UNIVERSIDADE FEDERAL DO PARANÁ

KARINA SIMONE SASS

TWO ESSAYS ON URBAN SPRAWL AND PROVISION OF PUBLIC GOODS BY LOCAL GOVERNMENTS

CURITIBA

2017

KARINA SIMONE SASS

TWO ESSAYS ON URBAN SPRAWL AND THE PROVISION OF PUBLIC GOODS BY LOCAL GOVERNMENTS

Dissertação apresentada como requisito parcial à obtenção do grau de Mestre em Desenvolvimento Econômico, no Curso de Pós-Graduação em Desenvolvimento Econômico, Setor de Ciências Sociais Aplicadas, da Universidade Federal do Paraná.

Orientador: Prof. Dr. Alexandre Alves Porsse.

CURITIBA

2017

MINISTÉRIO DA EDUCAÇÃO
UNIVERSIDADE FEDERAL DO PARANÁ
PRÓ-REITORIA DE PESQUISA E PÓS-GRADUAÇÃO
Setor CIÊNCIAS SOCIAIS APLICADAS
Programa de Pós-Graduação DESENVOLVIMENTO ECONÔMICO

TERMO DE APROVAÇÃO

Os membros da Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação em DESENVOLVIMENTO ECONÔMICO da Universidade Federal do Paraná foram convocados para realizar a arguição da dissertação de Mestrado de **KARINA SIMONE SASS** intitulada: **Two Essays on Urban Sprawl and Provision of Public Goods by Local Governments**, após terem inquirido a aluna e realizado a avaliação do trabalho, são de parecer pela sua APROVAÇÃO.

Curitiba, 28 de Março de 2017.

ALEXANDRE ALVES PORSSE
Presidente da Banca Examinadora (UFPR)

CARLOS ROBERTO AZZONI
Avaliador Externo (USP)

TERCIANE SABADINI CARVALHO
Avaliador Externo ()

AGRADECIMENTOS

Á Universidade Federal do Paraná (UFPR), por toda a formação e oportunidades proporcionadas ao longo de toda minha vida acadêmica e profissional.

Ao meu orientador, Prof. Dr. Alexandre Alves Porsse, pelo acompanhamento e dedicação ímpar não apenas no desenvolvimento deste trabalho, mas em todos os outros desenvolvidos ao logo dos dois anos de mestrado.

Aos meus amigos pelo suporte e incentivo durante o mestrado, em especial ao Otávio e ao Jeulliano, que há muito tempo me acompanham.

Aos professores e funcionários do PPGDE/UFPR pelo suporte técnico e acadêmico.

Aos membros da banca de dissertação, Prof. Dr. Carlos Roberto Azzoni e Profa. Dra. Terciane Sabadini Carvalho, pela disponibilidade em participar e pelas sugestões de melhorias dadas ao trabalho.

Á Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), pelo apoio financeiro.

RESUMO

Esta dissertação é composta por dois ensaios sobre o fenômeno *urban sprawl* nas cidades brasileiras. O primeiro ensaio tem como objetivo investigar o fenômeno *urban sprawl* em grandes e médias cidades no Brasil. A investigação emprega dois índices para medir o *urban sprawl*, o coeficiente de variação e o índice gravitacional. Para avaliar a relação entre desigualdade de renda e pobreza e *urban sprawl*, o índice gravitacional é calculado com base em dados da população geral classificada em três classes de renda. Os resultados revelam que o *urban sprawl* é um fenômeno comum nas maiores cidades do Brasil e afeta principalmente as pessoas com maior vulnerabilidade social. O segundo ensaio examina os efeitos do *urban sprawl* sobre o custo da prestação de serviços públicos nas cidades brasileiras. A análise se baseia nas cidades pertencentes a médias e altas concentrações urbanas e utiliza modelos econométricos espaciais para avaliar o gasto municipal agregado e nove itens de gastos municipais desagregados (administração, saneamento básico, cultura, gestão ambiental, habitação, polícia local, assistência social, esportes e lazer e infraestrutura urbana). Os resultados fornecem evidências de que a expansão urbana afeta positivamente o custo per capita de prestação de serviços públicos locais de cidades de alta concentração urbana.

Palavras-chave: Urban sprawl. Brasil. Finanças públicas municipais.

ABSTRACT

This dissertation consists of two essays about the phenomenon of urban sprawl in Brazilian cities. The first essay aims to investigate the phenomenon of urban sprawl in big and medium cities in Brazil. The investigation employs two indexes to measure urban sprawl, the coefficient of variation and the gravitational index. In order to evaluate the relation between income inequality and poverty and urban sprawl, the gravitational index is calculated by using data from the overall population classified into three income classes. The results reveal that urban sprawl is a common phenomenon in the biggest cities in Brazil and it affects mainly the more disadvantaged people. The second essay examines the effects of urban sprawl on the cost of providing public services in Brazilian cities. The analysis is based on the cities belonging to medium and high urban concentrations and uses spatial econometric models do evaluate one aggregate and nine disaggregate items of local spending (administration, basic sanitation, culture, environmental management, housing, local police, social assistance, sports and leisure, and urban infrastructure). The results provide evidences that the urban sprawl positively affects the per capita cost of provision of local public services of cities from high urban concentration.

Key-words: Urban sprawl. Brazil. Local public finance.

CONTENTS

1 MEASURING AND ASSESSING URBAN SPRAWL IN BRAZIL

1.1 INTRODUCTION

Growth patterns of cities have been for a long time object of analysis due to its effects on the environment and on the welfare of the population. Recently, a considerable literature has grown up around the theme of a specific urban growth pattern: the urban sprawl phenomenon.

The phenomenon of urban sprawl, often referred to as suburbanization, started at the end of the industrial era, and it has continued since throughout the world. It can be defined as a low-density, discontinuous and suburban style development, characterized by a fast, unplanned and uncoordinated growth; and it is found mainly in open, rural lands on the edge of metropolitan areas (FRENKEL; ASHKENAZI, 2008).

Population growth is one of the main causes of the urban sprawl because cities need to expand to accommodate new residents (HORTAS-RICO, 2014). Sprawl also occurs as a consequence of the fragmentation of control over land use in metropolitan areas. Harvey and Clark (1965) affirm that the rapid expansion of the economic base of a housing area tends to prompt many developers to respond to the demand for housing and produce a variety of discontinuous unrelated developments. The faster the rate of growth of an area and the greater the number of business firms operating in the housing area, the greater the number of fragmentation randomly located projects (HARVEY; CLARK, 1965).

In developing countries, another factor can be considered as a determinant of urban sprawl: the necessity of people move to the city in search of better employment and opportunities. For Bekele (2005), increased urban population leads to an increase in size well beyond the limits of the city. When the cities are not expanding, the people are forced to live in informal settlements.

The phenomenon of urban sprawl usually has a negative connotation due to its consequences to the environment. In a city, the urban sprawl can reduce farmland and open spaces, increases the consumption of water and energy, and increases the trip lengths, the congestion, and the air pollution (HORTAS-RICO, 2014). Sprawl also reduces social interactions and contributes to socioeconomic segregation between the ones living in the suburbs and the others who live inner city (BEKELE, 2005).

Carruthers and Úlfarsson (2003) argue that the discussion of the urban sprawl and its effects is important because it provides a practical point of departure for debates over the role that government should play in regulating the outcomes of urban growth. Many studies have been conducted to identify and measure the sprawling degree of a city and its consequences. Ewing, Pendall and Chen (2002), Gaslter et al. (2001), Brueckner and Kin (2003), Carruthers and Úlfarsson (2003), Yue, Liu and Fan (2013) and Hortas-Rico (2014) are examples of studies about urban sprawl.

Up to now, far too little attention has been paid to the urban sprawl in Latin America. Although it occurs in different forms in these countries, the phenomenon of urban sprawl is an important issue for Latin America because urbanization matters are straight linked with the economic development and social welfares.

This essay aims to analyses the pattern of urban sprawl in the big and the medium Brazilian cities. Historically, population has grown quickly in big cities as consequence of industrialization and rural-urban migration and over the last three decades population also has grown quickly in medium cities in Brazil. In order to measure the degree of sprawling, two indexes are calculated from population data disaggregated by census tract for 2010: the coefficient of variation of the urban population density (CV) and the gravitational index (GI). The CV indicates how dispersed the population is across space into the city and the GI measures how concentrated the population is in terms of mass density calculated from the center of the city. Additionally, seeking to analyze the relation between urban sprawl and income inequality, the GI is also calculated considering three different groups of people classified accordingly their level of income. This analysis highlights some important results and policy implications related to the phenomenon of urban sprawl in Brazil.

The discussion is organized in four sections. Section 1.2 gives a brief overview about the urbanization process of Brazilian cities. Section 1.3 presents the methodology and the data used in this study. Section 1.4 explores the results and Section 1.5 raises some policy implications.

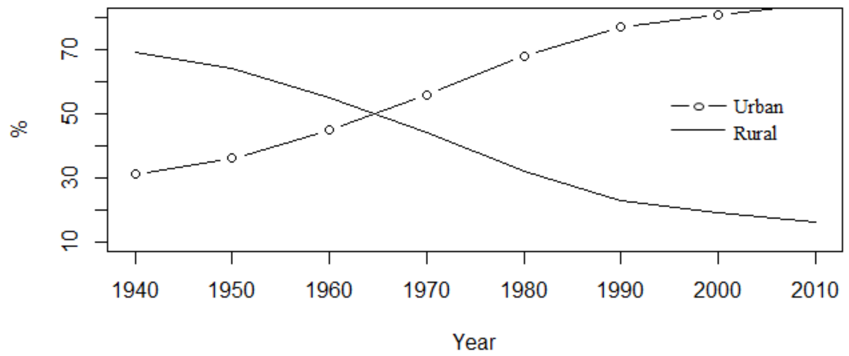
1.2 AN OVERVIEW OF THE BRAZILIAN URBANIZATION

1.2.1 The urbanization process

The Brazilian urbanization process is recent compared to the process of the developed countries. The cities started to grow only from the beginning of the 20^{th} century.

This growth was driven by the expansion of the industry, which was still incipient and dependent on the agriculture revenues and on the internal demand. Moreover, the industrial expansion in the urban areas was responsible for the rural exodus which increased after 1940. As can be seen in FIGURE 1.1, in 1940 only 30 percent of the population lived in the urban area, but twenty years later the percentage was 50 percent, and in 2010 the percentage was higher than 80 percent. Accordingly to Ojima and Homan (2009), the urban transition within the middle of the twentieth century was characterized by the long distance migration, particularly the northeast-southeast flow. Today the urban-urban migration prevails within the spatial mobility.

FIGURE 1.1 - COMPOSITION OF POPULATION IN BRAZIL, 1940-2010



SOURCE: IBGE (2016).

The urban population was distributed in different regions, mainly in coastal cities and in the southeastern Brazil. Accordingly to Brito, Horta, and Amaral (2001), the state capitals of these regions centralized the main public services, the commercial and financial intermediation of the regional economic activities and the services related to international trade. Until the 80s, the urban population was deeply concentrated in big cities, especially the ones with more than 500 thousand inhabitants. After the 80s, the cities with a population of 100 to 500 thousand inhabitants, also called medium cities or regional centers, started to grow faster than the cities with more than 500 thousand inhabitants (BRITO; HORTA; AMARAL, 2001). The expansion of the medium cities was led by the improvements of transport and communication infrastructure that occurred in the 60s and the 70s (SANTOS, 1988).

The growing of the urban concentration promoted the creation of Metropolitan Areas (MAs) in 1973/74. “The MAs were legally constituted with the objective of promoting integrated planning and common services of metropolitan interests, under the aegis of the federal government” (OJIMA; HOMAN, 2009). At first, nine MAs were created: Belém, Belo Horizonte, Curitiba, Fortaleza, Porto Alegre, Recife, Salvador, São Paulo and Rio de Janeiro. In 1988 the number of MAs increased to 26 with the proclamation of the Federal Constitution of 1988. Nowadays, there are 70 MAs in Brazil, however, this high number is not a reflection of the metropolitanization process, it reflects the amendment in the political-administrative process of creation of metropolitan areas.

The 26 MAs with over one million inhabitants have 94.2 million inhabitants, and they represent 45.7 percent of the overall population of Brazil (IBGE, 2016). The rise of the population in those regions occurred in an unplanned manner across the urban space of the cities and gave rise to numerous social and structural problems which still stand nowadays. Lack of appropriate urban structure, poor urban services, higher levels of congestion and pollution as well racial and social segregations are examples of such problems.

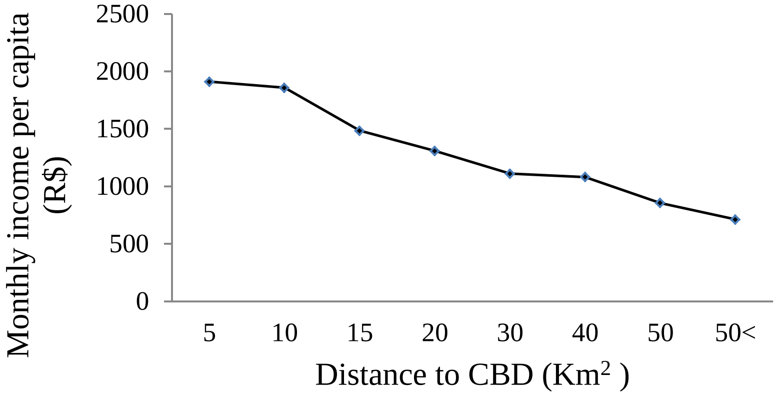
1.2.2 Urban sprawl in Brazil

In the US, urban sprawl refers to the suburban developing process that occurred after the Word War II. It was characterized by heavy migration of medium and high-income white people to the suburbs (BADASSARE, 1986). In Brazil, otherwise, the phenomenon of urban sprawl has a different form: it is driven by two kinds of urban occupation, the unregulated occupation and the occupation by social housing interest and low-cost housing projects (POLIDORO; LOLLO; BARROS, 2012). New housing lots located far removed from the city center were recently created by the local or the federal administration or by public or private companies for low-cost housing projects. These occupations model harm mainly lower-income population since they live in areas located far from the city center, where shopping, services and jobs are concentrated (POLIDORO; LOLLO; BARROS, 2012).

The relation between income and location of residence can be seen in FIGURE 1.2, as the distance to the CBD increase the income of the population falls. This evidence suggests that the urban sprawl in Brazil is straight linked with social and economic issues.

Few studies have dedicated attention to the urban sprawl phenomena in Brazil. Ojima and Hogan (2009) created a sprawl index to identify this process in the Brazilian agglomerations. The index was built based on a set of sprawl factors identified in the international literature as an important measure of sprawl like-situations. The authors showed that the most dispersed areas were found in the south-southeast portion of the country and the urban agglomerations located in the north and northeast were all among the most compact. Other two related studies explored this phenomenon considering the relation between urban sprawl and migration and the environment (TORRES, 2001) and for the specific case of city of Londrina (POLIDORO; LOLLO; BARROS, 2012).

FIGURE 1.2 - RELATION BETWEEN INCOME AND DISTANCE DO CBD FOR THE 26 BIGGEST URBAN CONCENTRATIONS



SOURCE: Author’s own elaboration with data from IBGE (2010).

Thus, the evaluation of urban sprawl in Brazil as well its causes and consequences is a subject still open to be properly explored. This essay proposes to apply to measure this phenomenon based on dispersion and gravity indexes calculated using population data by census tract and use the results achieved to subside the discussion about urban policies.

1.3 MEASURING URBAN SPRAWL IN BRAZIL

Measuring urban sprawl empirically is a highly challenging and complex undertaken because it can assume a variety of forms.

Accordingly to Frenkel and Ashkinazi (2008), the most suggested sprawl measures in the literature can be divided into five major groups: growth rates, density, spatial-geometry, accessibility, and aesthetic measures. A short description of each one of these groups follows:

1. Growth rates: urban sprawl is defined as a condition in which population growth rates in the suburbs are higher than in the central city (FRENKEL; ASHKINAZI, 2008).

2. Urban population density: is the ratio between the number of residents in a city and the urban area occupied. Urban sprawl is defined as a condition in which density is relatively low or decreases during a certain period (FRENKEL; ASHKINAZI, 2008). Population density is the most common measure of urban sprawl because it is simple and easily available. But population density is not a good measure of sprawl; it cannot capture how distributed a population is into the urban space. For example, two cities can have the same urban population density, but in one of them the population is concentrated and in another one is sprawled.

3. Spatial-geometry: it measures two components of the urban space: configuration and composition. An urban area will be considered sprawling as long as its geometric configuration is irregular, scattered, fragmented, and its land-use composition is more homogeneous and segregated (FRENKEL; ASHKINAZI, 2008). Landscape metrics created with geographic information systems (GIS) are the most used indexes by researchers who considered the spatial-geometry the best measure of sprawl.

4. Accessibility: sprawl is defined as a condition of poor accessibility, followed by the massive use of private vehicles (FRENKEL; ASHKINAZI, 2008).

5. Aesthetic measures: it is a subjective measure and can be defined as residential sprawl or strip-malls sprawl, and to compare various landscapes to those archetypes (FRENKEL; ASHKINAZI, 2008).

In general, researchers choose the measure of sprawl according to the definition of sprawl they are considering and to data availability.

Galster et al. (2001) present a complete guide for measuring urban sprawl. They created a range of eight distinct, objective dimensions of land use that, if present at low values and in some combination, characterize sprawl. The dimensions are density, continuity, concentration, clustering, centrality, nuclearity, mixed uses, and proximity.

1.3.1 Metodology

In this study, urban sprawl is considered as a low-density growth pattern characterized by the excessive and continuous spatial expansion throughout the borders of a city. The measures of the sprawl of the Brazilian cities are built considering the dimensions of concentration and centrality suggested by Gaslter et al. (2001).

Concentration

Concentration is the degree to which housing units are disproportionately located in relatively few areas or spread evenly in the urbanized area rather than spread evenly throughout (GALSTER et al., 2001).

The concentration dimension is one alternative for the density, the most used measure of urban sprawl. The density dimension (the ratio of the population to the area of a city) does not show how the population is distributed in the urban area. The concentration dimension identifies the urban areas in which most population is located comparatively in few places at high densities and the areas which the development is more evenly distributed across the urban area.

The coefficient of variation (CV) is the selected measure to capture the concentration dimension of the urban sprawl in Brazil. The CV is defined as the ratio of the standard deviation to the mean of the urban population density. It shows the extent of variability in relation to the mean of the population. Additionally, the CV is a good measure of the phenomenon of urban sprawl because it shows how the population is dispersed in the urban space. The bigger the coefficient the more sprawled the population will be.

$$\mathrm{CV} = \frac{Sd_i}{\mathrm{Me}_i} \tag{1.1}$$

Sd_i= Standard deviation of the urban population density of municipally *i*

Me_i= Mean of the urban population density of municipally *i*

Centrality

Centrality is the degree to which observations of a given land use are located near the Central Business District (CBD) (GASLTER et al., 2001), usually defined as the city centers. Considering the urban monocentric model formulated by Alonso (1964), Muth (1969) and Mills (1967), the population density (people per acre) is higher at the CBD than in the suburbs, thus measuring the concentration around the CBD could be a better indicator about the sprawling degree of the city.

Decentralized urban areas refer to the extent to which development has diffused across the landscape from the historic core or CBD of an urban area. An area will exhibit greater sprawl where greater distances from the center are required to contain the same proportion of development (GASLTER et al., 2001).

Galster et al. (2001) used the inverse of the sum of the distance of each observation to the center as a measure of centrality. However, Campante and Do (2009) pointed out that this approach does not cover the properties of decomposability and additivity, which are desirable for empirical applications. In response to these limitations, Campante and Do (2009) offered an index to measure the concentration around a specific point of interest, the index was called centered index of spatial concentration (CICS). The CICS is typically used to measure the concentration around capital cities. In the context of urban sprawl, it measures how concentrated the population is at the city center (CBD) and it captures the dimension of centrality.

The CICS index proposed by Campante and Do (2009) is based on basic and refinement axioms that together guarantee the applicability of the index. The basic axioms are decomposability and monotonicity. The property of decomposability assures that the index could be decomposed into the measures obtained from any regions into which space is partitioned (CANPANTE; DO, 2009). By the property of monotonicity, the index should increase when individual observations are moved closer to the point of interest to which the index refers (CANPANTE; DO, 2009). The refinement axioms are: order preservation (the index is invariant to the unit of measure); convexity (the movement of individual observations has a greater marginal impact on the measure of concentration the closer the observations are to the capital); and local Monotonicity (the index must not decrease when a uniform group of individuals moves closer to each other) (CAMPANTE; DO, 2009).

These axioms define a class of centered index of spatial concentration in the Euclidian space:

$$I(\mu, C) = \int h(|x - C|)d\mu \tag{1.2}$$

C being the center of interest, in the empirical analysis, it is represented by the city core located at the central area.

μ being the distribution of the population,

and h(d) = (|x-C|) is a decreasing function of distance (d) with constant coefficient of relative risk aversion.

The central point for empirical applications of the CICS is the choice of the impact function, h(x). For the plan $\mathbb{R}^2$, Campante and Do (2009) suggested the function h(d)=αlog(d)+β. The log function incorporates the property of gravity: for any point T, situated at distance d from the point of interest C, the CICS does not change when a uniform subdistribution over a circumference centered at T is squeezed around that point (CAMPANTE, DO;2009). The property of gravity is important because it separates the impact of the central point of interest from possible local impacts of other points. Considering that the population is symmetrically distributed within each unit of analysis, the property of gravity also allows that population to be represented as a mass point, which guarantees the practical implementation of the index.

In order to shape the CICS according to the population size and the area of the city, and to present an easily interpretable scale, it is reasonable to normalize the index. The most simple way is to express the index with the [0, 1] interval, with 0 representing the minimum concentration and 1 the maximum concentration.

Normalizing the index requires two procedures, as described by Campante and Do (2009):

1- Dividing the μ by population size, and
2- Setting

$$(\alpha, \beta) = \left(-\frac{1}{\log(\bar{d})}, 1\right) \tag{1.3}$$

Where $\bar{d} = \max|x - C|$ is the maximum distance between a point and the center of the city.

The empirical application of the CICS for the Brazilian case assumes the log function and the normalization procedures, both suggested by Campante and Do (2009). As the index is based on the gravity property, the index calculated for the Brazilian cities and analyzed in the following sections will be named Gravitational Urban Sprawl Index (GI).

1.3.2 Operationalization

The measures of urban sprawl proposed for the Brazilian cities are calculated by using data from the census tract of each city. These data are provided by the demographic census of 2010 realized by the Brazilian National Bureau of Statistics (IBGE).

The census tract is the territorial unit of data collection control, it is made up of contiguous areas and it respects the political and administrative division of others territorial structures of analysis. The census tracts are also classified into rural and urban tracts. In this analysis, only the urban census tract is selected.

The calculus of the CV requires information about the mean and the standard deviation of the urban population density (UPD) of each city of the analysis. The UPD is measured by the ratio of the total resident population and the area of the census tract. The area is estimated by using the shapefile provided by IBGE and by using a Geographic Information System (GIS)[1].

The calculation of GI demands the definition of the central point of interest, or the CBD of each city, and the estimation of the distance between each census tract to the CBD. The CBDs are taken from a shapefile (IBGE) which contain the main point of each city in Brazil; these points usually are located at the historical core and represent the city hall.The distance is calculated by using the tools centroid of a polygon and matrix of distance from the

[1] The software used was QGIS.

software Qgis. FIGURE 1.3 shows the procedure adopted, the distance is calculated from each centroid to the CBD.

FIGURE 1.3 - CALCULUS OF THE DISTANCE TO THE CBD

SOURCE: Author's own elaboration.

Four GIs are estimated for each municipality in the sample. The first one expresses the concentration around the CBD of the total resident population of the census tract. The other three show the concentration of the population classified into three income groups as follow:

- Low-income: 10 years old or older people who earn from zero to two minimum wages[2].
- Median-income: 10 years old or older people who earn from two to ten minimum wages.
- High-income: 10 years old or older people who earn who earn more than ten minimum wages.

This approach aims to identify the social characteristic of the urban sprawl in Brazil. Despite heterogeneity of residents in terms of income is recognized by theoretical literature on spatial urban distribution, to the best of our knowledge this is the first study that measures urban sprawl in Brazil considering income heterogeneity of residents.

1.3.3 Sample

The selection of the cities for the analysis was based on the definition of population arrangement settled by IBGE (2015). A population arrangement is a group of two or more municipalities with strong population integration due to commuting movements to work or study, or due to the contiguity between the main urban spots. There were 294 population

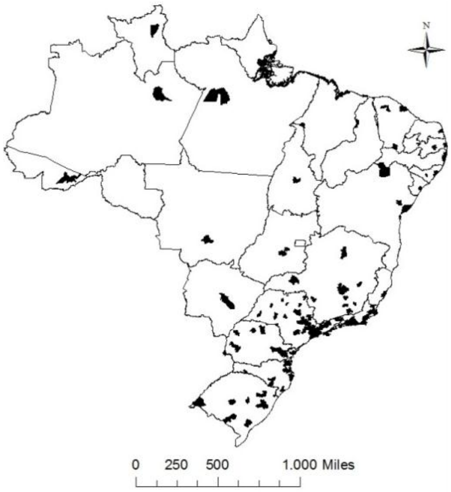
[2] A minimum wage in Brazil in 2016 was approximately US$ 245 per month.

arrangements in Brazil in 2010 composed of 938 municipalities which population represents 55.9% of the overall Brazilian population (IBGE, 2015).

The population arrangements are also classified into some groups according to their population size. Population arrangements with population from 100,000 to 750,000 inhabitants are called medium urban concentrations, and population arrangements or isolated municipality with more than 750,000 inhabitants are called high urban concentration. Each urban concentration has a main city that centralizes the substantial part of the population and jobs of the population arrangement.

Many arrangements have cities with a small population or a reduced urban area, for this reason, only the central cities of the urban high and medium concentration with more than 100,000 inhabitants were selected in this study to calculate the urban sprawl indexes. Thus, the sample has 26 central cities that belong to high urban concentrations and 79 central cities of medium urban concentrations. FIGURE 1.4 shows the locations of the cities across the country, the selected cities are represented by the points on the map. As can be seen, a high proportion of the cities belong to the south and southeast regions.

FIGURE 1.4 - SAMPLE OF CITIES USED IN THE STUDY



SOURCE: author's own elaboration. Shapefile is from IBGE (2010).

1.4 RESULTS AND DISCUSSION

TABLE 1.1 presents the urban population density and the urban sprawl indexes for the 26 municipalities belonging to high urban concentration. Summarily, the data show that these cities are dense and have a high degree of urban sprawl.

The CV shows the population dispersion in the urban area, a coefficient higher than 0.3 indicates higher dispersion in the space. It can be seen from the data in Table 1.1 that all the cities in the group of high urban concentration have a CV higher than 0.6, which means that in all of these cities, the distribution of the population is not homogeneous. São Luis (MA), Florianópolis (SC), Rio de Janeiro (RJ) and São Paulo (SP) are the cities with the most unequal population distribution. It is interesting to note that most of cities with the highest CV are in the south and southeast regions, the most populous and developed regions of the country.

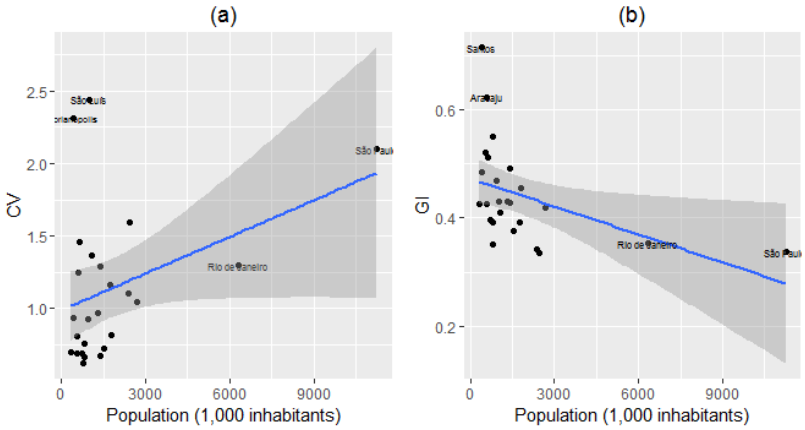
Regarding the index of centrality (GI total), it indicates that in Brazilian biggest cities the population tends to live far from the central area. The average GI is 0.435, and the most sprawled cities are Brasília, Fortaleza and São Paulo. On the other hand, the most compact cities are Santos and Aracaju. The regional differences are less intense concerning to the GI total, the most sprawled cities are located in the south, southeast and northeast regions.

The population size can be one of the factors behind the sprawling degree. FIGURES 1.5(a) and 1.5(b) show the best fit curve of data of the urban sprawl measures (CV and GI) and the population size of the cities of high urban concentration. As can be seen, there is a positive relation between the degree of urban sprawl and the population size. The bigger the population the less concentrated it is (see CV); and the bigger the population the less centralized it is (see GI). This evidence is in line with the monocentric city model: as the population grows it demands more housing, especially in the developed areas close to the city center, consequently, the housing prices increase and force the low-income population to move to the suburbs, where the housing prices are lower. Rio de Janeiro and São Paulo, for example, the two biggest cities of Brazil, have a high degree of dispersion.

The Figure 1.5 (a) and (b) also shows that the physical characteristics of some cities can influence the dispersion of the population across the urban space. The cities with the highest CV (São Luís and Florianópolis) are limited by the ocean and this fact can interfere on the dispersion of the population. On the other hand, the most compact cities (according to the GI) are Santos and Aracaju, two coastal cities in which the concentration degree can also be a consequence of the physical characteristics. The impact of the physical aspects on the concentration of the population will be evaluated in the future research agenda of this study.

Turning now to the results on the GI calculated for each income class, they confirm the information presented by FIGURE 1.2. The low-income population tends to live towards the edge of the city and, consequently, the high-income population is more concentrated close to the central area. This pattern is present in practically all cities in high urban concentration.

FIGURE 1.5 - URBAN SPRAWL AND POPULATION SIZE FOR CITIES WITH HIGH URBAN CONCENTRATION



SOURCE: author's own elaboration.

TABLE 1.1 - URBAN SPRAWL INDEXES- HIGH URBAN CONCENTRATION

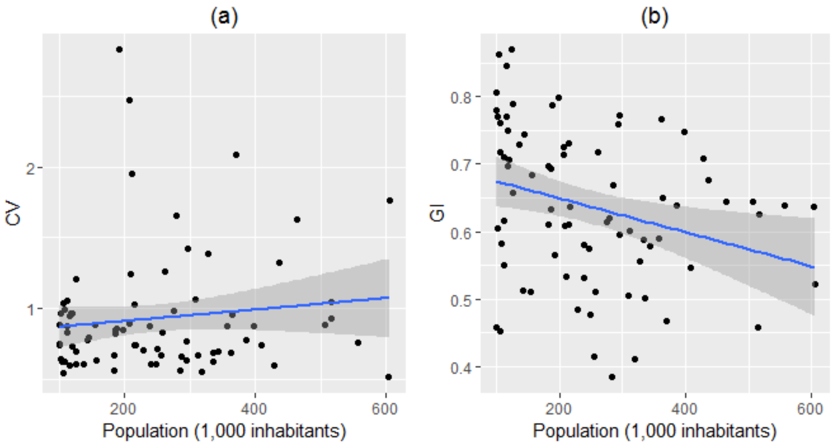
CITY	URBAN POPULATION DENSITY (POPULATION/KM^2)	CV	GI TOTAL	GI LOW-INCOME	GI MEDIUM-INCOME	GI HIGH-INCOME
Mean	**4015.476**	**1.134**	**0.435**	**0.422**	**0.482**	**0.555**
São Paulo (SP)	11301.821	2.097	0.337	0.315	0.395	0.494
Fortaleza (CE)	7768.841	1.598	0.335	0.331	0.382	0.392
Belo Horizonte (MG)	7146.721	1.109	0.341	0.313	0.410	0.544
Recife (PE)	7003.347	0.729	0.375	0.365	0.418	0.448
Rio de Janeiro (RJ)	5235.940	1.299	0.353	0.337	0.397	0.454
Santos (SP)	5126.792	0.939	0.715	0.700	0.748	0.749
Belém (PA)	4843.486	0.679	0.492	0.484	0.548	0.654
Natal (RN)	4789.957	0.665	0.352	0.341	0.411	0.523
João Pessoa (PB)	4329.352	0.690	0.396	0.385	0.452	0.515
Maceió (AL)	4191.318	0.927	0.470	0.462	0.523	0.574
Curitiba (PR)	4009.433	1.164	0.393	0.365	0.445	0.593
Salvador (BA)	3921.640	1.047	0.420	0.414	0.467	0.481
Vitória (ES)	3713.021	0.701	0.426	0.451	0.387	0.329
Aracaju (SE)	3130.652	0.813	0.624	0.630	0.622	0.586
Goiânia (GO)	3076.867	0.967	0.430	0.408	0.499	0.607
Teresina (PI)	3051.176	0.760	0.392	0.380	0.493	0.607
Porto Alegre (RS)	2815.630	1.293	0.429	0.395	0.502	0.571
Campinas (SP)	2734.320	1.369	0.411	0.379	0.496	0.568
Sorocaba (SP)	2512.839	1.249	0.427	0.414	0.476	0.542
Campo Grande (MS)	2142.873	0.625	0.550	0.542	0.587	0.610
São Luís (MA)	2134.471	2.439	0.430	0.433	0.429	0.468
Brasília (DF)	2084.330	1.049	0.246	0.216	0.293	0.439
Manaus (AM)	2075.532	0.817	0.456	0.449	0.521	0.651
Cuiabá (MT)	2001.518	0.696	0.520	0.501	0.576	0.709
São José dos Campos (SP)	1700.095	1.456	0.512	0.498	0.552	0.663
Florianópolis (SC)	1560.407	2.310	0.484	0.460	0.512	0.651

SOURCE: Author's own elaboration.

The results for the cities in medium urban concentration (TABLE 1.2) show that the characteristic of the population dispersion in these cities is quite different compared to cities of big concentrations. The urban population density is smaller, and the distribution of the population is more equally distributed within the city, as shown by the CV (the average of the CV is 0.931). The degree of centrality is also higher; the average is 0.63 against 0.43 found for big cities. This evidence suggests that the phenomenon of urban sprawl is more intense in big cities than in medium ones.

For cities of medium urban concentration, the negative relation between urban sprawl and population size also stands, as shown by the FIGURES 1.6(a) and 1.6(b).

FIGURE 1.6- URBAN SPRAWL AND POPULATION SIZE – MEDIUM URBAN CONCENTRATION



SOURCE: author’s own elaboration.

The GI for the high-income population is very high in medium cities, the average is 0.807. This implies that the high-income people live mainly close to the central area. In five cities (Bento Gonçalves, Birigui, Lages, Passos, and Uruguaiana), the GI high-income is equal to 1, which means that the entire high-income population lives in the central area.

TABLE 1.2 - URBAN SPRAWL INDEXES- MEDIUM URBAN CONCENTRATION

(continued)

CITY	URBAN POPULATION DENSITY (POPULATION/KM^2)	CV	GI TOTAL	GI LOW-INCOME	GI MEDIUM-INCOME	GI HIGH-INCOME
Mean	**1912.065**	**0.928**	**0.638**	**0.624**	**0.707**	**0.807**
Patos (PB)	3984.592	0.743	0.807	0.808	0.861	0.864
Franca (SP)	3898.902	0.549	0.411	0.395	0.510	0.692
Campina Grande (PB)	3676.489	0.775	0.638	0.632	0.690	0.767

TABLE 1.2 - URBAN SPRAWL INDEXES- MEDIUM URBAN CONCENTRATION

(continued)

CITY	URBAN POPULATION DENSITY (POPULATION/KM^2)	CV	GI TOTAL	GI LOW-INCOME	GI MEDIUM-INCOME	GI HIGH-INCOME
São José do Rio Preto (SP)	3388.848	0.746	0.546	0.534	0.590	0.648
Montes Claros (MG)	3175.666	0.690	0.766	0.761	0.828	0.816
Juazeiro do Norte (CE)	3165.205	0.719	0.476	0.477	0.510	0.403
Ipatinga (MG)	3156.625	0.606	0.531	0.519	0.578	0.572
Chapecó (SC)	3073.257	0.560	0.697	0.670	0.782	0.983
Mogi Guaçu (SP)	2981.078	0.608	0.729	0.720	0.776	0.925
Feira de Santana (BA)	2959.557	0.757	0.638	0.632	0.704	0.719
Umuarama (PR)	2825.262	0.747	0.780	0.774	0.813	0.855
Arapiraca (AL)	2682.130	0.742	0.730	0.728	0.821	0.827
São Carlos (SP)	2648.650	0.697	0.699	0.686	0.747	0.818
Uberlância (MG)	2606.913	0.518	0.636	0.625	0.683	0.774
Passos (MG)	2606.252	0.549	0.718	0.697	0.835	1.000
Maringá (PR)	2585.920	0.876	0.590	0.568	0.640	0.818
Imperatriz (MA)	2522.427	0.609	0.575	0.566	0.689	0.844
Araraquara (SP)	2479.490	1.246	0.608	0.588	0.675	0.809
Cascavel (PR)	2401.111	0.660	0.669	0.649	0.736	0.886
Barbacena (MG)	2366.655	0.693	0.788	0.775	0.896	0.960
Bagé (RS)	2309.199	0.945	0.846	0.835	0.907	0.988
Novo Hamburgo (RS)	2275.226	0.881	0.580	0.549	0.702	0.897
Joinville (SC)	2268.115	1.050	0.459	0.437	0.507	0.750
Sete Lagoas (MG)	2260.782	1.027	0.611	0.599	0.702	0.796
Rio Claro (SP)	2247.275	0.847	0.632	0.622	0.691	0.709
Uruguaiana (RS)	2234.063	0.606	0.869	0.862	0.940	1.000
Juazeiro (BA)	2195.145	0.853	0.799	0.792	0.922	0.917
Santarém (PA)	2175.626	0.634	0.771	0.770	0.807	0.804
Porto Velho (RO)	2167.470	0.599	0.708	0.702	0.748	0.805
Americana (SP)	2140.138	1.948	0.533	0.514	0.580	0.706
Rio Branco (AC)	2117.395	0.691	0.501	0.500	0.544	0.613
Birigui (SP)	2061.582	0.628	0.582	0.559	0.725	1.000
Sobral (CE)	2057.797	0.860	0.786	0.780	0.902	0.926
Marília (SP)	2026.142	0.738	0.637	0.617	0.704	0.840
Jundiaí (SP)	2012.120	2.087	0.467	0.447	0.511	0.648
Londrina (PR)	1976.504	0.883	0.643	0.627	0.702	0.772
Taubaté (SP)	1966.490	1.652	0.621	0.619	0.646	0.647
Resende (RJ)	1881.281	0.968	0.707	0.688	0.784	0.913
Volta Redonda (RJ)	1836.962	0.828	0.511	0.494	0.579	0.730
Bauru (SP)	1825.459	0.701	0.578	0.573	0.607	0.599
Santa Maria (RS)	1812.525	1.258	0.717	0.699	0.778	0.876
Itajaí (SC)	1731.379	0.668	0.611	0.596	0.672	0.778

TABLE 1.2 - URBAN SPRAWL INDEXES- MEDIUM URBAN CONCENTRATION

(continued)

CITY	URBAN POPULATION DENSITY (POPULATION/KM^2)	CV	GI TOTAL	GI LOW-INCOME	GI MEDIUM-INCOME	GI HIGH-INCOME
Anápolis (GO)	1714.202	0.625	0.588	0.574	0.674	0.797
Ribeirão Preto (SP)	1708.722	1.760	0.522	0.515	0.554	0.543
Caraguatatuba (SP)	1672.385	0.884	0.458	0.444	0.534	0.631
Caxias do Sul (RS)	1643.436	1.327	0.676	0.660	0.711	0.850
Petrolina (PE)	1635.522	0.773	0.758	0.750	0.845	0.906
Presidente Prudente (SP)	1633.638	2.475	0.726	0.713	0.773	0.869
Bento Gonçalves (RS)	1626.037	0.995	0.761	0.731	0.831	1.000
Limeira (SP)	1588.415	0.985	0.613	0.603	0.664	0.766
Ourinhos (SP)	1580.390	0.643	0.605	0.590	0.696	0.882
Pelotas (RS)	1546.991	1.390	0.556	0.533	0.671	0.816
Guaratinguetá (SP)	1545.570	0.832	0.709	0.694	0.771	0.929
Foz do Iguaçu (PR)	1543.361	0.673	0.415	0.390	0.520	0.714
Piracicaba (SP)	1510.843	0.957	0.650	0.635	0.696	0.806
Toledo (PR)	1509.904	0.736	0.697	0.676	0.782	0.942
Itapetininga (SP)	1500.436	0.796	0.743	0.729	0.831	0.885
Ponta Grossa (PR)	1488.408	0.671	0.601	0.586	0.666	0.816
Blumenau (SC)	1421.416	1.061	0.504	0.486	0.536	0.732
Conselheiro Lafaiete (MG)	1259.118	0.597	0.770	0.755	0.854	0.976
Itu (SP)	1257.770	0.886	0.512	0.490	0.598	0.689
Cabo Frio (RJ)	1236.702	0.823	0.694	0.675	0.804	0.885
Juiz de Fora (MG)	1231.100	0.926	0.625	0.609	0.692	0.764
Macapá (AP)	1191.335	0.876	0.748	0.742	0.795	0.833
Catanduva (SP)	1165.120	0.879	0.616	0.601	0.692	0.879
Campos dos Goytacazes (RJ)	1143.360	1.633	0.644	0.623	0.764	0.864
Criciúma (SC)	1122.968	2.827	0.566	0.534	0.652	0.932
Corumbá (MS)	1114.397	0.627	0.863	0.856	0.913	0.987
Jaraguá do Sul (SC)	1071.267	0.778	0.512	0.486	0.571	0.745
Araruama (RJ)	1048.170	1.058	0.551	0.545	0.601	0.602
Macaé (RJ)	888.184	0.891	0.714	0.703	0.763	0.781
Ubá (MG)	839.341	0.965	0.770	0.762	0.849	0.923
Palmas (TO)	760.454	0.704	0.485	0.466	0.554	0.614
Petrópolis (RJ)	749.218	1.423	0.596	0.585	0.655	0.706
Brusque (SC)	730.336	1.040	0.453	0.427	0.514	0.810
Lages (SC)	719.662	0.638	0.684	0.659	0.798	1.000
Santa Cruz do Sul (RS)	675.777	0.962	0.751	0.737	0.803	0.856
Atibaia (SP)	671.514	1.205	0.657	0.644	0.728	0.728
Boa Vista (RR)	543.937	0.566	0.385	0.370	0.494	0.564

SOURCE: author’s own elaboration.

The results of the GI for classes of income confirm the association between income inequality and urban sprawl in Brazil. The poorest people tend to be located in the suburbs of the cities, far from the central area. This pattern is common to all cities in the analysis and represents the most remarkable characteristic of the phenomenon of urban sprawl in Brazil: it is hardly influenced by social and economic forces.

A possible explanation for this pattern relies on the double causality between poverty and urban sprawl. First, poverty and income inequality are one of the causes of urban sprawl in Brazil. The disadvantaged people have no conditions to live in areas closed to the central city, where the rent price of land tends to be very high related to the income constraint of poor residents. Hence, they locate in areas closed to the borders of a city, where the houses are cheaper and there are open spaces for them to occupy. Second, sprawl is related to poverty and inequality mainly because sprawl creates more spatial segregation among residents of different income classes. In other words, the urban sprawl can accentuate the poverty.

Jargowsky (2002) highlighted that the suburban sprawl results in poverty that are physically and socially isolated from the mainstream of society and also from the educational resources and employment opportunities. The author also affirmed that this spatial segregation increases poverty in the short run and contribute to the inequality in the long run.

1.5 POLICY RECOMMENDATIONS

Urban sprawl, by virtue of being a multifaceted problem, is associated with multiple negative impacts, which can be social, economic and environmental. Urban sprawl leads to land-use patterns which are unsuitable to the development of sustainable transport modes. It increases the trip lengths, the congestion and the air pollution; reduces the farmland and open spaces; increases the consumption of water and energy, and causes environment degradation (BEKELE, 2005; FRENKEL and ASHKENAZI, 2008; CARRUTHERS and ÚLFARSSON, 2003; HORTAS-RICO, 2014). Sprawl also reduces social interactions and contributes to socioeconomic segregation between the ones living in suburbs and the others who live inner city. This segregation arises poverty relates problems in the poor neighborhoods, such as crimes rates and poor quality of public services (HORTAS-RICO; SOLLÉ-OLLÉ, 2010). In addition, the phenomenon of sprawl brings about impacts on local public finances. It increases the provision cost of local public services such as urban structure, street cleaning and lighting, public transportation, refuse collection, among others (CARRUTHERS; ÚLFARSSON, 2003).

Facing the problems related to urban sprawl is the main challenge of local government nowadays, especially because many of them do not have a long-term policy of urban planning. Indeed, in Brazil there is no strategy of urban development, such as the Smart Growth or the Compact City, two well-known concepts of urban planning in the US and in the UK respectively. The central idea of these concepts is to promote a development that encourages a mix of building types and uses, diverse housing and transportation options, development within existing neighborhoods, and community engagement (SMART GROWTH AMERICA, 2017).

In spite of the fact that creating a national urban planning strategy in Brazil like the Smart Growth or the Compact Cities is very difficult due its huge geographic and political disparities, there are some actions that local governments can put into practice in order to mitigate the progress of the urban sprawl:

- Promoting the development or redevelopment of already built up areas or increasing its population density are possible actions to dismiss the progress of the urban sprawl. These actions could control the occupation progress thought the edge of the cities, therefore, limiting the sprawling process.
- Supporting the growth management strategies, including the plan of zoning tools that help the cities on the management of the population growth. This is especially important for cities belonging to medium urban concentrations. As presented in the previous section, the phenomenon of urban sprawl is not too intense in such cities, but this scenario can change in the next few years as the population expands in areas of medium concentration. Having a strategy of zoning could prevent the sprawling process and all the consequences related to it.
- Policies that reduce the poverty and improve the social interaction in a city are also necessary to mitigate the suburbanization process which takes place in big cities. Attacking the social related problems in the suburbs of big cities will attenuate the urban sprawl caused by movement of low-income people along the edges of the cities.

1.6 CONCLUDING REMARKS

The analysis on urban sprawl in Brazil carried out in this study reveals this phenomenon is very common and more intense in the biggest Brazilian cities. The analysis also has shown the social context of the sprawling of cities located in high and medium urban concentration areas; it seems that urban sprawl and income inequality are highly correlated.

Despite this analysis is static since only data for 2010 were considered, the results highlights the importance of the phenomena and the need to build policy mechanisms to control land use in the urban space. Long term urban planning is a key policy to promote the economic development at the local level, because the most disadvantaged people are who the most suffer the consequence of the urban sprawl. However, the discussion of the urban growth process for the future of the cities is still incipient in Brazil, and changing this scenario depends on new studies.

This study contributes to further research not only by showing that the urban sprawl phenomenon is common in a developing country, but also presenting a new perspective for measuring and investigation of causes and consequences of the sprawl. The used technique of measuring the degree of sprawling of the population classified into classes of income was not used before in the literature of urban sprawl, and it encourages new studies of the relation between urban sprawl and income inequality. Additionally, this technique can be a key measure in future studies of assessing the causes and the ongoing process of urban sprawl in Brazilian municipalities.

Further research also should be undertaken to explore two points regarding urban sprawl that are important to urban planning. The first one is related to the measure of urban sprawl, yet there is no consensus among researchers about the best measure to account it, thus, setting more appropriate measures is fundamental to the investigation of the causes and consequences of urban sprawl. Secondly, as pointed out by Hayek et al. (2011), still it is not clear which degree of sprawl is considered harmful and should be avoided, hence, this fact can affect future policy recommendations of urban planning.

2 URBAN SPRAWL AND THE COST OF PROVIDING LOCAL PUBLIC SERVICES: THE CASE OF BRAZILIAN MUNICIPALITIES

2.1 INTRODUCTION

The literature of local finance in Brazil has been concentrated in the study of some specific topics such as the decentralization of the responsibilities, the impacts of the tax liability law, and the municipal debts; yet there is a lack of studies that address the determinants factors of the spending in public service. The analysis of these factors is important to provide information about the efficiency of the local spending and the sustainability of local finances in long-term.

Environmental factors such as the population size and the urban areas are determinant factors of the local spending as well as factors prices and quantum of output. Indeed, a growing number of regional and urban researchers have associated the urban sprawl, a specific pattern of urban development, with the allocation, distribution, and volume of spending on local public services. Urban sprawl is a low-density, discontinuous and suburban style development, often characterized as a rapid and unregulated pattern of growth. It is thought to increase the cost of providing public services because it fails to capitalize on economies of scale and/or optimize on facility location (CARRUTHERS; ÚLFARSSON, 2008). For example, the greater the dispersion of population in a municipality the major the investments required for extending the highway network, the water and sewer lines to a small number of residents. By contrast, it is believed that the alternative development pattern of urban sprawl, the compact city, reduces costs by concentrating residents together and creating locational efficiencies in access and delivery (CARRUTHERS; ÚLFARSSON, 2008). Likewise, the compact city model is associated with environmental and social benefits: it encourages the development of more sustainable transport modes, which might reduce the congestion and the pollution; and it reduces the social segregation between the ones living in the suburbs and inner city, diminishing the poverty-related problems such as crime rates and poor quality of public service (HORTAS-RICO, 2014).

Most of the empirical analysis of the relation between urban sprawl and spending on local public service is concentrated in the case of developed countries. An extension of this analysis for Brazil can be valuable for the empirical literature of urban sprawl and its impacts on local spending; it offers a perspective of a country which went through a different urbanization process and presents a distinct local finance system.

The aim of this study is to contribute to the empirical literature on the urban sprawl and its effects on local public finance by offering a perspective of the analysis of a developing country. “Does the positive relation between urban sprawl and cost of providing local public services stand for the case of Brazilian municipalities?” This is the main question attempted in this analysis, and its answer can be a starting point for discussing the role that the local and regional government should play in regulating the urban sprawl process in Brazil. To the best of our knowledge, this is the first study addressing the role of urban sprawl on provision of public goods in Brazil.

The empirical analysis is based on a per capita local public spending equation both for aggregate spending and nine disaggregated spending categories that could be more influenced by urban sprawl: administration, basic sanitation, culture, environmental management, housing, local police, social assistance, sports and leisure, and urban infrastructure. Other important local public expenditure such as education and health services were not considered since the amount of resources are mandatory accordingly to constitutional rules. Four distinct measures of urban sprawl are considered in this study searching to explore which of them fit better for explaining the cost of provision public services: coefficient of variation, gravitational index, percentage of urban area, and urban population density. All the variables are measures at the municipal level – i.e. where the policy decisions concerning the spending functions are taken.

The essay is organized into six sections. Section 2.2 briefly reviews previous researches on the relationship between urban sprawl and the cost of providing local public services. Section 2.3 presents an overview of the Brazilian local finances. Section 2.4 presents the empirical analysis, including modeling framework, data, and estimation results, the results are discussed in section 2.5. Section 2.6 presents the final remarks.

2.2 URBAN SPRAWL AND LOCAL PUBLIC FINANCE

Urban sprawl and its effects on local finances are a trending topic of investigation nowadays mainly because urban sprawl has been associated with negative consequences to the cost of providing public services. Carruthers and Úlfarsson (2003) affirm that urban sprawl is associated with higher providing cost of public goods because of the considerable levels of investment required to expand basic infrastructure and other public services over greater distances so as to reach a relatively smaller number of residents.

Even though urban sprawl is an important issue to local public finance, empirical evidence regarding this topic, in general, are relatively scarce and concentrated primarily on US cities. Many of the empirical studies of this topic have adopted an approach based on econometric techniques to quantify the effects of urban sprawl on per capita local spending. However, the empirical results are still not conclusive and may vary from study-study.

Carruthers and Úlfarsson (2008), for example, pointed out evidence that the density of developed land (an urban sprawl measure) in US cities has a negative effect on five key measures of local government spending: total direct, education, parks and recreation, police protection and roadways; whereas Ladd (1992) found that there is a U-shaped relationship between public spending and density, except in sparsely populated areas, higher density typically increases public sector spending.

According to Hortas-Rico and Solé-Ollé (2010), the empirical results can be influenced by the measures used to account the effect of urban sprawl in the per capita local spending function; more accurate measures lead to better empirical results. Examples of works that used different measures of urban sprawl are Hortas-Rico and Solé-Ollé (2010) and Hortas-Rico (2014), both investigated the effects of urban sprawl on the provision of local public goods by the municipally in Spain. Hortas-Rico and Solé-Ollé (2010) used urbanized area per capita and Hortas-Rico (2014) considered the built-up area per capita as a measure of sprawl. Both papers had the same conclusion: there is a positive effect of urban sprawl on the cost of providing public goods, both aggregated and disaggregated categories (community facilities, basic infrastructure and transport, local police, general administration, and culture and sports).

Nakamura and Tahira (2008) also used a different measure for urban sprawl to evaluate its effect on the cost of public services. They developed an index similar to the Lorenz curve to represent the distribution of the population density within the Japanese municipalities. Their results show that the concentration of population within a city reduces per capita cost of providing the public services, although the results for disaggregated items of expenses are similar to but less obvious than that for the total cost.

2.3 THE BRAZILIAN MUNICIPAL PUBLIC SECTOR: AN OVERVIEW

The administration of Brazilian public sector is divided into four different levels of government: the federal government, the 26 states, the federal district and 5,570 local governments.

Until the 80s, the provision of public goods in Brazil was concentrated at the federal level. This scenario had changed with the reform promoted by the Brazilian Federal Constitution 1988, which promoted the decentralization of responsibilities among governments. The decentralization increased the responsibilities of the local government, and actually municipalities have played a more prominent role in providing public goods and in promoting regional economic development.

Generally, the local governments are responsible for basic education, urban structure, public transportation, refuse collection, street cleaning, street lighting, among others. The local provision of public services is primarily financed by local taxes, user charges and transfers from others government levels (federal and state). It is worth noting that the smaller the size of the municipality the bigger the dependency of transfers from other government levels.

The distribution of the Brazilian population in its 5,570 municipalities shows a high concentration in large urban centers. Around 56% of the population (114.6 million) live in only 5.5% of the cities (304 cities), which are those with more than 100 thousand inhabitants (IBGE, 2015). Conversely, only 6.3% of the population (1.4 million) lives in 2,451 Brazilian cities (44%) with up to 10,000 inhabitants.

This unequal population dispersion reflects on the revenues of each city and consequently on the level of public services provided by them. TABLE 2.1 provides evidence about the inverse correlation between the size of municipalities and the dependence of transfer revenues. Cities less populous have a limited capacity to obtain and handle resources, and are more dependable of transfers from other government levels. Due to it, these cities can face difficulties when trying to meet their expenditure needs. By contrast, cities with a bigger population are less dependable of transfers and hold a better capability to manage their own resources. Nevertheless, populous cities have a great challenge of managing the urban spaces; the public services can be compromised if the resources are not well allocated across the urban space.

Regarding the composition of local public spending, there are some differences across cities. TABLE 2.2 shows that expenditure with administration services is bigger in small cities than in big ones. On the other hand, big cities spend more in urban infrastructure than small cities. The spent in health and education is quite similar in all the cities groups, and represents almost fifty percent of the total spending.

TABLE 2.1 - RELATIVE PARTICIPATION OF LOCAL REVENUES ACCORDING TO POPULATION GROUPS IN 2010

POPULATION GROUPS (PER 1,000)	TOTAL REVENUES	TAXES REVENUES	TRANSFER REVENUES	OTHER REVENUES
TOTAL	1.00	0.15	0.76	0.09
until 2	1.00	0.03	0.93	0.04
2 |-- 5	1.00	0.04	0.92	0.04
5 |-- 10	1.00	0.05	0.91	0.04
10 |-- 20	1.00	0.06	0.90	0.04
20 |-- 50	1.00	0.08	0.86	0.07
50 |-- 100	1.00	0.11	0.80	0.09
100 |-- 200	1.00	0.15	0.73	0.12
200 |-- 500	1.00	0.19	0.67	0.14
500 |-- 1000	1.00	0.22	0.63	0.15
1000 |-- 5000	1.00	0.28	0.57	0.15
5000 and more	1.00	0.45	0.40	0.15

SOURCE: Author’s own elaboration based on data from Finbra (2010).

The expenditures on education and health have some specificities; the Brazilian Federal Constitution establishes a minimum percentage of spending on these two public services. The local governments have to spend a minimum of 25 percent of the total revenue, including taxes and transfers from other government levels, on education, and a minimum of 15 percent of the total revenue on health. Thus, it would not be expected that the per capita spending on education and health are affected by urban sprawl. It is possible that the quality and the level of the final output of these categories of expenditure may be affected by the urban sprawl, but this is a topic that requires more investigation. In this study, we dropped the expenditure of education and health from the analysis and focused on the cost of providing other categories of spending, more likely to be influenced by urban sprawl.

TABLE 2.2 - RELATIVE PARTICIPATION OF LOCAL EXPENDITURE ACCORDING TO POPULATION GROUPS IN 2010

POPULATION GROUPS (PER 1,000)	TOTAL	ADMINISTRA-TION	HEALTH	EDUCATION	URBAN INFRASTRUCTURE	OTHER SPENT
TOTAL	1.00	0.14	0.23	0.26	0.10	0.27
until 2	1.00	0.18	0.21	0.24	0.08	0.29
2 |-- 5	1.00	0.18	0.21	0.25	0.08	0.28
5 |-- 10	1.00	0.16	0.22	0.30	0.09	0.24
10 |-- 20	1.00	0.15	0.22	0.32	0.09	0.22
20 |-- 50	1.00	0.14	0.22	0.33	0.10	0.21
50 |-- 100	1.00	0.14	0.24	0.32	0.10	0.21
100 |-- 200	1.00	0.16	0.23	0.27	0.11	0.22
200 |-- 500	1.00	0.14	0.24	0.25	0.12	0.25
500 |-- 1000	1.00	0.12	0.30	0.22	0.11	0.26
1000 I—5000	1.00	0.11	0.27	0.19	0.13	0.30
5000 and more	1.00	0.04	0.18	0.19	0.11	0.47

SOURCE: Author’s own elaboration based on data from Finbra (2010).

2.4 EMPIRICAL ANALYSIS

2.4.1 Empirical model

The empirical strategy consists in estimating a public provision equation for each public service searching to achieve a deeper insight about the relationship between urban sprawl and local spending on public services. In each equation, the dependent variable (e) represents the per head cost of providing some public service and the explanatory variables measure the cost of and the demand for local government spending as well unobserved effects. Generically, the representation of the public provision equation is:

$$e = f(U, D, R, u) \tag{2.1}$$

where the explanatory variables are divided into three categories: urban sprawl variables (U); demand variables (D); and revenue variables (R).

Urban sprawl variables

Choosing the variables to capture the magnitude of the urban sprawl is the main challenge for the evaluation of the consequences of urban sprawl. One of the most well-known measures for assessing the urban sprawl employs variants of population density or developed areas as proxies. However, the use of this kind of variables has been criticized for two main reasons. First, as pointed out by Hortas-Rico and Solé-Ollé (2010), there is no agreement regarding the right variables to capture density (density of housing units, population or employment), the extent of the space over which density should be characterized (total or urbanized area), and the scale at which density should be measured (metropolitan or municipality). Secondly, the density does not describe the urban areas properly, although it indicates the presence of scale of certain urban services, it fails showing the distribution of the population within the cities (CARRUTHERS; ULFARSSON, 2003).

In our analysis, four measures were used to capture the effects of urban sprawl. The benefit of using multiple variables is that we can compare the results of each one and indicate the best measure of urban sprawl for the Brazilian municipalities in terms of the significance and fitting adjustment obtained in the estimation process. The selected measures are the percentage of urban area, urban population density (given by the ratio of the urban population to the urban area in kilometers), the coefficient of variation (CV), and the gravitational index

(GI). To the best of our knowledge, there are no empirical analyses that have used the last two mentioned variables, whereas the density and urban land were largely applied.

The CV shows the distribution of the population across the city's areas, and the GI indicates how concentrated in the central area is the population. Both of these variables were largely discussed in the first essay of this dissertation, therefore, in the current analysis, we are only limited by using its results as a measure of urban sprawl[3]. Considering GI, the results from the first essay indicated that the urban sprawl measured by this index prevails mainly in cities from high urban concentration. Due to it, we added a dummy variable to capture if the effects of urban sprawl on local public spending differ from cities of high urban concentration to cities of medium urban concentration; the GI is multiplied for a dummy that equals to 0 if the municipality belongs to a high urban concentration and 1 if the municipality belongs to a medium urban concentration. The motivation for this strategy was to capture non linearity in the relationship between urban sprawl and the cost of providing public services.

It is expected that sprawl raises the cost of providing public services because it fails to capitalize on economies of scale and/or optimize on facility location. Keeping the control variables equal, per capita spending on public services will be negatively influenced by population density and by GI, and positively influenced by the percentage of county urban land and by the CV.

Demand and revenue variables

The demand function of per capita local spending (equation1) depends on a bunch of demand factors, which works as control variables of the model. The selection of these demand variables is based on work done by Carruthers and Úlfarsson (2008), and Hortas-Rico and Sollé-Ollé (2010). It is worth to add that the specification does not match any of these identically, due the data availability and the different purposes of the analysis. Summarily, in this study, demographic, social and economic variables account for the demand factor in the empirical model.

First, we briefly present the demographic variables. In previous studies, the size of the population or the population growth was the most important demographic variable in a model of demand for public services. However, their effects on per capita spending are not clear. According to Ladd (1992), a positive rate of population growth negatively influences

[3] The calculus of the CV and the GI for the cities not present in the first essay followed the same procedure described in section 1.3.2.

per capita spending because the existing population almost always finances new development. Alternatively, bigger population demands more public services, pressing the spending up. We address this question by adding in the model the population size of each municipality in the natural log form.

Other demographic variables that should affect positively the demand for local public services are added to the model: percentage of children below five years old; percentage of people older than 60 years old; percentage of graduate people; and percentage of people without studies.

Regarding the social variables, it should represent the effect of what Hortas-Rico and Sollé-Ollé (2010) call harshness of the environment on local costs. The variable included is the unemployment rate, since it is a measure of disadvantaged people. The higher the number of disadvantaged people in a municipality the higher tends to be the spending on proving public services, especially in some services such as social assistance.

In terms of the economic variables, generally, in previous studies, the main economic variable introduced was the per capita income, usually represented by the Gross Domestic Product (GDP) per capita. Income was tested in the currently empirical analysis, but its inclusion led to a high degree of multicollinearity with some of revenue, demographic and social variables. For this reason, income was rejected as an explanatory variable. Conversely, another variable was introduced to capture the effect of the economic environment on the local spending: the percentage of the industry production on the total production. Given that industries require better infrastructure such as good roads and good sanitation condition to produce, a municipally with more industries will spend more on local public services.

Ultimately, we added a dummy variable in the model in order to measure the effects of the centrality of cities on local public spending. The dummy equals to 1 if the city is a central city with more than 100,000 inhabitants of a population arrangement; and 0 if it is not a central city. Central cities concentrate most part of the population and the jobs of a population arrangement, so it is acceptable to assume that in such cities there are gains of scale in providing public services; and consequently, the spending is lower compared to the cities that are not central.

Turning now to the resources variables, two fiscal capacity variables account for their effects on the demand for local public services. These variables are the local taxes per capita and local fees per capita; both are introduced in the natural log form. It is expected a positive coefficient for the tax per capita (the higher the taxes the higher the spending on public service) and a negative coefficient for the fees because it represents the price of the local public service. Another common resource variable added in models of demand for public service is the per capita government transfers. In the present analysis, this variable was not included in the model for two main reasons. First of all, it is high correlated with other variables and its inclusion led to controversial results; secondly, most of the transfers are linked to specific competencies of the local governments, such as education and health, thus it is expected that transfers do not significantly affect the spending in other public services.

Dependent variables

The selection of the local spending variables is based on previous studies that have addressed the effect of the urban sprawl on local public finances (HORTAS-RICO; SOLLÉ-OLLÉ, 2010; CARRUTHERS; ÚLFARSSON, 2008; CARRUTHERS; ÚLFARSSON, 2003; NAKAMURA; TAHIRA, 2008). All these studies focused on the local competencies most directly influenced by the urban sprawl. Thus, we analyze ten expenditure functions of the municipal budget: administration, basic sanitation, culture, environmental management, housing, local security, social assistance, sports and leisure, urban infrastructure; and aggregate spending.

The aggregate spending is the sum of direct expenditures, including salaries and wages, the spending on education and health were excluded from this categories due to the reasons exposed in section 2.3. TABLE 2.3 shows the description of each category of local expenditure analyzed empirically.

Empirical evidences (CARRUTHERS; ÚLFARSSON, 2003; HORTAS-RICO; SOLLÉ-OLLÉ, 2010) show that the effects of urban sprawl on the local cost are distinct, depending on the type of local public services under consideration. The costs of the spending on aggregate, administration, basic sanitation, housing, and urban infrastructure, for example, are positively affected by urban sprawl because higher degrees of population dispersion undermine the use of scale economies on the provision of local public services, leading to an increasing in their costs. It also costs more to local government to expand the roll of public services to achieve a small number of users. On the other hand, the effect of sprawl on the expenditure of environmental management, local police, and social assistance can be positive either negative due to the diseconomies of scale associated with the problems of high degrees of population concentration (poverty, crimes, pollution, and so on). In such cases, the population dispersion can rise and/or reduce the cost of providing these categories of public expenditures because it reduces the impacts of the diseconomies of scale. In the case of the spending on culture and sports and leisure, it tends to be higher where the population is more concentrated and demands more of the services.

TABLE 2.3 - PUBLIC EXPENDITURE VARIABLES

Variable	Description
Aggregate	Sum of direct expenditures, including salaries and wages.
Administration	Local spending on general administration, financial administration, management of human resources, among other.
Basic sanitation	Local spending on basic sanitation, including the water and sewerage systems.
Culture	Local spending on culture.
Environmental management	Local spending on environmental management, environmental preservation, and recovery of degraded areas.
Housing	Local spending on rural and urban housing development.
Local police	Local spending on security and police.
Social assistance	Local spending on children, elderly people, disabled people, and community assistance.
Sports and leisure	Local spending sports and leisure.
Urban infrastructure	Local spending on urban infrastructure, urban services and public transportation.

SOURCE: Finbra (2010).

2.4.2 Data and econometric specification

The local public service demand is estimated by employing a cross-sectional dataset of the Brazilian municipalities for the fiscal year of 2010. A dynamic analysis, which could capture better the process of sprawling, is not possible due to the data availability for Brazilian municipalities. The demand variables of the model and the data used to create the urban sprawl variables are provided by the demographic census, performed every ten years. Thus, in this analysis, the data from the last demographic census (2010) were used.

Due to the fact that urban sprawl is a phenomenon that occurs mainly in metropolitan areas, only municipalities belonging to medium and high urban concentrations were selected. The number of municipalities in the sample differs from model-to-model because municipalities, where no spending took place during the 2010 fiscal year, were dropped in the estimation process.

The municipalities with a population lower than 20,000 inhabitants were excluded from the analysis, due the fact that they do not share the same urbanization process or the finance characteristics of other municipalities in the same population arrangement. TABLE 2.4 lists the source and descriptive statistics for all the variables from the model.

TABLE 2.4 - DESCRIPTIVE STATISTICS

Dependent variables	Mean	Standard deviation	Maximum	Minimum	Data sources
per capita aggregated expenditure (R$)	934.933	684.737	6122.500	286.002	
per capita spending (R$) on					
Administration	271.397	250.133	2410.340	5.067	
basic sanitation	81.942	113.087	876.164	0.004	
Culture	21.449	42.891	644.108	0.036	Brazilian Mistry of Finance (Finbra,2010)
environmental management	23.593	48.858	507.432	0.002	
Housing	30.861	93.474	846.334	0.002	
local police	27.184	36.904	304.296	0.005	
social assistance	53.067	53.416	623.490	2.383	
sports and leisure	21.442	28.869	300.964	0.040	
urban infrastructure	215.085	192.848	2106.117	1.822	
Urban sprawl variables					
% Urban area	0.839	0.226	1.000	0.004	Author's own elaboration; Census 2010, IBGE
Coefficient of variation (CV)	1.061	0.669	7.648	0.352	
Gravitational index (GI)	0.590	0.170	1.000	0.099	
Urban population density (UPD)	2271.953	2012.221	13018.414	82.781	
Demographic, economic and social variables					
Population	291997	776605	11253503	20029	
% Graduates	10.222	5.802	33.700	1.810	
% Without studies	45.414	8.918	72.900	22.000	
% Population <5	9.034	6.717	95.100	5.530	Census 2010, IBGE
% Population >60	9.894	2.395	19.160	4.370	
% Unemployed	8.243	3.343	25.300	1.700	
% Industry production on total	0.283	0.136	0.838	0.059	
Resources variables (per capita R$)					
Taxes	325.678	331.792	2536.375	14.408	Finbra, 2010
Fees	31.539	31.189	212.036	0.000	

SOURCE: IBGE (2010); Finbra (2010).

The exact nature (shape) of the relationship between urban sprawl development pattern and public services expenditure is not well defined. Hortas-Rico and Solé-Ollé (2008) considered the log-log function the best specification to describe the relation between urban sprawl and per capita public spending. However, Carruthers and Úlfarsson (2003) found that neither linear nor log-linear forms are appropriated; they adopted the semi-log form by taking the log of the dependent variable only. In the current study, some of these functional forms were tested and the one that best fits the data from the Brazilian municipalities is the log-linear form and it is estimated by Ordinary Least Square (OLS), which presentation is defined as follow:

$$\text{Ln } e = \alpha + U + \beta_1 D + \beta_2 \ln R + \varepsilon \qquad (2.2)$$

Nevertheless, accordingly to Sollé-Ollé (2005) and Carruthers and Úlfassson (2008), this econometric specification is not complete. These authors maintain that there is a strategic interaction among local government of neighboring municipalities, which means that the per capita expenditure on public services in a jurisdiction *i* depends on per capita expenditure or other factors of surrounding jurisdictions.

As noted by Carruthers and Úlfassson (2008), the strategic interaction needs to be accounted in the framework of the empirical model for two main reasons. First, "to recognize the presence of an underlying behavioral model of public finance; and secondly to avoid an econometric misspecification that does not account for the spatial dependence introduced by various forms of strategic interaction" (CARRUTHERS; ÚLFASSSON, 2008).

We accounted for the strategic interaction framework by using the technique of spatial econometric (described in APPENDIX 1). The diagnostics for spatial dependence (see TABLE 1.A in APPENDIX 1) indicate that there is spatial dependence in the error term of some competences of local spending (aggregate, basic sanitation, housing, social assistance, sports and leisure, and urban infrastructure) and spatial dependence in both the dependent variable and the errors in the local police spending. Thus, for local police, we estimated the Spatial Autocorrelation Model (SAC) (equation 2.4) and for the other spending functions with spatial dependence, the model estimated is the Spatial Error Model (SEM) (equation 2.3).

$$\ln e = \alpha + U + \beta_1 D + \beta_2 \ln R + \nu \qquad (2.3)$$

$$\ln e = W \ln e + \alpha + U + \beta_1 D + \beta_2 \ln R + \nu \qquad (2.4)$$

where $\nu = \lambda W \nu + \varepsilon$ (W is the queen contiguity matrix)

The SEM is essentially a generalized normal linear model with spatially autocorrelated disturbances. Assuming independence between X and the error term, least squares estimates for β are not efficient, but still unbiased. Because of that, the SEM was estimated by the Method of Moments Estimators (MME)[4] developed by Kelejian and Prucha (1998). The SAC contains spatial dependence in both the dependent variable and the errors and it is estimated by a spatial two-stage least square (S2SLS)[5] strategy, also developed by Kelejian and Prucha (1998).

---

[4] Anselin (2001) presents the details of the MME estimator.
[5] Anselin (2001) presents the details of the S2SLS estimator.

2.4.3 Estimation results

TABLE 2.5 shows the results estimated by OLS (equation 2.2) for per capita local spending functions that do not present spatial dependence (administration, culture and environmental management), and TABLE 2.6 presents the results from the estimation of the spatial models, given by equations (2.3) and (2.4), for the categories of spending that have spatial dependence. Four estimations were performed for each spending category using the same model; the only difference is the urban sprawl variable inserted in each estimation. Thereby, in columns (1), (2), (3) and (4) we introduced as a measure of urban sprawl the variables percentage of urban area, coefficient of variation (CV), gravitational index (GI) and the dummy for medium concentration (GI Medium), and the urban population density (UPD) respectively.

The econometric specification enables the identification of the specific effects of urban sprawl on local spending since other municipal characteristics are controlled by a set of control variables. The following paragraphs summarize the results in a general way; a discussion of the findings and its implications is done in the next section.

Before presenting the estimations results, a note should be made about the estimations from the categories of spending that have spatial dependence. Comparing the estimated parameters from the OLS and the SEM and SAC estimations, we noted that the values of the parameter have a small decrease, and the sign and the level of significance of each parameter do not vary when a spatial component is added. Seeing that, we only present the spatial results for the categories of spending that have spatial dependence.

To begin with, we present the results from the parameters of the urban sprawl variables. The percentage of urban area carries a positive sign in the local security and urban infrastructure and a negative sign in all other categories; it is significant only in the administration spending, indicating that the bigger the proportion of urban area in a city the lower its spending on administration services. Regarding the estimation results of the models with the CV, the estimated parameters of this variable are not significant in all the spending functions analyzed, pointing out that the dimension of urban sprawl represented by the CV is not correlated with the cost of providing the categories of spending analyzed in this study. On the other hand, the estimated results of the GI indicate that there is a correlation between the degree of concentration around the city center and the cost of some categories of local expenditures. The estimated parameters for aggregate spending and spending on administration and environmental management are large and significant, additionally, it has a negative sign in the aggregate and administration spending, and a positive sign in the environmental management; in other expenditure categories, the estimated parameters are large, but not statistically significant. Additionally, the estimated parameters of the dummy for medium concentrations show that the GI is not a determinant factor of the spending on administration and environmental management for cities of medium urban concentrations, suggesting that the effects presented by the GI are strictly related to cities of high urban concentrations; however, the estimated parameter for the aggregate spending and spending on social assistance are positive and statistically significant. Lastly, the UPD has a positive and highly significant coefficient in the culture and sports and leisure spending; it also has a positive sign but not statistically significant parameter in housing and local security; in all other cases, the parameters are negative and statistically insignificant.

The control variables also show important elements of the per capita spending on local public services. The statistically significant parameters of these variables change according to the category of spending. Moreover, when the urban sprawl variable differs, the sign and the level of significance of each parameter do not alter in most cases and the values have a small change.

The population is one of the most important explanatory variables of the per capita expenditure function. It has a negative and statistically significant parameter in the aggregate, administration, culture, social assistance, sports and leisure, and urban infrastructure expenditure functions. As the population is in the log form, its coefficient can be interpreted as elasticity. Then, a 1 percent increase of the population decreases local spending by around 0.096[6] percent the aggregate spending (the lowest value) and by around 0.347 percent the spending on sports and leisure (the highest value. The results of the population also evidence the role that the economies of scale exert on the cost of provided some categories of local expenditure. The bigger the population the lower the per capita cost of providing local public service. This evidence indicates that big cities can be more efficient in the provision of public services than medium or small ones: the services can reach more people with a smaller per capita cost, especially in the expenditure categories that have high fixed costs, like the administration and urban infrastructure spending.

The demographic variables which represent the preferences of the individuals for public services (percentage of graduate and percentage of no educated people) are determinant factors of per capita spending on basic sanitation, culture, local security and

[6] This value is the average of the estimated parameters of each models estimated.

social assistance. The parameter of the percentage of graduate is positive and significant in the basic sanitation, culture, and social assistance; the percentage of people without education is significant and carries a negative sign and in the local security and a positive sign in the spending on social assistance. Regarding the remaining demographic variables, the percentage of the population that is less than five years old is mostly insignificant, the exception is in the social assistance function, in which the parameter is negative and significant; the percentage of people older than 60 years old has a positive and significant coefficient in the basic sanitation equation; and negative and significant coeffiecient in the local police spending equation. The unemployment rate has a highly and significant coefficient in eight categories of spending, but the direction of the effect varies according to the spending; it is positive in aggregate, administration, culture, and housing spending; and it is negative in basic sanitation, environment management, local security, and sports and leisure spending.

Concerning the revenue variables, as expected, the coefficient of the per capita taxes is positive, large and highly significant in most of the categories of spending; the higher the taxes in a city the higher its spendings on public services. Fees per capita parameters are positive and statistically significant in the environmental management; and negative and statistically significant in the culture spending function estimated by model 3.

The percentage of industry production appears to be an important element of the per capita local spending on public services. As shown by the estimation results, it has a high and positive effect on the cost of proving the aggregate spending and the spending on administration, culture, environment management, local police, and sports and leisure. This means that, with all other variables keep unchanged, the more industrialized a municipality is the higher its spending on these public services.

The dummy that represents the centrality indicates that the fact of a city been or not a central city does not influence the cost of providing public services, the exceptions are the spending on culture, in which the coefficient is large and positive; and the spending on housing, in which the coefficient is positive and significant (in the model 4). These results indicate that in central municipalities the spending on culture and on housing is bigger than the spending on not central municipalities. In a population arrangement, the cultural activities are concentrated in the central city, where the population is bigger and demands more of this kind of activities, for this reason, the spending on culture tends to be higher in central cities than in not central cities; similarly, in central cities the urban area is also higher and may demand more housing planning, this can explain the fact that the spending on housing is higher in this kinf of municipalities.

Moving on to consider the spatial variables (see Table 2.6). As indicated previously, the SEM was estimated for per capita spending on basic sanitation, housing, social assistance, sports and leisure, urban infrastructure, and aggregate spending; the SAC was estimated for per capita spending on local police. The coefficient of the spatial error term (λ) is positive and highly significant in all the disaggregated measures of spending and in the aggregate spending. This evidence suggests that some factors of a municipality *i* that are not specified in the models, positively affect the cost of providing public services in a municipality *j*. This result also indicates that the strategic interaction among the municipalities in a region is a fact that accounts for the per capita spending on local public services. With respect to the spatial variables in the spending on local police function, with the exception of the function estimated by model 1, both the λ and the *We* are statistically significant and have a considerable value. This implies that the per capita spending on local security in a municipality is affected by the spending on local security and other not identified characteristics of the surrounding municipalities.

TABLE 2.5- OLS ESTIMATION RESULTS

(continued)

MODEL	(1)		(2)		(3)		(4)	
ADMINISTRATION (n=326)								
Constant	**5.194*****	(6.270)	**4.943*****	(5.954)	**5.571*****	(6.061)	**4.887*****	(5.705)
% Urban area	**-0.295***	(-1.837)	-	-	-	-	-	-
CV	-	-	-0.089	(-1.701)	-	-	-	-
GI	-	-	-	-	**-0.568****	(-2.349)	-	-
GI Medium	-	-	-	-	0.198	(1.427)	-	-
UPD	-	-	-	-	-	-	0.000	(-0.879)
Central	0.019	(0.192)	0.035	(0.353)	0.047	(0.425)	0.055	(0.552)
Population	**-0.199*****	(-4.756)	**-0.201*****	(-4.788)	**-0.23*****	(-4.818)	**-0.189*****	(-3.973)
% Graduates	0.005	(0.402)	0.011	(0.892)	0.011	(0.872)	0.008	(0.668)
% Without studies	-0.004	(-0.555)	-0.002	(-0.245)	-0.003	(-0.409)	-0.003	(-0.399)
% Population <5	0.002	(0.470)	0.003	(0.602)	0.003	(0.619)	0.003	(0.642)
% Population >60	0.003	(0.209)	-0.001	(-0.031)	0.000	(-0.026)	-0.001	(-0.042)
% Unemployed	**0.044*****	(3.818)	**0.045*****	(3.903)	**0.054*****	(4.434)	**0.0467*****	(4.028)
% Industry production on total	**0.763*****	(2.957)	**0.727*****	(2.826)	**0.713*****	(2.771)	**0.708*****	(2.734)
Taxes	**0.4192*****	(7.340)	**0.414*****	(7.267)	**0.395*****	(6.804)	**0.406*****	(7.110)
Fees	-0.011	(-0.256)	-0.008	(-0.182)	-0.012	(-0.273)	-0.017	(-0.380)
R^2	0.357		0.356		0.362		0.351	
CULTURE (n=318)								
Constant	0.337	(0.233)	0.074	(0.051)	-0.525	(-0.326)	0.859	(0.577)
% Urban area	-0.443	(-1.583)	-	-	-	-	-	-
CV	-	-	-0.065	(-0.714)	-	-	-	-
GI	-	-	-	-	0.453	(1.042)	-	-
GI Medium	-	-	-	-	-0.020	(-0.081)	-	-
UPD	-	-	-	-	-	-	**0.0000649***	(1.869)
Central	0.288	(1.641)	**0.344****	(1.992)	**0.341***	(1.764)	**0.465*****	(2.692)
Population	**-0.237*****	(-3.236)	**-0.247*****	(-3.357)	**-0.216****	(-2.568)	**-0.328*****	(-3.951)
% Graduates	**0.054****	(2.427)	**0.062*****	(2.763)	**0.059*****	(2.631)	**0.060*****	(2.725)
% Without studies	0.016	(1.262)	0.018	(1.474)	0.018	(1.470)	0.019	(1.524)
% Population <5	-0.006	(-0.699)	-0.005	(-0.587)	-0.006	(-0.643)	-0.006	(-0.664)
% Population >60	-0.012	(-0.409)	-0.020	(-0.704)	-0.027	(-0.913)	-0.029	(-1.021)
% Unemployed	**0.065*****	(3.195)	**0.067*****	(3.296)	**0.064*****	(2.909)	**0.063*****	(3.066)

TABLE 2.5- OLS ESTIMATION RESULTS

(continued)

MODEL	(1)		(2)		(3)		(4)	
% Industry production on total	**1.261*****	(2.790)	**1.203*****	(2.663)	**1.187*****	(2.618)	**1.274*****	(2.823)
Taxes	**0.653*****	(6.524)	**0.639*****	(6.397)	**0.657*****	(6.423)	**0.644*****	(6.482)
Fees	-0.114	(-1.476)	-0.114	(-1.467)	**-0.130***	(-1.667)	-0.116	(-1.502)
R^2	0.314		0.310		0.3115		0.317	
ENVIRONMENTAL MANAGMENT (n=282)								
Constant	**-4.523***	(-1.686)	**-4.751***	(-1.766)	**-7.296***	(-2.447)	**-5.277***	(-1.919)
% Urban area	-0.298	(-0.589)	-	-	-	-	-	-
CV	-	-	-0.087	(-0.543)	-	-	-	-
GI	-	-	-	-	**1.759****	(2.132)	-	-
GI Medium	-	-	-	-	-0.188	(-0.408)	-	-
UPD	-	-	-	-	-	-	0.000	(-1.037)
Central	0.027	(0.085)	0.037	(0.118)	0.006	(0.017)	-0.005	(-0.017)
Population	0.104	(0.781)	0.103	(0.771)	0.219	(1.452)	0.167	(1.114)
% Graduates	-0.005	(-0.126)	0.002	(0.042)	-0.005	(-0.124)	-0.002	(-0.058)
% Without studies	0.024	(0.996)	0.026	(1.070)	0.030	(1.251)	0.023	(0.971)
% Population <5	-0.012	(-0.826)	-0.012	(-0.783)	-0.014	(-0.912)	-0.011	(-0.741)
% Population >60	0.034	(0.632)	0.028	(0.544)	0.011	(0.205)	0.034	(0.654)
% Unemployed	**-0.124*****	(-3.210)	**-0.123*****	(-3.191)	**-0.14*****	(-3.409)	**-0.117*****	(-3.015)
% Industry production on total	**1.851****	(2.273)	**1.822****	(2.242)	**1.793****	(2.216)	**1.744****	(2.141)
Taxes	**0.684*****	(3.807)	**0.676*****	(3.781)	**0.756*****	(4.140)	**0.664*****	(3.718)
Fees	**0.249***	(1.763)	**0.255***	(1.795)	0.217	(1.530)	**0.243***	(1.724)
R^2	0.224		0.223		0.236		0.226	

Note: *** denotes two-tailed hypothesis test significant at p <0.01; ** denotes two-tailed hypothesis test significant at p <0.05; * denotes two-tailed hypothesis test significant at p <0.10. T-value is in parentheses. Statistically significant parameters are in bold.
SOURCE: Estimation results.

TABLE 2.6 - SPATIAL MODEL ESTIMATION RESULTS

(continued)

MODEL	(1)		(2)		(3)		(4)	
AGGREGATE (n= 326)								
Constant	**4.737*****	(10.861)	**4.675*****	(10.657)	**4.562*****	(9.708)	**4.593*****	(10.361)
% Urban area	-0.106	(-1.325)	-	-	-	-	-	-
CV	-	-	-0.007	(-0.254)	-	-	-	-
GI	-	-	-	-	**-0.208***	(-1.723)	-	-
GI Medium	-	-	-	-	**0.236*****	(3.182)	-	-
UPD	-	-	-	-	-	-	0.000	(-1.064)
Central	0.031	(0.625)	0.046	(0.943)	-0.014	(-0.276)	0.037	(0.764)
Population	**-0.099*****	(-4.577)	**-0.101*****	(-4.673)	**-0.091*****	(-3.831)	**-0.091*****	(-3.836)
% Graduates	**0.012***	(1.806)	**0.014****	(2.081)	**0.015****	(2.311)	**0.013****	(2.036)
% Without studies	0.004	(1.080)	0.005	(1.278)	0.005	(1.287)	0.005	(1.205)
% Population <5	-0.002	(-0.854)	-0.002	(-0.759)	-0.003	(-1.037)	-0.002	(-0.723)
% Population >60	0.007	(0.805)	0.005	(0.579)	0.004	(0.446)	0.006	(0.710)
% Unemployed	0.010	(1.590)	**0.011***	(1.653)	**0.018*****	(2.640)	**0.012***	(1.765)
% Industry production on total	**0.550*****	(4.178)	**0.537*****	(4.081)	**0.510*****	(3.924)	**0.524*****	(3.964)
Taxes	**0.480*****	(16.208)	**0.475*****	(16.109)	**0.481*****	(16.213)	**0.473*****	(16.079)
Fees	-0.002	(-0.102)	-0.003	(-0.13)	-0.010	(-0.440)	-0.005	(-0.218)
λ	**0.220*****	(3.905)	**0.220*****	(3.933)	**0.219*****	(3.814)	**0.222*****	(3.976)
Pseudo-R^2	0.685		0.683		0.694		0.684	
BASIC SANITATION (n=238)								
Constant	-2.569	(-0.762)	-2.465	(-0.725)	-3.126	(-0.843)	-2.786	(-0.805)
% Urban area	-0.360	(-0.563)	-	-	-	-	-	-
CV	-	-	0.098	(0.473)	-	-	-	-
GI	-	-	-	-	0.203	(0.194)	-	-
GI Medium	-	-	-	-	0.085	(0.137)	-	-
UPD	-	-	-	-	-	-	0.000	(-0.193)

TABLE 2.6 - SPATIAL MODEL ESTIMATION RESULTS

(continued)

MODEL	(1)		(2)		(3)		(4)	
Central	-0.229	(-0.600)	-0.123	(-0.328)	-0.210	(-0.508)	-0.182	(-0.481)
Population	-0.008	(-0.045)	-0.032	(-0.182)	0.009	(0.965)	-0.004	(-0.020)
% Graduates	**0.099***	(1.903)	**0.101****	(1.964)	**0.103****	(2.015)	**0.103****	(2.027)
% Without studies	0.047	(1.571)	0.048	(1.582)	0.048	(1.618)	0.048	(1.610)
% Population <*5*	-0.002	(-0.130)	-0.002	(-0.090)	-0.002	(-0.122)	-0.001	(-0.082)
% Population >60	**0.147****	(2.049)	**0.133***	(1.929)	**0.132***	(1.882)	**0.138****	(1.974)
% Unemployed	**-0.124****	(-2.382)	**-0.120****	(-2.311)	**-0.121****	(-2.159)	**-0.121****	(-2.316)
% Industry production on total	1.348	(1.250)	1.299	(1.207)	1.294	(1.196)	1.285	(1.189)
Taxes	0.388	(1.602)	0.364	(1.516)	0.386	(1.569)	0.368	(1.532)
Fees	-0.021	(-0.116)	-0.040	(-0.217)	-0.035	(-0.193)	-0.030	(-0.164)
λ	**0.123***	(1.675)	**0.127***	(1.732)	**0.125***	(1.696)	**0.124***	(1.677)
Pseudo-R^2	0.176		0.175		0.175		0.175	
HOUSING (n=234)								
Constant	**-6.138***	(-1.916)	**-6.089***	(-1.895)	**-6.535***	(-1.843)	**-5.469***	(-1.692)
% Urban area	-0.359	(-0.662)	-	-	-	-	-	-
CV	-	-	0.102	(0.583)	-	-	-	-
GI	-	-	-	-	-0.262	(-0.261)	-	-
GI Medium	-	-	-	-	0.338	(0.571)	-	-
UPD	-	-	-	-	-	-	0.000	(1.359)
Central	0.421	(1.186)	0.551	(1.581)	0.396	(1.021)	**0.604***	(1.757)
Population	0.182	(1.140)	0.165	(1.035)	0.199	(1.099)	0.073	(0.416)
% Graduates	0.019	(0.395)	0.018	(0.379)	0.023	(0.484)	0.026	(0.545)
% Without studies	0.015	(0.509)	0.015	(0.496)	0.015	(0.506)	0.018	(0.614)
% Population <*5*	-0.012	(-0.773)	-0.011	(-0.725)	-0.012	(-0.772)	-0.012	(-0.759)
% Population >60	-0.056	(-0.890)	-0.070	(-1.138)	-0.066	(-1.081)	-0.075	(-1.219)
% Unemployed	**0.098****	(2.037)	**0.101****	(2.128)	**0.111****	(2.164)	**0.096****	(2.035)
% Industry production on total	1.285	(1.246)	1.255	(1.221)	1.202	(1.165)	1.514	(1.457)
Taxes	**0.769*****	(3.490)	**0.744*****	(3.427)	**0.752*****	(3.400)	**0.749*****	(3.465)
Fees	0.058	(0.330)	0.047	(0.265)	0.062	(0.354)	0.082	(0.467)
λ	**0.167***	**(1.870**)	**0.155***	(1.757)	**0.159***	(1.790)	0.148	(1.644)
Pseudo-R^2	0.170		0.171		0.171		0.178	
LOCAL SECURITY (n=251)								
Constant	3.076	(1.082)	3.431	(1.239)	3.595	(1.181)	4.010	(1.425)
% Urban area	0.745	(1.303)	-	-	-	-	-	-
CV	-	-	0.063	(0.417)	-	-	-	-
GI	-	-	-	-	0.294	(0.350)	-	-
GI Medium	-	-	-	-	-0.383	(-0.871)	-	-
UPD	-	-	-	-	-	-	0.000	(1.287)
Central	-0.077	(-0.235)	-0.056	(-0.171)	0.069	(0.183)	0.120	(0.382)
Population	-0.125	(-0.879)	-0.132	(-1.020)	-0.157	(-1.047)	-0.225	(-1.504)
% Graduates	0.012	(0.278)	0.003	(0.078)	0.002	(0.049)	0.009	(0.234)
% Without studies	**-0.054****	(-2.121)	**-0.055****	(-2.227)	**-0.054****	(-2.174)	**-0.050****	(-2.106)
% Population <*5*	0.005	(0.352)	0.003	(0.222)	0.002	(0.044)	0.002	(0.149)
% Population >60	**-0.093***	(-1.797)	**-0.080***	(-1.648)	-0.073	(-1.486)	**-0.085***	(-1.817)
% Unemployed	**-0.125*****	(-2.747)	**-0.106****	(-2.457)	**-0.117****	(-2.544)	**-0.102****	(-2.459)
% Industry production on total	**1.428***	(1.722)	**1.382***	(1.714)	**1.445***	(1.787)	**1.411***	(1.799)
Taxes	**0.516 ****	(2.525)	**0.534*****	(2.662)	**0.536*****	(2.647)	**0.530*****	(2.722)
Fees	0.161	(1.090)	0.134	(0.935)	0.149	(1.043)	0.133	(0.965)
We	0.165	(1.386)	**0.232****	(1.950)	**0.234****	(1.969)	**0.289****	(2.574)
λ	-0.125	(-0.969)	**-0.226***	(-1.821)	**-0.235****	(-1.904)	**-0.294****	(-2.523)
Pseudo-R^2	0.247		0.261		0.262		0.260	
SOCIAL ASSISTANCE (n=322)								
Constant	**2.190*****	(2.617)	**2.031****	(2.426)	**1.577***	(1.761)	**2.106****	(2.493)
% Urban area	-0.037	(-0.251)	-	-	-	-	-	-
CV	-	-	-0.068	(-1.400)	-	-	-	-

TABLE 2.6 - SPATIAL MODEL ESTIMATION RESULTS

(continued)

MODEL	(1)		(2)		(3)		(4)	
GI	-	-	-	-	0.019	(0.085)	-	-
GI Medium	-	-	-	-	**0.324****	(2.226)	-	-
UPD	-	-	-	-	-	-	0.000	(-0.448)
Central	0.143	(1.551)	0.119	(1.302)	0.046	(0.472)	0.141	(1.548)
Population	**-0.205*****	(-4.979)	**-0.198*****	(-4.803)	**-0.169*****	(-3.768)	**-0.198*****	(-4.429)
% Graduates	**0.043*****	(3.400)	**0.046*****	(3.672)	**0.045*****	(3.596)	**0.043*****	(3.488)
% Without studies	**0.0286*****	(3.941)	**0.030*****	(4.155)	**0.029*****	(4.030)	**0.029*****	(3.979)
% Population <5	**-0.012*****	(-2.607)	**-0.012*****	(-2.609)	**-0.013*****	(-2.890)	**-0.0112*****	(-2.582)
% Population >60	-0.023	(-1.314)	-0.022	(-1.292)	-0.028	(-1.636)	-0.023	(-1.305)
% Unemployed	0.012	(0.933)	0.012	(0.895)	0.020	(1.493)	0.100	(0.399)
% Industry production on total	0.117	(0.467)	0.108	(0.434)	0.078	(0.317)	0.013	(0.985)
Taxes	**0.458*****	(8.178)	**0.461*****	(8.303)	**0.479*****	(8.502)	0.455	(8.180)
Fees	-0.032	(-0.763)	-0.026	(-0.620)	-0.046	(-1.104)	-0.033	(-0.801)
λ	**0.304*****	(5.005)	**0.301*****	(4.990)	**0.298*****	(4.850)	**0.305*****	(5.017)
Pseudo-R^2	0.376		0.381		0.390		0.376	
SPORTS AND LEISURE (n=308)								
Constant	2.860	(1.692)	2.627	(1.549)	1.771	(0.949)	3.738	(2.201)
% Urban area	-0.194	(-0.627)	-	-	-	-	-	-
CV	-	-	-0.064	(-0.651)	-	-	-	-
GI	-	-	-	-	0.039	(0.082)	-	-
GI Medium	-	-	-	-	0.451	(1.636)	-	-
UPD	-	-	-	-	- -		**0.000101****	(2.558)
Central	-0.031	(-0.165)	-0.030	(-0.160)	-0.167	(-0.817)	0.127	(0.685)
Population	**-0.333*****	(-4.013)	**-0.33*****	(-3.965)	**-0.276*****	(-2.945)	**-0.446*****	(-4.910)
% Graduates	0.033	(1.293)	0.037	(1.487)	0.036	(1.454)	0.035	(1.414)
% Without studies	0.002	(0.138)	0.004	(0.276)	0.003	(0.210)	0.004	(0.284)
% Population <5	-0.009	(-1.008)	-0.009	(-0.962)	-0.011	(-1.134)	-0.010	(-1.060)
% Population >60	-0.012	(-0.355)	-0.014	(-0.416)	-0.025	(-0.746)	-0.028	(-0.857)
% Unemployed	**-0.068*****	(-2.768)	**-0.068*****	(-2.755)	**-0.057****	(-2.266)	**-0.074*****	(-3.066)
% Industry production on total	**1.398*****	(2.781)	**1.375*****	(2.741)	**1.312*****	(2.623)	**1.480*****	(2.973)
Taxes	**0.673*****	(6.011)	**0.669*****	(6.007)	**0.708*****	(6.252)	**0.684*****	(6.229)
Fees	-0.043	(-0.498)	-0.039	(-0.453)	-0.061	(-0.715)	-0.032	(-0.372)
λ	**0.133****	(2.260)	**0.133****	(2.292)	**0.112***	(1.900)	**0.111****	(1.881)
Pseudo-R^2	0.352		0.352		0.360		0.367	
URBAN INFRAESTRUCTURE (n=322)								
Constant	**4.878*****	(4.832)	**4.831*****	(4.759)	**5.386*****	(4.854)	**5.033*****	(4.896)
% Urban area	0.068	(0.360)	-	-	-	-	-	-
CV	-	-	-0.040	(-0.652)	-	-	-	-
GI	-	-	-	-	-0.139	(-0.485)	-	-
GI Medium	-	-	-	-	-0.122	(-0.712)	-	-
UPD	-	-	-	-	-	-	0.000	(0.584)
Central	0.060	(0.515)	0.027	(0.232)	0.107	(0.847)	0.064	(0.558)
Population	**-0.143*****	(-2.842)	**-0.136*****	(-2.685)	**-0.170*****	(-2.989)	**-0.155*****	(-2.787)
% Graduates	-0.013	(-0.822)	-0.012	(-0.803)	-0.014	(-0.898)	-0.013	(-0.886)
% Without studies	-0.010	(-1.192)	-0.010	(-1.179)	-0.011	(-1.267)	-0.010	(-1.214)
% Population <5	-0.008	(-1.405)	-0.008	(-1.436)	-0.008	(-1.319)	-0.008	(-1.454)
% Population >60	-0.015	(-0.719)	-0.012	(-0.607)	-0.020	(-0.494)	-0.015	(-0.732)
% Unemployed	0.012	(0.802)	0.011	(0.755)	0.010	(0.617)	0.011	(0.717)
% Industry production on total	-0.179	(-0.584)	-0.174	(-0.568)	-0.149	(-0.486)	-0.153	(-0.499)
Taxes	**0.519*****	(7.576)	**0.525*****	(7.690)	**0.507*****	(7.272)	**0.525*****	(7.701)
Fees	-0.074	(-1.423)	-0.070	(-1.348)	-0.065	(-1.239)	-0.072	(-1.378)
λ	**0.154****	(2.306)	**0.159****	(2.376)	**0.150****	(2.288)	0.152	(2.258)
Pseudo-R^2	0.280		0.280		0.283		0.281	

Note: *** denotes two-tailed hypothesis test significant at p <0.01; ** denotes two-tailed hypothesis test significant at p <0.05; * denotes two-tailed hypothesis test significant at p <0.10. T-values are in parentheses. Statistically significant parameters are in bold.
SOURCE: Estimation results.

2.5 DISCUSSIONS

The first argument to point out regards the estimated results is the effectiveness of the measures of urban sprawl. The population density and the percentage of urban area, the two most used measures of urban sprawl, do not seens to be correlated with the cost of providing public service in Brazilian municipalities; the parameters estimated, in most cases, are statistically insignificant and/or have a small value. By its turn, the CV, which shows the dispersion of the population in the urban area, is insignificant in all the estimated equations. Whereas the gravitational index appears to be the best measure (in terms of fitting to the model) to account the effects of urban sprawl on local public spending for Brazilian municipalities.

Contrary to expectations, none of the urban sprawl measures is statistically significant in the urban infrastructure per capita spending function, indicating that urban sprawl is not an important impacting factor on the cost of providing this public service. Similar result was found by Hortas-Rico and Sollé-Ollé (2010) in a cross-sectional analysis of the Spanish municipalities spending functions. A possible explanation for this might be that investments on urban infrastructure demand time to be done, in other words, the local governments do not respond to the urban sprawl at the same time it is identified, thus the cross-section analysis is not able to capture the effects of urban sprawl on the infrastructure expenditure. Furthermore, some important variables, like political issues and/or the spending on infrastructure by other government levels, not added in the model, can influence the effects of the urban sprawl. These explanations can also be extended to other expenditure items in which the parameters of urban sprawl are not statistically significant.

Focusing now on the aggregate per capita spending, the GI shows that municipalities that have a small degree of sprawl have lower aggregate spending on public services. Accordingly to this empirical evidence, urban sprawl, characterized as an expansion through the borders of a city, increases the cost of providing local public services. Although, the positive relation between urban sprawl and the cost of providing aggregate spending presented by the estimation results only holds for municipalities of high urban concentration. Concerning the cities of medium concentration, the total effect of urban sprawl on their aggregate spending is given by the sum of the coefficients of the GI and the GI Medium; as can be seen on the estimation results, the total effect is very small, indicating that urban sprawl is not a determinant factor of the aggregate spending of medium cities. This result may support the hypothesis that there is a threshold effect in the relation between urban sprawl and aggregate expenditures; which means that the pattern of urban sprawl meaningly press up the cost of local public services only after it achieves a certain degree.

Defining the degree of sprawl that is harmful to cities is one of the main challenges nowadays for the analysis of urban sprawl, mainly because empirical evidences to determinate it are scarce, and there is no theoretical consensus among the researchers about this degree. With regard to the Brazilian municipalities, the investigation of this issue is important especially for the medium cities. It is expected that such cities grow faster than the cities of high urban concentration in the next years; thus, promoting a strategy of urban planning that accounts for the impact of the sprawling process in medium cities is a key action to avoid the negative consequences of urban sprawl, already existing in big cities.

On the question of the effects of urban sprawl on disaggregated expenditure items; the results for the GI indicated that urban sprawl affects the per capita spending on administration and environmental management. In the administration spending, which inclues financial and human resourses expenditures and represents the third biggest spending of local governments, the effect is negative and significant for municipalities of high urban concentrations. A scale gain can explain the result; it cost less to main the local administration if the population is more concentrated close to the central area than sprawled in the urban area. Regards to the result of the environmental management, the effects of urban sprawl on this spending item is positive, the more concentrated the population the higher the per capita spending. This result indicates that more people living close to the central area causes more environment degradation, so the spending on preservation and recovery is higher. It worth to add that the coefficients of the GI Medium in the spending on administration and environmental management equations have the opposite sign of the coefficients of the GI. Although they are not statistically significant, they are in line with the relationship described in the last two paragraphs. Regards to the social assistance spending, there is a positive effect of sprawl on this category of spending, measured by the GI Medium. In medium cities, the concentration of people in the central area increases the per capita spending on social assistance.

Lastly, the findings of this study also evidence that the strategic interaction among the municipalities has an important role in the per capita cost of public service. As could be seen, the spatial component is a determinant factor of the per capita expenditure of seven items of spending. The direct implication of this evidence is that any politics that aims to reduce the cost of providing local public services should be taken at the regional level, notably at each urban concentration.

2.6 FINAL REMARKS

This essay set out to examine the consequences of the urban sprawl on the local public finances in Brazilian municipalities. Multiple regression analysis revealed the importance of testing new measures to evaluate the effects of urban sprawl on the cost of providing local public services. As shown by the estimation results, the gravitational index is the most correlated measure with the Brazilian local finances.

The findings of the empirical analysis also allow us to answer the question made in the introduction section. The estimation results suggest that there is a positive relation between urban sprawl and the cost of providing the aggregate spending and spending on administration, which stands for cities of high urban concentrations. This finding, while preliminary, proposes that the urban patterns of growth should be addressed in politics of promotion the long-term local finance sustainability.

Additionaly, the empirical results suggest an interesting fact regarding the effects of urban sprawl in big and medium cities of Brazil. The effect of urban sprawl on the spendings is not linear and it is characterized as a threshold effect: the sprawling process is harmful to the local spending only after it achieves a high degree. This evidence is quite important to medium cities since their degrees of urban sprawl are not high nowadays, but it is expected that this scenario changes in the next years, as medium cities expand in terms of population size and urban area. Thus, investigating the pattern of urban land occupation is necessary to the promotion of an urban pattern of growth consistent with a sustainable local finance system and with a high level of welfare of the population.

Some of the issues emerging from the empirical findings relate specifically to the current limitations of the analysis of urban sprawl and its effects. Until which limit is the process of urban sprawl acceptable? What is the best measure to account urban sprawl? The answers to these questions are two of the keys elements to the literature of urban economics and to urban planners and policy-makers; therefore, they should be contemplated in further studies.

The present study has raised important insights regarding the phenomenon of urban sprawl in Brazil, but yet there are many unanswered questions about it. To develop a full picture of this phenomenon in Brazilian municipalities, additional studies are needed to investigate the factors behind the causes of urban sprawl and its consequences other than financial.

REFERENCES

ALMEIDA, E. **Econometria Espacial Aplicada** [S.l.]: Campinas-SP. Alínea, 2012.

ALONSO, W. **Location and land use**. Harvard University Press, 1964.

ANSELIN, L. **Spatial econometrics: methods and models.** [S.l.]: Blackwell Publishing Ltd, 2001.

Baldassare, M.**Trouble in paradise: the suburban transformation of America**. New York: Columbia University Press, 1986.

BEKELE, H. **Urbanization and urban sprawl**. Master of Science Thesis - Department of Infrastructure Section of Building and Real Estate Economics Kungliga Tekniska Högskolan, 2005. Available in: < https://www.kth.se/polopoly_fs/1.176802!/Menu/general/column-content/attachment/294.pdf>. Access in February 10th, 2017.

BRITO, F.; HORTA, C. J. G.; AMARAL, E.F de L. A urbanização recente no Brasil e as aglomerações metropolitanas. In: **XXIV IUSSP General Conference**, p. 168-184, 2001.

BRUECKNER, J. K.; KIM, H.-A. Urban sprawl and the property tax. **International Tax and Public Finance**, Springer, v. 10, n. 1, p. 5–23, 2003.

CAMPANTE, F. R.; DO, Q. **A Centered Index of Spatial Concentration: Axiomatic Approach with an Application to Population and Capital Cities**. HKS Faculty Research Working Paper Series, RWP09-005, 2009.

CARRUTHERS, J. I.; ULFARSSON, G. F. Urban sprawl and the cost of public services. **Environment and Planning B: Planning and Design,** SAGE Publications, v. 30, n. 4, p. 503–522, 2003.

______.; ______. Does smart growth matter to public finance? **Urban Studies.** v. 45, n. 9, p. 1791-1823, 2008.

EWING, R.; PENDALL, R.; CHEN, D. Measuring sprawl and its impacts. **Smart Growth America**, 2002.

FRENKEL, A.; ASHKENAZI, M. Measuring urban sprawl: how can we deal with it? **Environment and Planning B: Planning and Design**, SAGE Publications, v. 35, n. 1, p. 56–79, 2008.

GALSTER, G. et al. Wrestling sprawl to the ground: defining and measuring an elusive concept. **Housing policy debate, Taylor & Francis**, v. 12, n. 4, p. 681–717, 2001.

FINBRA. **Finanças do Brasil – Dados Contábeis dos Municípios**. Available in: http://www.tesouro.fazenda.gov.br/pt_PT/contas-anuais. Access in February 10th, 2017.

HARVEY, R. O.; CLARK, W. A. The nature and economics of urban sprawl. Land Economics, **JSTOR,** v. 41, n. 1, p. 1–9, 1965.

HAYEK, U. W. et al. Measuring and assessing urban sprawl: What are the remaining options for future settlement development in Switzerland for 2030? **Applied Spatial Analysis and Policy**, v. 4, n. 4, p. 249-279, 2011.

HORTAS-RICO, M. Urban sprawl and municipal budgets in Spain: A dynamic panel data analysis. **Papers in Regional Science**, Wiley Online Library, v. 93, n. 4, p. 843–864, 2014.

HORTAS-RICO, M.; SOLÉ-OLLÉ, A. Does urban sprawl increase the costs of providing local public services? Evidence from Spanish municipalities. **Urban studies**, SAGE Publications, v. 47, n. 7, p. 1513–1540, 2010.

IBGE. **Census 2010**. 2010. Available in: < http://www.censo2010.ibge.gov.br/"> . Access in February 10th, 2017.

______. **Indicadores da População**. Available in: < http://www.ibge.gov.br>. Access in December 20th, 2016.

______. **Arranjos Populacionais e Concentrações Urbanas do Brasil. Rio de Janeiro**, 2015. Available in: < www.ibge.gov.br/apps/arranjos_populacionais/2015>. Access in December 20th, 2016.

JARGOWSKY, P. A. Sprawl, concentration of poverty, and urban inequality. In: SQUIRES, G.D, (Ed.).**Urban sprawl: Causes, consequences, and policy responses**, p. 39-72, 2002.

KELEJIAN, H. H.; PRUCHA, I. R. A generalized spatial two-stage least squares procedure for estimating a spatial autoregressive model with autoregressive disturbances. **The Journal of Real Estate Finance and Economics**, v. 17, n. 1, p. 99-121, 1998.

LADD, Helen F. Population growth, density and the costs of providing public services**. Urban Studies**, v. 29, n. 2, p. 273-295, 1992.

MILLS, E. S. An aggregative model of resource allocation in a metropolitan area. **The American Economic Review**, JSTOR, v. 57, n. 2, p. 197–210, 1967.

MUTH, R. F. **Cities and housing**. University of Chicago Press, 1969.

NAKAMURA, Kazuyuki; TAHIRA, M. **Distribution of Population Density and the Cost of Local Public Services: The Case of Japanese Municipalities**. Faculty of Economics, University of Toyama, v. 3190, 2008.

OLLÉ, Albert Solé. Expenditure spillovers and fiscal interactions: Empirical evidence from local governments in Spain. **Documents de treball IEB**, n. 3, p. 1, 2005.

OJIMA, R.; HOGAN, D. J. Mobility, Urban Sprawl and Environmental Risks in Brazilian Urban Agglomerations: Challenges for Urban Sustainability. **Urban Population-Environment Dynamics in the Developing World: Case Studies and Lessons Learned.** Paris: Committee for International Cooperation in National Research in Demography (CICRED), p. 281-316, 2009.

POLIDORO, M.; LOLLO, J.A. de; BARROS, M.V.F. Urban Sprawl and the Challenges for Urban Planning. **Journal of Environmental Protection**, v. 2012, 2012.

SANTOS, M. Espaço e sociedade no Brasil: a urbanização recente. **Geosul**, v. 3, n. 5, p. 85-100, 1988.

SMART GROWTH AMERICA. **What is smart growth?** Available in: < https://smartgrowthamerica.org/>. Access in February 10th, 2017.

TORRES, H.G. Migration and the Environment: a view from Brazilian Metropolitan Areas. In: **Population and Environment in Brazil**. CNPD/ABEP/NEPO: Campinas, São Paulo, Brazil, 2001.

YUE, W.; LIU, Y.; FAN, P. Measuring urban sprawl and its drivers in large Chinese cities: The case of Hangzhou. **Land use policy**, Elsevier, v. 31, p. 358–370, 2013.

APPENDIX 1 – DIAGNOSTIC OF SPATIAL DEPENDENCE

The detection of spatial dependence of a model and the choice of the most appropriated spatial model consist of the following steps[7]:

-Chose a matrix of spatial weights.

-Estimate the proposed model by OLS (equation 2.2).

-Test the spatial dependence of the error terms of the models estimated by OLS with the Moran's I statistic.

-If Moran's I is not statistically significant, there is not spatial dependence and the model can be estimated by OLS.

-If Moran's I is statistically significant, there is spatial dependence and a spatial model is more appropriated to the data.

-The choice of the spatial model can be done by the Lagrange Multiplier (lag) and Lagrange Multiplier (error). The most statistically significant indicate the type of the spatial dependence. Other spatial models can the tested to check the most appropriated.

In this analysis, the spatial matrix used was the queen contiguity: two regions are neighbors in this sense if they share any part of a common border, no matter how short.

The diagnostic for spatial dependence of each spending category with the model varying the urban sprawl variables is shown in TABLE 2.7.

TABLE 1.A: MORAN'S I ESTIMATION RESULTS

Dependent variable	Urbans sprawl variable in the model				Model
	%Urban Area	CV	GI	UPD	
Aggregate	**0.188*****	**0.187*****	**0.186*****	**0.190*****	SEM
Administrations	0.025	0.031	0.035	0.029	OLS
Basic sanitation	**0.141***	**0.121 ****	**0.118***	**0.115***	SEM
Culture	0.028	0.026	0.017	0.014	OLS
Environmental management	0.023	0.019	0.009	0.028	OLS
Housing	**0.129****	**0.119***	**0.122****	**0.114***	SEM
Local Security	**0.144****	**0.137****	**0.133****	**0.121****	SAC
Social Assistance	**0.237*****	**0.236*****	**0.235*****	**0.237*****	SEM
Sports and leisure	**0.111****	**0.112****	**0.090***	**0.092 ***	SEM
Urban infrastructure	**0.114****	**0.116****	**0.111****	**0.112****	SEM

Note: *** denotes two-tailed hypothesis test significant at p <0.01; ** denotes two-tailed hypothesis test significant at p <0.05; * denotes two-tailed hypothesis test significant at p <0.10.
Statistically significant parameters are in bold.
Source: Estimation results.

[7] Description based on Almeida (2012).