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Residential income segregation and commuting in a Latin American city

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1. Introduction

Numerous urban dwellers worldwide still live under residential segregation, which can act "as a poverty trap with job restrictions" (UN-Habitat, 2016, p. 79). Residential segregation occurs in a geographic space where individuals with similar socio-economic characteristics, such as income, are living close to each other and cut off from individuals of different socio-economic features. A clear understanding of the consequences that residential segregation has on poor people's urban economic mobility is imperative to ensure that they move out of poverty. This is a pressing challenge for cities around the world, urging policy makers to deliver alternative solutions about planning-related topics such as housing, and transportation.

Research on residential segregation has often focused on large cities in the Global North (for Sweden, see Nielsen & Hennerdal, 2017) and, within that framework, Chetty, Hendren, Kline, and Saez (2014) have developed a very important study in the literature. Chetty et al. (2014) found that, in American cities, residents living in areas with less residential segregation, according to income level, experience higher economic upward mobility than those living in areas with more residential segregation. They also found that the higher the fraction of working individuals with short commuting times, the higher the chance for upward mobility in that area (Chetty et al., 2014, p. 1617). In other words, residents are more likely to improve their economic conditions when they live in areas with job options nearby. This latter finding is based on the spatial mismatch hypothesis, which was firstly posed by Kain (1968). He argued that in U.S. cities "racial segregation in the housing markets affects the distribution of [black] employment and reduces [black] job opportunities" (Kain, 1968, p. 176).

This paper expands Chetty's et al. (2014) approach to the Global South context, and contributes to the empirical literature on segregation in Brazil, which "is still in its infancy" (Fernandes, 2017, p. 2). This study focuses on a sub-region of the Belo Horizonte Metropolitan Region (BHMR) as a case study to examine how residential income segregation functions in tandem with the time that individuals spend commuting to work, illustrating urban inequality in access to jobs in a Latin American city. The study has three main research objectives covering the period from 2000 to 2010: 1) to examine residential income segregation in the BHMR; 2) to describe the spatial dynamics of change in commuting patterns during that period of time; and 3) to understand how residential segregation is linked to the duration of individuals' commute to work, and other factors that influence segregation, including some urban characteristics. To achieve each of these objectives, the methodology included Local Indicators of Spatial Association technique, a novel visualization linking where people live and work, and seemingly unrelated regression models, respectively. This study could not include economic upward mobility in the same way as Chetty et al. (2014) because no such data is available.

My theoretical framework is built on the spatial mismatch hypothesis, allowing me to provide empirical evidence for this approach in the context of the Global South. The results show a notable spatial pattern of residential segregation between low-income areas located in the periphery and high-income areas located in the core of BHMR. Concerning the changes in commuting patterns, I observed that people were commuting farther to work in 2010 than in 2000. Additionally, commuters from low-income segregated areas tended to experience shorter commuting time to work in 2000 than in 2010. Over time, my findings suggested a 'trap' in which residents of low-income segregated areas experienced a high probability of having longer commute duration and of using public transportation, creating a mutually self-enforcing process. These finding illustrate that the spatial mismatch hypothesis is supported in the BHMR case study. Indeed, a geographical separation was observed between lower and higher-income commuters and the areas of economic growth, where most jobs were found, located in the center of the BHMR and far from the lower-income neighborhoods, located in the periphery.

Based on my findings, location of housing becomes an essential issue to be addressed. I recommend the expansion of the area that can be covered by the Special Zone of Social Interest (Zona especial de interesse social; ZEIS), and the allocation of the revenues from the Transfer of Development Rights (TDR) for the purpose of building social housing. Both pro-poor recommendations, explained in detail below, should be implemented in areas where there is a critical need to minimize residential segregation and the spatial mismatch in access to jobs for the urban poor.

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2. Segregation in Brazil in the context of the housing and labor markets

This study examines as its central concepts the spatial mismatch hypothesis along with residential segregation, and urban mobility in Brazil.

2.1. Spatial mismatch hypothesis

A large amount of empirical research has explored the spatial mismatch hypothesis in cities around the world, with much of the research focused on the U.S., and relatively little of this work is taking place in the Global South. The urban structure of cities plays a central role in the spatial mismatch hypothesis because it brings locational advantages and disadvantages to the job-housing match. As in the 1990's, the urban structure of American cities was characterized by having poor people living in the inner-city, and rich residents living in the suburbs. Brazilian cities, on the other hand, had an urban structure characterized by rich people living in the center, and the poor residents living in the periphery. Even though these very contrasting urban structures are indeed the mainstream in both countries, a few changes are slowly taking place: in the U.S., there is a movement of middle class to downtowns, and in Brazil, gated condominiums are being built in the peripheries for the middle and upper classes (Coy, Sandholz, Töpfer, & Zirkl, 2018).

Race is a central variable in Kain's original hypothesis, however not all studies in the literature include race. In fact, of the studies discussed in this section, Li, Campbell, and Fernandez (2013); Martin (2001); Ong and Miller (2005); Naudé (2008); Slovic, Tomasiello, Giannotti, Andrade, and Nardocci (2019); and Zenou (2013) considered race in their analyses. For this study, due to the absence of race-related data for both 2000 and 2010, I focused on income segregation. Unfortunately, lack of data presents a continuous barrier for researchers in developing countries (Di Giulio, Bedran-Martins, Vasconcellos, Ribeiro, & Lemos, 2018; du Toit et al., 2018).

In the U.S. context, Li et al. (2013) discuss the relationship between spatial mismatch and both racial and skill segregation in a variety of cities. They argue that racial segregation is socially and economically harmful to all communities, and that low-skilled and high-skilled jobs should be integrated. Zenou (2013) explores the relationship between spatial and social mismatch and argues that poor public transportation presents barriers to low-income minority workers' ability to connect with social networks other than those within their neighborhoods. Martin (2001) outlines the commuting issues that align with spatial mismatch and racial residential segregation, including the fact that low-income workers are less likely to have a car and more likely to use and incur the costs of poor public transit.

Research in the Global South has also found spatial mismatch to be a significant problem for socioeconomically-disadvantaged populations (for South Africa, see Naudé, 2008). Brazilian cities are no exception. Through a study in Rio de Janeiro, Barandier, Bodmer, and Lentino (2017) found that urban sprawl results in transport accessibility issues and concernedly high commute times, especially because of the country's significant disparity between the rich and the poor, allowing the wealthy to depend heavily on private automobiles, while the low-income population faces social exclusion and disadvantage. Haddad and Barufi (2017) present similar findings, showing that low-income residents in the São Paulo Metropolitan Region are more likely to rely on public transportation, facing longer commute times and lower job accessibility. These findings are corroborated by Slovic et al. (2019) in a study that reveals the spatial segregation between São Paulo's highest Municipal Human Development Index percentile group, who lives mostly in the center of the city, and the lowest percentile group (mostly non-white), who lives in the outskirts of the city and faced transportation accessibility issues and lower quality of life.

Interestingly, Suarez, Murata and Campos (2016) in a study of Mexico City, which has a typical urban structure of the Global South, show that concerning travel time, "low-income workers actually have the shortest commutes" (Suárez, Murata, & Delgado Campos, 2016, p. 2548). Their study is the only one included in this section that does not support the spatial mismatch hypothesis. They explain that the existence of informality is the main reason for their finding, because it allows informal work activities to be located in areas of the city where one would not expect.

My empirical study is a unique contribution to the literature of spatial mismatch because it combines income residential segregation and commuting time to work. Bringing the two together allows me to bridge part of Chetty et al. (2014) approach to the Global South. Even though several quantitative studies have focused on commuting time in the context of Brazilian cities (Barandier et al., 2017; Haddad & Barufi, 2017; Miranda & Domingues, 2010; Motte, Aguilera, Bonin, & Nassi, 2016; Silveira Neto, Duarte, & Páez, 2015; Tigre, Sampaio, & Menezes, 2017), there is no study that directly addresses the connections between residential segregation and time spent commuting to work.

2.2. Residential segregation

Residential segregation is a pervasive feature in many Brazilian cities, shaped by factors such as race (Telles, 2004), social classes, income, and years of schooling (Marques, Bichir, & Scalon, 2012). Residential segregation in Brazilian cities has been the subject of some studies demonstrating that urbanization and the resulting spatial structures have affected and continue to affect poverty rates and generate social, environmental, and spatial separation between income groups in the country. This segregation can prevent certain socio-economic groups from accessing services, job opportunities, and pathways towards upwards economic mobility.

Research has shown that residential segregation in Brazilian cities results in the perpetuation of urban inequality. Findings from Telles' study (2009) indicate the existence of racial segregation in Brazil and that it aligns with a disproportionate number of low-income non-white people, showing evidence that housing discrimination may contribute to segregation in Brazil, mirroring the U.S. experience. Cunha, Jimenez, Perez, and Andrade (2009) examine the effects of residential segregation on elementary school students' performance. According to their study, there is a connection between residential segregation and school performance, with lower test scores for students in schools in high-poverty neighborhoods. Marques' analyses (2015) reveals that the networks of poor individuals are smaller, less varied, and mostly consist of other poor individuals, indicating that these network patterns may actually reinforce residential segregation through time. These examples demonstrate the presence of residential segregation throughout Brazilian cities and its negative effects that have manifested as a result.

2.3. Urban mobility

As for the question of urban mobility, Brazil was in the spotlight of international media in 2013 because of protests that occurred in several cities and specifically voiced the population's discontent about the high fares and low quality of urban public transportation. This is not surprising considering that Brazilian policies favor the use of automobiles through various subsidies and incentives, while public transportation and non-motorized transport have long been ignored (Vasconcellos, 2018). As a result, low-income populations often pay the price (in time, money, and wellbeing) for associated transportation issues, including lack of safety measures for modes of transportation such as walking, cycling, and motorcycling, and unreliability, overcrowding, and poor infrastructure for public and non-motorized transportation (Vasconcellos, 2018).

Inequalities related to bus transportation in Brazil also result from a false equivalency between accessibility and mobility, which can particularly affect the urban poor with little access to automobiles.

Lessa, Lobo, and Cardoso (2019) report that high access to public transportation (for instance, in areas near city centers composed of high-income residents with personal vehicles) does not necessarily reflect the effectiveness of that transportation for mobility. Similarly, high mobility in areas where residents have no choice but to travel frequently does not indicate adequate accessibility.

To make bus fares more accessible, Brazilian employers are required to provide their employees a subsidy—'vale transporte'—so that they do not spend more than 6% of their salary on commuting. However, when examining the policy of 'vale transporte' in relation to commuters' income level, Carvalho et al. (2013) discovered that the subsidy is not as effective as it could be because the poor are not benefiting from it as they should. The reason for this limitation lies in the fact that the vast majority of poor residents work in the informal sector (i.e., unregulated employment) and their employers therefore do not provide them with 'vale transporte.'

3. Methodology

3.1. Study area

This study was conducted in a sub-region of the Belo Horizonte Metropolitan Region (BHMR), located in the State of Minas Gerais, in Brazil. The BHMR was chosen as study area because of its importance in the national economy, as it ranks among the top five Brazilian metropolitan regions in terms of GDP per capita and working population. Composed of 34 municipalities, the BHMR had in 2013 the fifth highest GDP per capita when compared to all Brazilian metropolitan regions and in 2014 the third largest working population in the nation. Additionally, as pointed out by Garmany (2011), there is a need in the literature on Brazilian cities to study urban areas other than Rio de Janeiro and São Paulo.

The sub-region, depicted in Fig. 1, is composed of eight municipalities (BH, Confins, Lagoa Santa, Pedro Leopoldo, São Jose da Lapa, Ribeirão das Neves, Santa Luzia, and Vespasiano) that are part of the BHMR's regional "Northern" axis of urban expansion. The left corner map shows the location of the sub-region within BHMR. This sub-region is characterized by ongoing urban growth. As Costa and Magalhães (2011) describe, there are several state initiatives located in the "Northern" axis, all contributing to the urban expansion of BHMR, including the construction of an enormous complex that houses most of the state government offices, and the expansion of the area's international airport to include an industrial airport.

The study area encompasses 64% of the total regional population in

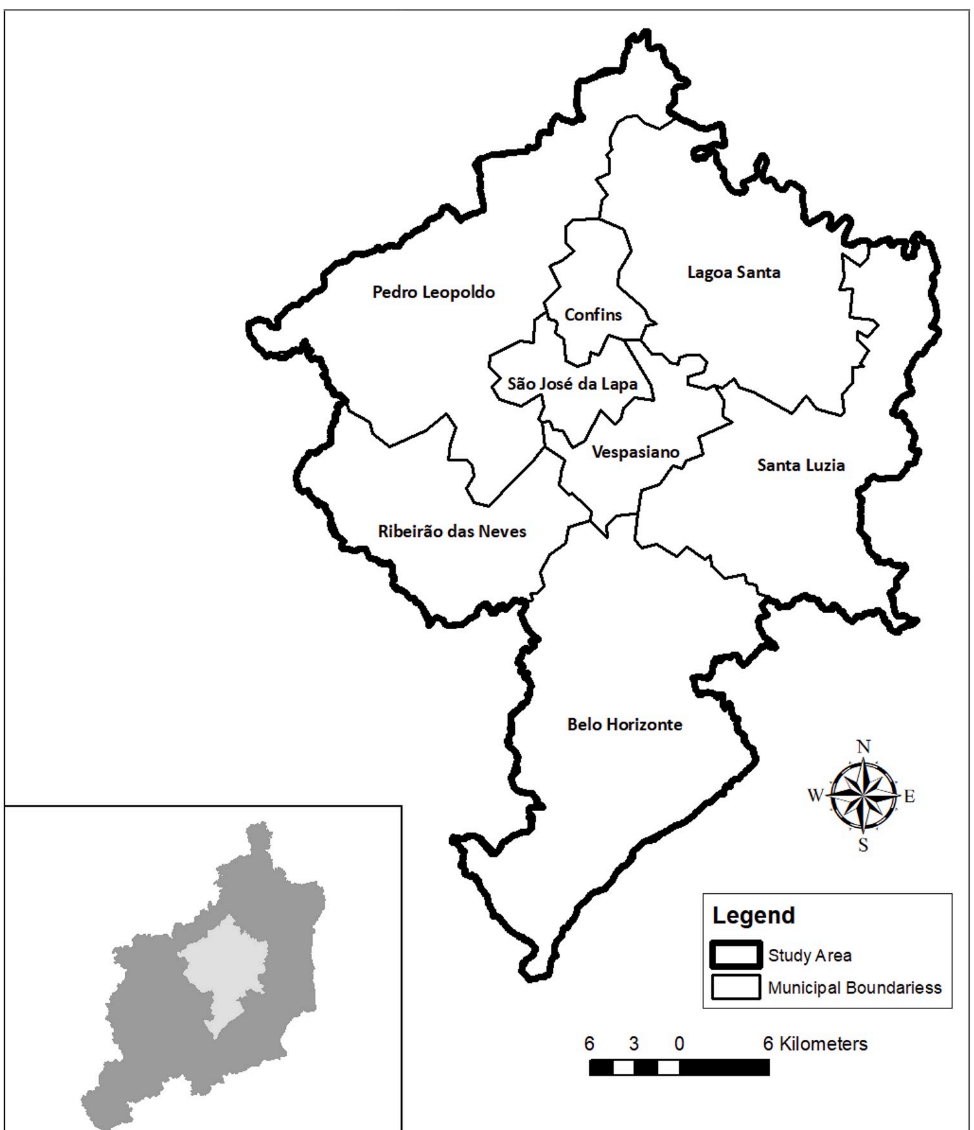


Fig. 1. Location of study area in BHMR and municipalities of study area.

2010. Of BHMR's seven densest municipalities in 2010, four are included in the study area. As depicted in Table 1, more than 90% of the existing jobs in both years were heavily concentrated in BH. Ribeirão das Neves, Santa Luzia, and Vespasiano had lower percentages of jobs relative to their populations. Additionally, the ratio of jobs per resident is a clear indication that most of the municipalities do not have enough jobs for their residents, which makes it necessary for many residents to commute to work. Over the decade under consideration, Confins had a dramatic increase in its ratio of jobs per resident because of the expansion of the international airport. Together, these statistics suggest that there may be a spatial mismatch in access to jobs in the area under study.

3.2. Data

As stated in the introduction, the three main objectives of this study are: 1) to examine residential income segregation in the BHMR; 2) to describe the spatial dynamics of change in commuting patterns over time (2000–2010); and 3) to understand how residential segregation is linked to the duration of individuals' commute to work, and other factors that influence segregation, including some urban characteristics. Data for the quantitative analysis come from three sources: the 2000 and 2010 Brazilian Demographic Census, conducted by the Brazilian Institute of Geography and Statistics (IBGE); the 2001–2002 and 2011–2012 Origin-Destination Surveys (ODS), conducted by Fundação João Pinheiro - FJP (henceforth 01–02 ODS and 11–12 ODS); and spatial layers from IBGE Geosciences and the Master Plan for the Integrated Development of the Metro Area of Belo Horizonte (Plano Diretor de Desenvolvimento Integrado da Região Metropolitana de Belo Horizonte-PDDI). To meet the first objective, the unit of analysis is the census tract; for the second objective, the unit of analysis is the homogenous area (which was demarcated by FJP when designing the ODS); and for the third, it is the individual who commutes to work.

Data on individuals come from both ODSs, in which origin and destination for commuters are defined on the scale of the "homogenous area," in turn based on the homogeneity of physical characteristics such as topography, land use categories, socio-economic characteristics, and transportation conditions (Minas Gerais, 2013). On average each homogeneous area (HA), which is a polygon, has three census tracts. The study area had: 581 HAs for the 01–02 ODS, 763 HAs for the 11–12 ODS, as well as 3,138 census tracts for 2000, and 4,904 census tracts for 2010.

In order to determine the income level of the origin and destination, the 2000 and 2010 "average household monthly income" variables by census tract were used (IBGE). To make both datasets compatible, I aggregated the census tract to HA using a mean that I calculated from the "average household monthly income." As an exploration, I also created categorical variables representing income levels based on six percentiles: lowest, low, middle, middle-high, high, and very high. Table 2 displays the percentage of people who commute to work according to the income level of the origin (i.e., where they live) and of the destination of each commuter (i.e., where s/he works). The diagonal represents commuters who live and work in the same HA. One can observe that HAs with higher income levels had more jobs in both ODSs, indicating that, most often, people tend to travel to high-income places to work. To illustrate, in 2001–2002 around 40% of commuters' destinations were "very high" HAs, and in 2011–2012 this figure was around 34%.

It is interesting to explore the income levels of places of origin and destination using the six income categories. There were individuals who commuted to destinations that had greater income than their points of origin (i.e. where they live), representing around 50% of the sampled individuals for both years. It included observations from Table 2 on the upper area of the diagonal. There were individuals who commuted to destinations with a lower income level than their point of origin, including observations from Table 2 on the lower area of the diagonal, representing only around 15% of the sampled individuals.

This exemplifies one of the aspects of the social inequality of Brazilian cities by showing that commuters from low-income segregated areas tended to work in higher income areas, where they experienced better infrastructure than where they lived. This population experience 'infrastructure inequality' in their daily routine. I define infrastructure as urban assets from the built environment such as parks, playgrounds, open spaces, sidewalks, and roads. In general these assets are present and very well maintained in wealthier areas, and most of the time, they do not exist in low-income segregated areas. Brazil is among the most unequal countries in the world and this is reflected in different ways in its cities, such as in access to infrastructure that wealthy neighborhoods enjoy while the residents of poor neighborhoods are systematically underserved (Barandier et al., 2017, p. 107).

Table 3 displays the descriptive statistics of all variables used in the analysis. Even when controlling for inflation, a 33% decrease in the average household monthly income from 2000 to 2010 in the whole area under study was observed. Details about other variables included in this table and the regressions are described below.

3.3. Local Indicator of Spatial Association

To understand whether the study area was characterized by residential income segregation, the 2000 and 2010 "average household monthly income" variables were analyzed at the scale of the census tract. I deflated all income values to August of 2010, so as to compare income data from 2000 to 2010. I performed hotspot analysis by applying the Local Indicators of Spatial Association (LISA) technique (Anselin, 1995), which allows for the identification of local clusters. The LISA technique can identify two types of spatial clusters (high values surrounded by other high values and low values surrounded by other low values) and two types of spatial outliers (low values surrounded by

Table 1
Jobs and population per municipality of the study area.

Municipality	2000					2010				
	Number of jobs	Percentage of jobs	Total population	Percentage of population	Job per capita	Number of jobs	Percentage of jobs	Total population	Percentage of population	Job per capita
Belo Horizonte	1,318,028	94.96	2,238,514	78.20	0.59	2,133,095	92.69	2,375,151	76.23	0.90
Confins	1,221	0.09	5,039	0.18	0.24	6,258	0.27	5,936	0.19	1.05
Lagoa Santa	7,416	0.53	37,872	1.32	0.20	20,010	0.87	52,520	1.69	0.38
Pedro Leopoldo	15,623	1.13	51,390	1.80	0.30	25,469	1.11	58,740	1.89	0.43
Ribeirão das Neves	15,109	1.09	253,545	8.86	0.06	45,606	1.98	296,317	9.51	0.15
Santa Luzia	17,497	1.26	184,903	6.46	0.09	43,152	1.88	202,942	6.51	0.21
São José da Lapa	2,460	0.18	15,000	0.52	0.16	4,976	0.22	19,799	0.64	0.25
Vespasiano	10,618	0.77	76,422	2.67	0.14	22,724	0.99	104,527	3.35	0.22
Total	***1,387,972***	***100***	***2,862,685***	***100***	__	***2,301,290***	***100***	***3,115,932***	***100***	__

Table 2
Percentage travels based on origin and destination income levels.

2001-2002		DESTINATION						
		Lowest	Low	Middle	Middle-High	High	Very High	Total travels
ORIGIN	Lowest	2.04	0.90	0.76	1.60	2.22	3.36	10.88
	Low	0.57	3.46	1.35	2.21	2.98	3.15	13.73
	Middle	0.57	1.11	3.75	2.80	3.96	4.83	17.02
	Middle-High	0.57	0.64	1.19	4.65	4.41	6.57	18.03
	High	0.39	0.37	0.96	2.44	7.15	8.31	19.63
	Very High	0.41	0.41	0.72	1.40	3.57	14.20	20.71
	Total travels	4.55	6.88	8.75	15.12	24.29	40.41	100
2011–2012		**DESTINATION**						
		Lowest	Low	Middle	Middle-High	High	Very High	Total travels
ORIGIN	Lowest	3.32	1.77	1.61	1.4	3.27	4.29	15.67
	Low	1.02	4.24	2.08	1.94	3.48	4.08	16.84
	Middle	0.63	1.68	5.07	2.55	3.96	4.72	18.61
	Middle-High	0.41	0.98	1.67	4.81	3.84	5.16	16.87
	High	0.25	0.57	0.98	1.84	7.28	5.94	16.86
	Very High	0.23	0.49	0.66	0.89	3.51	9.38	15.16
	Total travels	5.85	9.73	12.07	13.42	25.35	33.58	100

high values and high values surrounded by low values).

To perform LISA it is necessary to define spatial weight matrices, which impose a neighborhood structure on the data and can be defined in a variety of ways. I utilized two spatial weights for the LISA analysis: simple binary queen contiguity and six-nearest neighbors. The simple binary queen contiguity matrix is composed of 0 and 1: if a census tract has a common boundary and/or vertex with another census tract, then they are considered neighbors and receive a value of 1; if a census tract does not share a common boundary and/or vertex with another census tract, then they are not considered neighbors and receive a value of 0. The k-nearest neighbors' matrix is based on the smallest distance between census tracts such that each tract has exactly k neighbors. For this study $k = 6$ was applied. This value was chosen because it represented the highest frequency in the distribution of number of neighbors for BHMR tracts, based on the examination of the simple binary queen.

If residential segregation is present, then one would expect that the urban structure be characterized by clusters of high- and low-income values, demonstrating that people with similar income characteristics live close to each other in a geographic space. If residential segregation is not present, then one would expect income values to be randomly distributed across the area under study. For this study, based on my definition of hotspots, high-income areas should include all high-high (HH) and high-low (HL) locations that were statistically significant (at 5%) in both spatial matrices; and low-income areas should include all low-low (LL) and low-high (LH) locations that were statistically significant (at 5%) in both spatial matrices. The attention paid to both matrices in this approach aims to ensure the robustness of the results.

3.4. Regression models

Seemingly unrelated regression (SUR) models were estimated using STATA for the third objective. I chose this approach to address endogeneity issues that would have been present if OLS regressions were estimated. As described by Müller and Sikor (2006), "SUR uses generalized least squares (GLS) estimations for a set of equations that are "seemingly'' related through their disturbances only, by allowing the error terms to be correlated across equations" (Müller & Sikor, 2006, p. 181).

A system of four equations was used including the following dependent variables: low-income segregation, public transportation, rush hour, and commute duration. Table 3 shows that approximately 14% of the sampled individuals lived in low-income segregated areas in 2000, and approximately 24% did so in 2010. Two dependent variables, observed at the individual unit of analysis and extracted from ODSs, were dummy variables: one indicating whether the individual used public transportation to commute to work, and the other indicating whether the individual commuted to work during rush hour (6:30 to 8:30 am). The mean of "commute duration" variable increased by around 16 min from 2000 to 2010.

Geographic information systems (GIS) were used to obtain independent variables for SUR at the census tract level: straight-line distance from downtown CBD (in km), road density (in km^2), and population density (in km^2). The last two listed variables were included to capture urban characteristics. As Table 3 depicts, while the mean distance of commuters' point of origin to downtown only increased by 17% between 2000 and 2010, the commuting time for the sampled individuals increased by 64% during the same period. Additionally, I included in SURs other independent variables that also captured urban characteristics (with data from IBGE): three at the census tract, which I named "percentage of dwellings with sanitary sewer," "percentage of dwellings

Table 3
Descriptive statistics of all variables used in the analysis.

variable		mean	stand. dev.	minimum	maximum
2000	Commute duration	24.95	16.67	1	180.00
	Public transportation	0.439	0.496	0	1
	Rush hour	0.552	0.497	0	1
	Bus per capita	2.445	0.331	0	1
	Population density	12.060	9.740	0.032	124.870
	Road density	30.190	10.130	0	106.220
	Distance	4.89	5.02	0.000	39.67
	Percent sewerage	86.35	24.97	0.000	100.00
	Percent garbage	96.43	9.43	0.000	100.00
	Percent ownership	66.690	11.580	1.43	94.24
	Income	3,132	2,829	608	16,491
variable		**mean**	**stand. dev.**	**minimum**	**maximum**
2010	Commute duration	40.88	32.39	0	200.00
	Public transportation	0.322	0.467	0	1
	Rush hour	0.522	0.499	0	1
	Bus per capita	0.0035	0.0071	0	0.114
	Population density	11.640	8.280	0.0013	91.28
	Road density	30.39	12.33	0.286	106.53
	Distance	5.740	6.120	0	44.770
	Percent sewerage	86.05	24.82	0.000	100.00
	Percent garbage	98.15	6.62	3.650	100.00
	Percent ownership	67.94	11.01	1.280	98.12
	Income	2,118	2,009	590	15,815

Note: the following variables are at the individual unit of analysis: commute duration, public transportation, and rush hour. All other variables are at the homogeneous area unit of analysis.

with public garbage collection," and "percentage of owner-occupied dwellings;" and one at the municipal level measuring the number of municipal buses per capita, which mean values' doubled from 2000 to 2010. It is important to highlight that all independent variables available at the census tract and municipal units of analysis were average values aggregated or/disaggregated to HAs. This step was necessary because the dependent variables, representing individuals, were associated with the HAs as commuters' places of origin and destination.

In sum, Table 4 shows some of the variables included in this study, which are related to two main themes: the spatial mismatch hypothesis, and urban characteristics. This table helps understand the research design of this study. For instance, "commute duration" was included in the models to capture Chetty et al. (2014) approach related to working individuals with short or long commuting times.

4. Results

4.1. Residential segregation

LISA has been applied in other studies to examine residential segregation (e.g., Cunha et al., 2009; Nielsen & Hennerdal, 2017; Poulsen, Johnston, & Forrest, 2010), and also to assess transport infrastructure supply in the Brazilian context (Silva, Manzato, & Pereira, 2014); these studies include detailed description of this method. Fig. 2 displays the LISA clusters maps. A clear spatial pattern of residential segregation is noticeable with high-income areas located in the south of the area under study (corresponding to the center of BHMR), and low-income areas located in the north. The large majority of high-income dwellers lived in BH, which is the wealthiest municipality of the whole BHMR.

Table 5 quantifies the final LISA results, which are depicted in maps (c) and (f) of Fig. 2, and compares the results with the "total population." LISA results describe areas where commuter live (i.e., the origin). The low-income hotspots contained around 29% of the total population in 2000, and 27% in 2010. The high-income hotspots were almost a third smaller in percentage of the total population than the low-income hotspots, at around 10% and 11% respectively. Low-income areas covered around 48% of the total physical area in 2000, and 42% in 2010, much larger percentages than high-income areas, which were at approximately 3% in both years. This observed discrepancy in the magnitude between the percentage of population and the percentage of the area can be explained by the fact that most high-income dwellers live in densely populated areas in high-rise buildings, and most low-income dwellers live in single-family homes.

Table 4
Research Design – Justification of variables and expected outcomes for low-income segregated areas.

Variable	Description as expected for low-income segregated areas
Spatial mismatch hypothesis (justification to be included in the models)	
Commute duration	longer time spent to commute to work
Distance	home location further away from CBD, where most jobs are located
Public transportation	commuters should use public transportation to commute to work
Rush hour	commuter should leave home before rush hour to get to work on time
Urban characteristics (justification to be included in the models)	
Percentage sewerage	less dwellings with connection to sanitary sewerage indicating poor housing conditions
Percentage garbage	less dwellings with connection to garbage collection indicating poor housing conditions
Percentage ownership	less dwellings with owner-occupied indicating insecure land tenure
Bus per capita	lower number bus to represent public transportation system as described in the literature
Pop density	higher population density expected due to aggregation at homogenous areas level
Roads density	higher road density expected due to aggregation and the urban structure

4.2. Understanding the spatial dynamics of change in commuting patterns

To examine the spatial dynamics of change in commuting patterns between 2000 and 2010, the results of LISA analysis were aggregated at the HA scale. I created the "low-income segregation" variable, assigning 1 to census tracts that were LL or LH and statistically significant (at 5%) in both spatial matrices; and then I mean aggregated these census tracts at the HA level. The "low-income segregation" is a dummy, with 1 assigned to individuals living in HAs with mean greater or equal to 0.5, and "no low-income segregation" is also a dummy with 0s.

The examination was based on the distances between where people live (origin) and where people work (destination). I developed a novel visualization method with a Python script, using the HA as the place of origin (where people live) and destination (where people work). The script was executed twice, once for HA origins characterized as "low-income segregation" and another time for HA origins characterized as "no low-income segregation." For each HA polygon, its centroid was used as input in the script, and the following tasks were performed on each HA point: X and Y for origin were computed, X and Y for destination were computed, distance between origin and destination was calculated, and a line was drawn to represent each trip to work.

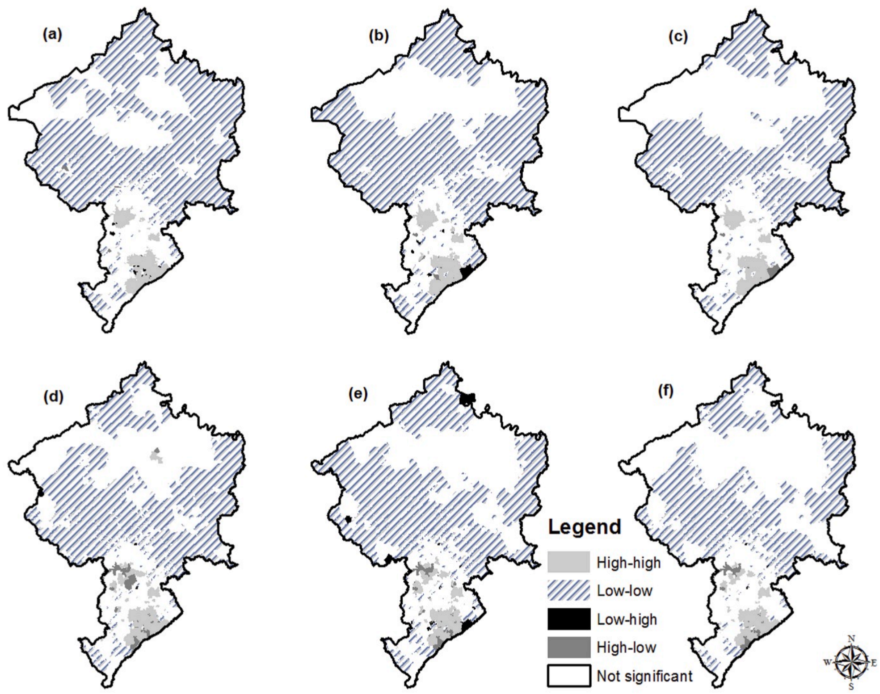
Fig. 3 depicts the changes in the spatial pattern of commuting to work for the "low-income segregation" areas, allowing a visual comparison. One can observe that commuting patterns expanded greatly in space from 2000 to 2010, amounting to a 27% increase in the area of commuting patterns. A higher number of commutes from "low-income segregation" HAs of origin was observed in 2010 (i.e., 170) when compared to 2000 (i.e., 97). These HAs were located mostly in the northern part of the area under study, corresponding to the BHMR periphery; contrasting with places of work, which were mostly located in the BH municipality - the core of the BHMR. The average distance between origin and destination was 7.5 km in 2000 and 8 km in 2010.

Fig. 4 displays the changes in the spatial pattern of commuting to work for the areas with "no low-income segregation". In those areas, one can observe that the commuting patterns had a minimal expansion in space from 2000 to 2010, only 3 percent. The HAs of origin were located in the northern part of the study area, corresponding to the BHMR periphery; contrasting with places of work that were mostly located in the BH municipality, which is the core of the BHMR.

4.3. Time spent commuting to work and segregation

In order to address potential endogenous relationships among variables, following Müller and Sikor (2006), I used seemingly unrelated regression models. I focused on 18,898 individual commuters for 2000, and 15,793 individual commuters for 2010. Table 5 depicts the estimations for the 2000 SUR, and Table 6 for the 2010 SUR. The "commute duration' equations show the higher explanatory power for 2000 and 2010, having R^2 of 43 percent and 59 percent, respectively. For all my models the "Breusch-Pagan tests confirm that the correlations of the residuals [were] significantly different from zero and, consequently, the SUR approach [was] a more efficient estimation technique than [four] separate OLS models and [yielded] consistently lower standard errors than OLS" (Müller & Sikor, 2006, p. 188).

For the "low-income segregation" equations, results suggest that in 2000, living in low-income segregated areas was associated with shorter commuting time to work, and in 2010, commuters who lived in low-income segregated areas tended to experience longer commuting time to work. This change is not good news for the urban poor, indicating that residential income segregation is a driving force of commuting patterns. The "public transportation" coefficient was positive and significant for both years, demonstrating the fact, well described in the literature, that public transportation is heavily used by low-income commuters for their



(a) 2000 using queen; (b) 2000 using five-nearest; (c) 2000 spatially coinciding in both matrices; (d) 2010 using queen; (e) 2010 using six-nearest; and (f) 2010 spatially coinciding in both matrices.

Fig. 2. Residential segregation based on income, 2000 and 2010.

Table 5
Estimations for the seemingly unrelated regressions, 2000

	Model 2000			
	Low-income segregation	Public transportation	Rush hour	Commute duration
Low-income segregation	–	0.151***	−0.064***	−1.299***
Public transportation	0.072***	–	−0.092***	17.573***
Rush hour	−0.024***	−0.072***	–	0.311*
Commute duration	−0.001***	0.023***	0.000***	–
Distance to CBD	0.000***	0.000***	0.000**	0.002***
Bus per capita	−0.042***	0.000	−0.014	0.239
Percentage garbage	−0.011***	0.002***	0.000	−0.069***
Percentage ownership	0.005***	−0.001***	0.000	0.038***
Percentage sewerage	−0.002***	0.000	0.000	0.033***
Population density	0.003***	0.001	0.000	0.015
Roads density	0.002***	0.002***	0.001*	−0.026**
Constant	1.024***	−0.193***	0.672***	10.902***
Number of observations	18,898	18,898	18,898	18,898
R^2	0.252	0.154	0.003	0.428

urban mobility. The “rush hour” coefficient was negative and significant for both years. Anecdotally, on average, commuters from low-income segregated areas go to work earlier than the rush hour to avoid a super overcrowded public transportation system, and the heavier traffic congestion during the rush hour. When low-income commuters live in the periphery, they must leave home very early in order to arrive on time in their jobs, mostly located in BH core.

For 2000 and 2010, commuters who used “public transportation” to go to work were more likely to live in low-income segregated areas, not commute during rush hour, and experience longer commuting time to work. These results echo the “low-income segregation” equations. When examining the “rush hour” equations, commuters were more likely, for both years, to live in non-low-income segregated areas, not use public transportation to go to work, and spend longer time to go to work. Indeed, these findings mirror the average middle and upper classes commuting behavior, typical in several Brazilian metropolitan areas.

The variable “commute duration” had a negative association with commuter living in “low-income segregated areas” in 2000, and that relationship had changed to positive by 2010. The estimated coefficient changed from −1.299 in 2000 to +1.412 in 2010, indicating that the Chetty et al. (2014) approach about the importance of having shorter commuting when living in segregated areas held for 2000, but became a problem in 2010. These findings are also related to increasing trends in traffic congestion in Brazilian metropolitan regions, and to insufficient and uneven investments by municipal governments to improve urban mobility in low-income segregated areas (Maricato, 2013). The variable “distance to CBD” had a positive association with all four dependent variables, for both years. Living in a low-income segregated area, using

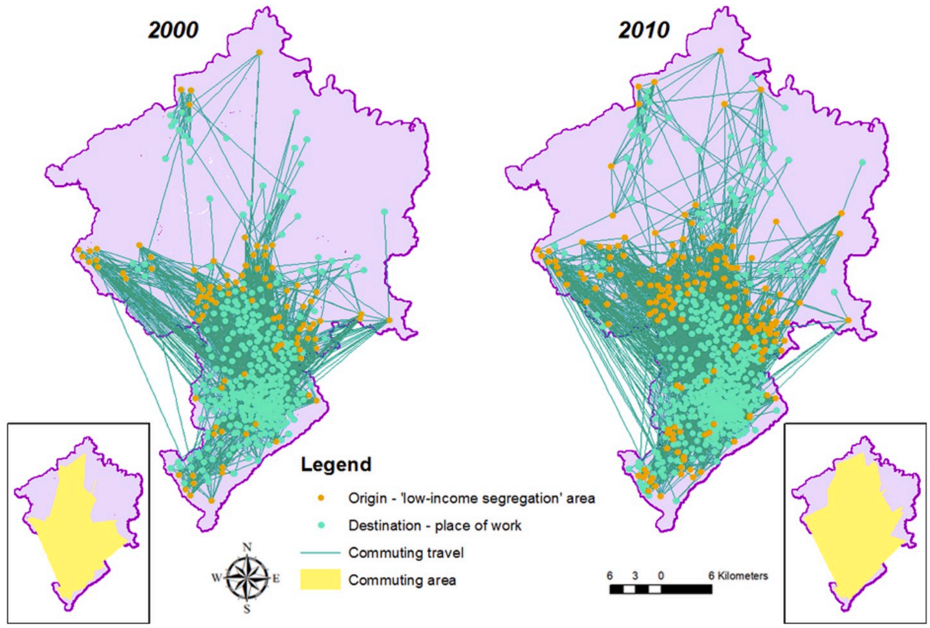


Fig. 3. Comparison of the spatial dynamics of commuting pattern in low-income segregated areas.

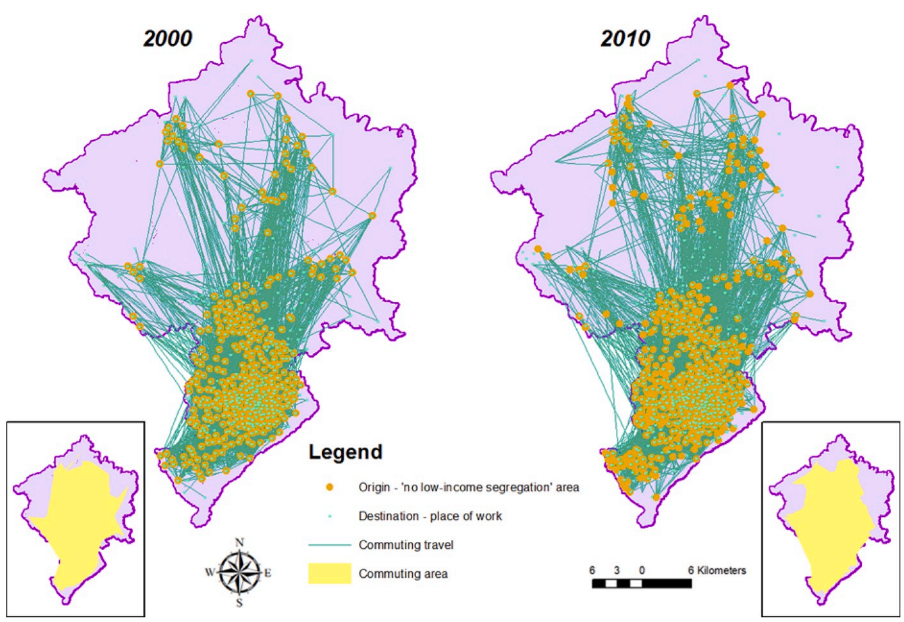


Fig. 4. Comparison of the spatial dynamics of commuting pattern in no low-income segregated areas.

public transportation, commuting during rush hour, and experiencing longer commuting, all four increased the probability of living farther away from the CBD.

The results from this system of equations illustrate a 'trap' that is mutually self-reinforcing for commuters living in low-income segregated areas. Over time, if a commuters lives in a low-income segregated area, he/she has higher chances to experience longer commute to work, which in term, increases his/her probability of using public transportation. Longer commuting time to work became a reality from 2000 to 2010 for commuters living in low-income segregated areas, indicating that the spatial mismatch hypothesis is supported by this study. These results are in line with Chetty et al.'s (2014) argument stating that individuals who experience shorter commuting times have better chances of economic upward mobility. Even though my models did not include economic upward mobility due to lack of data, the observed increase in the duration of commuting to work for commuters who live in low-income segregated areas is not encouraging news for the urban poor. The situation got worse from 2000 to 2010.

As mentioned earlier, the urban structure of cities plays a central role in the spatial mismatch, and, therefore, some urban characteristics were included in the system of equations as independent variables. For both the 2000 and 2010 models, commuters living in low-income segregated HAs tended to live in areas with: a higher population density, higher number of homeowners, lower numbers of dwellings with adequate sanitary sewerage, lower number of dwellings with garbage collection, and lower number of buses. Certainly, lack of adequate sanitary sewage is a noticeable housing condition of the periphery of Brazilian cities, deteriorating the quality of life for numerous dwellers. Basic sanitation for all should be highly ranked in the public sector agendas all over the country.

Table 6
Estimations for the seemingly unrelated regressions, 2010

	Model 2010			
	Low-income segregation	Public transportation	Rush hour	Commute duration
Low-income segregation	–	0.056***	−0.107***	1.412***
Public transportation	0.063***	–	−0.187***	47.006***
Rush hour	−0.063***	−0.098***	–	1.09***
Commute duration	0.001***	0.016***	0.001***	–
Distance to CBD	0.000***	0.000***	0.000***	0.002***
Bus per capita	−0.01***	0.001**	−0.001*	−0.021
Percentage garbage	−0.013***	0.002***	−0.001	−0.061**
Percentage ownership	0.007***	0.000***	0.000	−0.014
Percentage sewerage	−0.003***	−0.001***	0.000***	0.06***
Population density	0.004***	0.000	0.001**	0.008
Roads density	−0.001***	0.000	0.001*	0.052***
Constant	1.333***	−0.153***	0.708***	11.688***
Number of observations	15,793	15,793	15,793	15,793
R^2	0.211	0.347	0.027	0.592

Results about ownership may be difficult to explain because slum areas, often present in low-income areas, are characterized by informal land tenure, where dwellers occupy land without paying rent, living under tenure insecurity (Brueckner, Mation, & Nadalin, 2019). On the other hand, according to Ferreira and Ávila (2018), who conducted a study in the BHMR, insecure land tenure is an unsolved problem in several Brazilian urban areas not only inside slums, but also outside. The significant negative result for "bus per capita," suggested that investments in public transportation may not be meeting commuters' demand for buses, as Maricato (2013) explains. Indeed, in BHMR there are informal private vans available for paid ridership, competing with the formal public transportation that does not meet the needs of the urban poor.

For the "public transportation" equations, some urban characteristics were insignificant and there was not consistency between years. For instance, a higher number of "bus per capita' influenced the use of public transportation in 2010, but not in 2000. The "rush hour" equations performed in the same way as the former. As an example, in 2010, a higher share of commuters during the rush hour was more likely to be found in areas with higher percentage of dwellings with adequate sanitary sewage in 2010, but not in 2000. The "commute duration" equations also had some urban characteristics being insignificant and with inconsistency between years. To illustrate, "road density" was negatively associated with "commute duration" in 2000, and positively associated in 2010.

5. Conclusion

This study expands Chetty's et al. (2014) approach, based on the spatial mismatch hypothesis, to a Latin American city, focusing on residential income segregation and commuting time to work. Based on a three-step quantitative analysis presented in this case study, commuting characteristics such as longer "commute duration," longer "distance to CBD," and the use of "public transportation," were observed as important factors explaining the type of residential area commuters live in, i.e., low-income segregated or non-low-income segregated areas. Over time, my results suggested a 'trap' in which residents of low-income segregated areas experienced a high probability of having longer commute duration and of using public transportation, creating a mutually self-enforcing process. These findings illustrate that the spatial mismatch hypothesis is supported in the BHMR case study, and that Chetty et al. (2014) approach that advocates shorter commuting time to work is an issue that needs to be addressed for the urban poor of the study area.

This case study illustrates spatial inequality in access to jobs. My findings showed a geographical separation between lower and higher-income commuters and the areas of economic growth, where most jobs were found, located in the center of the BHMR and far from the lower-income neighborhoods, located in the periphery. This inequality depicts the urban structure of cities in the Global South, contrasting with the downtown-suburb structure of American cities. However, as I conclude, low-income residents from both - Global North and Global South - struggle with the same spatial mismatch job-housing even though living in cities with very different urban structures. What is unique about cities in the Global South is the fact informality is a ubiquitous for jobs and housing options. My models did not capture informality, but anecdotally, for many dwellers, being active actors in the informal urbanization process is the path to have a livelihood. It is important that these dwellers fully exert citizenship so they can move towards a decent livelihood with good quality of life (Rocco & van Ballegooijen, 2019).

Within the context of urban planning in Brazil, the 2001 Law City Statute (Estatuto da Cidade) lays out a variety of tools for planners that could be used to lessen both residential segregation and spatial mismatch, and improve the commuting situation for the urban poor with the ultimate goal of facilitating their upward economic mobility. Based on this Law, I offer two pro-poor recommendations.

Expand the area that ZEIS's can cover: The urban poor have been experiencing longer commuting times to work. If social housing were built closer to their jobs, their commuting could be improved. ZEIS is a legal tool that enables the adoption of specific and flexible patterns of urban development to be adopted when working in informal settlements (Watson, 2009). I recommend that ZEISes could be designated in both vacant land and currently developed areas, in order to cover a larger percentage of the study area (Soares, de Azevedo, Stephan, de Carvalho, & Arantes, 2012). Also, ZEISes should not only be demarcated in zoning maps, they should truly be implemented Soares et al. (2012). Moreover, low-income dwellers should be made aware of ZEIS, so that they can advocate for the implementation of this zoning category. As Caldeira and Holston (2015) alert, a planning agency produced "a booklet to explain the Zoning Law to the general population that omits discussion of the ZEIS" (Caldeira & Holston, 2015, p. 2010) during a participatory planning process in São Paulo.

Allocate Transfer of Development Rights revenues to social housing: How could these social housing projects be funded? Another tool from the City Statute that goes hand in hand with ZEIS is the Transfer of Development Rights (TDR) which "involves purchasing development rights [from one area] and using them to develop land in another location" (Payne, 2014, p. 22). I recommend that most of the public revenue originated from TDR should be allocated for social housing. The TDR makes it possible to generate public revenues that can be used "to expand housing programs of social interest" (Macedo, 2008, p. 267), among others things. To illustrate, if a developer owns land where he/she could build a maximum of two floors, he/she can purchase the "right" to build one extra floor on the same land. The revenue from this transaction involving rights should be used by the public sector to invest in social housing as described in the law itself.

In Brazil, however, even though tools for urban planning exist that could be used to minimize spatial mismatch, implementation is proving to be a challenge. I argue that this limitation is an illustration of Watson's "conflict of rationalities" between public and private sectors, which arises "at the interface between the different logics (or rationalities) of various urban actors" (Watson, 2014, p. 28). Watson explains that "two ideas are central to the conception of planning as a product of conflicting rationalities – [echoing Foucault's concept of] power and the importance of context" (Watson, 2014, p. 29). Even though urban planners may wish to implement pro-poor policies, they do not have enough power to do so; politicians and developers do, however, have such power.

I believe that urban planners face a "conflict of rationalities" with politicians and developers who are not willing to implement tools such as ZEIS. At the same time, because of lack of available data to understand the use of these tools, it becomes unclear if the lack of implementation is related to a conflict of rationalities. This may also be partially related to how equity planning is included in planning education in Brazil. Most of the time, in higher education institutions, planning is embedded in only two semesters of a five-year degree in architecture that emphasizes architecture projects. Planning for the ones who need the most opportunities and resources should be expanded in the planning curriculum, so we could have more urban planners wearing the hat of equity planners, as they should.

A few limitations of this study need to be addressed. I could not include Chetty's et al. (2014) economic upward mobility in my SUR models because of lack of data. I could not include race in my analysis, but if I could, I am positive that the performance of my model would improve drastically. Some other variables could not be included in my analysis because they were not available: employment, informal and formal employment, and more disaggregated infrastructure and transportation characteristics. Concerning opportunities for future research, one study could look at a different aspect of Chetty's et al. approach (2014) to promote economic upward mobility: the development of better primary schools in urban areas.

CRediT authorship contribution statement

Mônica A. Haddad: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.apgeog.2020.102186.

References

Anselin, L. (1995). Local indicators of spatial association—LISA. *Geographical Analysis, 27*(2), 93–115.

Barandier, J. R., Bodmer, M., & Lentino, I. (2017). Evidence of the impacts of the national housing programme on the accessibility of the low-income population in Rio de Janeiro. *National Resources Forum: A United Nations Sustainable Development Journal, 41*(2), 105–118.

Brueckner, J. K., Mation, L., & Nadalin, V. G. (2019). Slums in Brazil: Where are they located, who lives in them, and do they 'squeeze'the formal housing market? *Journal of Housing Economics, 44*, 48–60.

Caldeira, T., & Holston, J. (2015). Participatory urban planning in Brazil. *Urban Studies, 52*(11), 2001–2017.

Carvalho, C., Gomide, A., Pereira, R., Mation, L., Balbim, R., Lima Neto, V., … Guedes, E. P. (2013). *Tarifação e financiamento do transporte público urbano. Nota Técnica, Instituto de Pesquisa Econômica Aplicada* (IPEA), 24 pp.

Chetty, R., Hendren, N., Kline, P., & Saez, E. (2014). Where is the land of opportunity? The geography of intergenerational mobility in the United States. *Quarterly Journal of Economics, 129*(4), 1553–1623.

Costa, G., & Magalhães, F. (2011). Processos socioespaciais de metrópoles de países de industrialização periférica: Reflexões sobre a produção do espaço metropolitano de Belo Horizonte, brasil. *Revista Brasileira de Estudos Urbanos e Regionais, 13*(1), 9–25.

Coy, P. D. M., Sandholz, D. S., Töpfer, D. T., & Zirkl, D. F. (2018). Metropolitan regions: Challenges for sustainability and governance of periurban areas in Brazil. *Confins. Revue franco-brésilienne de géographie/Revista franco-brasilera de geografia, 38*.

Cunha, J. M. P., Jimenez, M. A., Perez, J. R. R., & Andrade, C. Y.d. (2009). Social segregation and academic achievement in state-run elementary schools in the municipality of Campinas, Brazil. *Geoforum, 40*(5), 873–883.

Di Giulio, G. M., Bedran-Martins, A. M. B., Vasconcellos, M.d. P., Ribeiro, W. C., & Lemos, M. C. (2018). Mainstreaming climate adaptation in the megacity of São Paulo, Brazil. *Cities, 72*(B), 237–244.

Fernandes, G. A. D. A. L. (2017). Is the Brazilian tale of peaceful racial coexistence true? Some evidence from school segregation and the huge racial gap in the largest Brazilian city. *World Development, 98*, 179–194.

Ferreira, F. P. M., & Ávila, P. C. (2018). Who has secure land tenure in the urban areas of Brazil? Evidence from the state of Minas Gerais. *Land Use Policy, 75*, 494–504.

Garmany, J. (2011). Situating Fortaleza: Urban space and uneven development in northeastern Brazil. *Cities, 28*(1), 45–52.

Gerais, M. (2013). *Secretaria Extraordinária de Gestão Metropolitana, Agência de Desenvolvimento da Região Metropolitana de Belo Horizonte Pesquisa Origem e Destino. 2011-2012–Relatório Completo*.

Haddad, E. A., & Barufi, A. M. B. (2017). From rivers to roads: Spatial mismatch and inequality of opportunity in urban labor markets of a megacity. *Habitat International, 68*, 3–14.

Kain, J. F. (1968). Housing segregation, negro employment, and metropolitan decentralization. *Quarterly Journal of Economics, 82*(2), 175–197.

Lessa, D. A., Lobo, C., & Cardoso, L. (2019). Accessibility and urban mobility by bus in Belo horizonte/minas Gerais – Brazil. *Journal of Transport Geography, 77*, 1–10.

Li, H., Campbell, H., & Fernandez, S. (2013). Residential segregation, spatial mismatch and economic growth across US metropolitan areas. *Urban Studies, 50*(13), 2642–2660.

Macedo, J. (2008). Urban land policy and new land tenure paradigms: Legitimacy vs. legality in Brazilian cities. *Land Use Policy, 25*(2), 259–270.

Maricato, E. (2013). É a questão urbana, estúpido! *Le Monde Diplomatique Brasil, 73*, 6–7.

Marques, E. (2015). Urban poverty, segregation and social networks in São Paulo and salvador, Brazil. *International Journal of Urban and Regional Research, 39*(6), 1067–1083.

Marques, E., Bichir, R., & Scalon, C. (2012). *Residential segregation and social structure in São Paulo: Continuity and change since the 1990s. Residential Segregation around the world: Why context matters*. London: Ashgate.

Martin, R. W. (2001). Spatial mismatch and costly suburban commutes: Can commuting subsidies help? *Urban Studies, 38*(8), 1305–1318.

Miranda, R., & Domingues, E. (2010). Commuting to work and residential choices in the metropolitan area of Belo Horizonte, Brazil. *Urban Public Economics Review, 12*, 40–71.

Motte, B., Aguilera, A., Bonin, O., & Nassi, C. D. (2016). Commuting patterns in the metropolitan region of Rio de Janeiro. What differences between formal and informal jobs? *Journal of Transport Geography, 51*, 59–69.

Müller, D., & Sikor, T. (2006). Effects of postsocialist reforms on land cover and land use in South-Eastern Albania. *Applied Geography, 26*(3–4), 175–191.

Naudé, W. (2008). Is there a spatial mismatch in South Africa's metropolitan labour market? *Cities, 25*(5), 268–276.

Nielsen, M. M., & Hennerdal, P. (2017). Changes in the residential segregation of immigrants in Sweden from 1990 to 2012: Using a multi-scalar segregation measure that accounts for the modifiable areal unit problem. *Applied Geography, 87*, 73–84.

Ong, P. M., & Miller, D. (2005). Spatial and transportation mismatch in los angeles. *Journal of Planning Education and Research, 25*(1), 43–56.

Payne, G. (2014). *Policy and politics in urban land market management. Affordable housing in the urban Global South: Seeking sustainable solutions*.

Poulsen, M., Johnston, R., & Forrest, J. (2010). The intensity of ethnic residential clustering: Exploring scale effects using local indicators of spatial association. *Environment & Planning A, 42*(4), 874–894.

Rocco, R., & van Ballegooijen, J. (2019). The political meaning of informal urbanization. In R. Rocco, & J. van Ballegooijen (Eds.), *The routledge handbook on informal urbanization*. New York: Routledge.

Silva, A. N. R., Manzato, G. G., & Pereira, H. T. S. (2014). Defining functional urban regions in Bahia, Brazil, using roadway coverage and population density variables. *Journal of Transport Geography, 36*, 79–88.

Silveira Neto, R., Duarte, G., & Páez, A. (2015). Gender and commuting time in São Paulo metropolitan region. *Urban Studies, 52*(2), 298–313.

Slovic, A. D., Tomasiello, D. B., Giannotti, M., Andrade, M.d. F., & Nardocci, A. C. (2019). The long road to achieving equity: Job accessibility restrictions and overlapping inequalities in the city of São Paulo. *Journal of Transport Geography, 78*, 181–193.

Soares, I. O., de Azevedo, M. D. L. P., Stephan, Í. I. C., de Carvalho, A. W. B., & Arantes, P. T. L. (2012). A instituição de ZEIS na legislação municipal: Estudo de seis cidades médias de Minas Gerais. *Risco: Revista de Pesquisa em Arquitetura e Urbanismo (Online)*, (15), 21–37.

Suárez, M., Murata, M., & Delgado Campos, J. (2016). Why do the poor travel less? Urban structure, commuting and economic informality in Mexico city. *Urban Studies, 53*(12), 2548–2566.

Telles, E. E. (2004). *Race in another America: The significance of skin color in Brazil*. Princeton University Press.

Telles, E. E. (2009). Race, class and space in Brazilian cities. *International Journal of Urban and Regional Research, 19*, 395–406.

Tigre, R., Sampaio, B., & Menezes, T. (2017). The impact of commuting time on youth's school performance. *Journal of Regional Science, 57*(1), 28–47.
du Toit, M. J., Cilliers, S. S., Dallimer, M., Goddard, M., Guenat, S., & Cornelius, S. F. (2018). Urban green infrastructure and ecosystem services in sub-saharan Africa. *Landscape and Urban Planning, 180*, 249–261.
Un-Habitat. (2016). *Urbanization and development: Emerging futures*. Nairobi: United Nations Human Settlements Programme.
Vasconcellos, E. A. (2018). Urban transport policies in Brazil: The creation of a discriminatory mobility system. *Journal of Transport Geography, 67*, 85–91.
Watson, V. (2009). 'The planned city sweeps the poor away…': Urban planning and 21st century urbanisation. *Progress in Planning, 72*(3), 151–193.
Watson, V. (2014). The case for a southern perspective in planning theory. *International Journal of E-Planning Research (IJEPR), 3*(1), 23–37.
Zenou, Y. (2013). Spatial versus social mismatch. *Journal of Urban Economics, 74*, 113–132.