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Abstract

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Keywords	accessibility; job-related mobility; activity participation; social inclusion; Buenos Aires

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Inequalities in job-related accessibility: testing an evaluative approach and its policy relevance in Buenos Aires

Abstract
Accessibility, as a requisite to guarantee the individual ability to participate in valued activities, has been receiving increasing yet scattered attention from diverse theoretical and operational approaches. These approaches focus on how individuals are able to engage in out-of-home activities, participate in social life as well as their involvement in other activities that contribute to their overall well-being. The paper aims at further investigating such approaches, analysing forms of inequality in job-related mobilities while assuming that a person's accessibility depends on both contextual and individual factors. Taking the Buenos Aires metropolitan area as a suitable testbed, the paper offers an approach to identify the inequalities in job-related accessibility at the neighbourhood scale. The approach considers the relationship between the quality and supply of public transport, level of social exclusion and reachable employment opportunities. The research proposes a synthetic index of inequalities in access to job opportunities (IAO) to identify disadvantaged urban areas characterized by a confluence of problems related to socio-economic deprivations, low accessibility to employment as well as a low mobility and poor quality of transport supply. The approach has an explicit operational dimension and intends to contribute to outlining tailored measures to guarantee better job opportunities, as in the case of people living in areas experiencing sub-standard levels of accessibility to workplaces.

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1. Introduction

A growing stream of research, dealing with transport-related social exclusion, demonstrates the necessity of mobility as a condition to participate in the job market and recognises accessibility as a requisite for social inclusion (SEU, 2003; Orfeuil, 2004; Le Breton, 2005; Lucas, 2012). Accessibility is a material, spatial and social phenomenon that results in a situated effect of mobilities, which frames mobility as spatial capital: mobility practices in fact "mobilise capital but, at the same time, thanks to the various forms of interaction triggered, they in turn generate new capital" (Coleman 1990, p. 302). Because mobility combines available resources (material and immaterial, physical and personal), personal projects and capabilities (both economic and cultural), it becomes a spatial capital, that is, "a resource for action" (Coleman, 1990).

By increasing extensive mobility, accessibility provides a suitable principle to assess and design mobility (Lucas, 2012; Farrington & Farrington, 2005; Farrington, 2007), and it can be regarded as a contributor to individual ability to reach a wide range of opportunities, as well as a reference principle for assuring a more efficient use of resources.

In this paper, we re-conceptualize the accessibility that infrastructure and transport systems produce in light of the concept of 'activity participation' (Martens, 2017)**.** We consider the material conditions of mobility and the associated practices, while also assuming a focus on job opportunities as a basic condition to participate in social life. This perspective seems more effective in pursuing objectives of equity and inclusiveness, for at least three reasons. First, in considering the concept of 'activity participation', accessibility serves as a 'social indicator' (Geurs & Van Wee, 2004) of individual capabilities that allows us to focus on individuals' ability to engage in out-of-home activities and their participation in social life and other activities that contribute to their general well-being (Farrington & Farrington, 2005; Farrington, 2007). Second, accessibility suggests considering mobility as a condition to access opportunities and participate in activities, as well as being an 'analyser' (Bourdin, 2005) for understanding the transformations that take place in the times, places, social life and work routines of individuals (Sheller & Urry, 2006; Cresswell, 2006, Kaufmann, 2002). Third, this perspective allows an intervention on transport systems to achieve a selective enhancement of accessibility, especially for people whose opportunities are directly limited due to their current level of accessibility.

In this way, according to Martens et al. (2014), 'fairness' is not guaranteed by an equal distribution of accessibility over different populations, but rather by selective actions addressing the problems of access to opportunities. This consequence leads to a more significant potential impact on people's lives and promotes the implementation of more effective interventions (Martens, Di Ciommo, & Papanikolau, 2014). While

accessibility evaluations are quite established as methods for considering mobility-related social exclusion (Kenyon, Lyons, & Rafferty, 2002; Lucas, 2012; Preston & Rajé, 2007; Stanley & Vella-Brodrick, 2009), the paper intends to explore their potential contribution to planning and policy. In doing so, the aim is to outline an approach to assess the relation between quality and supply of public transport and the level of social exclusion, evaluated in terms of accessibility to job opportunities, and accordingly to defined operational measures.

The focus on job opportunities concerns the essential contribution that work provides in the daily life of an individual's welfare and social inclusion (Schneider & Meil, 2009; Schneider & Collet, 2010; Viry & Kaufmann, 2015). Specifically, the paper presents a discussion based on the metropolitan area of Buenos Aires where the unequal access to job opportunities strongly relates to the structural imbalances of the transport supply, compared to the mobility demand and the urban settings. In fact, according to Gutierrez (2012) "the metropolis expands, transport networks reduce their coverage, and their differences increase with unequal territorial distribution". This territorial context serves as a promising field to test an operative methodology able to orient policy actions for selectively enhancing participation in activities. To do so, a synthetic index of inequalities in access to job opportunities (IAO) has been proposed to identify vulnerable areas affected by the confluence of socio-economic deprivation, low job-accessibility and a low quality of transport supply that local planning authorities should consider as targets to prioritize for interventions in the field of transport planning.

In the paper, we first discuss the manifold relationship between accessibility and social inclusion, outlining why 'activity participation' can be a suitable reference concept and how to translate it into an evaluative protocol for examining transport systems (section 2). Then, the discussion moves to the setting of Buenos Aires (section 3) where we apply an approach for analysing the emerging forms of inequality in job-related mobilities through a synthetic index (section 4). The index is then used to assess the urban areas experiencing sub-standard levels of accessibility to workplaces and job opportunities, and its relevance for assessing and designing mobility and urban policies is finally discussed (section 5).

2. Transport and social exclusion: the scarce operational impacts of a growing concern

Transport planning has only recently begun to focus on how transport systems contribute to individuals' access to opportunities and, consequently, to one's wellbeing. Traditional approaches to transport planning and policy tend rather to focus on the internal efficiency of transport systems (Litman, 2013) and their capacity to accommodate the overall travel demand generated by individual travel behaviours (Dijst, Rietveld, & Steg, 2013). The emphasis on the systems instead of on the users significantly limits the effectiveness of traditional approaches to tackle issues of mobility-related social exclusion, definable as "the process by which people are prevented from participating in the economic, political and social life of the community because of reduced accessibility to opportunities, services and social networks, due in whole or part to insufficient mobility" (Kenyon, Lyons, & Rafferty, 2002, pp. 210–211).

The attention on how mobility, guaranteed by transport systems, contributes to an individual's ability to take part in activities, is the issue at the centre of the recent debate on 'transport justice' (Martens, 2017; Pereira, Schwanen, & Banister, 2017; Sheller, 2018). A concern for justice is the first element of attention that inspires the interest in individuals and their opportunities. Increasingly, the academic debate discusses "not *whether* transportation planning should be based on principles of justice, but on *which* principles of justice it should be based" (Martens, 2017, p. 7).

The focus on access granted by mobility suggests a substantive approach to justice issues, focused on the outcomes rather than the procedures of planning decision-making processes. Nonetheless, the examined outcomes depend on the philosophical principles chosen to assess distributive justice and equity, which usually privilege egalitarian and sufficientarian perspectives (Pereira et al., 2017).

The object of evaluation may also differ when considering either the distribution of transport resources or instead the access they provide (Lucas, Mattioli, Verlinghieri, & Guzman, 2016). However, mobility resources are not valuable in and of themselves, but rather as a "means to achievement" (Sen, 1992, p. 33). Mobility is significant for its contribution to enhancing individuals' freedom to reach valued opportunities, granting "the possibility of a person to translate the resource into something useful" (Martens & Golub, 2012, p. 202). When a person freely chooses to concretely put such ability into practice, it guarantees access to other valuable functionalities (Nordbakke & Schwanen, 2014). In fact, accessibility conveys individuals' "capabilities

of performing activities at certain locations" (van Wee, 2011, p. 32). Within this framework, transport systems contribute to individuals' mobility, enhancing their ability to access opportunities, participate in activities and consequently be an active part of their society.

Transport systems may have a multifaceted relevance according to the subjects taken into account, as well as the opportunities they have reason to value. First, opportunities are manifold and include "whatever the person as a responsible agent, decides he or she should achieve" (Sen, 1985, pp. 203–204). The spatial features of the examined setting define the amount, quality and distribution of the opportunities available amongst those that people could be interested in. Furthermore, each person has a differentiated ability to move, which depends on both individual features and contextual constraints (Kaufmann et al., 2004). Transport systems therefore contribute significantly – though not exclusively - to the individual mobility required to overcome the spatial friction between each person and the activities she values. These may thus be assessed and designed in order to secure individuals' access to valued opportunities.

The contribution of transport systems to individuals' access is increasingly at the core of evaluative approaches concerned with the social dimensions of mobility, though deriving accessibility-based analyses are quite varied (van Wee & Geurs, 2011). First, they tend to focus on the most fragile groups of a population, usually defined by their income (Guzman & Oviedo, 2018), age (Nordbakke & Schwanen, 2014) or gender (Kwan, 1999). Second, these approaches typically estimate access to different typologies of opportunities, focusing on primary activities such as jobs and schools (Grengs, 2012), health care facilities (Paez et al., 2010), local shops (Lucas, van Wee, & Maat, 2016), but may also take into consideration leisure activities (Cascetta, Cartenì, & Montanino, 2016). Third, different modal options are examined, even if evaluations focused on the most fragile groups of a population privilege public transport systems (Bocarejo & Oviedo, 2013); in this sense, the quality of the walking environment through which transport is accessed is also a significant aspect to be considered (Tiznado-Aitken, Muñoz, & Hurtubia, 2018). Fourth, the economic and temporal costs of travel constrain the accessibility available to each person (Mokhtarian & Cao, 2004), even if subjective elements condition, for example, the acceptability of travel times (Milakis et al., 2015) and the overall personal perception of accessibility (Cheng & Chen, 2015; Lättman, Friman, & Olsson 2016; Lättman, Olsson, & Friman, 2016).

While the complexity and the precision of socially-oriented evaluative approaches grow, their impact on planning and policy processes remains limited. Policymakers tend not to adopt transport and social exclusion agendas (Lucas, 2012) due to the huge amount of data required and the difficulty of knowing the actual mobility needs of different groups (Lucas et al., 2016b). Therefore, it becomes relevant to outline approaches that may be readily used as a reference for assessing and planning transport systems in light of their contribution to activity participation. First, accessibility is recognized as the main aim of transport planning (Martens, 2017). Accordingly, its evaluations are defined in relation to what forms of participation are significant, for which subjects and by which transport systems. Accessibility analyses should firstly focus on the potential participation as conveyed by the number of accessible activities, since "from the perspective of justice it is crucial to measure persons' possibility of engaging in a variety of out-of-home activities" (Martens, 2017, p. 137). The overall attractiveness of an area may be considered specifically in relation to a set of 'basic activities' that "are assumed to be necessary to prevent households from social exclusion" (Lucas et al., 2016b, p. 482). Transport systems should guarantee a minimum threshold level of accessibility to these activities. However, basic opportunities may be available also at the local scale, despite the inadequateness of the examined public transport. It is then significant to specifically evaluate as well the potential mobility available to individuals, definable as a 'mobility project' that depends on the abilities, skills, acquired knowledge, organisational capacity and social bonds that are themselves reinforced or weakened by our practices (Ehrenberg 1995, Urry, 2007; Kaufmann, 2002; Orfueil 2004). In this way, it becomes possible to highlight eventual inefficiencies in the available mobility opportunities and identify the groups which suffer as a result. In fact, individuals may "experience a sub-standard level of accessibility that is caused, at least to a large extent, by a poorly functioning transportation system. Transportation planning based on principles of justice should, first and foremost, address the plight of these population groups" (Martens, 2017, p. 157).

To enhance a transport agenda focused on the social impacts of accessibility, the elements discussed until now could become part of a socially-oriented evaluative approach, recognising which interventions should be prioritised and where. The approach may then move from the assumption that individuals need to reach some basic activities to which the transport systems are a major contributor in this sense. Consequently, two

elements become central: on the one hand, mobility demand, as conveyed by the journeys that each area generates and attracts; on the other hand, available transport supply, considering its overall quality and the accessibility it provides to specific opportunities. Given that different groups of a population have different needs and available resources, we must also consider their different socio-economic profiles, to better convey the eventual existing inequalities between these groups. The following sections outline this approach in a specific setting, showing how its composing features need to be differently inflected according to the place and the issues taken into consideration.

3. Buenos Aires as a testbed

Due to the interactions between the socio-territorial organization, transport infrastructures and mobility patterns, the Buenos Aires metropolitan area was selected as a valid research field to assess transport systems due to their contribution to 'activity participation'. As a representative Latin American city, Buenos Aires allows us to address issues related to mobility inequalities (Keeling, 2013), innovative projects and measures (Hidalgo & Huizenga, 2013) as well as forms of 'contested mobilities' (Blanco et al., 2018). The socio-spatial differentiations of the Buenos Aires metropolitan area can be read as resulting from the radial expansion of the infrastructural corridors (i.e. rail and high-speed transportation networks), conditioning of the settlement of growth and the land use patterns, whereas today a more dispersed growth challenges this transport armature. While low-income groups settled around the main public transport corridors (tramways and trains) in the 20th century, the more recent process of peri-urbanization, led by middle and high-income groups, has urbanized portions of land through gated communities and associated highways (Blanco & Apaolaza, 2018).

The urban realm today is composed of a system of concentric crowns with different physical and functional features, population density and socio-economic conditions, unevenly served by transport modes[1]. The backbone of the metropolitan mobility network is comprised of six main radial corridors formed by the compresence of railways and highways, which converge on the City of Buenos Aires (CABA) along with four concentric main roads that are partially under construction. The rail network, designed to allow fast connections between the suburban settlements and the central city, is composed of eight lines with varying degrees of frequency, commercial speed, and structural quality (figure 1). Except for some low frequency services, all rail lines are radially headed to their own terminuses in CABA, most of which are connected, though not always efficiently, to the subway system. The latter is composed of six lines (four radial and two transversal) that are entirely included inside city boundaries and, together with eight bus rapid transit lanes and one pre-metro (over-ground light rail), represent the most reliable and fastest way to move from the core of CABA to the outskirts.

[1] The metropolitan area – with a population of almost 13 million inhabitants, growing at a rate of 11% between 2001 and 2010 (INDEC, 2010) - is administratively formed by the Autonomous city of Buenos Aires (CABA), acting as the core of the region, and several municipalities located within the Province of Buenos Aires, which surrounds the former with both compact and sprawling settlements.

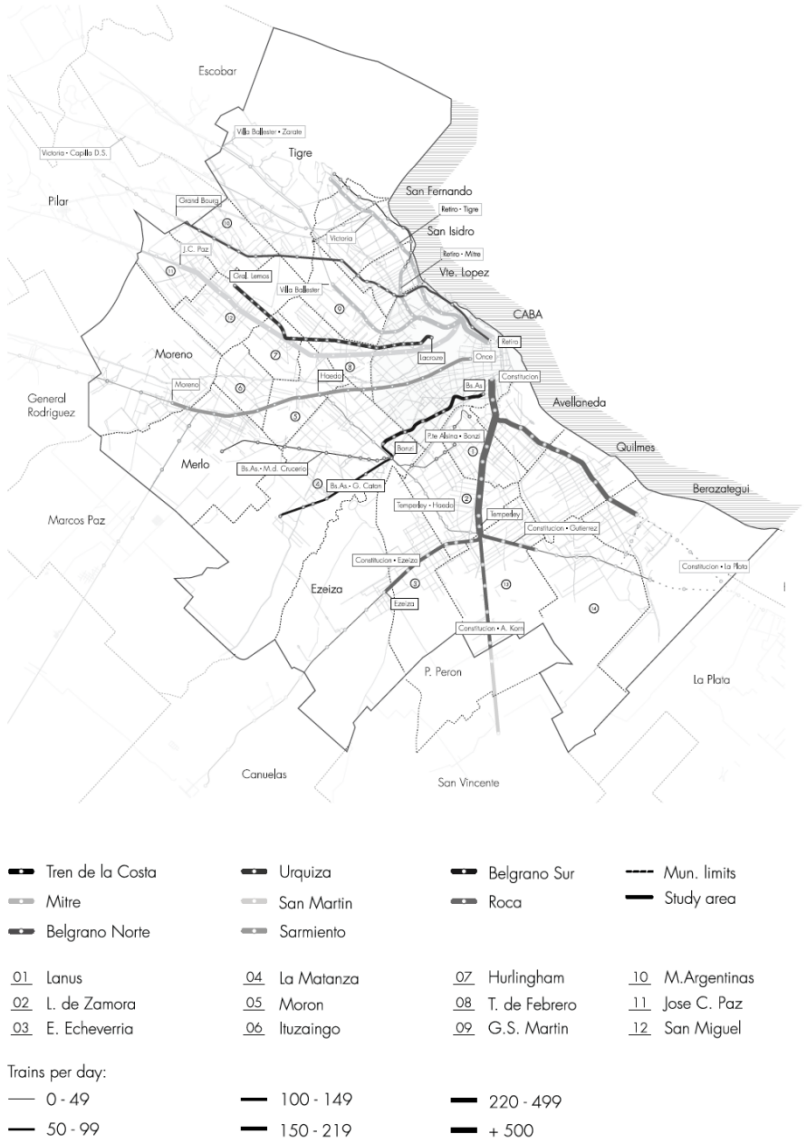


Fig. 1 – Railway network and supply

However, since mass rapid transit lines do not cover the whole territory, particularly the most recent urban settlements typically located in-between the main radial corridors, the most used means of transport, both in CABA and in the rest of the metropolitan area, is the public bus (ENMODO, 2010). This different degree of accessibility is, at the same time, both cause and effect of the strong socio spatial segregation that affects the metropolitan area of Buenos Aires, where the better-off neighbourhoods are usually located along the main high frequency rail lines (see the NBI index map in figure 2).
While current planning policies[2] propose transport and land use strategies to deal with these segregation issues, no specific evaluative tools have been applied to consider a possible interdependence between social disparity and the quality of the public transport system. Consequently, the metropolitan area of Buenos Aires may contribute to defining and testing evaluative indicators, reliable data and solid empirical evidence that

[2] Two strategic spatial plans, by Province of Buenos Aires (*Lineamientos Estrategicos para la Region Metropolitana de Buenos Aires*, 2007) and by CABA (*Modelo Territorial Buenos Aires 2010-2060*, 2010), express the main guidelines to orient and to correct the ongoing negative dynamics, such as the process of sprawling expansion of the urban fabric and the consequent level of congestion due to the increasingly massive use of cars.

are usually missing when discussing urban mobility and social inclusion in Latin America (Bocarejo & Oviedo, 2012; Jaramillo, Lizárraga, & Grindlay, 2012; Keeling, 2008).

4. Methodology

The approach analyses the emerging forms of inequality concerning job-related mobilities in Buenos Aires, in order to assess which urban areas experience sub-standard levels of accessibility to workplaces and job opportunities, according to the following methodology. The main goal of the approach is to orient and promote policies able to ensure a 'basic accessibility', defined as the ability to reach valued opportunities "assumed to be necessary to prevent households from social exclusion" (Lucas et al., 2016b, p. 482), in this case employment opportunities. Because basic accessibility is affected by the transport system, the approach intends to assess correlations between the quality of the public transport system, the level of social exclusion and job opportunities reachable by public transport in the setting of Buenos Aires.

Overcoming approaches focused solely on the real demand for movement where less mobile people, often with reduced capability of reaching places of valued opportunities, are not considered, the proposed methodology correlates indexes that can describe mobility demand, accessibility patterns and public transport supply in relation to the socio-economic profile of the population by working at the neighbourhood scale.[3] A synthetic index of inequalities in access to job opportunities (IAO) is proposed to identify neighbourhoods characterized by a confluence of problems related to socio-economic deprivations, low accessibility to jobs, low mobility and low quality of transport supply.

To do so, the approach is organized in the following steps (figures 2a and 2b):

1. Collection and selection of the existing databases, able to describe the current job-related mobility demand, the quality of the transport system supply and the socio-economic profile of the population in each neighbourhood;
2. Construction of five indexes on the basis of the data availability, able to describe the current accessibility to job opportunities in Buenos Aires, and statistical data classification of the indexes by using the Jenks optimization function[4], as introduced in the next section;
3. Construction of a synthetic index (IAO) – an index of inequalities relating to the access to job opportunities based on the five selected indexes, and introduced in the next section;
4. Construction of the Self Containment Index (SCI) and correlation between this index and the Mobility Index (MI) - both described in detail in the next section - to identify neighbourhoods where the improvement in the public transport supply can contribute to mitigate substandard level of accessibility to job-opportunities

[3] In the metropolitan area of Buenos Aires, each municipality is administratively divided into an internal subdivision called *localidad* (locality) or *barrio* (neighbourhood). To simplify, the research names both kinds of subdivisions as "neighbourhoods". All the data provided by ENMODO enquiry (2010) refers both to the municipal and neighbourhood scale. The latter is the one considered necessary to realize the present research, which analysed 235 neighbourhoods throughout the metropolitan area.

[4] The Jenks optimization function is a methodology of statistical data classification that divides data into classes applying an algorithm that calculates groupings of data values based on the data distribution. This process was carried out using a GIS software.

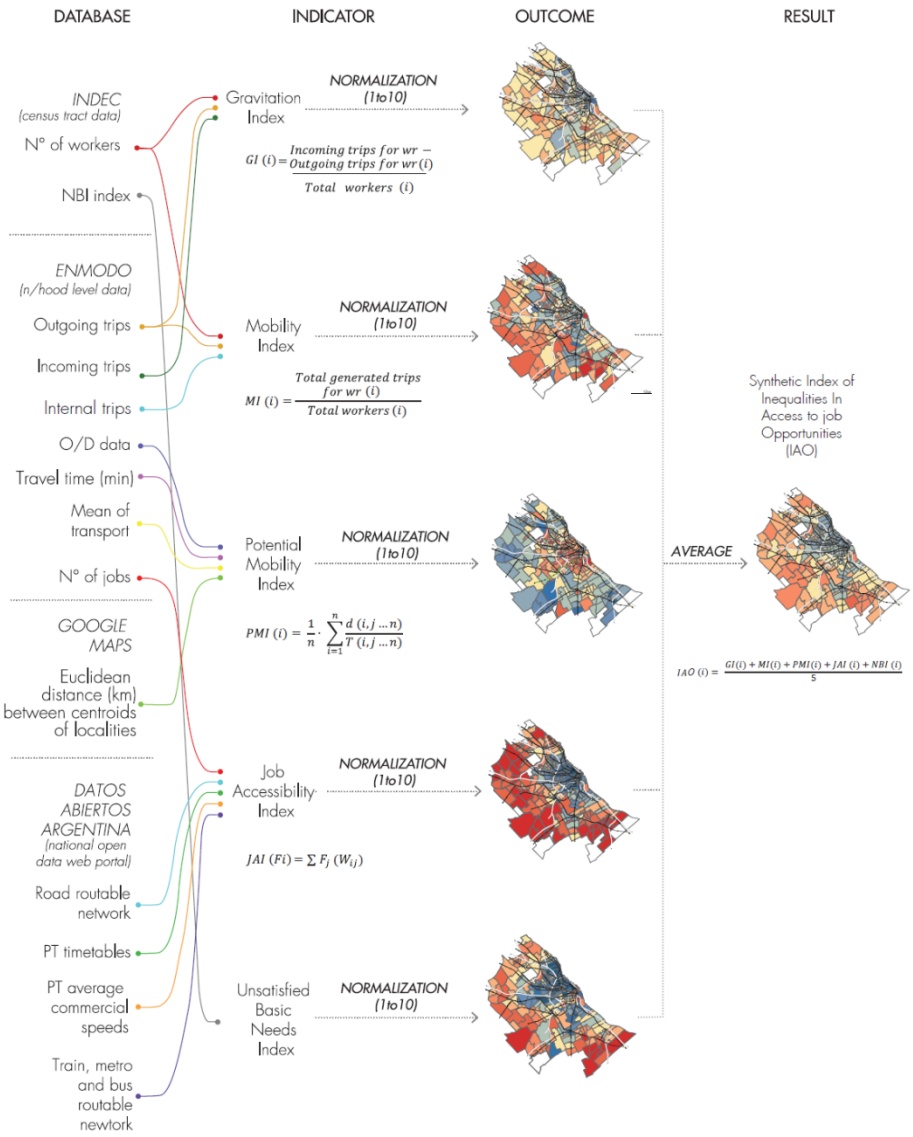


Fig. 2a – Methodological scheme: index of inequalities in access to job opportunities (IAO)

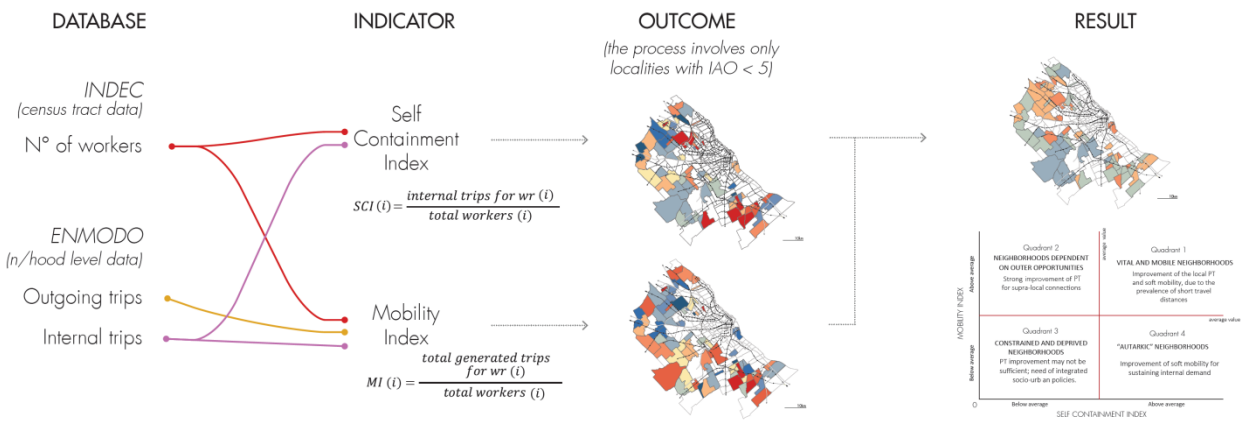


Fig. 2b – Methodological scheme: matrix of policy orientations

4.1 Description of indexes

The synthetic index of inequalities in access to job opportunities (IAO) is based on the following five indexes. Two indexes express the job-related mobility demand, as follows:

- the Gravitation Index (GI) highlights the attractiveness of a locality ("*i*") for working reasons ("*wr*");
- the Mobility Index (MI) describes the density of displacements for working reasons ("*wr*") and thus the vitality of a locality ("*i*").

Gravitation Index (GI) is calculated for each locality ("*i*") through the following equation:

$$GI\ (i) = \frac{Incoming\ trips\ for\ wr - Outgoing\ trips\ for\ wr\ (i)}{Total\ workers\ (i)}$$

Mobility Index (MI) is calculated for each locality ("*i*") through the following equation:

$$MI\ (i) = \frac{Total\ generated\ trips\ for\ wr\ (i)}{Total\ workers\ (i)}$$

The quality of the transport system supply - as an expression of how the public transport system sustains the possibility to access job opportunities - is expressed through the following indexes:

- Potential Mobility Index (PMI) measures the quality of the transport system, depending on the structure of the network and average speed, based on the Martens' approach (2017);
- Job Accessibility Index (JAI) measures the potential accessibility to workplaces in a given travel time using public transport, applying a location-based accessibility model.

The Potential Mobility Index (PMI) as proposed by Martens (2017) is a pure mobility indicator. It characterizes each neighbourhood "i" based on the quality of its public transport system by considering data related to the travel time (*T*) of public transport between neighbourhood *i* and neighbourhood *j* and the Euclidean distance (*d*) between their geographical centroids. The research considers all the neighbourhoods that are daily reached for working reasons from the neighbourhood of origin as relevant destinations, according to the trends described by the ENMODO enquiry:

$$PMI\ (i) = \frac{1}{n} \cdot \sum_{i=1}^{n} \frac{d\ (i, j \ldots n)}{T\ (i, j \ldots n)}$$

The Job Accessibility Index (JAI) is calculated by applying a location-based accessibility model, analysing the range of available workplaces with respect to their distribution in space and time. To calculate accessibility, measures of attraction are the number of workplaces at the destination zone (*Fi*) and the measure of impedance (*Wij*) is calculated considering the average time of displacements for each means of public transport from "i" to "j" and assuming a travel time threshold of 60 minutes.

$$JAI\ (Fi) = \sum F_j\ (W_{ij})$$

In the measure of impedance (*Wij*) travel time has been estimated considering walking/public transit travel between each locality in a GIS environment using a custom-made routable GIS graph. The graph was built merging the public transport network GIS graph, obtained from the national open data portal (Datos Abiertos Argentina) featuring railways, metro lines, the stations of both systems, and buses, with the road network graph obtained through Open Street Map. Both GIS graphs have been merged to superimpose on the road network the paths covered by the public transport systems. Consequently, an average speed of 4km/h was applied on the whole road network to simulate walking displacements while, in the parts of the network covered by the public transport systems, the average speed was calculated by referring to official data related to average commercial speeds (Brennan, 2010; Buenos Aires Ciudad P.E.T.E.R.S., 2015).
In a second step, the process involved the definition of urban fabric's centroids on the graph as point of origin and destination for each locality. This process was carried out to avoid that the centroid of a locality does not

coincide with the urbanized area, an aspect that is common when analyzing the most peripheral and rural spots of the metropolitan region.
In a third step, on the same graph an isochronal analysis has been carried out for each locality where the maximum travel distance that can be covered by a combination of means has been set to 60 minutes which represents a proxy of the average time in the context of study (ENMODO, 2010).
Finally, the number of available jobs opportunities from a given locality has been calculated hypothesizing that every destination features a homogeneous diffusion of workplaces in space. This is due to the fact that an isochrone from an origin may not cover the centroid of a destination, leading to a possible underestimation of the reachable job opportunities. By consequence, the number of reachable jobs opportunities is proportionally related to the extent of the surfaces of the localities of destination covered by the 60 minutes isochrone.

The index describing the socio-economic profile of the population in each *neighbourhood*, is the Unsatisfied Basic Need Index (NBI), which expresses the percentage of households that feature social and/or housing deprivation[5]. Due to the aim of this approach, which considers this aspect as a 'dependent' variable with respect to mobility related issues, other social equity measures shall not be applied. This is also due to the difficulty of finding data at the scale chosen for the analysis.
Further analysis has been conducted to orient public transport policies to target the most disadvantaged areas, considering the correlation between Mobility Index (MI) and the Self Containment Index (SCI), describing the level of integration between workplaces and home-places at the *neighbourhood* level. SCI measures the share of trips for working reasons (wr) inside a single *neighbourhood (i)*, towards the total workers in the same neighbourhood, as calculated through the following equation:

$$SCI\ (i) = \frac{internal\ trips\ for\ wr\ (i)}{total\ workers\ (i)}$$

The synthetic index of inequalities relating to the access to job opportunities (IAO) has been calculated for each locality (*i*) applying a linear function: the five indexes have been linearly rescaled according to their impact on the condition of inequality in accessibility to job opportunities, using a scale from 1 (low inequality) to 10 (high inequality). IAO has been calculated for every locality as the average of the five indexes, assuming that each index contributes in the same way to the overall value of job inequality.

$$IAO\ (i) = \frac{GI(i) + MI(i) + PMI(i) + JAI\ (i) + NBI\ (i)}{5}$$

4.2 Data sources

Dealing with the Buenos Aires metropolitan area, some challenges arise when collecting data. Considering the urban setting analysed, such issues included: data availability, data accessibility and the inhomogeneous quality of the databases, produced by different public and private authorities, and at the base, issues of interoperability that could compromise the possibility to analyse topics that interest at the same time different territorial fields. Regarding the socio-economic data, the population numbers were obtained from the INDEC National Census (2010). The number of workers were calculated using the INDEC National Census data on population between the ages of 15 and 64 at the census tract scale and then multiplying it by the INDEC 2010 employment rate. NBI (Unsatisfied Basic Needs) is a compound indicator of social and housing

[5] This index, provided by 2010 INDEC census data, has been obtained by considering the percentage of households, in each census tract, that feature at least one of the following conditions of socio-economic deprivation:

- Household living in a precarious building or/and with rent affordability problems;
- Lack of sanitation;
- Residential overcrowding;
- Lack of access to the educational system;
- The presence of a single low educated employed in a household with four or more inhabitants.

deprivation at census tract level, available in the INDEC census (2010). The number of workplaces was obtained by an ENMODO mobility enquiry (2010), taking into account the statistically weighted number of workers reaching a specific location for working reasons. This data also includes all the internal workers of each neighbourhood.
Regarding mobility patterns, the data has been obtained from the ENMODO O/D matrix (2010) that provides data on point of origin and destination, travel time, reason of travel and means of transport. Data refers to the neighbourhood scale which, in the case of the municipalities, are also known as 'localities' (statistical confidence level).
Travel time has been estimated starting from the distances travelled in the official routable network and considering the travel time obtained by official data related to public transport average commercial speeds (train, metro and buses), referring to the morning peak hour of a weekday.

5. Applying the approach: main findings and relevant suggestions for mobility policy

Thanks to the implementation of the approach, two main outcomes have been obtained, useful to highlight difficult conditions of access to job opportunities and priorities for mobility policy.
On one hand, we define a synthetic index (IAO) that expresses the inequalities in the access to job opportunities in each neighbourhood, based on the selected five indexes described in section 4.1. and processed by calculating the average between their normalized values in the scalar field from 1 (low inequality) to 10 (high inequality). The index allows the mapping of the more disadvantaged neighbourhoods in terms of access to job opportunities (figure 3).
On the other hand, a matrix of policy orientation correlates the Mobility Index (MI) and the Self Containment Index (SCI). The matrix distinguishes which of the most disadvantaged areas need policies devoted to improving the supply of public transport and which areas instead need integrated policies (among them social, mobility, land use policy) resulting from the complexity of the critical issues that cause the deprivation and exclusion of their inhabitants from urban opportunities (table 1 and figure 4).
This matrix uses the two indices pro-actively: while SCI describes the level of integration between work-places and home-places at the neighbourhood level, areas with a high SCI are those where there is a high integration between home-places and work-places. Thus, the travel distances are short because the inhabitants work close to their home. Correlating SCI with Mobility Index (MI) describes the density of displacements and thus the vitality of a selected area. Such situations are detailed in section 5.2 A framework for mobility policy.

5.1 Inequalities in job opportunities

The empirical evidence of the index of inequalities in access to job opportunities (figure 3) allows the testing of its effectiveness in outlining those neighbourhoods characterized by low values in term of basic accessibility, mobility trends and socio-economic inequalities, which limit the possibility for local inhabitants to access job opportunities.

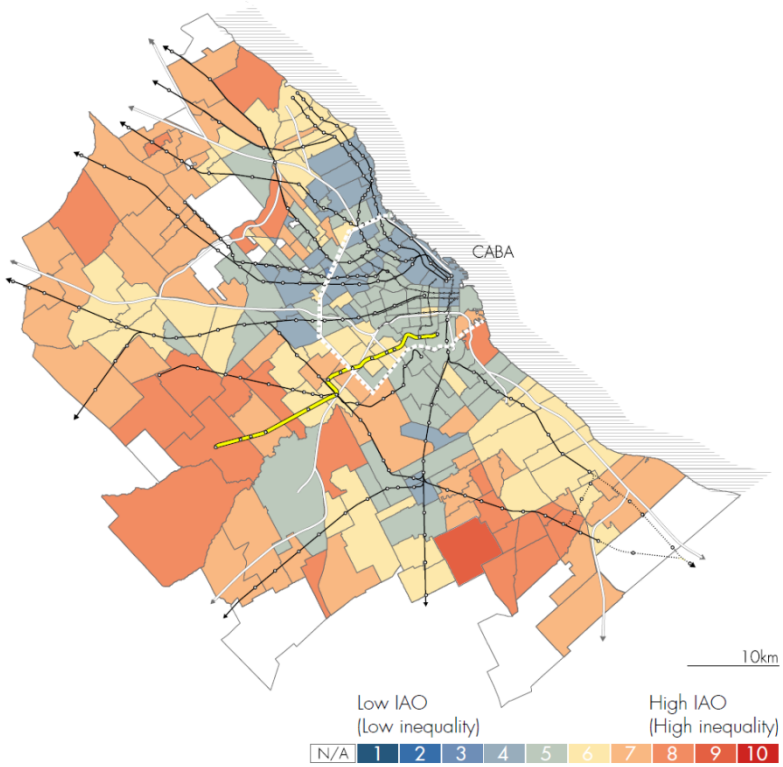
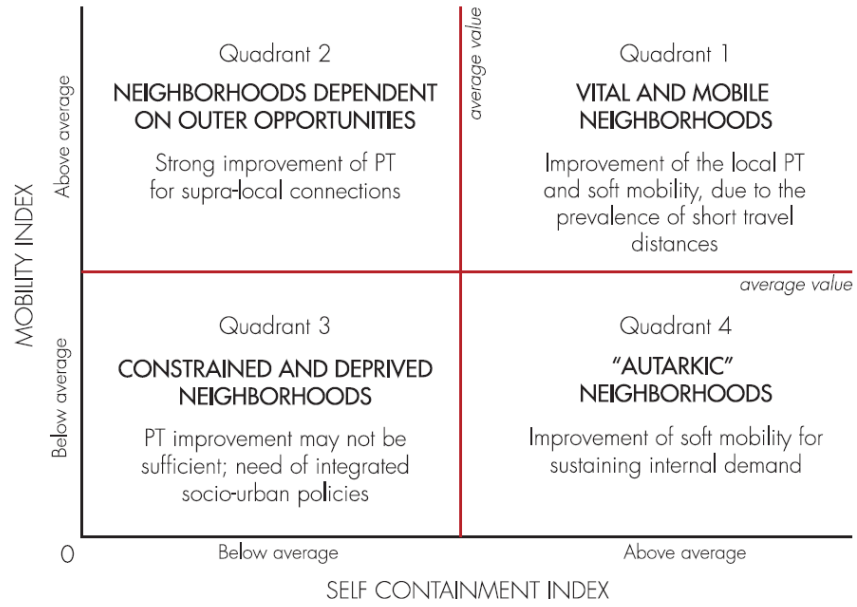


Fig. 3 – Index of inequalities in the access to job opportunities (IAO)

Three main territorial dynamics prove the effectiveness of using a synthetic index (IAO) to map the different profiles of the neighbourhoods. Firstly, there is a concentration of low-performance neighbourhoods in the second crown of the metropolitan area. This build-up results from the presence of large mono-functional low-density residential areas, inhabited by socially disadvantaged groups with few available local job opportunities. The poor level of accessibility experienced by the local inhabitants derives from the combined effect of the necessity to commute and the low quality of the supply of a fast and reliable public transport system. Many rail lines are usually operated with high frequencies up to the neighbourhoods of the first crown, but beyond these lines the number of daily trains drops consistently and constrains peripheral inhabitants to depend more heavily on the slower public bus network.
Secondly, the apparent contradiction between a concentration of neighbourhoods with a high level of the index of inequality (IAO) along a railway line (for example a branch of Belgrano Sur railway line, highlighted with a greater thickness in figure 3) can be explained by the technical performance of that line, with a low frequency of supply, a weak physical integration of its stations with the urban fabric, a low level of connectivity with the inner city and with the other means of transport and finally its location in a metropolitan context characterized by few job opportunities and deprived social conditions.
Thirdly, most of the neighbourhoods placed in the first crown and in the inner city feature low levels of index of inequalities in access to the job opportunities (IAO). This implies that even though local populations may also be affected by the low quality of the public transport system (mainly evidenced by high levels of congestion), better social conditions or more available local jobs opportunities provide the base for a potentially higher level of societal inclusion.
Despite the outcomes proving the effectiveness of using a synthetic index (IAO) for mapping the different profiles of the neighbourhoods, further steps are needed to address the mobility policies of the Buenos Aires Metropolitan Area in order to improve basic accessibility to job opportunities.

5.2 A framework for mobility policy
The analytical tool tested in the Buenos Aires metropolitan area is an experimental approach to be further refined. The index of inequalities (IAO) that measures accessibility to job opportunities may be useful to

provide a general overview of the current dynamics and to highlight disadvantaged areas, in terms of access to job opportunities, that - according to a prioritarianist perspective - should determine the places most in need of intervening with policies related to the sphere of public transport.
To address the specific interventions on the transport system in the urban areas characterized by a low accessibility index to employment opportunities, a further step has been experimented that helps selecting amongst the most disadvantaged neighbourhoods those that would benefit more through the enhancement of the public transport system. This benefit is expected to be greater in neighbourhoods that show an already existent, even if minimal, demand for movement while, for the less mobile neighbourhoods, other sets of policies may be more appropriate (e.g. directed to the improvement of the primary infrastructures, measures for social inclusion, etc.).
To orient short-term public transport policies to the least advantaged neighbourhoods, according to the benefit they may accrue by the enhancement of the local public transport system, we need to investigate whether there is a correlation between Mobility Index (MI) and the Self-Containment Index (SCI).
As explained in section 3, the Mobility Index (MI) expresses the density of total work-related displacements, while the Self-Containment Index (SCI) reveals the density of internal displacements. Based on this, the correlation between these two indexes allows us to identify, among the most disadvantaged neighborhoods, those in which an improvement of the public transport sector can trigger virtuous processes and, on the contrary, those neighbourhoods in need of more structural policies. The chart in table 1 correlates MI with SCI, defining four quadrants on the basis of the average values of each index. Each quadrant defines a precise profile that may justify the proposal of a specific set of policies (figure 4). Areas whose MI and SCI are considerably below the average would require priority interventions, while areas not distant from the average could be the object of subsequent actions.



Tab. 1 - Matrix of policy orientation

The neighbourhoods placed in Quadrant 1 are characterized by a relatively high level of inner vitality (due to a high SCI value) with positive external exchanges (due to a high MI value). In this condition, the available opportunities at a short distance, even if few, are present. This profile suggests that the amelioration of the inner public transport system, combined with softer interventions that may promote the use of bikes or improve the quality of pedestrian paths, could be a significant step in facilitating access to valued opportunities.
In Quadrant 2, it is possible to identify places that are vital (due to a high MI value), but clearly dependent on outbound job opportunities as expressed by a low level of SCI. To sustain these existing relations and to, eventually, create new ones, the most effective policy should be oriented to the improvement of the intra-

neighbourhood public transport network to ease outbound connections. This kind of policy, for instance, may involve the creation of new bus lines, change of the actual paths or the connection with fast rapid transit stations.
Quadrants 3 and 4 feature the neighbourhoods with low values of mobility. Even if characterized by lower or higher levels of internal trips, the inhabitants tend not to move for working reasons. This can be due, in the first case, to a chronic deficiency of job opportunities inside the locality and supposedly a problematic social condition that constrains the inhabitants. In the second case, the scarce vitality of the population is still present even in a context where a few opportunities may be available (because the high value of SCI highlights a high work-related mobility within the area). This last profile may be related to the presence, inside the same locality, of areas with a strong social deprivation that may function as "autarkic" areas. Neighbourhoods from quadrants 3 and 4 thus may require more integrated policies that go beyond actions related solely to the sphere of public transportation. For instance, a possible strategy could be the promotion of policies aimed at enhancing the structural quality of informal settlements by providing basic infrastructures, housing improvements and social support. In any case, it must be considered that such interventions should be carried out considering the potential negative impact they may have on rent affordability and tenure security.

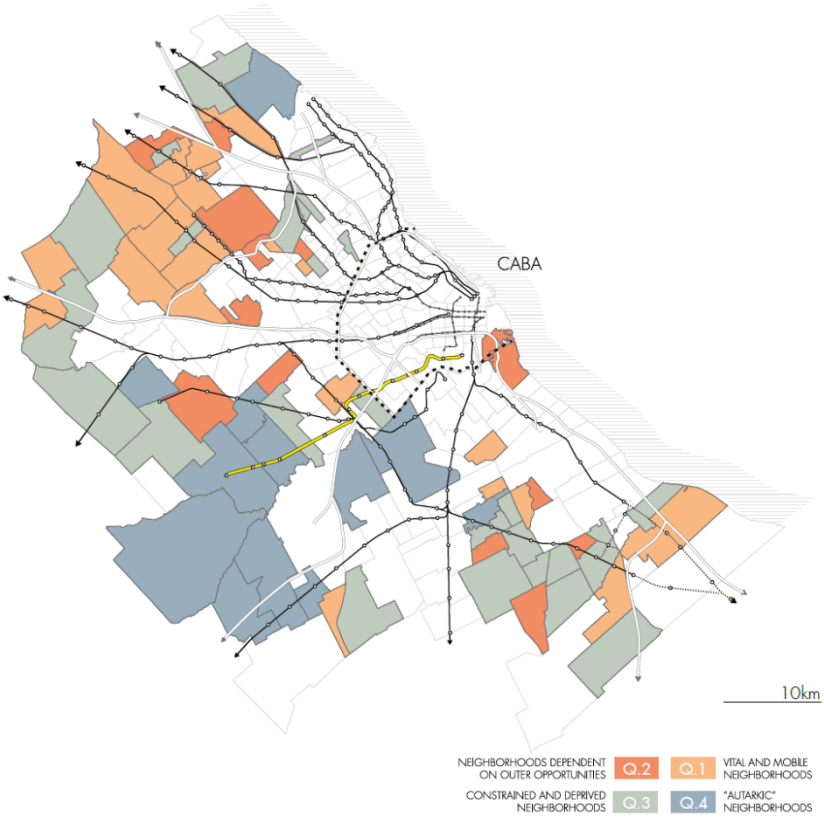


Fig. 4 – Policy orientations map

The approach applied to the Buenos Aires metropolitan area represents a tool, albeit preliminary, but easily implementable and replicable that can help in the preliminarily selection of the most urgent actions for managing the forms of inequalities in the access of job opportunities, as well as to evaluate mobility policies considering their contribution to individuals' level of activity participation.

6. Conclusions

By reconsidering accessibility as the possibility to participate in job related activities, the experimental approach proposed in the Buenos Aires metropolitan area analyses accessibility patterns and individual mobility practices to consider how transportation systems contribute to basic forms of accessibility to job opportunities. Empirical evidence highlights that the suggested approach - with necessary refinements (e.g.

accessibility measures based on the available data) - could be usefully applied to current local planning approaches, in order to assess the equity effects of transport investments and address the distinct needs of disadvantaged mobility groups.

By focusing attention on current forms of mobility, their spatial reflections, the social dynamics they generate and how they support the access to job opportunities, the approach allows us to identify differentiated needs and projects. While in the case of Buenos Aires it seemed relevant to focus on access to job opportunities made possible by public transport, the approach may be also easily adapted to other settings, considering other significant modal choices or valued opportunities. The approach distinguishes between areas in which an improvement in transport supply can entail general benefits for its inhabitants and those areas where it is necessary to implement more complex and integrated actions that will enhance the range of activity participation for people experiencing sub-standard levels of accessibility. In those settings, a simple improvement of the mobility supply would not affect the other existing forms of social exclusion.

Therefore, this approach is a first contribution to multidimensional interventions that can more effectively address existing inequalities in any given setting. As a framework for policy, a practical policy packaging design process (Givoni & Banister, 2013) is relevant for increasing the effectiveness and fairness of established transport planning approaches and mobility policies in complex situations, as well as for minimizing implementation efforts (financial, though not only). Policy packaging consists of strategically considering and deploying several policy measures in combination to promote sustainable mobility policy (Givoni, 2014), increasing their effectiveness while minimizing implementation efforts. A practical policy packaging design process helps to strategically consider and deploy several policy measures in combination to promote fair mobility policy; it effectively satisfies the demand and its variability, also for people with very specific mobility needs while also providing flexible solutions both over time and in location.

The operational focus of the outlined approach distinguishes our proposal from other evaluations that, despite their explicit interest in justice and mobility, are often less focused on specifying their policy implications. Considering simply works devoted to mobility-related social exclusion and accessibility in Latin America, most works provide evaluations of existing transport systems and the access they provide to opportunities, limiting themselves to an analysis of current settings. Even when providing operational suggestions that are not vague (such as the need of higher integration between transport and land use), evaluations focus on systemic elements that are relevant from a justice perspective but do not define priorities of intervention; an example in this sense is the recent attention for public transport fares (Guzman & Oviedo, 2018). Moreover, the proposed interventions are often limited to improving transport services and infrastructures, while the approach we propose in the paper allows more complex, multidimensional interventions, involving different fields of public policy.

The preliminary results obtained by the application of the proposed method may justify and address transport-related policies in a more selective and efficient way, working towards at least three aims. First, to provide a minimum standard of transport supply and ad hoc mobility solutions to improve the activity participation of disadvantaged areas experiencing limited opportunities and low work-related mobility practices. Second, to address interventions on transport systems to selectively enhance accessibility. Third, to convey the benefits that transport investments may generate in relation to differentiated individual needs and mobility practices, emphasizing the transport equity impacts and their significance in the overall transport investment evaluation process. The approach thus contributes to differentiate priorities in terms of both policy contents and time of implementation, assuming that policies to improve the transport supply can produce effective results for social inclusion only under certain conditions. However, the approach may benefit from the availability of more precise data, which could better associate different job typologies with the diverse socio-economic profiles of a population. Furthermore, other variables – such as the economic cost of travel and their different incidence on individuals' income – would be valuable in providing greater insight into current accessibility issues and the possible operational measures necessary to address them.

More discussions on the proposed approach as well as its feasibility and replicability is required. The use of available data and easily implementable indicators intends to provide local authorities with 'feasible' analytical tools for monitoring mobility practices and evaluating the individual's ability to participate in valued activities. However, the proposed approach may not be extensively used for depicting all current forms of inequality in job-related mobilities. Even if the used accessibility measures are based on the available data, our experimentation raises issues of feasibility (how to operationalize the activity participation concept,

how to define basic accessibility and which subjects should be responsible for it) and effectiveness (how to differently inflect the approach according to the different urban setting and available data). The reflection proposed here intends thus to pave the way towards more analytical and operational approaches, which may in turn result in more effective strategies for addressing the inequalities in reaching basic opportunities.

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Tren de la Costa
Mitre
Belgrano Norte
Urquiza
San Martin
Sarmiento
Belgrano Sur
Roca
Mun. limits
Study area

01 Lanus
02 L. de Zamora
03 E. Echeverria
04 La Matanza
05 Moron
06 Ituzaingo
07 Hurlingham
08 T. de Febrero
09 G.S. Martin
10 M.Argentinas
11 Jose C. Paz
12 San Miguel

Trains per day:

0 - 49
50 - 99
100 - 149
150 - 219
220 - 499
+ 500

DATABASE

INDICATOR

OUTCOME

RESULT

INDEC
(census tract data)

N° of workers

NBI index

ENMODO
(n/hood level data)

Outgoing trips

Incoming trips

Internal trips

O/D data

Travel time (min)

Mean of transport

N° of jobs

GOOGLE MAPS

Euclidean distance (km) between centroids of localities

DATOS ABIERTOS ARGENTINA
(national open data web portal)

Road routable network

PT timetables

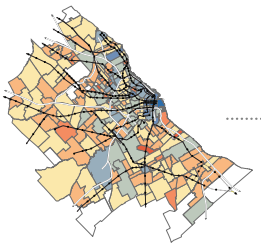
PT average commercial speeds

Train, metro and bus routable newtork

Gravitation Index

NORMALIZATION (1to10)

$$GI\,(i) = \frac{Incoming\ trips\ for\ wr - Outgoing\ trips\ for\ wr\,(i)}{Total\ \ workers\ \ (i)}$$



Mobility Index

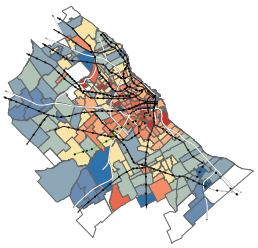
NORMALIZATION (1to10)

$$MI\,(i) = \frac{Total\ generated\ trips\ for\ wr\ (i)}{Total\ workers\ (i)}$$

Potential Mobility Index

NORMALIZATION (1to10)

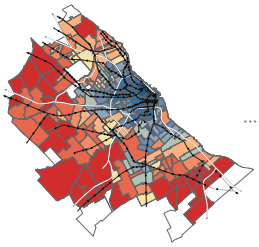
$$PMI\,(i) = \frac{1}{n} \cdot \sum_{i=1}^{n} \frac{d\,(i, j \ldots n)}{T\,(i, j \ldots n)}$$



Job Accessibility Index

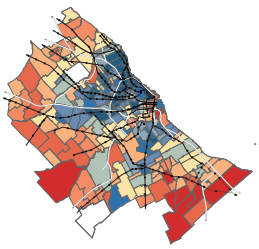
NORMALIZATION (1to10)

$$JAI\,(Fi) = \sum F_j\,(W_{ij})$$



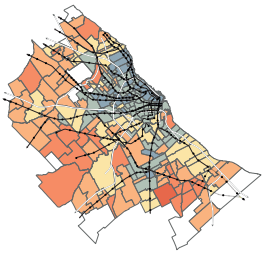
Unsatisfied Basic Needs Index

NORMALIZATION (1to10)



AVERAGE

Synthetic Index of Inequalities In Access to job Opportunities (IAO)



$$IAO\,(i) = \frac{GI(i) + MI(i) + PMI(i) + JAI\,(i) + NBI\,(i)}{5}$$

DATABASE

INDEC
(census tract data)

N° of workers

ENMODO
(n/hood level data)

Outgoing trips

Internal trips

INDICATOR

Self Containment Index

$$SCI\,(i) = \frac{internal\ trips\ for\ wr\ (i)}{total\ workers\ (i)}$$

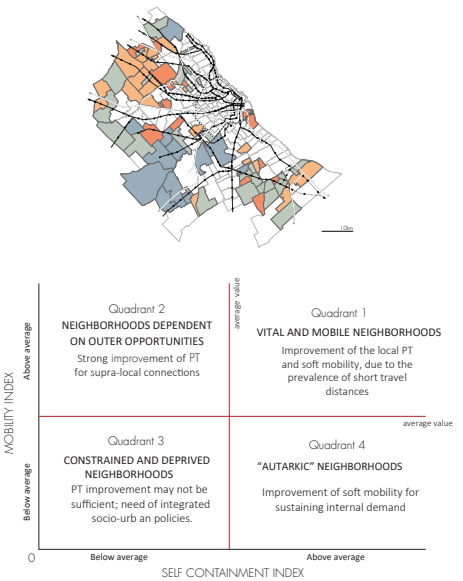
Mobility Index

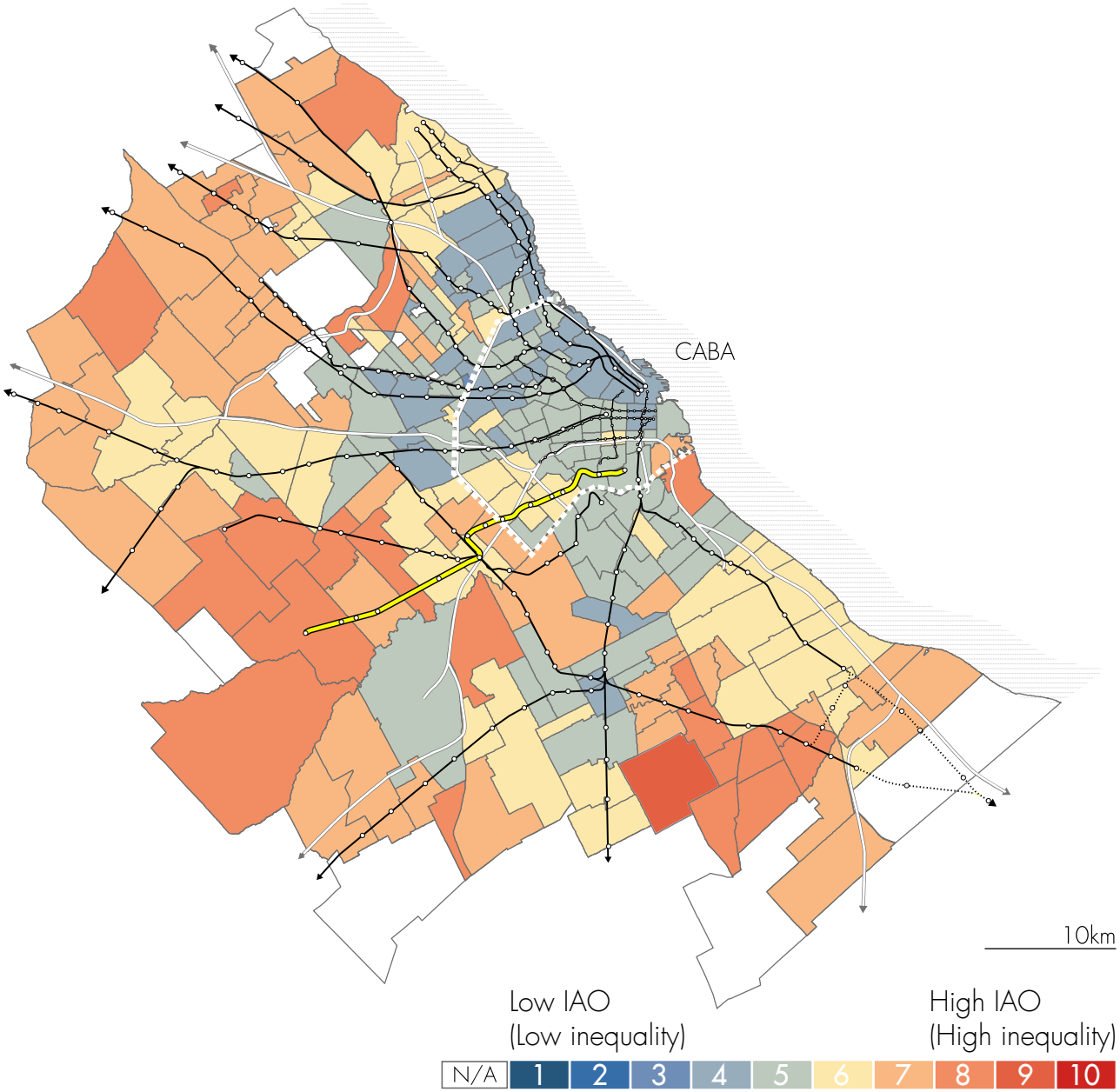
$$MI\,(i) = \frac{total\ generated\ trips\ for\ wr\ (i)}{total\ workers\ (i)}$$

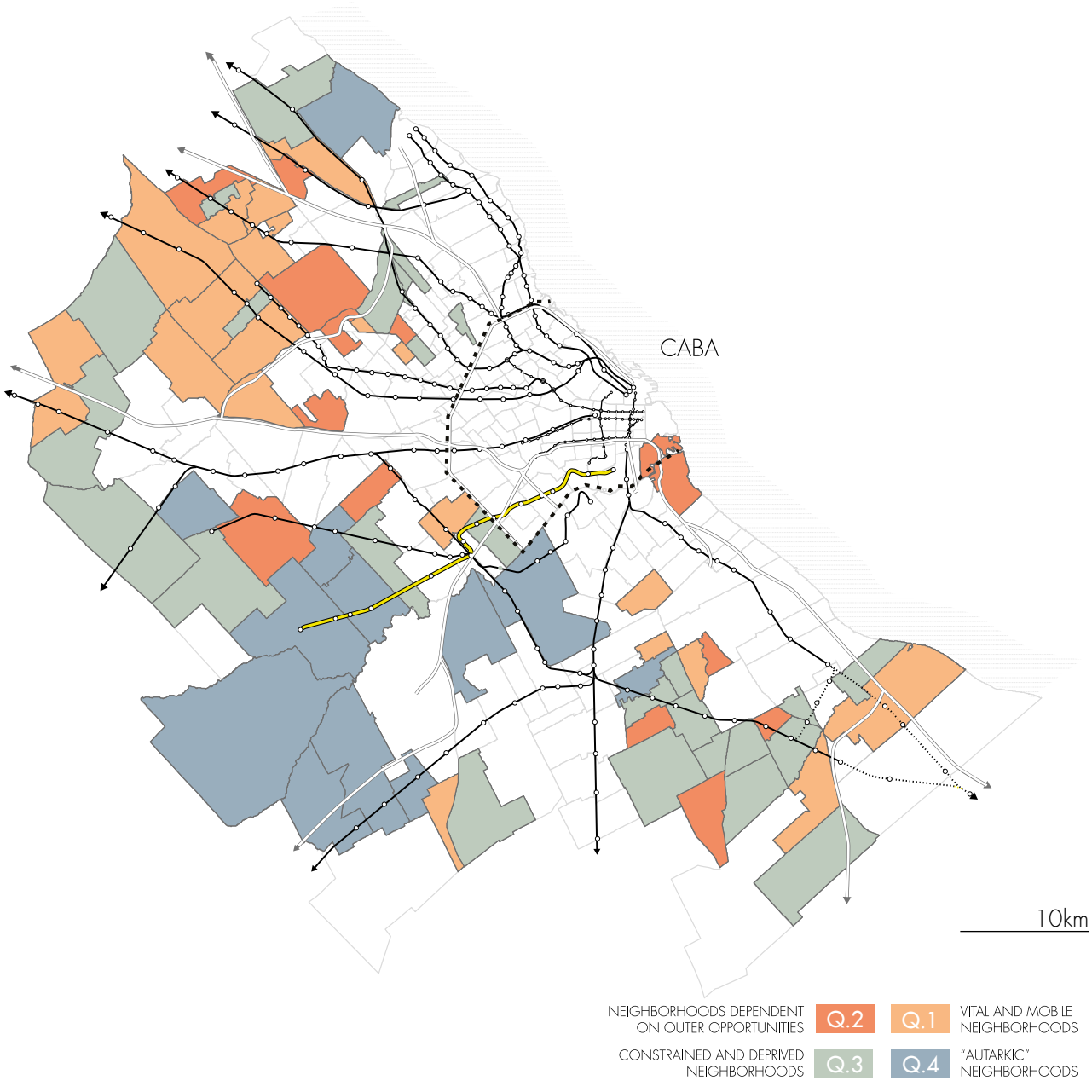
OUTCOME

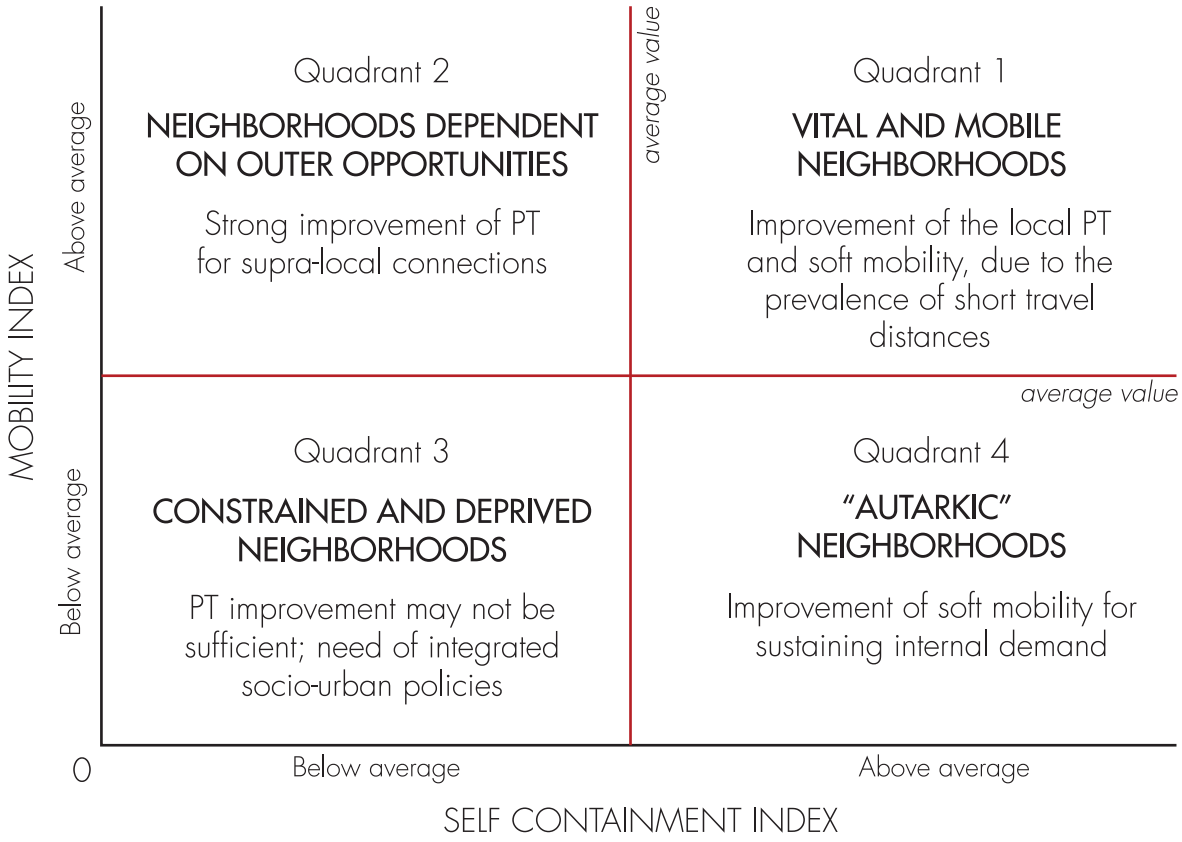
(the process involves only localities with IAO < 5)

RESULT




CABA
10km
Low IAO
(Low inequality)
High IAO
(High inequality)
N/A
1
2
3
4
5
6
7
8
9
10


CABA
10km
NEIGHBORHOODS DEPENDENT ON OUTER OPPORTUNITIES
Q.2
Q.1
VITAL AND MOBILE NEIGHBORHOODS
CONSTRAINED AND DEPRIVED NEIGHBORHOODS
Q.3
Q.4
"AUTARKIC" NEIGHBORHOODS


Quadrant 2
NEIGHBORHOODS DEPENDENT ON OUTER OPPORTUNITIES
Strong improvement of PT for supra-local connections
Quadrant 1
VITAL AND MOBILE NEIGHBORHOODS
Improvement of the local PT and soft mobility, due to the prevalence of short travel distances
Quadrant 3
CONSTRAINED AND DEPRIVED NEIGHBORHOODS
PT improvement may not be sufficient; need of integrated socio-urban policies
Quadrant 4
"AUTARKIC" NEIGHBORHOODS
Improvement of soft mobility for sustaining internal demand
average value
average value
MOBILITY INDEX
Above average
Below average
0
Below average
Above average
SELF CONTAINMENT INDEX