener ciertas cosas. En el tema acá Peñalolén, como dicen, son proyectos. Como que ellos avanzan según los proyectos. No piensan en una comuna así como integral"

- Peñalolén tiene sectores muy diversos en cuanto a entorno

Lorena: "Eso iba a decir. Más allá que la comuna, el sector. Por ejemplo, acá si tú cambias de una calle a otra, en una calle está todo muy lindo, jardines, verde y tú pasas a otra calle y no es así"

Katiuska: "Pero Peñalolén tiene esa dualidad"

- **Priorizar recursos. Hoy se gasta mucho en limpieza. Tema cultural. Reciclaje como oportunidad.**

Lorena: “Tan linda que es el velódromo, el parque, que se yó, al frente hay casas y siempre es un vertedero. Te juro que es, así botar desde camas, sillones, muebles. O sea, como que lo usan como para botar cosas”

Jorge: “Eso es porque, por ejemplo, el barrio, la comuna no tira para arriba por lo mismo (…) Se gastan 120 millones de pesos mensuales en sacar basura. Esa plata que se gasta en limpiar la comuna, si la gente fuera un poco más, tuviera un poco más cultura, más educación, se gastaría en otras cosas.”

Sobre reciclaje…

Felipe: Pero no son iniciativas municipales.

Rodrigo: Son iniciativas privadas.

Katiuska: Pero no hay centros como de acopio. Y de lo mismo que decías tú, de los escombros, los cachureos, en Ñuñoa, yo me acuerdo hace un par de años atrás, lo hacían.

Felipe: El día del cachureo.

- **Seguridad**

Katiuska: “A mí, por ejemplo, por Grecia me da susto. Cruzar Grecia por Tobalaba hacia la rotonda a mí me da miedo después de cierta hora”.

Jorge A: “Es que en realidad ese de Tobalaba con Grecia, ahí pasan cosas”.

- **Estado de calles**

George: “Yo creo que igual como comuna es bastante despreocupada en las calles. Hay calles que son un asco. De verdad que acá mismo saliendo, llegando casi a la esquina, hay unos montones de asfaltos. Esa calle debería estar lisa, debería estar plana”

7. TRANSANTIAGO VS MICROS AMARILLAS

Jorge A: “Pero hay un tema, yo creo que también cuando uno habla del Transantiago le tiene tanto odio, pero también hay que acordarse de las micros amarillas. Yo creo que las micros amarillas eran mil quinientas veces peor”

- **La tarjeta BIP. Mas rápido y seguro, mejor que andar con sencillo**

Lorena: “Es como el medio de pago más rápido, seguro.”

George: “Es mejor que andar con sencillo”.

Ángela: “Claro, lo único que de repente no tenís donde cargarla, excepto el metro que es como seguro. Pero la tarjeta, pasai y pasai no más. No tenís que estar esperando vuelto, que, ay, que no me diste el boleto...”

- **Conductores mucho mejores, más capacitados, menos agresivos**

Felipe: “Yo encontraba que las micros amarillas eran terribles. Yo encontraba que, no voy a decir que los conductores ahora del Transantiago son espectaculares, pero yo encuentro que son mil veces mejores que los de las micros amarillas”

George: “Se los ha capacitado más po. Se los ha capacitado con los buses nuevos”.

Felipe: “Y no andan compitiendo”.

- Trasbordos. Servicios poco directos. Puede ser más eficientes, pero el cambio es radical

Katiuska: “Yo me acuerdo antes, las micros amarillas, que los trayectos eran muy largos, muy largos, pero perdona como lo voy a decir, pero tú te apotingabai y llegabas apotingado hasta donde ibas. Te demorabas más, pero ibas más cómodo. Ahora, tienes que bajarte en una, subirte en otra, hacer el, y más encima vas así”

Felipe: “Es tal vez más eficiente desde un punto de vista urbanístico, pero, yo lo que critico es que pasar de esta micro eterna a pasar a estas 3 estaciones, es muy radical”

8. ELEMENTOS NEGATIVOS DE TRANSANTIAGO

- Carga de la tarjeta BIP. Debiera poderse por internet y no pasar por tótem

- Atochamiento, indigna la aglomeración

Lorena: “Yo creo que eso es lo más indigno de todo”

Rodrigo: “Y el ir apretados. Mira si el bus, por último fuera en malas condiciones, pero si todos pudieran ir sentados, o no sé, 10 personas paradas, a lo mucho, es algo como”

- Escasa preocupación por personas mayores. Quizás más tiempo, pero más cómodo y directo

Ángela: “A lo mejor, para una persona mayor, porque por ejemplo, mi suegra, ella se transporta en micro y metro, y ella dice no yo prefería mil veces la que tu te subías y no te bajabas, y que te ponías a leer, tejías un rato, llegabas con el chaleco hecho a la casa, pero te ibas tranquila, para una persona mayor.

- **Hay poco conocimiento de las alternativas, metro es más conocido. Hubo poca información al inicio, tarjeta, trasbordos, información de rutas**

Ángela: “Y también hay gente que no usa la micro, o sea, todo este estigma que se ha generado y que también tiene que ver con la realidad, hace que la gente no tome una micro. Por ejemplo, toda la gente se toma la micro acá en Arrieta y se baja en el metro Plaza Egaña. Nadie hace un trasbordo con una micro que llega al centro. O sea, a veces uno, si quiere comodidad, quizás te tienes que demorar más, también hay un tema de educación, la gente no sabe. Como que dicen "no, tengo que tomar el metro porque no tengo otra alternativa".

Jorge A: “Siempre la hay”

Rodrigo: “Es por lo rápido”

Jorge A: “La alternativa de buscar por donde desplazarte está, o sea, tú te metí a la aplicación, o te metí a internet, y te la micro, te da el metro, te da todo”

Ángela: “Pero es que, la aplicación, claro, ¿quién maneja la aplicación? O sea, yo pienso en mi papá, por ejemplo, o sea, olvídate que va a usar la aplicación, ¿cachai?”

George: “Pero antes había mapas. Las amarillas”

Ángela: “Yo creo que también es un tema de que nadie nos capacitó para esto. Fue como que de repente, uuh, Transantiago, tengo que usar una tarjeta y hacer trasbordos y uuh, no hay una alternativa para ir al centro que no sea el metro, como no, en verdad hay”

George: “O sea, siempre hay alternativas, hay gente que toma colectivos, que también conozco”

9. IMPORTANCIA DE UN BUEN TRANSPORTE PÚBLICO

- Podría generar cambio de comportamiento

George: “Es que, de verdad, para mí si fuera mejor, yo andaría”

Felipe: “A mí me gustaría tener una mejor alternativa y de verdad consideraría dejar el auto”

Katiuska: “Yo también”

Jorge: “Si fuera más cómodo, más..”

Rodrigo: “Claro, mucha gente se pasaría al transporte público. Y aparte que es verdad que es mucho más barato”

- Empatía con aquellos cautivos del sistema

Katiuska: “Para mí es importante porque yo, claro, yo uso auto, mi marido usa auto, pero dentro de mi núcleo o mí familia, hay varias personas que ocupan el transporte público. Y yo nunca he escuchado nada bueno”

- Comodidad y seguridad como elementos claves, permite distracción

Katiuska: “Yo creo que si fuera más cómodo, no te diera tanto susto, porque, por ejemplo, a mi hija le da susto andar en las orugas, porque dice que algunas que están casi hilachentas, ¿cachai? como tela de cebolla la parte que es de oruga. Y eso le da susto, entonces ella prefiere esperar la otra, que no sea igual, y se demora mucho más esperando la siguiente”

Jorge: “Y por otro lado te saca también tensiones. O sea, yo insisto que a mí me carga manejar en el taco, por lo tanto, si tu vay en la micro, leyendo el diario, o haciendo cualquier cosa”

George: “Claro, mientras tengas el espacio para poder leer un diario. O mientras te sientas seguro sacando el teléfono para leer, porque también es un tema de seguridad”

- **Importancia de los colectivos, claves para zonas como San Bernardo y Puente Alto**

George: “Hay gente que toma colectivos, que también conozco. Acá, no sé, por lo menos por este sector veo muy poco colectivo. Donde vivía antes, que era San Bernardo, lleno de colectivos”

Lorena: “Lleno, en Puente Alto también”

10. CONSTRUCCIONES SOCIALES

- **Transantiago: solo buses**

Felipe: “La micro”.

George: “Es que el metro, todavía yo lo siento aparte del Transantiago”.

Rodrigo: “En realidad no hay integración entre el metro y las micros, son 2 sistemas aparte”

- **Metro: calor, aglomeración, rapidez. Más seguro y certero**
- **Micro: Incomodidad, lleno, feo, sucio, evasión**

FOCUS GROUPS CERRILLOS TRANSANTIAGO

1. VIAJE HABITUAL

- La mayoría por trabajo, por diversos lugares de la ciudad y diferentes horarios. No necesariamente son estrictos (flexibilidad) y algunos fuera de punta

Paula: Yo de lunes a viernes al trabajo, y el fin de semana igual hago recorridos como bien diversos, porque salgo a ver amigos, o voy a ver a mi pareja, entonces voy a La Florida, Ñuñoa, Santiago Centro, Estación Central, Quinta Normal, entonces me muevo harto, el fin de semana más que nada.

Paula: "Yo de lunes a viernes al trabajo, y el fin de semana igual hago recorridos como bien diversos, porque salgo a ver amigos, o voy a ver a mi pareja, entonces voy a La Florida, Ñuñoa, Santiago Centro, Estación Central, Quinta Normal, entonces me muevo harto, el fin de semana más que nada"

- Permite hacer actividades extra como leer, a diferencia del automóvil. Escuchar música también.

Bárbara: "Por lo general me informo harto cuando tengo que hacer trayectos largos, como que trato de informarme, Twitter, o Facebook, pero leer harto, cosas que por lo general no las hago cuando no estoy en el transporte público"

2. COMBINAR VIAJES

- Si son más convenientes o más seguros, se busca combinar con otros modos

Bárbara: “Yo por lo general, por temas de seguridad, siempre trato de acercarme, a la estación de metro o micro en Uber o en taxi, o en colectivo, porque es tarde, cuando es más peligroso, entonces ahí ya acudo al colectivo o al taxi”

Catalina: “Lo que pasa es que por donde pasa la micro que me lleva a mi trabajo, si tomo otra micro, es muy largo el trayecto hacia ese punto, en colectivo lo hago más corto, por eso priorizo”

Bárbara: “Donde yo vivo, no estoy cerca de ninguna estación, entonces, eso es como lo más complejo, que tengo que saber llegar a la estación, o en la noche, si llego tarde, tengo que saber llegar de mi casa al metro, no puedo irme caminando, o tengo que saber tomar un Uber”

3. CALIDAD DE LOS VIAJES

- Agotador. Cansador. Metro es agobiante. Ánimo de la gente es terrible, búscar tomárselo de la mejor forma posible.

Daniela: “Bueno yo, del horario en que lo tomo, lo encuentro super incómodo, lleno, la gente va enojada, empujándose, sobre todo en el metro, es terrible. Es agobiante subirte al metro y ver la cara de las otras personas que van más chatos que tú”

Yerko: “Eso ha sido lo terrible de algo que yo pienso, que hubo un tiempo en que me interesé mucho en ver cómo iba la gente en el metro, todo el mundo apretado, etc. Pero empecé a compartir sonrisas y se me quitó, o sea, tení a una persona chata en frente y compartes una sonrisa y te poní a conversar y ya se acaba el problema, en serio. Es como te la tomai también"

- **Poca frecuencia y recorridos. Poca certeza, inseguridad. Tema especialmente sensible para mujeres.**

Paula: "Por donde yo vivo pasa solamente una micro y tiene poca frecuencia, entonces eso es bastante incómodo (…) donde yo vivo la opción es salir en auto a un punto más, donde pase más locomoción al menos, pero es complicado, sobretodo la cantidad de recorridos que hay"

Bárbara: "Le sumaría la inseguridad que entrega el servicio con respecto a la frecuencia, porque uno pasa mucho rato en el paradero, de repente en horas que son peligrosas, esperando la micro, no sabes si va a pasar, o no va a pasar, el tema de los mensajes o de la aplicación de Transantiago que existe para el celular, tampoco es muy efectiva (…) a veces uno puede estar media hora esperándola, entonces al final, la integridad de uno es la que se pone en riesgo"

Paula: "El tema también que no hay certezas como para preparar un viaje, de repente te puedes demorar 40 minutos, o de repente te puedes demorar 1 hora 20, en la misma semana, entonces eso es complejo, porque no te permite planificarte bien para llegar a cierta hora a un lugar."

Catalina: "El tema de la frecuencia yo creo que es el gran problema que tiene, porque la micro que yo tomo, no sé po, llego a veces a las 7:10, son las 7:40 y no ha pasado, o de repente son las 7:11 y ya voy en camino, cachai? Entonces es muy variable, es muy incierto, como dices tú, no te permite planificar el viaje bien, sobre todo en las noches que es súper peligroso también”

Bárbara: “Si, ahí uno que es mujer, también”

- **Inseguridad. Cambio de comportamiento por esto (cambiar de micro).**

Daniela: “Además que igual hay poblaciones que tienen alto índice delictual. Está la población Oreste Prat, o los Presidentes de Chile, que igual, después de las 11 de la noche, 12 de la noche es súper peligroso pasar por ahí, por avenida Lo Errazuriz. Porque pasai por Villa Francia, en Estación Central, pero, la otra vez me agarraron a piedrazos en la micro.”

Bárbara: “A mi igual me pasó (…) en el recorrido I04, que pasa por la Villa Francia, un día iba en la noche y el chofer, parece que por precaución, apagó las luces del bus, entonces, pasó con las luces apagadas, como para que nadie lo hiciera parar yo creo. Seguramente la gente que ahí toma el bus no es de mucha confianza para el chofer, entonces ahí apagó la luz, tomó esa determinación, y cuando íbamos por la mitad de la Villa Francia, entró una piedra que pasó por delante de mí. Como que voló así, y chocó justo al frente, por donde van las sillas de rueda. Y era un camote como de este porte, pasó por delante de mío, o sea, me podría haber caído en la cara fácilmente. Entonces, yo en ese momento tomé la determinación de no tomar más ese recorrido y en realidad me voy por camino a Melipilla. Siempre tomo por camino a Melipilla o por la plaza Maipú, pero ya no paso por Lo Errázuriz. Por esos lados, no, ya no. No tomo ni la I04 ni la I18 que pasan por ahí”

- Ir en contra del sentido del tráfico: experiencia agradable

Catalina: "Para mí, yo diría que es super cómodo, porque yo voy como en el sentido contrario que todo el mundo, entonces la micro va relativamente vacía, poca gente, incluso me puedo ir sentada, cómodamente, llego rápido, entonces, para mí, es super cómodo el viaje, y de vuelta lo mismo, porque salgo temprano, salgo a las 4 de la tarde, entonces, salgo en un super buen horario, para mí, no es incómodo"

4. RESILIENCIA DEL SISTEMA

- Tener recorridos de micros que hagan lo mismo que Metro. Mejor coordinación y respuesta ante fallas y emergencias.

Catalina: "Deberían haber micros que hicieran el mismo recorrido que el metro, cachai? Para cuando queda así como la embarrada en las estaciones, y ponen como estas micros de emergencia que hacen los trayectos, se despeja inmediatamente, yo creo que por ahí va, sobre todo la línea 1, que es la que más se colapsa, tener trayectos de micro, que paren en los puntos exactos"

Yerko: "El problema sería que en alameda tení un taco tremendo, entonces, si querí hacer el mismo circuito, en la micro sería pero a paso tortuga"

Paula: A fallar harto, o sea, a que se queda un metro parado en una estación, o que no avanza, o que no pasó, no sé, yo creo que de los 5 días de la semana, 3 debe tener problemas

Catalina: Está super sobre exigido el metro.

Yerko: Y diste con una palabra clave, el plan de emergencia. Cuando ocurre un problema, el resolverlo es lento, es muy lento, el sacar a la gente es muy lento, el que te pasen el boleto es muy lento. Tú lo dijiste hace un rato, que te pasen el boleto de nuevo es muy lento, el, no sé, que alguien se tire al tren, se murió, vale, perfecto, pobre hombre, pero ahí está la gente que tiene que… Y no hablo de la empatía de los chilenos, pucha que por culpa de este voy a llegar tarde, no, no hablo de la empatía, hablo del tema de cómo la gente te toma y te pone arriba de un bus, y que tu llegues a tu trabajo. En eso tienes 2, 3 horas y eso te alimenta mucho el tema, o sea, el poder tomar un problema y resolverlo, es muy lento en metro, demasiado.

5. PRECIO DEL TRANSPORTE

- Item es importante pero no está tan claramente identificado. 40 mil pesos mensuales en general, sin contar lo que se puede elevar por Uber u otros usos. Caro respecto a otros contextos y calidad recibida.

Marcelo: "No es como un cálculo que lo que gastai sea 1 o 2 lucas, para colocarle diario así, para ir y volver, pongámosle unas 10 lucas mensuales, por eso el cálculo de 40 mil, o que tienes que tener reservado para locomoción"

Daniela: Mira, yo vivía en Valparaíso, y allá la locomoción vale mucho menos que lo que vale acá en Santiago, el plan cerro vale 400 pesos, 500 pesos, encuentro que en comparación precio calidad, no está acorde con lo que nos deberían estar cobrando, que son $740 en horario punta, ¿no? Creo que es muy caro para el servicio, en calidad, que se está entregando.

- **Precio excesivo considerando la calidad**

Daniela: "son $740 en horario punta, ¿no? Creo que es muy caro para el servicio, en calidad, que se está entregando. Por ejemplo, allá, Viña – Valpo sale como 500 pesos, algo así, y es un viaje que te dan ganas de ir en la micro, que no estai saturada con la guagua acá, no sé, no es tan incómodo"

- **No usan automóvil por los costos que implica. En otros casos también resulta más conveniente.**

Paula: "Yo trabajo en el centro, entonces me demoro más en llegar en auto, que en la combinación micro metro, me demoro mucho más, como 20 minutos más"

Yerko: "Más barato, porque el estacionamiento debe ser carísimo"

Marcelo: "Yo tengo auto, pero no lo uso, por un tema de gastos, la bencina, estacionamientos, me sale mucho más barato ocupar la locomoción colectiva, y el auto lo ocupo para salir, principalmente"

6. JUSTICIA, DIGNIDAD

- En servicio de transporte público y en entorno. Violación de dignidad e injusticia, estrés, cansancio, abusos. Posibles medidas para separar, aunque sea "retroceso".

Daniela: "La saturación de la gente que hay, sí, yo siento que es muy, muy saturado, hay muchas personas, en un metro cuadrado estai con 6 personas más, entonces creo que no es grato, no está dentro de las condiciones humanas poder transportarse así todos los días, para todos los habitantes que viven acá, imagínate estai todo el día trabajando y tení que transportarte en ese medio 1 hora, 1 hora y media, creo que no es justo"

Bárbara: "En realidad no todas las personas tienen esa posibilidad. Entonces, tenemos que ser como bien justos, y que el entorno sea para todos iguales, independiente que la persona pueda tener una predisposición positiva. Todos deberíamos tener la misma posibilidad de tener un entorno grato"

Daniela: O sea, yo creo que no es lo que tu esperas de una sociedad que se supone que ya está avanzada, pero viendo la realidad, o sea, yo creo que lamentablemente es un retroceso social tener que separarte por vagones, pero bajo las circunstancias de abuso, yo creo que es una medida que hay que tomar.

Bárbara: A mí con el metro me pasa que siento que se pasa a llevar mucho la dignidad de las personas, con el tema de lo que antes llamaron ganado, pero me da esa impresión. Como que siento que se pasa a llevar mucho la dignidad de la gente, se sobrepasa el metro cuadrado, al tener que ir apretado con el otro, enojado, eso no debería pasar, entonces, a mí una de las sensaciones que me deja el Transantiago.

Bárbara: Esa es, de lo que decíai, hay un tema de dignidad y también de falta de respeto, falta de respeto con la intimidad humana. Lo mismo que con los tiempos de los recorridos de las micros, tampoco respetan tus tiempos, tus tiempos de estar con la familia, tus tiempos de poder hacer alguna actividad extra programática. Las decisiones que tú quieras tomar con tu vida, lo que quieras hacer con tu tiempo no se respeta con el tema de la frecuencia. Entonces, también me deja esa sensación, como de falta de respeto.

7. ENTORNO URBANO

- Es seco, sin mucha área verde. Poca sombra.

Bárbara: Yo considero que, por lo menos el trayecto que yo hago, por Vespucio, desde Cerrillos a La Florida, le falta bastante área verde, es como bien seco, siento que los entornos ahí no son muy gratos como para la población, esa impresión me da cuando paso en la micro y miro por la ventana.

Daniela: Yo creo que es un problema general de Cerrillos el tema de las áreas verdes, que por donde tú pases no hay espacios de esparcimiento para la comunidad.

Paula: Sí, como también con el tema de las áreas verdes. Yo encuentro que a Cerrillos lo que le falta son como árboles como grandes, porque en días de calor, hay poca sombra, no es muy cómodo como para andar caminando, los árboles son chiquititos. Más que más áreas verdes, faltan más árboles grandes para que den sombra.

- Precariedad, peligroso. Luminaria es escasa.

Daniela: “Hay mucha precariedad social en la comuna de Cerrillos”

Catalina: “Sí, yo en el trayecto que hago paso por una línea del tren, y ahí hay gente que vive ahí, entonces hay mucha basura y es peligroso además”

Daniela: “Es peligroso, no hay luminaria”

Catalina: “Claro, es peligroso cruzar en ese sector, yo cruzo ahí, tomai el colectivo en ese sector, entonces igual es un sector peligroso, y además, hay muchas, en las noches, insisto, hay gente que está enfiestada ahí, hay gente que vive ahí, en la calle, entonces, es un sector como, no muy agradable”

Catalina: Para mí, es importante el tema de la luminaria, en todo trayecto, día y noche. Para mí ese tema es como, si uno se siente seguro, el ambiente es más grato, entonces yo creo que eso es clave, en Cerrillos y en muchas comunas. Yo viajo mucho por Maipú, hay muchos paraderos que tienen luminarias, pero están malas, ¿cachai? Entonces de noche igual es peligroso. Yo ando sola, imagínate, me preocupo más po, naturalmente, que si anduviera en grupo. Creo que eso es clave, la seguridad, sentirse seguro.

Yerko: Ahora, no sé, yo creo, estoy de acuerdo contigo, como nunca, que el tema de la luminaria en las noches. Yo en lo personal no me siento inseguro, pero sí creo que a la mujer le influye mucho el tema de la seguridad, o sea, si tu vay caminando atrás y empiezan a caminar más rápido, y es porque están asustadas. En la comuna, la gente está asustada

- **Comparación con otras comunas**

Daniela: "En comparación a otras comunas con Cerrillos, yo lo noto, por ejemplo, con Ñuñoa, Providencia, que es muy distinta la cantidad de áreas verdes por habitante que hay respecto a lo que hay en Cerrillos"

Daniela: Si, ese sector de la línea del tren (tiene basural), comparto, que ahí hay vertedero y cosas así, pero, en general, no se ve sucia la comuna.

Daniela: "Ahí ves la diferencia, porque se juntan Maipú, Estación Central y Cerrillos, Maipú verde, Estación Central como precario, y Cerrillos seco."

Marcelo: Si, si hay algo visualmente agradable hace más ameno el recorrido, no sé. Ponte, en Las Condes, si tu veí un paradero, con flores, tienen maceteros, o sea, agradable, en cambio si tú vai por Maipú, o Cerrillos, son paraderos no más, son paraderos. Por ahí hay algunos con techos caídos.

- **Inseguridad**

Daniela: “Si, ese sector de la línea del tren, comparto, que ahí hay vertedero y cosas así, pero, en general, no se ve sucia la comuna”

Catalina: “Sí, ese sector es inseguro.”

Daniela: “Sí, aparte que no tiene luminaria.”

Bárbara: “Por lo general, la luminaria es super precaria. Los paraderos, el trayecto que uno hace del paradero a la casa, tienes que pasar por calles oscuras, y eso claro que genera inseguridad. Y eso no pasa en otras comunas de la misma forma.”

- **Efecto de un lindo entorno sobre la percepción del viaje. Dificultad de mantener estas condiciones. Tema cultural**

Catalina: Lo hace más ameno.

Marcelo: Pero igual es rico ver, no sé, una planta, cachai, tení algo al menos que le da colores.

Daniela: O igual la espera de la micro sería más grata si estás en un paradero en buenas condiciones del entorno, pero no po, igual hay algunos que no tienen ni siquiera asiento.

Marcelo: Mas encima están super llenos, todo eso afecta, veís como está la limpieza, de si la municipalidad se preocupa de tener un entorno lindo, así es como sería un trayecto lindo y cómodo.

Marcelo: No es lo mismo acá, en comunas más abajo, se lo van a robar, se lo van a robar, lo pueden dejar bonito, todo, no va a durar un día y van a sacar todo.

8. TRANSPORTE PÚBLICO

- **Características de un buen transporte público**

Frecuencia tema principal. Lugares para cargar la bip.Torniquetes

Catalina: Yo le sacaría esto de los torniquetes que tienen ahora, lo encuentro super incómodo para todo el mundo, embarazadas no pueden pasar, porque el espacio, la guata como que se les aprieta, no, es terrible, he visto personas que son más obesas, digamos, también, no pueden pasar, yo que tengo un hijo chico, tengo como que pasarlo al otro lado, entonces es como súper complejo.

- **Diseño del bus. Debe ser inclusivo para la tercera edad y discapacitados**

Daniela: No sé si está dentro de la pregunta, pero yo lo que cambiaría es la infraestructura interna de la micro, porque son re incómodos los asientos, sobre todo si te vai sentada atrás, frena y como que te vai para adelante.

Yerko: O sea, usai pantalones así como de tela y si no te afirmai terminai en el suelo.

Bárbara: Los asientos, por ejemplo, la subida del bus, los movimientos que tiene el bus en su trayecto. Bueno, ni hablar de tema de la tarifa respecto a las jubilaciones, porque eso ya es otro tema, pero creo que no es un transporte hecho para la tercera edad. El metro menos, imagínate una persona de la tercera edad entrando en hora punta a un tren lleno, o sea, le puede dar un paro cardíaco, le puede pasar de todo, puede ser hipertenso. Entonces, el transporte en general no es para personas de la tercera edad, y es una población de nuestro país, así que igual…

Yerko: O sea, es que no es un transporte hecho para la tercera edad.

Daniela: Una persona en silla de ruedas igual es súper complicado.

Catalina: Tiene que andar con alguien, para que la ayude con la barandita.

9. CONSTRUCCIONES SOCIALES

- Transantiago: asociado a la micro. No se menciona Metro.

- Metro: aspectos negativos asociados a fallas e incomodidad, positivo es rapidez y eficiencia

- Ganado, saturación, calor, incomodidad, fallas. Rapidez, eficiencia. Diferencias evidentes en horarios punta y fuera de punta

Catalina: Yo creo que la gente quiere llegar rápido a su pega o llegar rápido a su casa y por eso la gente prioriza el metro antes que las micros, por lo mismo, por eso el metro está sobre exigido.

- Micro: caos, altos tiempos de viaje. Sin embargo, algunos lo prefieren por sobre metro. Depende del recorrido y distancias.

Paula: Que a mí, como más en general, me gusta más andar en micro que en metro, pero el problema es que igual hay más tacos, es como más incierta la hora en la que vas a llegar, pero encuentro al menos que el recorrido que tengo yo es como bastante amigable, no va tan lleno, entonces, yo prefiero andar en micro que en metro, por regla general.

Daniela: Yo igual prefiero andar en micro que en metro, pero cuando son distancias muy largas tengo que tomar metro, por ejemplo, para venir para acá, pero si tuviera que elegir entre los dos, elijo la micro.

- **Importancia del transporte público**

Esencial en la ciudad. En la vida cotidiana.

Catalina: Cuando ha colapsado el metro, colapsa la ciudad completa, entonces.

Bárbara: Sí, y eso tiene relación con las horas que uno le entrega al transporte público en el día, de su vida, o por lo menos la gente que trabaja. Yo por lo menos trabajo cerca, pero cuando uno tiene que ir lejos, la gente que trabaja lejos, no sé, cruza Santiago. Me imagino que el transporte público significa una importancia muy grande en su vida cotidiana, yo creo que es muy importante, es necesario.

- **El Metro no es solución (nueva estación Cerrillos).**

Faltan micros que te lleven directo, queda todo a trasmano. El acceso es complejo. Quizás el trazado debió ser distinto.

Bárbara: La avenida camino a Melipilla es como la avenida principal que cruza Cerrillos, de punta a punta, llega a Maipú, entonces tenía mucho más sentido que la estación Cerrillos pasara por camino a Melipilla al menos, para que uno pudiera acceder de manera más expedita, y porque, claro, Cerrillos llega hasta la línea del tren, avenida del Ferrocarril, y claro, de ahí uno tiene que tomar una locomoción o caminar unos 20 minutos para llegar al metro Plaza de Maipú, pero no hay un punto medio, dejaron mucho espacio, y casi toda la comuna, sin metro, entonces el acceso es muy limitado, demasiado.

Paula: El problema es que la mayor parte de la comuna no tiene acceso directo al metro, no hay recorridos para llegar allá, entonces es poca la gente de Cerrillos que se beneficia con la llegada del metro. Queda a tras mano donde queda la estación de metro.

Bárbara: Eso, hubiese sido bueno que la línea no llegara hasta Cerrillos, sino que llegara por camino a Melipilla hasta Maipú, Vespucio, pajaritos con camino a Melipilla, ahí hubiese sido mucho más útil, porque como que nos llegó la última estación no más, o la primera, pero nos llegó, no es una línea propiamente tal de Cerrillos, como que llegó a una parte de Cerrillos y esa es la última parte de Cerrillos, la que limita con Pedro Aguirre Cerda, entonces no es tan nuestra esa línea nueva.

Paula: No es un proyecto habitual, o sea, un recorrido que antes te demorabas una hora, es era como de Providencia a la estación de Cerrillos ahora te demorai 20 minutos, o sea, es mucho menos el tiempo, el tema es que después para ir a las otras partes de Cerrillos no hay locomoción, no hay micro.

- **Lo más negativo de Transantiago**

Frecuencias. Limitados ya que es su única opción disponible (cautivos).

Bárbara: Yo estaba pensando en eso, porque, a mi con las razones, si, pero, claro, tampoco uno tiene la posibilidad de cambiar de modo de transporte, porque es el transporte de Santiago. Entonces, aunque a mí me pasara, o a todos nos pasara algo muy terrible, tendríamos que superarlo y volver a tomar la micro (…) Yo personalmente, el transporte público ha sido uno de los factores que a mí me ha hecho pensar en la posibilidad de irme a vivir al sur, ya no quiero vivir en Santiago por, uno de esos motivos es el transporte público, encuentro que afecta directamente la calidad de vida de todos.

- **Aspectos positivos de Transantiago: Sistema tronco-alimentador si es que funcionara con buena frecuencia. Integración tarifaria**

Bárbara: Si tu decías, el tema de los alimentadores y los troncales era bueno, si tuviera la frecuencia correcta, yo creo que sí, es una buena medida, y además que el Transantiago integró el metro con la micro, eso igual es positivo, porque si antes querías subirte al metro era un pasaje adicional.

- **Menores tiempos en algunos trayectos**

Yerko: O sea, sí, creo que Transantiago redujo los tiempos de transporte. Yo cuando era chico, me acuerdo que vivía en San Bernardo y había que tomar una micro, la 117, una amarilla. Oye, ahí hay mucha agua bajo el puente, y te demorabai una hora y quince en llegar a Bandera con Alameda, una hora y quince. Y después salío el Transantiago, tomabai una micro, tomabai el Transantiago y estabai en 25 minutos. Entonces sí, redujo los tiempos. Lamentablemente, el tema de esperar a que la micro pase te quita el resto de la media hora, ¿cachai? Pero el traslado es mucho menor.

- **Intermodales. La BIP (salvo por los puntos de carga)**

Bárbara: Si, bueno, el sistema de los intermodales también, que la micro te deja adentro del metro, que puedas tomar micro ahí mismo dentro de la estación también.

Yerko: Más, para ustedes que son mujeres, más seguro.

Paula: Y el tema del uso de la bip, a mi al menos, me gusta, la bip, en vez de andar con dinero en efectivo.

FOCUS GROUP PEÑALOLÉN – TRANSANTIAGO

1. VIAJE HABITUAL

- **Viaje al trabajo de lunes a viernes. El fin de semana en menor medida, con otros motivos.**

Gianina: "Yo el fin de semana lo uso, la micro y el metro para ir a ver a mis papás a Puente Alto. Ahí ya es el único tema que voy para otro lado, pero en la semana viajo acá a San Joaquín. Metro y micro"

- **Horario punta es el más usual, pero también se utiliza en horarios valle.**

Carolina: Yo lo uso a las 9 de la mañana y después en la tarde de las 7:15 para adelante.

Leonor: La verdad es que yo ocupo como varios horarios. Porque yo trabajo por turnos rotativos, entonces lo puedo ocupar a las 9 de la mañana, como lo puedo ocupar a las 4 de la tarde. Y después 6 de la tarde, 8 de la noche. En realidad, lo ocupo como en varios horarios.

Janet: No lo mío es fijo. De las 6:30 y después volver a las 4. Todos los días fijo.

Luz: Yo lo ocupo de 7 y después en la tarde a las 5:30.

- **Permite realizar otras actividades. Algunas son más incómodas de hacer hoy en día**

Gianina: Radio. Escucho radio.

Leonor: A veces leer, cuando se puede.

Janet: Sí, cuando se puede. Porque yo antiguamente tejía, ahora no puedo tejer porque no hay espacio, al menos no es muy cómodo.

Sebastián: Redes sociales, Whatsapp, Facebook, revisar el correo, todo por el celular.

2. METRO VS BUSES

- Uso de modos depende de cada contexto. Algunos prefieren metro, otros buses. Existe una opinión generalizada de evitar el metro. Combinación con colectivos.

Carolina: “Yo no uso el metro. No me subo al metro, para nada. No me gusta, me da miedo, no, no. Obligada me subo, pero no subo. Sólo micro y colectivo. Todos los días colectivo para mi trabajo, porque trabajo para Las Pircas, entonces no hay otra locomoción más que colectivo para arriba”

Sebastián: “Yo ocupo el metro todos los días, en la mañana sobre todo, porque vivo al lado del metro, cerca de la rotonda Quilín, entonces tengo el metro al lado. Y después hago combinación con el colectivo en Estación Central. Y hay un día que tomo micro, pero prefiero no tomar micro porque se demora mucho y el colectivo pasa a cada rato. (…) Pero es que es por la rapidez. Un rato no más estas apretado, pero es más rápido. Por eso más que nada”

Angelina: “Yo ocupo micro y los fines de semana cuando viajo donde mi mamá, ahí ocupo micro y metro. Cuando voy sola ocupo metro porque con mis dos hijas me incomoda más el metro. No hay mucho espacio, además con bolsos. Entonces, prefiero tomarme una micro que me va a dejar directo no más al centro. Trato de buscar más la comodidad cuando ando con las niñas. El metro me gusta cuando ando sola porque, bueno, no es que me encante, pero es un tema porque es más rápido. Pero lo que me aburre es andar con bolsos, el transbordo, más andar con niños es más complicado el metro. Me es mucho mejor la micro"

Luz: "Si, yo tomo micro, pero si tengo que llegar a otra actividad por la tarde, tomo metro. Pero, claro, es por algo obligatorio"

Janet: "No, yo utilizo solamente micro. Diariamente son dos. Y el metro alguna vez, por necesidad si tengo que andar rápido, sí. Pero, muy pocas veces"

- **Conocimiento del Metro vs buses**

Igor: Yo vivo a tres cuadras del metro Las Torres, por eso priorizo el metro. Aparte que con el metro llegas a todos lados. Porque de repente micro, no tengo idea. Por ejemplo, antes yo de mi casa podía tomarme una micro que me dejaba en Maipú. Se iba por todo el centro, se daba la vuelta en Pajaritos y todo el cuento. Pero ahora tendría que tomar como 5 o 6 micros para llegar a… Entonces, yo por eso priorizo el metro.

Igor: Antes tú tomabas una micro y sabías para dónde ibas y cuál micro te servía para todos lados. No era tan necesaria la combinación del metro. Yo creo que esto se hubiese solucionado si hubiesen dejado los mismos recorridos, pero con la ampliación del metro. Nada más. Porque es súper complicado

- **Buen nivel de servicio de buses. Alto flujo, en algunos casos permite irse sentado**

Angelina: yo tengo la suerte de que vivo en Peñalolén Alto así que cuando en mi paradero espero la micro, las micros ya no vienen llenas. Entonces, tengo asiento, ya no estoy como, ay no que va a estar lleno. No. Entonces, tengo la oportunidad de irme sentada y viajar sentada, todo. Pero, ya a la hora de bajarme, ya es un estrés.

Carolina: Yo igual. Yo tomo la micro, súper relajada, voy todos los días contenta a trabajar. El colectivo es lo que se demora más, pero la micro no tengo ningún problema.

Gianina: Yo estoy contenta. Ahora me vengo súper bien. Abrieron la línea 6, así que llego al estadio, me vengo acá a Ñuble y llego aquí al trabajo. No tengo ningún drama, porque también vivo en Peñalolén Alto y tiene mucho flujo de micro a cada rato, así que no tengo drama con la locomoción. Yo estoy así todo el rato. No, es rico allá. En otras comunas es imposible, pero en Peñalolén, no. Hay harto flujo de micro. Más por Grecia.

- **Avenida Grecia y corredor son una ventaja**

Gianina: Ahí me vengo relajada (Grecia). Ni para bajarme, ni para subirme, nada.

Janet: No. Avenida Grecia es la mejor avenida.

Igor: No, es que avenida Grecia es súper rápida.

Carolina: Es como una avenida principal. Es amplia.

Igor: Además que ese corredor siempre funciona súper bien. El trayecto también es rápido por avenida Grecia. Si tú la tomas, no sé, por ejemplo, yo que de Salvador hacia arriba, 25 minutos estay ya en Tobalaba yo creo. No se demora tanto. El corredor es súper rápido ese de Transantiago.

3. EXPERIENCIA DE VIAJE

- **Búsqueda de un viaje tranquilo, sin estrés, a pesar de las condiciones o calidad de servicio**

Igor: Para mí, yo me hago el viaje. O sea, independientemente de que vaya lleno o no, yo voy mentalizado de que a la hora de que tomes el transporte público vas a ir apretado.

Entonces trato de no calentarme la cabeza, como se dice, y ya… lo que dure. Es mí comodidad. Si voy parado, chao. Tratar de no molestar tampoco a los demás. Tratar de estar en mis milímetros cuadrados que tienes porque no tienes metro, ¿cachai? Entonces, eso es por lo menos lo que hago yo cuando viajo, en lo que sea.

Janet: Yo evito también, porque normalmente ando con un bolso grande. Entonces, de repente las personas andan enojadas. Pasas a rozar… (…) Señoras, hombres, niños, jóvenes, todos enojados. Hay días en que amanecen todos enojados. De verdad. Y yo les pongo la mejor sonrisa. Digo, oh, estamos despertando y ya estamos enojados.

- **Respeto, empatía por el resto. Adultos mayores, personas con movilidad reducida, entre otros.**

Leonor: Yo me acuerdo que, pucha, tú antes tomabas una micro y si tu ibas sentada y yo era más joven, veías una persona embarazada o veías un adulto o alguien con deficiencia, pucha tú te parabas y le dabas el asiento. Pero, hoy en día nada. Una mujer embarazada puede estar al lado tuyo, así con una guata y nadie da el asiento.

Igor: Siendo que tú vay sentado en el asiento que dice para personas con movilidad reducida. Nadie. O se hacen los dormidos.

- **Estrés de la gente en la ciudad**

Luz: Está muy agresiva la gente también. Está muy agresiva.

Igor: Yo creo que tiene que ver también con la vida en Santiago igual, que es muy estresante. Pero, a la vez, si fuera estresante, pero tuvieras un sistema de transporte que fuera de calidad, a lo mejor las cosas, por lo menos en el sistema de transporte se mantendrían. Pero, la gente aquí en Santiago está muy estresada, para manejar, para todo.

Gianina: Estresada y apurada. Inconscientemente te apuras cuando andas en la calle. Inconscientemente te apuras.

- **Incomodidad del torniquete**

Gianina: El único problema que me ha pasado en la micro es que pusieron cuestiones de rejas que no puedo pasar con mi hija. El otro día pasó un susto ella, porque pensó que yo la iba a dejar arriba y yo tuve que dar la vuelta por la otra puerta para entrar. Y yo entré por la puerta de al medio, porque no podían pasar dos y pagué uno y no podía seguir pasando yo. Pero, esa reja es lo único incómodo y pal coche y para la gente con muletas y todo lo demás.

Leonor: Es muy angosto y muy duro. Entonces, uno que anda con hijos chicos, tienes que andar con el bolso, que la cartera, que no sé, que un montón de cuestiones. Más encima, andar con la guagua en brazos, es como que vay luchando con el torniquete y más encima, porque es súper angosto.

- **Frecuencias y comodidad. Regularidad y detención en paraderos.**

Luz: Sí, a veces los paraderos están muy llenos cuando uno quiere bajar. O al momento de tomar la micro, a veces va llena y para llegar a la avenida principal es más difícil, porque cuesta subirse.

Sebastián: Yo veo la dificultad, primero de la frecuencia de la micro, a veces no es tan buena como un quisiera. En el metro, yo creo que en la hora punta está muy sobrepoblado. Creo que es excesiva la cantidad de gente que se concentra por metro cuadrado. Uno finalmente paga por la eficiencia del tiempo, más que por la comodidad. Uno si quiere irse cómodo, no se va en metro, ocupa otros medios de transporte.

Igor: Sí, porque de repente se te pasaron dos seguidas, y pasó una hora y no pasa ninguna. No sé si las mandan juntas, no sé cómo funcionará eso, pero de repente estas esperando una micro y pasan dos seguidas y después una hora y ahí recién pasa otra de nuevo.

Angelina: O a veces no paran, sino que siguen por detrás y pasan de largo. Y uno lleva esperando 15 minutos.

- **Horarios de funcionamientos. Resiliencia del sistema.**

Y lo otro que es una dificultad, son los horarios. Yo creo que podría ser mucho mejor si el metro se extendiera hasta la noche. No sé si toda la noche, pero sí que aumente la cantidad de horas en la noche. Sobre todo, los fines de semana.

Leonor: El caos queda cuando muere una línea, cuando se paraliza una de las líneas. Entonces, claro, te une con otra, pero al final la gente igual queda…Porque, ponte tú que muera la línea 4. La línea 4 te hace transbordo con… te lleva a Tobalaba. ¿Con cuántas líneas te une la 4?

Luz: Con la 4 a la Cisterna.

Igor: Con la 4, la 5.

Leonor: Y ahí ¿qué colapsan? Las micros, po.

Gianina: Están los paraderos llenos cuando pasa eso.

4. COSTOS DEL TRANSPORTE PÚBLICO

- Costos son importantes para el nivel de servicio que se observa. Se podría genera run sistema de incentivos para alivianar carga económica.

Leonor: Yo creo que es harto. Para lo que pagamos es harto. Para un servicio que se está dando como a medias, que a lo mejor podría ser mucho mejor y si se mejora, a lo mejor mucha gente ya… ya no habría tanta evasión.

Gianina: Para el servicio que dan, sí (es caro). 40 o 50 lucas tenís que dejar guardadas para la locomoción, más o menos. Pero igual es una suma igual importante, porque podrías ocupar en otra cosa.

Igor: Podrían aprovechar, por la calidad del servicio que están dando, de darle una bonificación a la gente que paga siempre su pasaje. Pucha, por 10 pasajes, uno gratis. Yo creo que mucha gente ayudaría como a que "a ya, voy a pagar, por último, el 10, el 11 va a ser gratis". O que juntes puntos, así como lo hacen las tarjetas de crédito, cosas así.

- Evasión. Antes todos pagaban. Pago por viajes largos puede ser doble.

Igor: porque antes todos pagaban su pasaje. Todos. Incluso, cuando te subías por atrás, las monedas llegaban, el boleto se devolvía. Te llegaba el vuelto cuando pagabas con luca

Janet: Si po en la mañana uno se fija cuando, supongamos que entren 10 pasajeros, 5 pagaran y los otros nada.

Igor: Y de repente, los cuatros pasajes que supuestamente te aguanta por tarjeta, o las dos horas, no es tiempo suficiente. De repente tenis que hacer a lo mejor dos transbordos, pero el tramo que tú te demoras del metro a la micro y de ahí para hacer otro transbordo, se te pasaron las dos horas y jodiste. Tenís que pagar de nuevo.

Leonor: Claro, porque antes, antiguamente uno cancelaba el pasaje que en las otras micros uno recorría casi todo Santiago con un puro pasaje.

5. ENTORNO URBANO

- Seguridad y entorno es dispar. Depende mucho del sector.

Gianina: A mí me gusta la comuna. Es bonita. Yo creo que la mejor municipalidad de Santiago. Ahí te ayudan, han agrandado, han hecho más consultorios.

Carolina: Las áreas verdes. Esa es la ventaja de Peñalolén.

Leonor: Sí, han hecho hartas plazas, el mejoramiento de las calles, juegos, es bien bonito.

Leonor: Yo creo que igual está como súper sectorizado. Porque ponte tú, yo vivo por Las Parcelas, entonces, yo trabajo en Plaza Egaña. Entonces, yo evito pasar por Grecia, porque Grecia no es un sector... si bien no es un sector peligroso, pero hay malandros, como en todas partes. Entonces, yo evito Grecia y mi recorrido es, no sé po, Orientales, otras partes.

Angelina: Igual es como en todas partes. En todas partes igual hay partes malas y todo, pero en lo general, así como la comuna yo encuentro que… Tenemos locomoción, tenemos supermercados, colegios, tenemos de todo. Bancos. También lo que dice ella, la municipalidad ha hecho muchas cosas. Yo por lo menos, encuentro súper positivo cómo estamos.

- **Existe una alta satisfacción con la comuna. Servicios sociales, servicios básicos y actividades. La comuna ha mejorado mucho.**

Leonor: La 506 pasa por Grecia y te deja en Maipú. Y tomé la 506 ese día y sabís que Maipú tiene partes muy lindas, pero hay otras partes que tu pasai y decí "no, aquí quedo sin cartera". Entonces, yo decía "no, yo me quedo acá". No, definitivamente yo no cambio la comuna.

Carolina: yo vivía en San Joaquín hace 9 años cuando me fui a vivir con él, empecé a ir a Peñalolén. Y ustedes tienen, bueno Peñalolén es todo, de verdad que tienen de todo. Los verdes, los carabineros, los Sapu, el hospital, el banco. Para qué decirles. Y todo eso de que les arreglan las plazas.

Igor: No sé, yo adoro mi comuna. Toda mi vida he vivido ahí y en donde vivo yo es un sector yo creo privilegiado. Tranquilo, te conocí con todo el mundo. Yo vivo en el sector de San Luís. Yo digo que mi casa es desde Tobalaba, Vespucio, Departamental y Quilín. Porque conozco a todo el mundo de todos lados. A todo el mundo. Se conoce toda la gente. Me encanta a mí donde vivo.

6. CARÁCTERÍSTICAS DE UN BUEN TRANSPORTE PÚBLICO

- **Frecuencia y regularidad**

Igor: Primero que nada, yo creo que flujo. No sé, 10 minutos, cada 5 minutos. Que tú no tengas que de repente ver dos micros en 15 minutos y después en una hora no pasa nada. Yo creo que sería lo fundamental.

Janet: Y así no se juntaría tanta gente en los paraderos, porque se demora 15 a 20 minutos. O sea, yo que tomo la micro pensando a las 6:30, pero normalmente pasa 20 para las 7. Yo miro y digo “oh, que rico que no hay nadie”. Y después vuelvo a mirar y hay 5, 10, 15, 20.

- Un sistema más humano y relajado.

Janet: En Chillán yo anduve hace poco y no, era todo cerca. Poco menos, es día yo me acuerdo que venía del centro y el chofer tanto conversa y yo quería llegar rápido. Tantos años viviendo acá. Y no po, el chofer se había dado, “vaya a comprar flores”, la niña bajó a la avenida del cementerio, compró su ramo de flores, la esperó, se subió y se sentó. Le dio esa oportunidad para ir a otro cementerio más abajo. Yo dije, “oh, estoy en el paraíso”.

Carolina: Es que la gente afuera no está tan estresada como aquí. Nosotros también, nos fuimos a vivir a la playa y era todo relajado, cerraban a las dos, de colación hasta las 5 y todos duermen. Espectacular la playa.

7. CONSTRUCCIONES SOCIALES

- A diferencia de los demás focus groups, Transantiago se percibe como Metro y buses en algunos casos, en otros solo buses.

Metro: incomodidad, caos, rapidez, certeza

Leonor: Caos. Yo me acuerdo cuando lo utilicé cuando estuve estudiando y dejaba pasar un metro. Ya el otro. Y pasaba el otro. Y en una de esas, una compañera que siempre llegaba más tarde y me dijo “¿todavía estay aquí?”, “sí, todavía no puedo tomar, mira la gente”, “ya, gánate al lado mío". Y de repente abrieron la puerta y lo único que yo sentí es que estaba en la otra puerta pegada a la pared. "Así tení que hacerlo".

Igor: Eso, rapidez y, aunque suene raro, accesibilidad, porque con el metro tú llegas a todos lados. Relativamente a casi todo te deja cerca. Yo para donde voy, metro y después micro, si es que tengo que tomar. Si no, si son dos, tres, cuatro, las camino.

Gianina: Sabís que en tres minutos va a estar ahí.

- **Micro: lentitud, evasión, estrés, incertidumbre**

Carolina: A mí me gusta. Yo uso puro Uber y Transantiago.

Igor: Enojo. Andan todos enojados en el Transantiago. Sobre todo, en las horas punta. Sí, andan todos mal genio. Si la micro partió, no te alcanzaste a agarrar de algo y le pegai a alguien y te hacen así altiro. Pero, si no es culpa tuya, no tenís donde agarrarte.

Gianina: Que uno nunca sabe si va a pasar, si ya pasó, si van a pasar todas juntas. También como vulnerabilidad, así como…

8. IMPORTANCIA DEL TRANSPORTE PÚBLICO

- **Esencial. De primera necesidad para acceder al trabajo**

Gianina: Sí, porque si no, no llegai po. No llegai a tu pega. Yo, desde allá de donde yo vengo no puedo venir en bicicleta. Si no, me vendría en bicicleta. De venida es rico, venís en bajada, pero de subida llegai hecha mierda.

Luz: A veces no están los medios para tomar un taxi. Es necesario, igual.

Igor: Es un mal necesario. Sí, porque no está funcionando bien el sistema po. Y lamentablemente no hay otro, no tení otra opción de elegir.

- **Lo más negativo: frecuencias y mantenciones de buses**

Leonor: La frecuencia. Yo creo que un poco de todo lo que hemos hablado. Yo creo que hasta de las mantenciones. Porque yo creo que si hubiera una mantención como corresponde, tú tomarías una micro y no tendría por qué quedar en pana 10 minutos o 15 minutos después.

Igor: Porque las máquinas que traen son de la mejor tecnología, lo que pasa es que acá no las cuidamos. Porque con un transporte así, tu vay a Inglaterra y tienen las micros re parecidas a las de nosotros y están impecables. Y es un buen sistema, pero porque ellos tienen, a lo mejor flujo, no sé. No sé cómo será la coordinación de ellos, pero si tu hablai del material, de las maquinarias como son cuando llegan aquí a Chile, son buenas. Son buenas máquinas. Y son accesibles para discapacitados y para todos. Son máquinas seguras. Lo que pasa es que a lo mejor aquí las mantenciones no son seguras. Y nosotros que no las cuidamos también. Porque también es culpa de nosotros los usuarios. Están todas rayadas. Que si rompen los vidrios para los partidos.

- **Diseño del bus y paraderos. Asientos incómodos**

Igor: yo si podría criticar algo, los paraderos, esos asientos curvos, no te podí sentar. Te resbalas. Yo no sé a quién se le ocurrió la brillante idea de esos asientos. ¿Sí o no?

Varios: (ríen) Es verdad.

Igor. No podí andar sentado. Tení que a cada rato acomodarte, acomodarte.

Leonor: O los que van dados vuelta hacia atrás. Yo me mareo en esos. No me puedo sentar en esos. Tiene que ser derecho, pero no hacia atrás.

- **Lo más positivo: permite acceso, conexión con metro, pagar un solo pasaje dentro de 2 horas, saldo de emergencia, cobertura**

Sebastián: Yo diría que lo bueno es la cobertura. O sea, donde uno esté, por mucho o poco que uno esté lejos, va a estar cerca de un paradero de micro o de una estación de metro. A grandes rasgos. Claro, si te vay a Buin, probablemente te cueste más tomar el transporte público al centro. Pero, en general como que uno tiene al alcance un paradero o una estación de metro, más o menos.

APPENDIX IV: MISTI MIT-CHILE-PUC PROJECT

This appendix allows us to understand the context and the main objectives of the collaboration project between the Massachusets Institute of Technology (MIT) and the Pontifical Catholic University of Chile (PUC) through the MISTI MIT-CHILE-PUC GRADUATE STUDENT SEED FUND program. This initiative allows collaboration between postgraduate students from both universities around a specific research topic for a two-year period.

Figure 1. MISTI Team

The project is entitled “Explore whether the use of a visualization tool can encourage improvements in the urban transportation planning process in Santiago, Chile”. This visualization tool corresponds to CoAXs (Collaborative Accessibility-Based Stakeholder

Engagement) is an open, online platform, based on open data developed by MIT, that helps users visualize, modify and evaluate the performance of public transport systems.
CoAXs (http://coaxs.scripts.mit.edu/home/) focuses on accessibility, that is, how easy it is for people reaching activities and opportunities within the city. This is an essential concept to understand the social and spatial impacts that transport systems have. Accessibility-based tools can represent transport and project development information in a simple way, involving community groups and stakeholders to overcome their financial and technical limitations.

The main objective of this project is to test CoAXs in the context of Chile and, in particular, of its capital, Santiago. The tool has currently been applied in the Boston context, and it is expected to complement the functionalities of the platform, aiming to conduct a global assessment of our territory. This implies not only analyzing transport networks but also taking into account the distribution of activities, housing and equity issues, and the impact this has in terms of accessibility and affordability. This way, the objective is to create comprehensive scenarios that can better inform the transport policy formulation and allow comparison for decision-makers.

This project seeks to enhance the analysis of accessibility to basic services and opportunities through public transport. The objective is to analyze how equitable is accessibility to the city and evaluate the impacts of different transportation projects (executed, in execution and planned) on vulnerable groups. For this, traditional analyzes are proposed based on people’s origin or locations, but also an ‘inverse accessibility analysis’, based on the trip destinations, which allows knowing which areas of the city are restricted to access vital basic services.

To achieve this integrated approach, participatory planning is an essential component as it recognizes the right of citizens to participate in decisions that will ultimately affect their lives (Figure 1). It also allows planners to leverage local knowledge to create grounded solutions based on experience. As such, the project proposes the inclusion of different transport actors as an integral part of the overall research experience.

Figure 1. User interaction with the CoAXs platform on Touch Screen (Source: Ricardo Hurtubia, 2016)

Thus, it is possible to note that the proposal goes beyond what this platform can do today, looking to adapt the tool to specific objectives in Santiago, promoting a metropolitan vision with a central authority endowed with powers to regulate and ensure a coherent development of the city.

The platform is essential to promote decision-making and citizen participation. Since this process is complex, the project may reflect non-definitive work, which can be fed and complemented in the future under formal initiatives and not just this collaborative project.

A full paper for the Chilean Conference of Engineering Transport can be found in this link http://www.cedeus.cl/wp-content/uploads/2017/07/CCHIT-18-STC.pdf. The aim of this paper is to analyze the impact of the Collaborative Accessibility-Based Stakeholder Engagement (CoAXs) web platform. On the one hand, a case study is presented in the commune of Cerrillos in Santiago, Chile, where the impact of Metro line 6 in terms of access is analyzed. On the other hand, the scope of the platform is analyzed in practical terms, with the aim of encouraging a paradigm shift towards participatory planning. We concluded that the visualization of these impacts can be useful for decision-making related to transport infrastructure and opportunity location.