# Measuring Multidimensional Inequality of Human Opportunity: An Assessment for Brazilian Municipalities (2000 – 2010)

Diego Ferreira* Paulo de Andrade Jacinto†

**Abstract**

This paper analyzes the evolution of opportunity inequality in Brazilian municipalities over the period 2000-2010. Given the complementarity in the provision of basic services, a Multidimensional Human Opportunity Index is estimated in order to directly account for such effect. While Brazil improved its fairness in terms of the simultaneous access to public goods over the years, adequate sanitation and safe water remained the country's most severe housing infrastructure bottlenecks. Regarding the spatial association patterns, Exploratory Spatial Data Analysis corroborated the recent literature evidences of spatial autocorrelation and a North-South polarization in the period.

**Keywords:** Multidimensional · Equality of Opportunity · Human Opportunity Index · Spatial Analysis

**JEL Classification:** C43 · D63 · D39 · R10

**Resumo**

O presente estudo analisa a evolução da desigualdade de oportunidade nos municípios brasileiros no período 2000-2010. Dada a complementariedade na provisão de serviços básicos, o Índice de Oportunidade Humana Multidimensional foi estumado de modo a considerar diretamente tal efeito. Apesar do Brasil ter melhorado ao longo dos anos sua justiça social em termos de acesso simultâneo a bens públicos, saneamento adequado e água encanada ainda são os gargalos de infraestrutura residencial mais serveros no país. Com relaçnao ao padrão de associação espacial, análises exploratórias de dados espaciais demonstraram evidência de autocorrelação espacial e reforçaram os resultados da literatura sobre uma polarização Norte-Sul no período.

**Palavras-Chave:** Multidimensional · Igualdade de Oportunidade · Índice de Oportunidade Humana · Análise Espacial

**Classificação JEL:** C43 · D63 · D39 · R10

**Área ANPEC:** Área 10 – Economia Regional e Urbana

*PhD candidate at the Department of Applied Social Sciences, Graduate Program in Development Economics (PPGDE), Federal University of Paraná (UFPR), Curitiba, Brazil. E-mail: diegoferreira.eco@gmail.com.

†Professor at the Department of Applied Social Sciences, Graduate Program in Development Economics (PPGDE), Federal University of Paraná (UFPR), Curitiba, Brazil. E-mail: paulo.jacinto@ufpr.br.

# 1 Introduction

The research on the emergence of social inequalities among individuals has produced a variety of theoretical and empirical studies. From the viewpoint of the full distribution of resources among the members of a society, the existence of inequality would constitute an obstacle to social justice. Yet, from the seminal work of Rawls (1971), outcome differentials would only be considered morally and normatively acceptable if originated from factors for which individuals are held responsible.

Within the realm of Economics, the interplay of outcome, opportunity, innate characteristics and effort was first discussed in Roemer (1998). A fair society would not be the one in which equality of outcome is necessarily observed, but the one in which there is universal access to the necessary goods and services for future individual development. In this sense, as long as the access to these fundamental services is conditioned by circumstances, inequality of opportunity will prevail. Thus, in order to ensure distributive justice, public policy is to be designed as to equalize opportunities among individuals within society, not their outcome.

Brazil is a country profoundly characterized by diversity and inequality. Although the empirical literature is rather scarce, there are evidences that inequality of opportunity not only represents a significant share of total inequality (Figueiredo and Ziegelmann, 2010; Figueiredo and Silva, 2012), but is also unevenly distributed in space (Dill and Gonçalves, 2013; Ferreira et al., 2017). Yet, as discussed in Islam and Mitra (2017), equality of opportunity should be understood through a multidimensional framework in which the complementarity in the provision of each basic service is directly accounted for. The present paper, to the best of our knowledge, is the first study to measure such complementarity through the Multidimensional Human Opportunity Index using Brazilian data. The latter index was developed by Islam and Mitra (2017) and is constructed by assessing the joint access to basic services by children under 16 years of age. Methodologically, the Multidimensional Human Opportunity Index extends the Human Opportunity Index of Barros et al. (2009) to a holistic approach. Furthermore, the focus on children is assumed as to expurgate the influence of effort on the access to these services.

The contributions of this paper are twofold. First, we evaluate the degree of opportunity inequality in the Brazilian municipalities through estimates of the Multidimensional Human Opportunity Index using data from the 2000 and 2010 Demographic Censuses. The obtained results suggest that Brazil has substantially improved its fairness in terms of equalizing the access to adequate sanitation, safe water, electricity and basic education during the period. Second, spatial association patterns are evaluated in order to statistically identify potential inequality clusters and outliers within Brazil. Based on global Moran's I statistics, there are evidences of positive spatial autocorrelation in both 2000 and 2010. In addition, a North-South polarization was identified through local Moran's I statistics. In fact, high-high clusters were found in the Centre-South region whereas the North and Northeast regions reported the presence of low-low clusters. Overall, the results extend those obtained by Ferreira et al. (2017).

Besides this introduction and the concluding remarks, the paper is organized in five sections. First, Section 2 focuses on the theoretical interplay of distributive justice and equality of opportunity. Section 3 discusses the empirical results obtained by both the international and Brazilian literature concerning inequality of opportunity. Section 4 describes the methodological aspects of the Multidimensional Human Opportunity Index. Section 5 evaluates the estimates of the logistic regressions as well as the results for the Multidimensional Human Opportunity Index at the municipality level. Last, but not least, Section 6 presents the estimates for the spatial association patterns, discussing spatial autocorrelation and the existence of spatial clusters and outliers.

# 2 Distributive Justice and Equality of Opportunity

The distributions of benefits and burdens in a society are intrinsically related to the social, political and economic structures from which they are built on. Theories of distributive justice are particularly concerned with the morality of these structures and their resulting distributions. Given the limited resources of any society, principles of distributive justice therefore provide the moral guidance to the political processes and structures that define the allotment of these burdens and benefits among its members.

In *A Theory of Justice*, Rawls (1971) outlines the notion of justice as *fairness* in the sense that it is

considered to be what free persons holding equal basic rights would agree to as fundamental features of the social contract within an egalitarian societal structure. Under the aegis of the *veil of ignorance* (that is, the deprivation of knowledge of individuals about their characteristics and their position within the society), the social contract would be designed as to establish moral and social principles according to which all members of society would agree to abide. Moreover, in contrast to the teleological reasoning of utilitarianism, the existence of an *inviolability founded on justice* should ensure the non-violation of basic human liberties even in the course of fomenting aggregate welfare. Hence, justice is responsible for securing a fair distribution of *primary social goods*, that is:

> All social values – liberty and opportunity, income and wealth, and the bases of self-respect – are to be distributed equally unless an unequal distribution of any, or all, of these values is to everyone's advantage. (Rawls, 1971, p. 64)

Consequently, injustice should then be considered as "*inequalities that are not to the benefit of all*" (Rawls, 1971, p. 62). From the viewpoint of social justice, the amount of primary social goods held by an individual defines their socio-economic and legal statuses. Ultimately, the resulting basic structure depicted by the social contract in Rawls (1971) does not necessarily imply maximizing the amount of primary social goods of the worst-off group.

On fair equality of opportunities, Rawls (1971) emphasizes that the merely availability of sufficient opportunities to the least advantaged members of society does not satisfy the underlying requirements of a fair societal structure. From the Rawlsian perspective, the equality of opportunities within society must also account for factors beyond individuals' responsibility. However, outcome differentials solely determined by factors for which individuals are held responsible are perceived as normatively acceptable. Note that the fair equality of opportunity argument does not require perfect equality of wealth and/or income *per se*, but the compensation of characteristics beyond individual control, so that outcome disparities are exclusively due to differences arising from factors individuals are deemed responsible. Equality of opportunities translates into equality of primary social goods.

The central problem associated with the Rawlsian concept of justice, according to Sen (2009), is its foundation on the perfect arrangement of a social contract. Even under the hypothetical veil of ignorance, establishing a single set of principles to select just institutions would be virtually unfeasible due to the plural nature of human reasoning, i.e., "*there may be no reasoned agreement at all, even under strict conditions of impartiality and open-minded scrutiny* [...] *on the nature of the 'just society'* [...]" (Sen, 2009, p. 6). Further, Sen (1979) also criticizes the resourcist approach in Rawls (1971). For the purposes of a theory of justice, opportunities should not be purely indexed to the amount of primary social goods one has, but measured by the substantive freedoms and abilities one has to convert the latter goods into well-being in the context of their individual characteristics.

The seminal work of Sen (1979), *Equality of What?*, presents the concept of equality of opportunities as freedom to achieve equal functionings. From the perspective of the capability approach, these functionings are referred to as observable states of "beings" and "doings", that is, "*the various things that* [*a person*] *manages to do and be in leading a life*" (Sen, 1993, p. 31). Capabilities are then defined as alternative sets of valuable functionings an individual is able to effectively achieve and to freely choose from. Consequently, the purpose of distributive justice is to equalize capabilities, compensating unequal capacities to convert primary goods (e.g. wealth and income) into functionings. Equality of opportunities is thus regarded as *attainment equality*.

Despite also rejecting the utilitarian framework of maximization of welfare, the luck egalitarian conception of distributive justice, first propelled by Dworkin (1981*a*,*b*), emphasizes that unequal distributions of resources due to *brute luck* should be compensated for, whereas inequalities arising from *option luck* are deemed fair. As Dworkin (1981*b*, p. 293) defines,

> Option luck is a matter of how deliberate and calculated gambles turn out – whether someone gains or loses through accepting an isolated risk he or she should have anticipated and might have declined. Brute luck is a matter of how risks fall out that are not in that sense deliberate gambles.

In this sense, brute luck constitutes outcomes an individual achieves that are not a (direct) consequence of their decisions and intentional actions. The distinction between brute luck and option luck implicitly identifies in which situations redistribution is morally justifiable or not. Hence, the equalization of brute luck among individuals within society would ensure equality of opportunity.

However, for Arneson (1989), the emphasis on resources as the *equalisandum* for distributive justice is not appropriate. Opportunity should be defined as the "*chance of getting a good if one seeks it*" (Arneson, 1989, p. 85). Consequently, in contrast to the equality of resources in Dworkin (1981*a*,*b*), the moral purpose of justice is to equalize opportunities for welfare. Instead of relying on the insurance mechanism under a veil of ignorance, Arneson (1989) proposes that resources are to be distributed among individuals so that equal opportunity for welfare achievement holds. Yet, regarding actual welfare achieved, outcome differentials are fair insofar as they are the result of individuals' own choices. Here, the conception of personal responsibility requires the accountability of only choices which are under absolute control of those concerned. Hence,

> Whether or not two persons enjoy equal opportunity for welfare at a time depends only on whether they face effectively equivalent arrays of options at that time. [...] We may say that in an extended sense people share equal opportunity for welfare just in case there is some time at which their opportunities are equal and if any inequalities in their opportunities at later times are due to their voluntary choice or differentially negligent behavior for which they are rightly deemed personally responsible. (Arneson, 1989, p. 86)

In a similar fashion, Cohen (1989) underscores the intertwined relationship among preferences, innate characteristics and resource availability, advocating against full accountability of individuals' own decisions. By integrating the principles of resource equality and welfare equality, Cohen (1989) accounts for access to advantage as the proper *equalisandum* for distributive justice, being *advantage* defined as both welfare and resources. By the term *access*, the author refers to the standard concept of opportunity as well as the ability to exploit such opportunity. Accordingly, the equal access to advantage approach therefore stipulates that the only permissible inequalities are those arising from choices individuals can sensibly be considered responsible. As stated by Cohen (1989, p. 934), "*In a theory of distributive justice whose axis is the distinction between luck and choice, the positive injunction is to equalize advantage, save where inequality of advantage reflects choice.*"

Within the realm of Economics, the interplay of outcomes, opportunities, exogenous characteristics and effort saw its first formalization in Roemer (1993). Socio-economic and genetic characteristics, which are beyond individuals' responsibility, are conceived as *circumstances*, whereas *effort* is articulated as the autonomous behavior individuals' are to be held accountable for. Outcome inequalities are just insofar as they are only the result of different effort levels. For Roemer (1993, p. 181), "[...] *equality of opportunity for X holds when the values of X for all those who exercised a comparable degree of responsibility are equal, regardless of their circumstances.*" Consequently, unfairness arises due to either the direct or indirect influence of circumstances on outcome. Therefore, in terms of distributive justice, such unfairness is to be corrected through the removal of differences in circumstances or the compensation of their effect on individual achievements.

## 3 The Empirics of Inequality of Opportunity

Despite being a growing field, the Economics of Distributive Justice is still considered relatively limited. In recent years, empirical research has attempted to evaluate the extent to which inequality of opportunity affects individual achievement. In general, these studies are usually categorized into two strands of work, which are reliant on their use of either *ex ante* or *ex post* approaches. More specifically, from an *ex ante* perspective, equality of opportunity is assessed by evaluating the differences between outcome prospects and the availability of opportunities across different types of individuals, that is, across different groups of individuals partitioned on the basis of shared circumstances. Neither identification nor measurement of effort is required. On the contrary, the *ex post* approach addresses outcome inequalities among individuals with different circumstances but similar levels of exerted effort, thus requiring a measure for the latter variable. As a consequence, inequality of opportunity is perceived as inequality within the class of individuals at the same effort level. Note that both direct and indirect measures of inequality of opportunities as well

as parametric and nonparametric estimation methods are viable within each of these strands.[1] However, due to the rather unobservable nature of effort and circumstances, the ongoing debate on the appropriate measurement procedure is yet far from being settled.

Even though *ex post* empirical assessments are rather scare, the literature has grown in the last few years. For instance, Pistolesi (2009) analyzed the extent of inequality of opportunity for earnings acquisition in the United States. Effort consists of two characteristics, namely human capital accumulation (identified as individual schooling attainment) and labor supply behavior (identified as annual working hours). Circumstances are comprised of individual social background. Using the Panel Study of Income Dynamics from 1968 to 2001, the results showed that schooling choices are relatively more affected by social background in comparison to the effects on labor supply decisions. In order to measure inequality of opportunity, the observed earnings distributions are thus compared to the simulated counterfactual distributions of equalized effort and of identical circumstances. Inequality of opportunity was found to account for 20 to 43 percent of earnings inequality over the period considered.

In contrast to the parametric proposal in Pistolesi (2009), the *ex post* analysis in Checchi and Peragine (2010) implemented the mean logarithmic deviation – a nonparametric index with path-independent decomposition – as the inequality index for the smoothed distribution of earnings acquisition in Italy. The latter index is then decomposed to evaluate the share of inequalities due to circumstances (gender, family background and geographic location). In general, their findings suggest that inequality of opportunity for the entire Italian population is responsible for 19.5 percent of overall inequality. Nevertheless, given the Italian population heterogeneity, inequality of opportunities in the North is greater than in the South, corresponding to 18 and 16.6 percent of overall inequality, respectively. Gender decomposition showed that women are the most penalized group in terms of inequality of opportunity, especially in Southern regions.

On the other hand, relative to the *ex post* approach, the *ex ante* strand of work has received more attention from researchers over the years. Focusing on the contribution of unequal opportunities to earnings inequality in Brazil, Bourguignon et al. (2007) decomposed the effect of opportunities on earnings into direct and indirect components, where the transmission channel of the latter is established through effort variables. Based on data from Brazil's 1996 National Household Survey (*Pesquisa Nacional por Amostra de Domicilios*, PNAD), the obtained estimates indicate that 10 to 37 percent of the Theil index for male earnings in urban Brazil is due to circumstance factors (namely race, place of birth, father's occupation, and mother's and father's education), with 60 percent of this result being attributed to the direct effect. Parental education was found to be the dominant circumstance affecting earnings, followed by the occupation of the father and race.

In an *ex ante* study for nine developed countries during the 1990s, Lefranc et al. (2008) proposed the use of nonparametric stochastic dominance tests to evaluate equality of opportunity. More specifically, the authors defined that opportunities are more equally distributed if the outcome distribution conditional on circumstances cannot be ranked according to the stochastic dominance criteria. Their results indicate considerable disparities in the equality of opportunity across countries over the years, with Italy and the United States being the most unequal ones. On the contrary, estimates for the Gini of Opportunities index are the lowest for the Scandinavian countries. In general, inequality of opportunity was mostly driven by differences in mean income conditional on social origin.

Based on the social welfare function proposed in Sen (1976), an alternative set of *ex ante* studies on inequality of opportunity focus on the unequal access to basic social services. First presented by Barros et al. (2009), the Human Opportunity Index – a synthetic measure of inequality of opportunity in basic services for children – combines both the coverage rate of basic services and the degree of equity in their distribution within society. Using data for 19 Latin American and Caribbean countries from 1995 to 2005, Barros et al. (2009) found evidences of overall low levels of opportunity in El Salvador, Guatemala and Nicaragua whereas Chile presented almost universal access to the basic services considered. However, the results are heterogeneous across the specific opportunities within each country. For instance, despite the virtually universal access to electricity in Brazil, the estimates for sanitation and education are rather low. On the other hand, Jamaica showed relatively high levels of equity regarding the access to education, but

[1] Direct and indirect measures refer to the amount of inequality that remains after any disparities in effort have been eliminated and to the amount of inequality that remains after equalization of opportunities among individuals, respectively (Ramos and Van de Gaer, 2012).

precarious provision of water and sanitation.

Regarding the Brazilian literature, Dill and Gonçalves (2012) evaluated the inequality of opportunity in terms of access to basic services in Brazil from 1999 to 2009. Through an application of the Human Opportunity Index using data from the 1999 and 2009 waves of PNAD, the authors provided evidences of considerable improvement during the period. Shapley decompositions showed that differences within subgroups (such as race or residence location) are more relevant to the observed national inequality than differences between subgroups. However, given the extent of heterogeneity among Brazilian regions, Ferreira et al. (2017) underscored the importance of estimating the latter index for the Brazilian municipalities in order to provide a better understanding of regional disparities as well as an analysis of potential spatial correlation. Using household data from Brazil's 2010 Demographic Census and Exploratory Spatial Data Analysis (ESDA), the authors presented evidences of well-defined spatial clusters in the Northeast and Centre-South regions, which are characterized by direct and positive spatial correlation.

Finally, in a recent study closely related to this paper, Islam and Mitra (2017) proposed a multidimensional approach to the Human Opportunity Index by considering the joint access to a bundle of basic services.[2] Besides measuring how socio-economic characteristics beyond the control of the child influence their access to basic services, the Multidimensional Human Opportunity Index is also able to account for complementaries among multiple services. Despite the individual access to basic services being almost universally available, the application of the latter multidimensional index to two Himalayan states of South Asian countries indicated that only about 63 percent and about 50 percent of the population in Bhutan and Nepal have access to the bundle of basic services over the period 2011–2012, respectively.

## 4 The Multidimensional Human Opportunity Index

In terms of development strategies, the equitable provision of basic opportunities across individuals is considered a necessary condition for intergenerational mobility and, ultimately, escaping ongoing poverty traps. Developed by Barros et al. (2009), the Human Opportunity Index consists of a synthetic measure of inequality of opportunity in basic services for children.[3] By combining both coverage rate and the degree of equity in their distribution, the latter index is sensitive to biased distribution of basic opportunities toward specific groups of children. Equality of opportunity is only attainable if the access to basic services is not correlated to circumstance variables. Since circumstances are personal and/or family characteristics a child cannot be deemed accountable for, detrimental allocation of opportunities to any particular social group is perceived as ethically unjust (Molinas Vega et al., 2012). In this sense, the design of public policy should ensure further distribution of these opportunities as to mostly benefit vulnerable groups, that is, any increase in the coverage rate of basic services should be mainly biased toward groups composed by children from disadvantaged households.

Assume the existence of a society with $N$ total children, such that $i = 1, \ldots, N$. Define a binary variable $y_i$ which assumes value 1 if the $i$-th child has access to a basic opportunity. Let $X$ be the set of $k$ circumstances, with $x_j \in X$, where $j = 1, \ldots, k$. Consequently, $x_{ij}$ corresponds to the $j$-th circumstance of the $i$-th child. As the probability of access to a given opportunity is a function of the set of circumstances, this relation can be estimated by means of a logistic regression model, so that

$$\hat{p}_i(y_i = 1|x_1, \ldots, x_k) = \frac{\exp\left(\hat{\beta}_0 + \sum_{j=1}^{k} x_{ij}\hat{\beta}_j\right)}{1 + \exp\left(\hat{\beta}_0 + \sum_{j=1}^{k} x_{ij}\hat{\beta}_j\right)}, \tag{1}$$

where equation (1) is the estimated probability of the $i$-th child having access to a specific basic opportunity conditional on circumstance variables.

As in Barros et al. (2009), the coverage rate is computed by averaging the estimated conditional probability across all children. In general, it provides information on the availability of a bundle or specific basic service. Therefore,

[2] Even though Islam and Mitra (2017) first presented an analytical treatment for the Multidimensional Human Opportunity Index, the concept was already briefly discussed by Molinas Vega et al. (2012).

[3] According to Molinas Vega et al. (2012), since children (ages 0 to 16) cannot be held responsible for their fate, they were established as the unit of focus as to isolate the endogeneity problem of effort and choice.

$$C = \frac{1}{N}\sum_{i=1}^{N}\hat{p}_i. \tag{2}$$

Here, $C$ corresponds to the coverage rate, with $0 \leq C \leq 1$. As $C \to 1$, the greater is the availability of a specific basic service within society.

However, this measure is insensitive to how equitably these services are distributed across individuals. The degree of opportunity inequality is then assessed by the Dissimilarity Index, an indicator responsible for measuring the differences in the access to a given service for groups defined by circumstance factors compared with the coverage rate for the whole population. In the words of Barros et al. (2009, p. 6), the Dissimilarity Index "[...] *can be interpreted as showing the fraction of all available opportunities that need to be reassigned from better-off groups to worse-off groups to achieve equal opportunity for all.*" Hence, it is considered a measure of opportunity inequality. Algebraically, it is given by

$$D = \frac{1}{2C}\sum_{i=1}^{N}\frac{1}{N}|\hat{p}_i - C|, \tag{3}$$

with $0 \leq D \leq 1$. As $D \to 0$, the greater is the degree of equity and fairness regarding the access distribution within society. Given that equation (3) represents inequality of opportunity, $(1 - D)$ is consequently interpreted as the percentage of properly allocated opportunities (Barros et al., 2009).

Accordingly, the Human Opportunity Index is composed by equations (2) and (3), so that

$$\text{HOI} = C \times (1 - D), \tag{4}$$

with $0 \leq \text{HOI} \leq 1$. This index is generally interpreted as an equality of opportunity-sensitive coverage rate (Molinas Vega et al., 2012). Note that if opportunities are not correlated to circumstances, $D = 0$. As a consequence, $\text{HOI} = C$. Thus, as basic opportunities are usually not available (that is, $C < 1$), there will always be loss of opportunity equality across members of society.

Yet, as discussed in Islam and Mitra (2017), one might be interested in evaluating the probability of having access to a *bundle* of basic services, that is, the joint access to multiple services. Let $Y$ be the set of $m$ basic services, with $y_h \in Y$, where $h = 1, \ldots, m$. If the $i$-th child has access to the $h$-th service, then $y_{ih} = 1$; otherwise, $y_{ih} = 0$. We define *strict* joint access as the situation in which the child has access to *all* basic services. Thus, a child is considered to be disadvantaged if they are unable to access *any* of the services. Algebraically, the strict joint access is given by

$$\gamma_i = \prod_{h=1}^{m}(y_{ih}). \tag{5}$$

Note that $\gamma_i = 1$ corresponds to the full access to the basic services by the $i$-th child; $\gamma_i = 0$, otherwise.

On the other hand, one might consider a child as disadvantage if they lack access to less than $z$ services, with $0 < z < m$ by definition. This *flexible* joint access is represented by

$$\psi_i = I\left[\sum_{h=1}^{m}(y_{ih}) \geq z\right], \tag{6}$$

with $I[\cdot]$ being an indicator function which assigns the value 1 when the statement is true and 0 otherwise. In case of $\psi_i = 1$, the $i$-th child has flexible access to the basic services, thus not being considered disadvantaged. According to Islam and Mitra (2017), analyzing the results for different values of $z$ provides a robustness check.

Despite the multidimensional nature of equations (5) and (6), the probability of strict (or flexible) joint access to basic services conditional on circumstance variables can also be estimated through a logistic regression model as in equation (1). First, define $\omega_i = \{\gamma_i; \psi_i\}$. Consequently, we have

$$\hat{\rho}_i(\omega_i = 1|x_1, \ldots, x_k) = \frac{\exp\left(\hat{\alpha}_0 + \sum_{j=1}^{k} x_{ij}\hat{\alpha}_j\right)}{1 + \exp\left(\hat{\alpha}_0 + \sum_{j=1}^{k} x_{ij}\hat{\alpha}_j\right)}, \tag{7}$$

where equation (7) is the estimated probability of the $i$-th child having strict (or flexible) joint access to basic services conditional on their circumstances.

Based on the estimated probability obtained from equation (7), the coverage rate and the dissimilarity index are computed as

$$\tilde{C} = \frac{1}{N}\sum_{i=1}^{N}\hat{\rho}_i \tag{8}$$

and

$$\tilde{D} = \frac{1}{2\tilde{C}}\sum_{i=1}^{N}\frac{1}{N}|\hat{\rho}_i - \tilde{C}|, \tag{9}$$

respectively. Note that the latter two measures are symmetrical versions of equations (2) and (3).

Finally, the Multidimensional Human Opportunity Index is given by

$$\text{MHOI} = \tilde{C} \times (1 - \tilde{D}). \tag{10}$$

Similarly to the Human Opportunity Index in equation (4), the multidimensional approach accounts only for the coverage of a bundle of services that is adequately allocated among distinct circumstance groups. Therefore, universal coverage of all services could be achieved by either improving total availability of services (coverage), by further equalizing opportunity across circumstance groups (distribution equity), or by combining both strategies.

## 5 Equality of Opportunities in Brazilian Municipalities

In a society where circumstances are determinants of access to basic services, inequality of opportunity and outcome are inexorable facts. People are not homogeneous in terms of their innate characteristics. And these assertions are valid for Brazil, a country profoundly stratified by race, gender and geographic location. For instance, in 2000, the probability of having simultaneous access to all basic services (adequate sanitation, safe water, electricity and basic education) for a 10-year-old white girl in a three-people urban household, located in a metropolitan area of the Southeast region, where the household head is a literate woman with annual *per capita* income of US$ 3,739.12, is approximately 114 times larger than for a 10-year-old non-white boy in a five-people rural household, located in a non-metropolitan area of the Centre-West region, where the household head is an illiterate man with annual *per capita* income of US$ 693.5 (Table 1).[4]

However, the effect of circumstances on the access to these services have changed over the years (Tables 1 and 2). Even though girls were found to have a higher chance of accessing all basic services, the discrepancies relative to boys decreased from 2000 to 2010. More specifically, in 2000, the chance of a girl (ages 6 to 16) having simultaneous access to all services was 1.25 times higher than a boy. In 2010, the same chance decreased to 1.08. Overall, results for each service suggest that gender has one of the largest effects in determining the probability of access to basic education: girls were nearly 1.36 and 1.28 times more likely to have access to basic education than boys in 2000 and 2010, respectively. These findings are intrinsically related to the recent reversal of the gender gap in Brazilian education mainly due to the resolutions of international conferences engendered by multilateral organizations (e.g. the IV Conference on Women in 1995; the World Education Forum in 2000; and the Millennium Summit in 2000) as well as the historical effort by the feminist movement in the last century (Beltrão and Alves, 2009). Note that gender has been found to be not statistically significant, at the 5% level, for adequate sanitation and safe water.

[4]The annual *per capita* income of US$ 3,739.12 corresponds to the Brazilian *per capita* income in 2000. As for the value of US$ 693.5, it corresponds to the annualized international poverty line of US$1.90 a day.

Table 1: Logistic Regressions for Human Opportunities – 2000 Demographic Census

| Circumstance Variable | All Basic Services | | Adequate Sanitation | | Safe Water | | Electricity | | Basic Education | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coefficient | Odds-Ratio | Coefficient | Odds-Ratio | Coefficient | Odds-Ratio | Coefficient | Odds-Ratio | Coefficient | Odds-Ratio |
| Constant | -7.073*** | 0.000848*** | -6.090*** | 0.00227*** | -6.153*** | 0.00213*** | -2.976*** | 0.0510*** | -2.855*** | 0.0575*** |
| | (0.0131) | (0.0000111) | (0.00940) | (0.0000213) | (0.0111) | (0.0000236) | (0.0140) | (0.000716) | (0.00941) | (0.000542) |
| Gender | -0.222*** | 0.801*** | -0.00281 | 0.997 | -0.00348 | 0.997 | -0.0204*** | 0.980*** | -0.303*** | 0.738*** |
| | (0.00269) | (0.00216) | (0.00216) | (0.00216) | (0.00264) | (0.00263) | (0.00356) | (0.00349) | (0.00226) | (0.00167) |
| Race | 0.404*** | 1.498*** | 0.245*** | 1.277*** | 0.432*** | 1.540*** | 0.357*** | 1.429*** | 0.342*** | 1.408*** |
| | (0.00295) | (0.00443) | (0.00237) | (0.00302) | (0.00286) | (0.00440) | (0.00403) | (0.00577) | (0.00246) | (0.00346) |
| Gender of Household Head | 0.109*** | 1.116*** | -0.261*** | 0.770*** | -0.0663*** | 0.936*** | -0.152*** | 0.859*** | 0.288*** | 1.334*** |
| | (0.00341) | (0.00381) | (0.00274) | (0.00211) | (0.00347) | (0.00324) | (0.00573) | (0.00492) | (0.00290) | (0.00387) |
| Literate Household Head | 0.780*** | 2.181*** | 0.497*** | 1.643*** | 0.645*** | 1.906*** | 0.526*** | 1.691*** | 0.579*** | 1.783*** |
| | (0.00497) | (0.0108) | (0.00311) | (0.00512) | (0.00304) | (0.00579) | (0.00388) | (0.00656) | (0.00322) | (0.00574) |
| *Per Capita* Income | 0.622*** | 1.864*** | 0.617*** | 1.854*** | 0.836*** | 2.306*** | 0.558*** | 1.748*** | 0.362*** | 1.436*** |
| | (0.00161) | (0.00299) | (0.00129) | (0.00239) | (0.00170) | (0.00393) | (0.00222) | (0.00388) | (0.00130) | (0.00187) |
| Household Size | -0.0673*** | 0.935*** | 0.0114*** | 1.011*** | -0.00914*** | 0.991*** | -0.0195*** | 0.981*** | -0.0860*** | 0.918*** |
| | (0.000824) | (0.000770) | (0.000542) | (0.000549) | (0.000586) | (0.000581) | (0.000752) | (0.000737) | (0.000632) | (0.000580) |
| Residence Location | 1.792*** | 5.999*** | 2.115*** | 8.287*** | 1.763*** | 5.832*** | 2.748*** | 15.61*** | 0.395*** | 1.485*** |
| | (0.00546) | (0.0327) | (0.00330) | (0.0274) | (0.00291) | (0.0170) | (0.00471) | (0.0736) | (0.00298) | (0.00443) |
| Metropolitan Area | 0.147*** | 1.158*** | 0.466*** | 1.593*** | 0.297*** | 1.345*** | 0.955*** | 2.598*** | -0.0775*** | 0.925*** |
| | (0.00288) | (0.00334) | (0.00241) | (0.00383) | (0.00352) | (0.00473) | (0.00861) | (0.0224) | (0.00260) | (0.00241) |
| Northeast | 0.264*** | 1.302*** | 0.313*** | 1.367*** | 0.770*** | 2.160*** | 1.026*** | 2.790*** | 0.193*** | 1.212*** |
| | (0.00643) | (0.00838) | (0.00404) | (0.00552) | (0.00397) | (0.00858) | (0.00494) | (0.0138) | (0.00448) | (0.00543) |
| Centre-West | -0.0148 | 0.985 | -0.444*** | 0.642*** | 1.460*** | 4.308*** | 0.770*** | 2.160*** | 0.378*** | 1.459*** |
| | (0.00775) | (0.00763) | (0.00513) | (0.00329) | (0.00620) | (0.0267) | (0.00845) | (0.0182) | (0.00577) | (0.00842) |
| Southeast | 1.209*** | 3.349*** | 1.558*** | 4.749*** | 2.362*** | 10.61*** | 1.707*** | 5.513*** | 0.595*** | 1.812*** |
| | (0.00611) | (0.0205) | (0.00403) | (0.0191) | (0.00466) | (0.0495) | (0.00630) | (0.0347) | (0.00448) | (0.00812) |
| South | 0.824*** | 2.279*** | 0.696*** | 2.006*** | 2.703*** | 14.92*** | 1.679*** | 5.362*** | 0.673*** | 1.961*** |
| | (0.00669) | (0.0153) | (0.00459) | (0.00921) | (0.00632) | (0.0942) | (0.00818) | (0.0439) | (0.00511) | (0.0100) |
| $\chi^2$ (*d.f.* = 12) | 714025.7 | | 1392207.8 | | 1276000.7 | | 673976.4 | | 505665.5 | |
| $p > \chi^2$ | 0.000 | | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| Log-Pseudolikelihood | -16474772.1 | | -25042179.9 | | -16833876.8 | | -8738856.1 | | -21349782.0 | |
| Pseudo-$R^2$ | 0.254 | | 0.319 | | 0.422 | | 0.420 | | 0.122 | |
| Number of Observations | 4,312,829 | | 6,540,165 | | 6,540,165 | | 6,540,165 | | 4,312,829 | |

*Notes:* The estimation procedure for access to basic education considered only children with ages 6 to 16. Robust standard deviation are reported in brackets. The term *d.f.* refers to degrees of freedom. Note that * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$. The $\chi^2$ Wald tests assert the global statistical significance of the models at the 0.1% level.

Table 2: Logistic Regressions for Human Opportunities – 2010 Demographic Census

| Circumstance Variable | All Basic Services | | Adequate Sanitation | | Safe Water | | Electricity | | Basic Education | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coefficient | Odds-Ratio | Coefficient | Odds-Ratio | Coefficient | Odds-Ratio | Coefficient | Odds-Ratio | Coefficient | Odds-Ratio |
| Constant | -5.816*** | 0.00298*** | -5.529*** | 0.00397*** | -3.172*** | 0.0419*** | -1.096*** | 0.334*** | 0.363*** | 1.438*** |
| | (0.0138) | (0.0000410) | (0.0110) | (0.0000435) | (0.0117) | (0.000491) | (0.0220) | (0.00736) | (0.0129) | (0.0185) |
| Gender | -0.0799*** | 0.923*** | 0.000233 | 1.000 | -0.00573 | 0.994 | -0.0275*** | 0.973*** | -0.250*** | 0.779*** |
| | (0.00292) | (0.00270) | (0.00247) | (0.00247) | (0.00323) | (0.00322) | (0.00680) | (0.00661) | (0.00349) | (0.00272) |
| Race | 0.239*** | 1.270*** | 0.236*** | 1.266*** | 0.230*** | 1.259*** | 0.352*** | 1.422*** | 0.150*** | 1.162*** |
| | (0.00313) | (0.00398) | (0.00266) | (0.00337) | (0.00368) | (0.00463) | (0.00881) | (0.0125) | (0.00391) | (0.00455) |
| Gender of Household Head | -0.0502*** | 0.951*** | -0.113*** | 0.893*** | 0.0395*** | 1.040*** | -0.0984*** | 0.906*** | 0.0682*** | 1.071*** |
| | (0.00306) | (0.00291) | (0.00260) | (0.00233) | (0.00347) | (0.00361) | (0.00779) | (0.00706) | (0.00363) | (0.00389) |
| Literate Household Head | 0.448*** | 1.566*** | 0.372*** | 1.451*** | 0.536*** | 1.709*** | 0.473*** | 1.605*** | 0.248*** | 1.282*** |
| | (0.00469) | (0.00734) | (0.00387) | (0.00562) | (0.00360) | (0.00615) | (0.00754) | (0.0121) | (0.00447) | (0.00573) |
| *Per Capita* Income | 0.456*** | 1.577*** | 0.451*** | 1.569*** | 0.469*** | 1.598*** | 0.506*** | 1.658*** | 0.238*** | 1.269*** |
| | (0.00180) | (0.00284) | (0.00144) | (0.00226) | (0.00175) | (0.00279) | (0.00353) | (0.00585) | (0.00187) | (0.00237) |
| Household Size | -0.0203*** | 0.980*** | 0.00160* | 1.002* | -0.0445*** | 0.956*** | -0.0370*** | 0.964*** | -0.0393*** | 0.961*** |
| | (0.000877) | (0.000859) | (0.000703) | (0.000704) | (0.000756) | (0.000723) | (0.00144) | (0.00139) | (0.000872) | (0.000838) |
| Residence Location | 1.871*** | 6.492*** | 1.924*** | 6.847*** | 1.664*** | 5.280*** | 2.391*** | 10.92*** | 0.0415*** | 1.042*** |
| | (0.00447) | (0.0290) | (0.00350) | (0.0240) | (0.00330) | (0.0174) | (0.0104) | (0.114) | (0.00415) | (0.00433) |
| Metropolitan Area | 0.326*** | 1.385*** | 0.530*** | 1.698*** | 0.167*** | 1.181*** | 0.861*** | 2.366*** | -0.0612*** | 0.941*** |
| | (0.00306) | (0.00424) | (0.00268) | (0.00456) | (0.00421) | (0.00498) | (0.0151) | (0.0357) | (0.00390) | (0.00367) |
| Northeast | 0.735*** | 2.086*** | 0.736*** | 2.087*** | 0.736*** | 2.087*** | 1.394*** | 4.029*** | 0.114*** | 1.121*** |
| | (0.00602) | (0.0126) | (0.00458) | (0.00956) | (0.00432) | (0.00901) | (0.00802) | (0.0323) | (0.00567) | (0.00636) |
| Centre-West | 0.457*** | 1.579*** | 0.335*** | 1.398*** | 1.513*** | 4.541*** | 0.923*** | 2.516*** | 0.204*** | 1.226*** |
| | (0.00752) | (0.0119) | (0.00580) | (0.00811) | (0.00903) | (0.0410) | (0.0163) | (0.0411) | (0.00876) | (0.0107) |
| Southeast | 1.873*** | 6.509*** | 2.205*** | 9.071*** | 1.929*** | 6.885*** | 1.993*** | 7.336*** | 0.221*** | 1.247*** |
| | (0.00591) | (0.0385) | (0.00466) | (0.0423) | (0.00581) | (0.0400) | (0.0141) | (0.103) | (0.00607) | (0.00757) |
| South | 1.318*** | 3.735*** | 1.288*** | 3.627*** | 2.534*** | 12.61*** | 1.752*** | 5.768*** | 0.337*** | 1.401*** |
| | (0.00652) | (0.0243) | (0.00512) | (0.0186) | (0.00911) | (0.115) | (0.0193) | (0.112) | (0.00743) | (0.0104) |
| $\chi^2$ ($d.f.$ = 12) | 610835.4 | | 1009329.0 | | 687625.6 | | 197261.7 | | 71091.3 | |
| $p > \chi^2$ | 0.000 | | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| Pseudo-Loglikelihood | -18323510.1 | | -24445869.7 | | -13921841.1 | | -3047217.2 | | -13780393.1 | |
| Pseudo-$R^2$ | 0.241 | | 0.290 | | 0.313 | | 0.332 | | 0.0278 | |
| Number of Observations | 3,919,543 | | 5,693,462 | | 5,693,462 | | 5,693,462 | | 3,919,543 | |

*Notes:* The estimation procedure for access to basic education considered only children with ages 6 to 16. Robust standard deviation are reported in brackets. The term *d.f.* refers to degrees of freedom. Note that * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$. The $\chi^2$ Wald tests assert the global statistical significance of the models at the 0.1% level.

Similar gains were observed concerning ethnic discrimination. Relative to non-white children, the chance of a white child having access to all services decreased from 1.50 to 1.27 over the period (Tables 1 and 2). Notwithstanding the positive advance, racial inequality remains a challenge in Brazil. Moreover, whether the household is located in a rural or urban area was found to be an important driver behind the probability of a child having access to the basic services in Brazil. In fact, the results are rather striking regarding housing conditions. In 2010, a child living in an urban area had 10.92 times more chance of having access to electricity than a child in a rural area (Table 2). Although nearly 18 percent of the total population under 16 years of age, children in rural areas compose roughly 86 percent of those without access to electricity in 2010. Moreover, for the same year, a child in an urban area was 6.85 and 5.28 times more likely to have access to adequate sanitation and safe water than a child living in a rural area, respectively. As for the simultaneous access to all services, the chance of a child in an urban area was 6.49 times greater than a child in a rural area in 2010 – a 8.2 percent increase in relation to 2000 (Tables 1 and 2).

The obtained results also suggest that a child in a male-headed household had 1.12 more chances of having access to all services than those who live with a female household head in 2000 (Table 1). However, in 2010, a female-headed household would lead to a chance 1.05 times higher than a male one (Table 2). Among the potential explanations for such increase, one must highlight the cumulative effects of the deinstitutionalization of marriage and the higher life expectancy for women in comparison to men (Barros, 2001) as well as the process of female empowerment through (i) greater participation of females in the labor market (Haussmann and Golgher, 2016) and (ii) erosion of patriarchal precepts of gender (Gandelman, 2009). In quantitative terms, among those children without joint access to the four basic services (approximately 58 percent of the total population under 16 years of age), nearly 64 percent were living in a male-headed household in 2010.

Higher *per capita* income leads to greater probability of access to basic services in both 2000 and 2010 (Tables 1 and 2). Yet, this positive correlation has decreased over the years for all services considered. Similarly, the presence of a literate household head is also positively correlated with the probability of access to basic services during the period. With exception of adequate sanitation, the higher the number of people living in a household, the lower the probability of a child having access to basic services. Since larger households in Brazil are generally poorer (Ferreira et al., 2003; Stampini et al., 2016), this negative relationship corroborates the stylized fact that poorer households have consistently had less access to basic services. The latter results are in accordance with those found in the Brazilian literature on the Human Opportunity Index (Barros et al., 2008; Dill and Gonçalves, 2012, 2013; Ferreira et al., 2017).

Metropolitan location is positively correlated to the joint access to the four basic services in both 2000 and 2010 (Tables 1 and 2). In fact, a child living in a metropolitan household was 1.16 times more likely to have simultaneous access to the services in 2000. In 2010, the same child would have a chance 1.39 times higher. This result is similar to those in which the access to each services is individually considered. Finally, relative to the North region, children living in the Southeast and South regions have the highest probability of accessing the services. For instance, in 2010, the likelihood of a child having simultaneous access to all basic services in the Southeast region is 6.51 times greater than a child in the North region.

Even though these findings provide valuable information on the importance of each circumstance in determining the probability of access to basic services in Brazil, evaluating coverage rates and distribution patterns of these services within each Brazilian municipality is still imperative in order to fully comprehend intra-national heterogeneity regarding human opportunities. Consequently, the Human Opportunity Index emerges as an effective tool for that purpose. Subsection 5.1 is responsible for such analysis.

### 5.1 Evidences from the Multidimensional Human Opportunity Index

Human Opportunity in Brazil has increased considerably between 2000 and 2010. The Multidimensional Human Opportunity Index (henceforth, MHOI) grew by approximately 5.5 percent per year over the period (Table 3). This result seems to be mainly driven by the growth in the access to basic education, with annual change of 7.6 percent, followed by access to safe water (2.2 percent per year) and electricity (1.4 percent per year). Adequate sanitation and to a lesser extent safe water are the most challenging services in terms of provision and distribution in Brazil. These findings are in line with the evidences for Latin American countries (Barros et al., 2009; Molinas Vega et al., 2012).

Overall availability also increased during the period. The coverage rate for the joint access to all basic

services improved from 29.6 percent in 2000 to 44 percent in 2010 – an annual growth rate of 4 percent (Table 3). Among the four services, basic education experienced greater expansion: its coverage rate roughly increased 5.8 percent per year, which corresponds to an overall growth of 76.1 percent from 2000 to 2010. According to Bruns et al. (2012), the expansion of basic education in Brazil is the outcome of several innovations in education policy since 2000, such as education finance equalization and reduction of schooling costs for poor children through conditional cash transfer programs. Although beyond the scope of this study, one should also mention that this educational expansion was mainly focused on the sole increment of enrollments, without any major concerns about quality and inefficiency (Oliveira, 2004).

Table 3: Multidimensional Human Opportunity Index and Its Components – Brazil

| | Opportunity Index | | | Coverage Rate | | | Dissimilarity Index | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2010 | Annual Change | 2000 | 2010 | Annual Change | 2000 | 2010 | Annual Change |
| All Basic Services | 18.7 | 31.8 | 5.5% | 29.6 | 44.0 | 4.0% | 36.6 | 27.8 | -2.7% |
| Adequate Sanitation | 36.2 | 39.2 | 0.8% | 50.3 | 52.5 | 0.4% | 28.0 | 25.2 | -1.1% |
| Safe Water | 60.7 | 75.5 | 2.2% | 73.4 | 83.5 | 1.3% | 17.3 | 9.6 | -5.7% |
| Electricity | 83.7 | 96.1 | 1.4% | 90.0 | 97.7 | 0.8% | 7.0 | 1.6 | -13.7% |
| Basic Education | 39.9 | 83.2 | 7.6 % | 48.5 | 85.4 | 5.8% | 17.8 | 2.6 | -17.5% |

*Notes:* All results are expressed in percentage. Annual change is the annual geometric growth rate. Note that the term *All Basic Services* corresponds to the joint access to the four basic services considered.

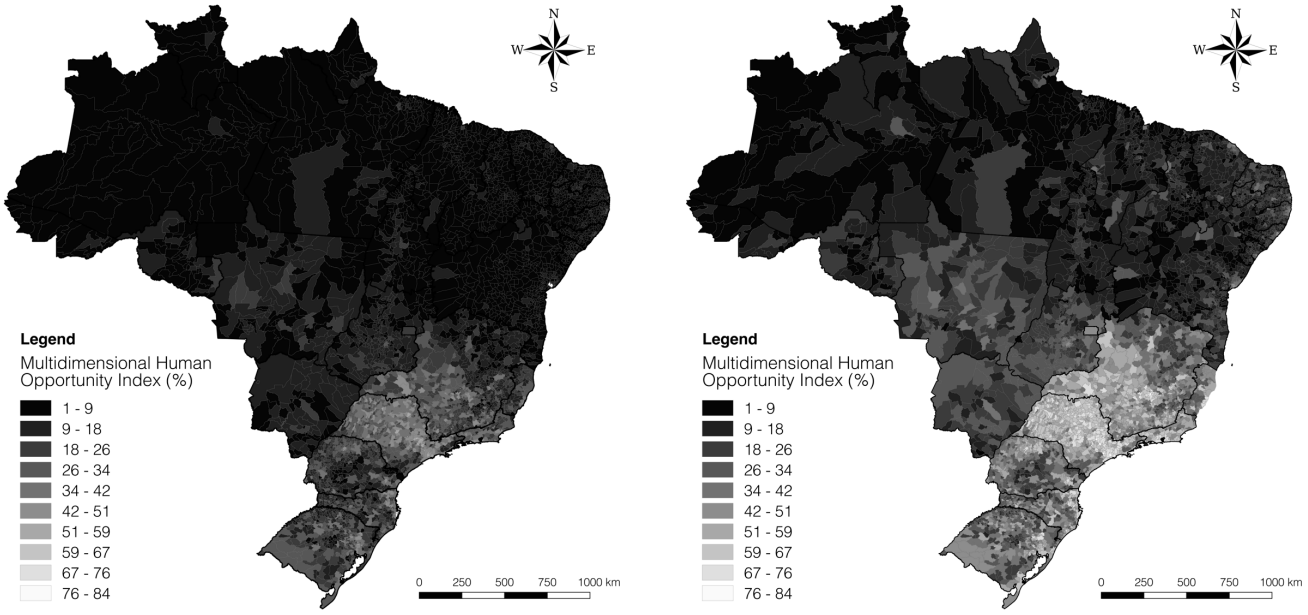
But to what extent did the distributive aspects of opportunities change between 2000 and 2010? The dissimilarity level for the joint access to all four basic services decreased 2.7 percent per year (an overall decrease of 24 percent) over the period, which suggests that Brazil was rather successful in the pursuit of the equitably allocation of opportunities among the population (Table 3). Although the dissimilarity index for basic education decreased substantially (17.5 percent per year), inequality of opportunity in access to electricity remained as the lowest one in both 2000 and 2010. The latter result might be explained by the effectiveness of the *Luz para Todos* (Light for All; henceforth, LPT) electrification program, which was adopted by the Brazilian government in November 2003. For instance, the literature has provided evidences for the positive influence of the LPT program on rural development (Gómez and Silveira, 2010; Coelho and Goldemberg, 2013) and, more generally, on the components of the Human Development Index (Bezerra et al., 2017).

Yet, the unequal access to adequate sanitation remains a severe constraint in Brazil. Since sanitation deficits are mostly correlated with low-income households, usually located in rural areas and/or small municipalities, the higher provision costs associated to these characteristics led to the continued underinvestment in the sector (Toneto Junior and Saiani, 2006). In fact, the findings for 2000 suggest that, in average, approximately 28 percent of the sanitation opportunities would need to be reassigned from the non-vulnerable groups to the vulnerable groups for equality of opportunity to prevail (Table 3). In 2010, this redistribution would consist of 23 percent – an annual decrease of 1.9 percent.

Overall, these findings suggest that Brazil has improved its fairness in terms of equality of opportunity. However, Brazil is a multicultural and socio-economic diverse country, characterized by profound regional heterogeneity. Therefore, in order to effectively contemplate such regional heterogeneity, the spatial distribution of opportunities among the Brazilian municipalities is evaluated. Figure 1 presents the results for the MHOI among the Brazilian municipalities in 2000 and 2010. Even though overall improvement is readily evident, North and Northeast regions remained with the worst indicators. For instance, only 45.5 percent of the Brazilian municipalities exhibited MHOI above the national average – 25.6 percent (Table 3) – in 2010. Yet, Northern and Northeastern municipalities composed merely 12 percent of those above the national average. In other words, from a total of 2242 municipalities in these regions, only 303 reported MHOI above 25.6 percent in 2010. Note that the highest value in these regions was 50.5 percent, which corresponds to the MHOI of Fernando de Noronha, in the state of Pernambuco.

The findings also suggest that opportunities to the joint access to basic services are more equitably allo-

Figure 1: Multidimensional Human Opportunity Index – Brazilian Municipalities




(a) 2000

(b) 2010

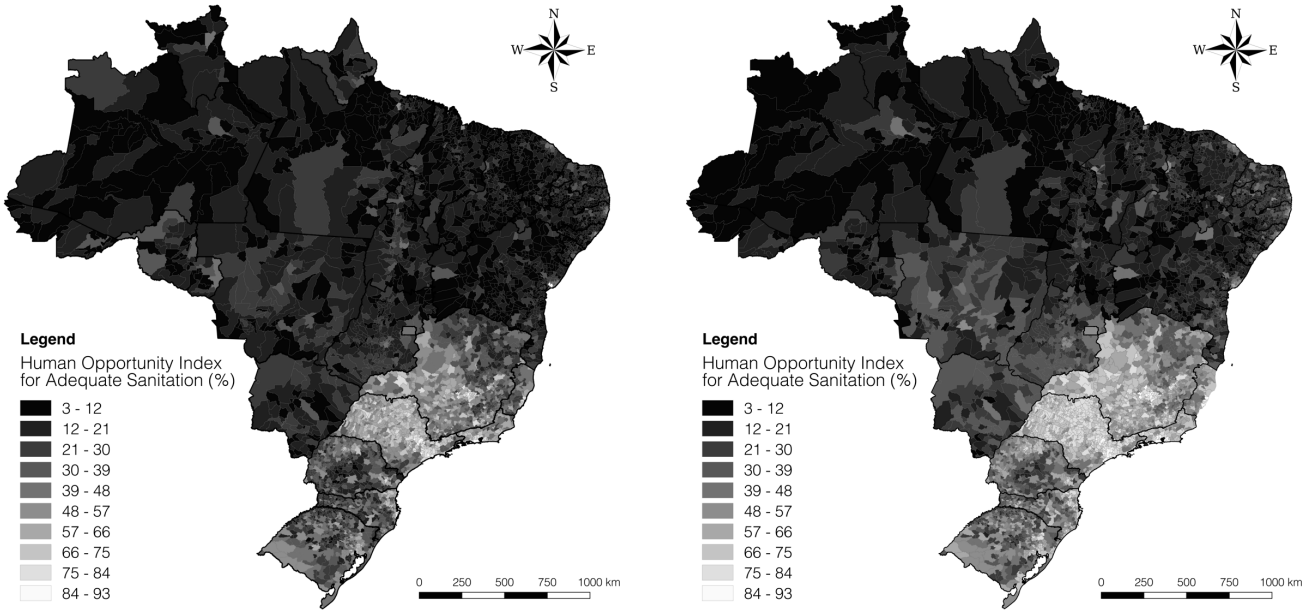
cated in the South and Southeast regions in comparison to the rest of the country. Southern municipalities presented an average MHOI of 22.7 percent and 30.2 percent in 2000 and 2010, respectively. As for the Southeast region, the average MHOI was 23.1 percent in 2000 and 32.7 percent in 2010. Note that these results were above the national average in both years. In fact, approximately 74.5 percent of the Brazilian municipalities with MHOI above 25.6 percent were located in these regions in 2010. More specifically, the state of São Paulo concentrated nearly 24 percent of the latter municipalities, followed by the states of Minas Gerais (18 percent) and Paraná (11 percent).

The distribution patterns vary substantially across basic services. Despite the marginal improvement between 2000 and 2010, opportunity to access adequate sanitation still remained Brazil's biggest housing infrastructure deficit. Yet, the results for the Northeastern municipalities suggest a slight advance toward equality in the region (Figure 2). More specifically, the Human Opportunity Index (henceforth, HOI) for adequate sanitation increased, in average, 6.2 percentage points – from 18.9 percent in 2000 to 25.1 percent in 2010. However, both results were bellow the national average for the service (Table 3). On the other hand, the Centre-South region has historically shown results above the national average – 39.5 percent in 2000 and 46.4 percent in 2010.[5] During the period, the standard deviation of the HOI for adequate sanitation decreased from 15.3 to 14.4 in the region. The latter findings imply that not only did the Centre-Southern municipalities improve their position in terms of access to adequate sanitation, but they also became slightly more homogeneous.

In regard to the access to safe water in Brazil, significant progress was achieved over the years. The national average for the HOI increased from 58.5 percent in 2000 to 73.1 percent in 2010 (Table 3). Nonetheless, these results are characterized by high dispersion among Brazilian municipalities. Despite a 28 percent decrease, the HOI for safe water reported a standard deviation of 14.5 in 2010. Similarly to the case of adequate sanitation, the low opportunities for safe water are mainly concentrated in the North and Northeast regions (Figure 3). In 2000, the average of the HOI for safe water for the Northern municipalities was approximately 50.2 percent, that is, 8.3 percentage points bellow the national average. The situation in the Northeastern municipalities was even more precarious in 2000: an average of 38.6 percent. Even though these regions remained bellow the national average, the HOI for safe water increased to 65.1 percent in the North region and to 60.4 percent in the Northeast region in 2010. As for the Centre-South region, the HOI for safe water increased from 70.5 percent in 2000 to 82.2 percent in 2010 – both results being above their

[5]The Centre-South region corresponds to the Centre-West, Southeast and South regions.

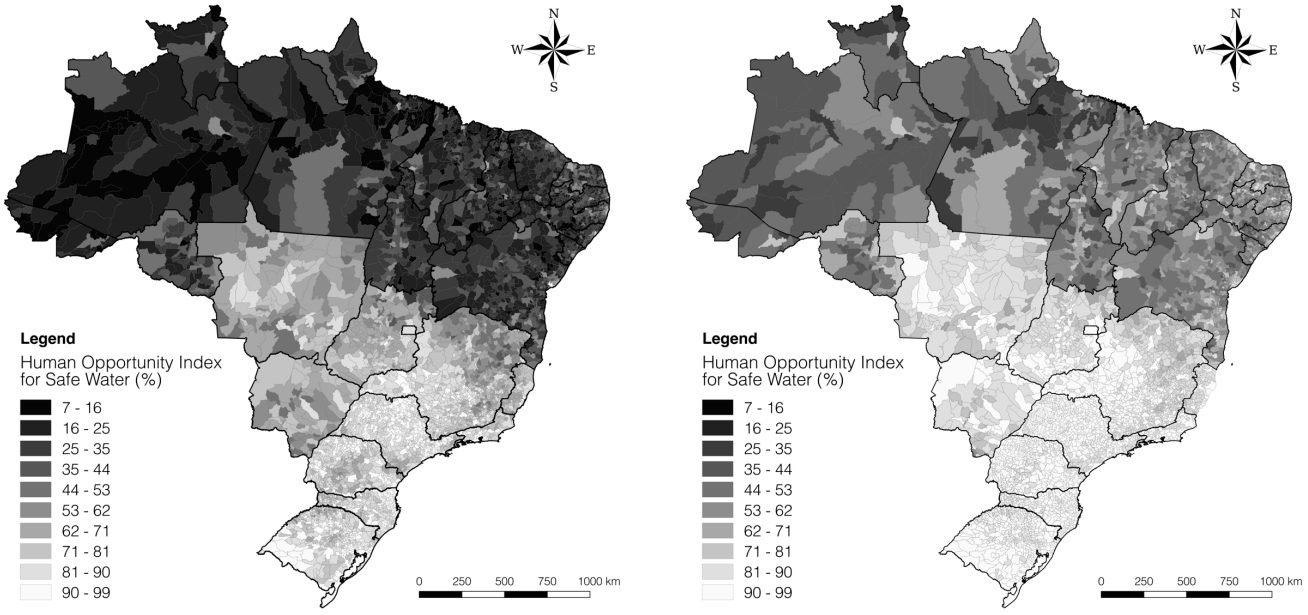
Figure 2: Human Opportunity Index for Adequate Sanitation – Brazilian Municipalities




(a) 2000 (b) 2010

respective national averages. While these findings suggest that Brazil has recently embarked on a trend toward equalizing opportunities to safe water among its municipalities, further improvements in the North and Northeast regions are still needed.

Figure 3: Human Opportunity Index for Safe Water – Brazilian Municipalities

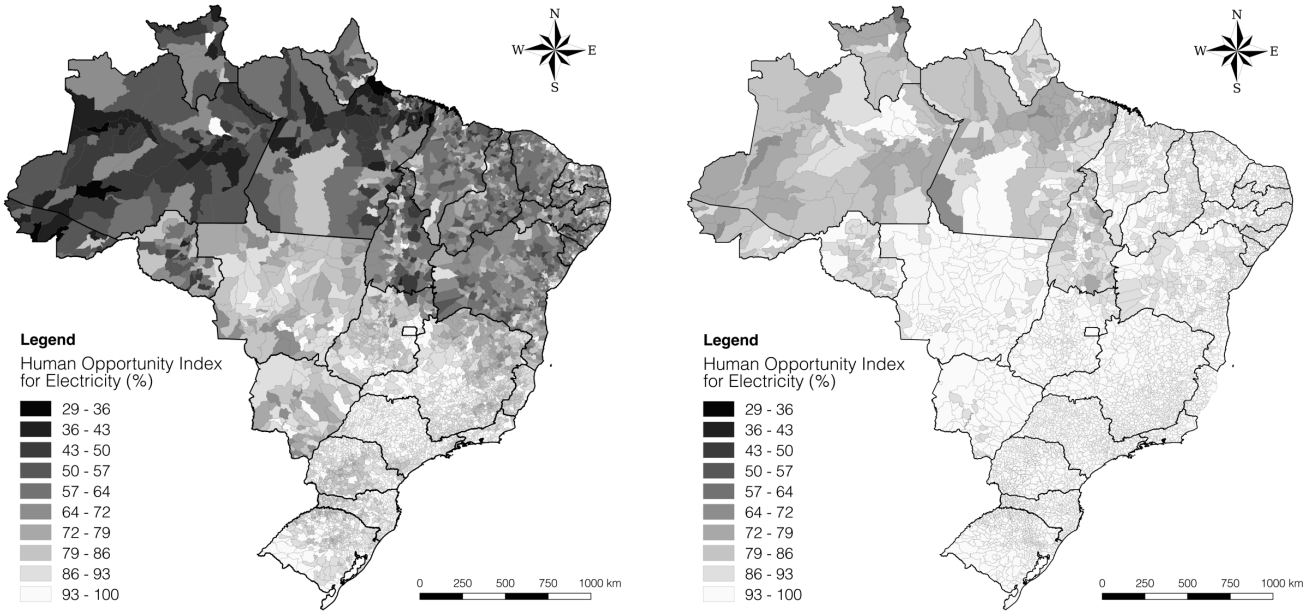



(a) 2000 (b) 2010

Between 2000 and 2010, access to electricity became virtually universal among children in Brazil. The HOI for electricity increased from 82.3 percent to 95.7 percent during the period. Yet, this positive growth was mainly driven by the results for the North and Northeast regions (Figure 4). In average, the opportunities to electricity increased 30 percent in the Northeastern municipalities, whereas in the Northern municipalities

this increase was of 17.6 percent. For instance, in 2010, 92.7 percent of electricity services were available and equitably allocated in the Northeast region; the figure was around 93.3 percent in the North region. Besides, the dispersion of the HOI for electricity among these municipalities decreased considerably. In the North region, the standard deviation declined from 9.2 to 3.5 between 2000 and 2010. Similarly, the standard deviation for the Northeast region declined from 9.8 to 3.1 during the period. Hence, these findings reflect not only the effectiveness of governmental efforts to provide children with equitable access to electricity, mainly through the LPT program, but also a development process toward homogeneity in the regions. Moreover, despite the average increase of 10 percent in the period, the opportunities to electricity were nearly universal and uniform in the Centre-South region (HOI of 97.5 percent and standard deviation of 2 points) in 2010.

Figure 4: Human Opportunity Index for Electricity – Brazilian Municipalities

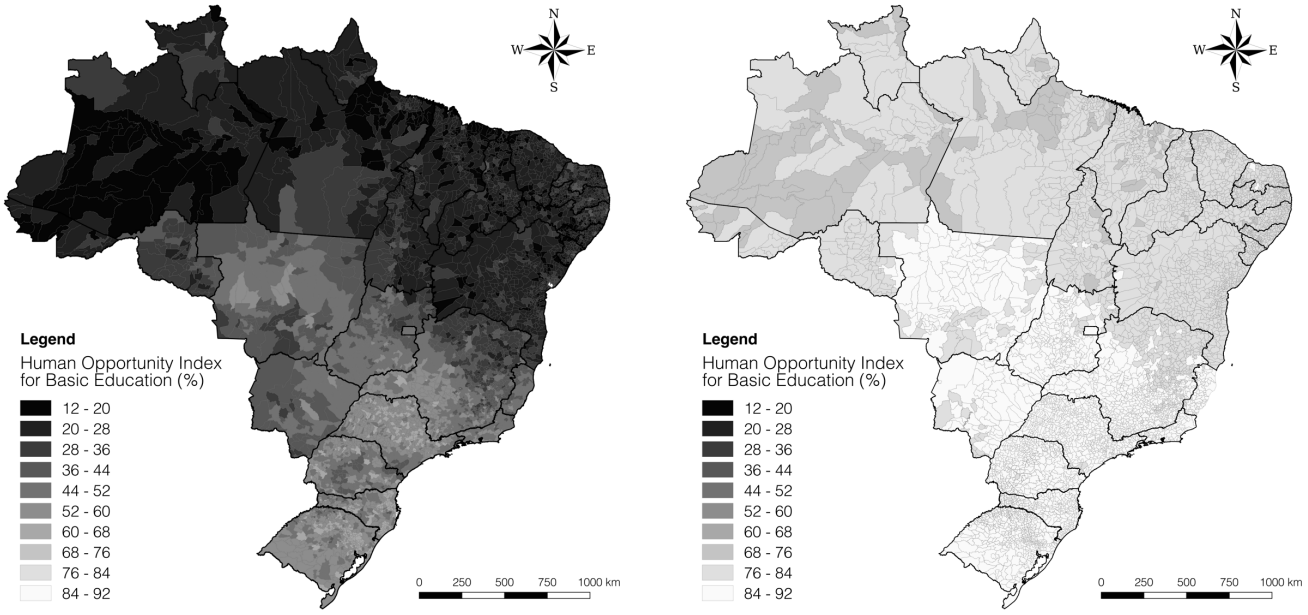



(a) 2000 (b) 2010

The case of opportunities to basic education is similar to the latter one. Between 2000 and 2010, the equitable access to education essentially doubled in Brazil (Table 3). The expansion of the national HOI for basic education is mainly determined by the respective gains of the North and Northeast regions (Figure 5). In 2000, the these regions reported HOI for basic education of 34.4 percent and 29.3 percent, respectively. These findings are the direct result of the low coverage rate and the highly unequal distribution of educational services within those regions. For instance, only 38 percent of children in the North and Northeast regions were in the correct grade for their respective age in 2000. Yet, in 2010, these regions improved substantially their ability to provide children with equitable opportunities to education. In fact, the Northeast region reported average HOI for basic education of 78.5 percent in 2010, which indicates that approximately four-fifth of the educational services were available and equitably allocated among its municipalities. Similarly, the North region presented average HOI for basic education of 79.6 percent – a growth of 132 percent relative to 2000. Nonetheless, the Centre-South region also underwent considerable improvement during the period. In 2000, the region's education HOI was 50 percent, meaning that nearly 50 percent of educational services were available and equitably allocated within Centre-Southern municipalities. In 2010, the region achieved a HOI of 84.9 percent for this indicator, that is, a geometric growth rate of 5.4 percent per year.

In general, the obtained results suggest heterogeneous patterns of spatial distribution among Brazilian municipalities for both the MHOI and the HOIs for the four basic services considered. However, between 2000 and 2010, regional disparities have shown a tendency to gradually decrease, further suggesting the presence of regional convergence processes throughout the country. Comparatively, the largest improvement was observed in the opportunities to basic education, but significant improvement was also noted in the

Figure 5: Human Opportunity Index for Basic Education – Brazilian Municipalities




(a) 2000

(b) 2010

access to safe water. Electricity achieved almost universal access among the Brazilian municipalities whereas adequate sanitation still is the country's greatest housing infrastructure bottleneck. Note that these findings are in line with other evidences for Latin America (Barros et al., 2009; Molinas Vega et al., 2012) and Brazil (Dill and Gonçalves, 2013; Ferreira et al., 2017).

## 6 Spatial Association Patterns of Equality of Opportunities in Brazilian Municipalities

So far, the results for the MHOI have shown significant heterogeneity in terms of spatial distribution within Brazil. More specifically, the findings suggest that inequality of opportunity is mainly prevalent in the North and Northeast regions. Yet, a quantitative statistical assessment of potential spatial association patterns is still needed. To this end, Exploratory Spatial Data Analysis (ESDA) is performed. This subsection further analyzes the existence of spatial regimes and spatial clusters in order to draw precise conclusions on the interaction of opportunity inequality among the Brazilian municipalities.

The first step in a spatial analysis is to determine whether there exists any spatial autocorrelation in data. Accordingly, we ask, are opportunities randomly distributed in space? The underlying null hypothesis of spatial randomness is rejected for 2000 and 2010, implying the presence of spatial dependence in the MHOI. In fact, the global Moran's I statistics (Moran, 1948) for the MHOI of both years reported strong positive spatial autocorrelation among the Brazilian municipalities (Table 4).[6] Consequently, there were more municipalities with a high (low) MHOI surrounded by municipalities with a high (low) MHOI than would be the case if opportunities were randomly distributed. These results indicate that equality of multi-dimensional opportunity was spatially clustered within Brazil, which is in consonance with the preliminary assessment of vulnerable children being concentrated in the North and Northeast regions (Figure 1). Yet, the latter positive spatial association slightly decreased during the period considered. Note that these results are highly significant at $p < 0.001$.

The HOI for each basic service also presented positive spatial autocorrelation for both years (Table 4). Despite the decline between 2000 and 2010, basic education and safe water remained as the services with the highest positive global Moran's I statistics. For instance, the global Moran's I for basic education is 0.892

[6]The global Moran's I statistics are based on Queen contiguity weights. However, the results are robust to different contiguity assumptions. These results are available upon request.

in 2000 and 0.890 in 2010, which suggests a rather well-defined spatial polarization pattern in the period. According to these results, as opportunity inequality in neighboring municipalities increases, the likelihood of relatively higher opportunity inequality in their neighbors increases as well. Similarly to the results for the MHOI, the latter ones are also significant at $p < 0.001$.

Table 4: Test of Spatial Autocorrelation for Opportunity Indexes – Global Moran's I

| Opportunity Index | 2000 | | 2010 | |
|---|---|---|---|---|
| | Global Moran's I | $p$-Value | Global Moran's I | $p$-Value |
| Multidimensional | 0.714 | 0.000 | 0.662 | 0.000 |
| Adequate Sanitation | 0.644 | 0.000 | 0.671 | 0.000 |
| Safe Water | 0.794 | 0.000 | 0.762 | 0.000 |
| Electricity | 0.711 | 0.000 | 0.715 | 0.000 |
| Basic Education | 0.892 | 0.000 | 0.890 | 0.000 |

*Notes:* Results computed with the contiguity-based Queen weighting matrix. The term *p-Value* corresponds to the empirical pseudo-significance level, which is based on 999 random permutations.

Although global indicators are compelling tools to evaluate spatial association, they are not capable of identifying potential spatial patterns at the local level, such as local clusters or spatial outliers. First introduced by Anselin (1995), local indicators of spatial autocorrelation (LISA) provide useful information on the matter. The underlying null hypothesis assumes no local spatial association. Consequently, the rejection of the null hypothesis suggests the existence of local clusters (*e.g.* a low value surrounded by low values) or local spatial outliers (*e.g.* a low value surrounded by high values).

Accordingly, the local Moran's I statistics (Anselin, 1995) for the MHOI indicate the presence of spatial grouping among the Brazilian municipalities in both 2000 and 2010 (Figure 6). These results are statistically significant at $p < 0.05$. A North-South polarization is readily evident. In fact, municipalities with high MHOI surrounded by neighbors with high MHOI as well (that is, high-high clusters) were mostly located in the Centre-South region. For instance, the Northern municipality of Espigão d'Oeste, in the state of Rondônia, was the only high-high cluster core located outside the Centre-South region in 2000. In 2010, six municipalities outside the latter region were classified as high-high cluster cores.[7] In general, the number of high-high clusters did not change dramatically during the period. On the other hand, most of the municipality clusters with low MHOI (that is, low-low clusters) were in the North and Northeast regions during the period. Only 10 percent of the low-low municipality clusters were found outside the latter regions in 2000; the figure was around 8 percent in 2010.

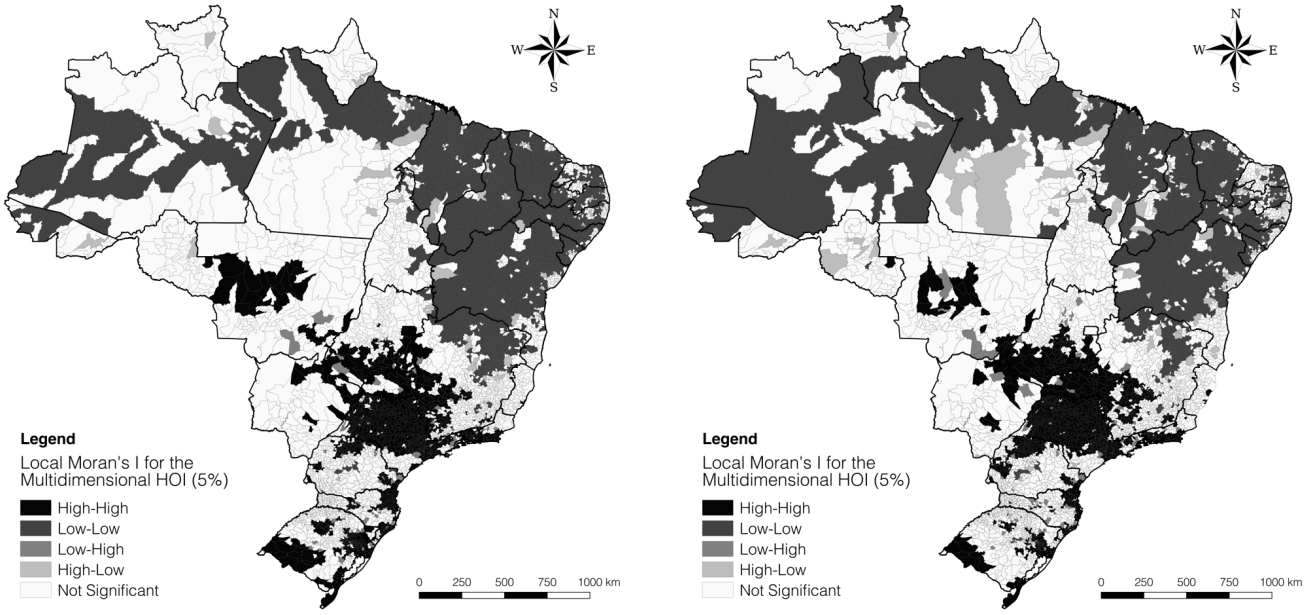
Based upon the above evidences, the spatial segregation regarding the equal access to basic opportunities seems to be intrinsically related to the uneven development of Brazilian regions. As discussed in Smith (1991), the perpetuation of unequal development patterns, coupled with regional economic growth disparities, would reinforce social stratification even further. Governmental efforts toward spatial (re)planning are still imperative in Brazil. In the words of Roemer (2006, p. 243), "*The rate of economic development should be taken to be the rate at which the mean advantage level of the worst-off types grows over time.*" Therefore, in order to promote regional socio-economic development, public policy must be holistically designed as to ensure greater access to basic opportunities to the population of these vulnerable areas.

## 7 Concluding Remarks

Has equality of opportunity recently increased among Brazilian municipalities? Even though the existing literature provides evidences of the overall improvement regarding the access to basic opportunities in Brazil,

[7] The six municipalities are Espigão D'Oeste (state of Rondônia; North), Recife and Paulista (state of Pernambuco; Northeast), Lauro de Freitas and Simões Filho (state of Bahia, Northeast), and Fortaleza (state of Ceará; Northeast). Note that Recife and Fortaleza are the state capitals.

Figure 6: Local Moran's I for the MHOI – Brazilian Municipalities




(a) 2000 (b) 2010

analyzes at the regional level are rather scarce. In this paper, we evaluate the degree of opportunity inequality in the Brazilian municipalities concerning the access to adequate sanitation, safe water, electricity and basic education by children under 16 years of age. Specifically, we compute a multidimensional version of the Human Opportunity Index for the Brazilian municipalities, in which the simultaneous access to the basic services is used as the criterion to define whether a child is socially disadvantaged or not. The obtained results suggest that Brazil considerably improved its fairness in terms of equality of opportunity between 2000 and 2010. Yet, access to proper sanitation facilities and safe water remained as severe housing infrastructure bottlenecks. With regard to the influence of circumstances, whether a child lives in a rural or urban area was found to be the most important source of opportunity inequality within Brazilian municipalities, followed by *per capita* income and the presence of literate household head. These results are in line with recent studies for Latin America.

Visual inspection provided preliminary evidences that opportunities were heterogeneously distributed in space, with the Northern and Northeastern municipalities reporting the worst results for the Multidimensional Human Opportunity Index. In order to statistically assess the spatial distribution of opportunities within Brazil, Exploratory Spatial Data Analysis is performed. Based on the global Moran's I, we found evidences of positive spatial autocorrelation for both 2000 and 2010 indexes. Furthermore, local Moran's I estimates indicate the presence of a North-South polarization, with high-high clusters located in the Centre-South region and low-low clusters located in the North and Northeast regions. More specifically, given that the number of spatial clusters with below-average equality of opportunities increased in the North region during the period (especially in the states of Amazonas and Pará), these findings suggest the intensification of diffusion effects within the area.

As the spatial heterogeneity in the distribution of equal opportunities among the Brazilian municipalities is linked to their rather uneven development process, public policy is to be holistically designed and then conducted as to reduce regional disparities. Only by effectively targeting children in vulnerable circumstance groups will Brazil be able to lead advances in reducing inequalities among its population.

## References

Anselin, L. (1995), 'Local Indicators of Spatial Association – LISA', *Geographical Analysis* **27**(2), 93–115.

Arneson, R. (1989), 'Equality and Equal Opportunity for Welfare', *Philosophical Studies* **56**(1), 77–93.

Barros, R. P. (2001), 'A Dynamic Analysis of Household Decision-Making: The Brazilian Case', IDB Research Network Working Paper, Vol. 417. Inter-American Development Bank (IDB), Washington DC.

Barros, R. P., Ferreira, F. H. G., Molinas Vega, J. R. and Saavedra Chanduvi, J. (2009), *Measuring Inequality of Opportunities in Latin America and the Caribbean*, 1 edn, World Bank Publications, Washington DC.

Barros, R. P., Molinas Vega, J. R. and Saavedra Chanduvi, J. (2008), 'Measuring Inequality of Opportunities for Children', Discussion Paper. World Bank, Washington, D.C.

Beltrão, K. I. and Alves, J. E. D. (2009), 'A Reversão do Hiato de Gênero na Educação Brasileira no Século XX', *Cadernos de Pesquisa* **39**(136), 125–156.

Bezerra, P. B. S., Callegari, C. L., Ribas, A., Lucena, A. F. P., Portugal-Pereira, J., Koberle, A., Szklo, A. and Schaeffer, R. (2017), 'The power of light: socio-economic and environmental implications of a rural electrification program in Brazil', *Environmental Research Letters* **12**(9), 1–14.

Bourguignon, F., Ferreira, F. H. G. and Menéndez, M. (2007), 'Inequality of Opportunity in Brazil', *Review of Income and Wealth* **53**(4), 585–618.

Bruns, B., Evans, D. and Luque, J. (2012), *Achieving World-Class Education in Brazil: The Next Agenda*, World Bank Publications, Washington DC.

Checchi, D. and Peragine, V. (2010), 'Inequality of Opportunity in Italy', *Journal of Economic Inequality* **8**(4), 429–450.

Coelho, S. T. and Goldemberg, J. (2013), 'Energy Access: Lessons Learned in Brazil and Perspectives for Replication in Other Developing Countries', *Energy Policy* **61**, 1088–1096.

Cohen, G. A. (1989), 'On The Currency of Egalitarian Justice', *Ethics* **99**(4), 906–944.

Dill, H. C. and Gonçalves, F. O. (2012), 'Índice de Oportunidade no Brasil entre 1999 e 2009: Estimação e Decomposição através do Valor de Shapley', *Pesquisa e Planejamento Econômico* **42**(2), 187–210.

Dill, H. C. and Gonçalves, F. O. (2013), 'Igualdade de Oportunidade Entre os Estados Brasileiros: Uma Análise Microeconométrica com Base nos Dados da PNAD 2009', *Nova Economia* **23**(2), 307–328.

Dworkin, R. (1981*a*), 'What is Equality? Part 1: Equality of Welfare', *Philosophy & Public Affairs* **10**(3), 185–246.

Dworkin, R. (1981*b*), 'What is Equality? Part 2: Equality of Resources', *Philosophy & Public Affairs* **10**(4), 283–345.

Ferreira, D., Diniz, G. M., Oliveira, V. R. and Gonçalves, F. O. (2017), 'Igualdade de Oportunidades: Uma Análise Espacial para os Municípios Brasileiros a partir do Censo de 2010', *Ensaios FEE* **38**(1), 75–106.

Ferreira, F. H. G., Lanjouw, P. and Neri, M. (2003), 'A Robust Poverty Profile for Brazil Using Multiple Data Sources', *Revista Brasileira de Economia* **57**(1), 59–92.

Figueiredo, E. A. and Silva, C. R. F. (2012), 'Desigualdade de oportunidades no Brasil: uma decomposição quantílica contrafactual', *Pesquisa e Planejamento Econômico* **42**(1), 29–48.

Figueiredo, E. A. and Ziegelmann, F. A. (2010), 'Estimation of opportunity inequality in Brazil using nonparametric local logistic regression', *Journal of Development Studies* **46**(9), 1593–1606.

Gandelman, N. (2009), 'Female Headed Households and Homeownership in Latin America', *Housing Studies* **24**(4), 525–549.

Gómez, M. F. and Silveira, S. (2010), 'Rural electrification of the Brazilian Amazon: Achievements and Lessons', *Energy Policy* **38**(10), 6251–6260.

Haussmann, S. and Golgher, A. B. (2016), 'Shrinking Gender Wage Gaps in the Brazilian Labor Market: An Application of the APC Approach', *Nova Economia* **26**(2), 429–464.

Islam, T. M. T. and Mitra, S. (2017), 'Multidimensional Human Opportunity Index', *Social Indicators Research* **130**(2), 523–535.

Lefranc, A., Pistolesi, N. and Trannoy, A. (2008), 'Inequality of Opportunities vs. Inequality of Outcomes: Are Western Societies All Alike?', *Review of Income and Wealth* **54**(4), 513–546.

Molinas Vega, J. R., Barros, R. P., Saavedra Chanduvi, J., Giugale, M., Cord, L. J., Pessino, C. and Hasan, A. (2012), *Do Our Children Have a Chance? A Human Opportunity Report for Latin America and the Caribbean*, 1 edn, World Bank Publications, Washington DC.

Moran, P. A. P. (1948), 'The Interpretation of Statistical Maps', *Journal of the Royal Statistical Society: Series B (Methodological)* **10**(2), 243–251.

Oliveira, J. B. A. (2004), Expansion and Inequality in Brazilian Education, *in* C. Brock and S. Schwartzman, eds, 'The Challenges of Education in Brazil', Triangle Journals, Oxford, pp. 41–60.

Pistolesi, N. (2009), 'Inequality of Opportunity in the Land of Opportunities, 1968–2001', *Journal of Economic Inequality* **7**(4), 411–433.

Ramos, X. and Van de Gaer, D. (2012), 'Empirical Approaches to Inequality of Opportunity: Principles, Measures and Evidence', IZA Discussion Paper, No. 6672. The Institute for the Study of Labor (IZA), Bonn.

Rawls, J. (1971), *A Theory of Justice*, 1 edn, Harvard University Press, Cambridge.

Roemer, J. (1993), 'A Pragmatic Theory of Responsibility for the Egalitarian Planner', *Philosophy & Public Affairs* **22**(2), 146–166.

Roemer, J. (1998), *Equality of Opportunity*, 1 edn, Harvard University Press, Cambridge.

Roemer, J. (2006), 'Review Essay: The 2006 World Development Report: Equity and Development', *Journal of Economic Inequality* **4**(2), 233–244.

Sen, A. K. (1976), 'Real National Income', *Review of Economic Studies* **43**(1), 19–39.

Sen, A. K. (1979), Equality of What?, *in* S. McMurrin, ed., 'The Tanner Lectures on Human Values', University of Utah Press, pp. 197–220.

Sen, A. K. (1993), Capability and Well-Being, *in* M. Nussbaum and A. Sen, eds, 'The Quality of Life', Clarendon Press, pp. 30–53.

Sen, A. K. (2009), *The Idea of Justice*, 1 edn, Belknap, Cambridge.

Smith, N. (1991), *Uneven Development: Nature, Capital, and the Production of Space*, Blackwell Press, Oxford.

Stampini, M., Robles, M., Sáenz, M., Ibarrarán, P. and Medellín, N. (2016), 'Poverty, Vulnerability and the Middle Class in Latin America', *Latin American Economic Review* **25**(4), 1–44.

Toneto Junior, R. and Saiani, C. C. S. (2006), 'Restrições à expansão dos investimentos no saneamento básico brasileiro', *Revista Econômica do Nordeste* **37**(4), 572–591.