The Spatial Structure of Health Services Supply in Brazil and Great Britain

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Abstract

This paper aims at the verification of the spatial structure in the distribution of health services in Brazil and Great Britain, searching for any spatial pattern or correlation, under the light of the Central Place Theory. To address this subject, this paper is based on a panel data model proposed by Fingleton (2008) with spatial lag and components of the error correlated in space as well as in time.

The comparison of the Brazilian and Great Britain's data brings out some very interesting results. The positive estimated coefficient for the spatial lag of the ratio of health professionals indicates that there is a spatially concentrated distribution of health professionals in Brazil, resulting in the formation of over attended regions and regions with low levels of health service in commission. As shown by the exploratory Moran's I, the spatial structure of the provision of health professionals in Brazil presents several gaps and absences among the north-eastern micro-regions and juxtapositions among the central and southern micro-regions. The results for Great Britain's data are very different. There is no significant spatial correlation in the ratio of health services professionals among the GB's UALADs, which might indicate a very structured regional network of health services supply in which the UALADs are self-contained supply regions and only the very central services are spatially concentrated, which would not cause imbalances to the ratio of health professionals amongst the UALADs.

Keywords: health services supply, spatial structure, Brazil, Great Britain.

JEL codes: I11, R12.

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Introduction

The provision of health services in developing countries is characterized by large regional disparities. In Brazil, the geographical distribution of productive capacity in health is an important constraint on the access to these services, given that the distance between the location of supply and of demand imposes additional difficulties to the use of the services. Aiming to the decentralization of the supply of health services, the Brazilian Unique Health System (SUS) have been facing several barriers to reach the poorest regions of the country. These barriers are imposed, among other factors, by the lack of availability of basic and specialized health professionals in those areas.

Meanwhile, developed countries usually present a denser urban network and the transportation system is more efficient, reducing the problems derived from geographical distance between health services demand and supply. In the United Kingdom, the National Health Service (NHS) establishes several regional strategies in order to secure an evenly distributed supply of health services, taking into account regional demand disparities and transportation issues.

This paper focuses on the spatial structure of health supply in Brazil and Great Britain (GB), considering purely the supply side, not considering different needs or health outcomes. The supply of health services is measured by the ratio of health professionals over the total amount of employees, disregarding their specialties, complexity and efficiency. The Brazilian data for 2005 to 2007 were mainly extracted from the Annual Relation of Social Information (RAIS), an annual census of firms and its employees. The geographical units are the 442 micro-regions in the Northern, South-eastern and Southern regions of the country. In addition to the RAIS, the Demographic Census 2000 and the Population Counting 2007 were also accessed.

The GB data were extracted from the Annual Population Survey also from 2005 to 2007. The geographical units are the Unitary Authority and Local Authority Districts (UALADs) in England, Wales and Scotland, summing 407 UALADs[1].

The main objective of the paper is to verify the spatial structure in the distribution of health services, searching for any spatial pattern or correlation. Under the light of the Central Place Theory (Christäller, 1966), the economic activities would be spatially distributed

[1] Due to the lack of data, the Isles of Scilly were removed from the sample.

according to its hierarchy, or centrality, being spatially concentrated at central places. Those goods or services with a higher level of hierarchy would have a wider range and threshold. Hence, their supply would be spatially concentrated at the central area, which would provide those goods and services to its neighbourhood. In order to estimate the spatial structure of the health services, this paper is based on the method of estimation of spatial panel data proposed by Fingleton (2008).

After this small introduction, the first part of this paper introduces the Brazilian Unique Health System. The second presents the GB`s National Health Service. The third section presents the contextualization of the health services supply under the Central Place Theory. The forth section presents the estimation strategy. The fifth and sixth parts show an exploratory analysis of the data and the results of the estimations. These sections are followed by some final remarks.

As the reader shall see, in addition to an exploratory analysis of the spatial data, the econometric results show that in the GB the supply of health services in one region has no significant influence over its neighbourhood. This indicates that the supply of health services in GB is spatially independent. On the other hand, in Brazil, there is a strong positive spatial association in the supply of health services, indicating a spatial imbalance in the provision of health services. The Southern and Southeastern concentrate most of the health services supply, while the Northeastern presents a large area that has access to an insufficient supply of health services.

The Brazilian Unique Health System

The Brazilian 1988 Constitution has created the Unique Health System (SUS) aiming to reduce inequalities in the supply of health services, by providing adequate access to these services at no cost to the population. The SUS establishes that the access to health services is to be guaranteed to all citizens, with full coverage of medical needs and equal treatment to people with equal needs. Its organizational principles are decentralization, regionalization and hierarchy of services, as well as community participation. It intends to promote the decentralization of the health system at the local level, both in the management and funding of the services, aiming to adjust the model of assistance to the real medical needs of the population by bringing the solution of the problems to the same regions where they occur.

The process of decentralization and regionalization of health services has gradually developed over time with the implementation of government policies, the so-called NOB/SUS (Basic Operational Norms of SUS), aiming at regulating and defining strategies for the efficient operation of the system. The negotiation of aspects relating to health services are made by the *Bipartite* Management Commission (composed by members from municipalities and states) and *Tripartite* Management Commission (with members from local, state and federal governments). Such commissions are responsible for formulating strategies to consolidate the SUS and integrate all levels of government.

Since the beginning of the 1990s there have been several attempts to transfer duties related to the health system to the municipalities. The norms NOB/SUS 01/91 and NOB/SUS 01/92 had emphasized the importance of decentralizing the actions and services of the health system, but only after norm NOB 01/93 such process of decentralization has actually taken place. Norm NOB 01/93 has defined the conditions under which the municipalities would qualify for the receipt of resources from the National Health Fund (*Fundo Nacional de Saúde*) and has identified criteria according to the various management conditions (incipient, partial, semi-full). Due to difficulties in managing the services, norm NOB/SUS 01/96 has been established in 1996 aiming to define the conditions for managing services at local and state levels. This norm, which is still ruling nowadays, has allowed a rapid expansion of the network of medical services at the local level. In this case, mangers at state and federal levels are co-responsible for the provision of health services.

The Operational Norm of Health Assistance (NOAS/SUS 2001) was established in 2001 in order to promote regional health care centres and to avoid inefficiencies in the provision of services in each municipality. In this norm, the focus has changed from atomization of services (locally) to optimization of services (regionally). NOAS/SUS 2001 has established a Regionalization Guiding Plan – henceforth PDR – which proposes to organize the health care system at regional level, under the coordination of a state manager. This norm aims to identify the roles of the municipalities in the state health system and to tackle inequalities in the provision of services. In order to do so, it defines a set of actions to be taken by all municipalities regarding basic health care and supports the creation of regional units, able to fulfil the medical needs of a larger population according to its geographical location.

NOAS/SUS 2001 provided greater flexibility in dealing with regional health care issues, because the PDR has been created in accordance with the epidemiological, sanitary, geographical and social specificities of each state, as well as the particular conditions regarding the access to health services in each region. However, serious problems in the management and funding of the system still persist, despite the efforts to promote and facilitate the provision of all kinds of health services to the population. As Cordeiro (2001: 324) puts it,

> *The atomization of the network of services, due to the increase in the number of small towns (ten to twenty thousand inhabitants) represents a political and administrative difficulty for a regionalized and hierarchical system. The agreement between federal, state, and local governments, which was already complex in the Brazilian federation, has become even more complicated for the implementation of SUS, given that the* Lei Orgânica da Saúde *has defined five administrative levels for the SUS (federal, state, regional, municipal, and district levels), with political and financial autonomy for the management to health subsystems at each level.*

In addition, the funding of SUS depends to a certain degree on the productive capacity of the health system in each region, which is sometimes not in accordance with the real needs of the population. Despite the intents to guarantee universal and equal health care to the entire population under the rules guiding the creation of SUS, it is important to check on the spatial distribution of these services, in order to advance in the understanding of the inequalities that persist between regions in Brazil.

GB's National Health Service

The Great Britain's NHS is comprised by the National Health Service of England, Wales and Scotland. The system as whole, known as United Kingdom's NHS, also comprises the NHS Northern Ireland, which is not considered in this paper due to spatial discontinuity. The three NHS are publicly funded healthcare systems managed individually by their home countries, but there is no residency discrimination in all of them for any United Kingdom's citizen. The system was established 60 years ago, in 1948, and continues to be funded centrally from national taxation and to be considered as a single and unified system, despite some recent modifications at country levels.

The NHS provides free healthcare for all UK residents, excluding some charged prescriptions and optical and dental services. The range of the provided services goes from the most simple primary health attention to complex surgeries. The whole system had a budge in 2007/8 of £90 billion and employs around 1.6 million people: 81% are concentrated in the England NHS, 10% in Scotland and around 4% in Wales and Northern Ireland each.

The NHS constitution states that it is a responsibility of the local Primary Care Trusts (PCT) to provide the health services necessary to meet the local demands and needs.

However, the specialised services are commissioned either regionally or nationally from a few specialist centres (NHS, 2009).

The NHS management is regionally structured. The England NHS has 10 regional headquarters named Strategic Health Authorities to carry out functions delegated to them by the Secretary of State. Each Strategic Health Authority is responsible for ensuring that patients have access to high-quality services in its area. The Scottish health services are delivered through 14 regional NHS Boards. In Wales, the NHS has 3 Regional Offices, for North Wales, Mid & West Wales and South & East Wales, which act as agent of the Chief Executive NHS Wales.

Urban Network and Centrality

The provision of health care is composed by basic services, which are used frequently and have lower costs, and by complex services which are subject to economies of scale, because they involve higher technology and lower spatial density of demand. For this reason, the distribution of health services supply is spatially differentiated. As pointed out by Vlahov & Gálea (2002:37),

> (...) social service systems in cities often provide a far wider range of services than are available in smaller cities or in non-urban areas. Although use of these services may be limited by sparse staffing and by difficult, complicated access, their availability in cities suggests that resources may already exist in many urban contexts that can contribute to well-being.

Given the existence of such differentiation and such complexity in the supply of health services, it is necessary to search for theoretical elements to interpret this issue. In this case, the Central Place Theory (CPT) and its contemporary developments seem to provide a valuable theoretical benchmark to the analysis of the spatial distribution of health services. Despite the restrictive assumptions of the original model (such as uniform population density, equal transport costs, equal consumer preferences, equal income distribution), its basic concepts of threshold and range can help us in the general understanding of urban networks in the supply of services.

The Central Place Theory, developed by Christäller (1966), is based on the principle of centrality and considers the space to be organized around a main urban core, called central place. The complementary region, or hinterland, presents a relation of co-dependency with the main core, since this is the locus of supply of goods and services that are urban in nature.

The main role of an urban core is to be a centre of services to its immediate hinterland, by providing essential goods and services. These, in turn, have different features, and generate a hierarchy of urban cores according to the services provided. There are two key concepts to understand CPT: i) threshold, defined as the minimum level of demand necessary to promote the supply of a good or service, which reflects the economies of scale in the production of the service as well as the urban agglomeration economies; and ii) range, defined as the maximum distance the consumer is willing to move in order to access a given good or service, and which varies with the complexity of the service.

Therefore, the threshold may be represented as the smallest concentric circle that justifies the supply of a good or service, and the range may be described as the largest concentric circle that forms the complementary region of the central place and defines its area of influence. The limits of such area of influence are given by the existence of another area of influence of another centre of similar or higher hierarchy. The size of this exterior circle varies according to the different goods and services that are supplied, and the demand in its interior varies inversely with the distance to the urban core.

The model intends to demonstrate that the sizes of the areas of influence of each central place depend directly to the size and hierarchy of the centres, being the periphery of smaller centres included in the complementary regions of larger ones. The largest the centrality of a central place, the largest is its hinterland, i.e., the largest the complexity of the services provided, the largest is the area influenced by this centre. According to Regales (1992), the areas of influence of centres of different sizes overlap according to the complexity (hierarchy) of the services supplied, building up urban networks of supply of complementary and interdependent services. Ullman (1970) stresses that the distribution of central places and its areas of influence are not static, and that investment and economic development change the spatial distribution in the supply of services. Richardson (1969) points up that CPT has limits to its applicability due to its extremely restrictive assumption of a uniform distribution of purchasing power, and given that not all areas receive adequate supply of all services demanded. Despite the limitations of CPT, we agree with Richardson (1969:167) when he states that "(…) no other theory emphasizes so much the interdependence between a city and the region where it is located."

Regarding the spatial distribution of complex services, Berry and Parr (1988) argues that in many occasions the services are used very rarely. This argument can be considered given the fact that the supply of health services does not have the same frequency as its utilization. That is to say, emergency services do not present the same spatial frequency as non-emergency services. More than this, there are periodic services that follow identified epidemiologic patterns, but there are also unforeseen and sporadic demands that would justify the supply of complex services without reaching the critical limit that would validate it. From this perspective, a centralized network of distribution of such demands is extremely necessary in order to optimize the system of provision.

This argument would be valid for regions in which the distribution of a given service is efficient, i.e., where the services supplied are sufficient for the demands of the region. The complementarities and interdependencies in the supply of complex services, as described by the original model and its extensions, can explain some specific processes regarding services that are public in nature, such as health care, especially in the case of developed countries, such as the United Kingdom. In the case of peripheral countries such as Brazil – which has a very unequal income distribution, presents regional imbalances in terms of physical, economic and social infrastructure and shows an erratic pattern of social public spending – the notions of complementarities and interdependence in the supply of services are harder to define and describe. That is to say, what we usually find are gaps and juxtapositions in the Brazilian urban network – or else redundancies and absences – that are expressed in many aspects, including the health care system.

The concepts of “place” and “hinterland” found in the Central Place Theory bring along a very traditional problem on spatial analysis: the definition of a neighbourhood and of the areal unit of analysis, i.e. the Modifiable Areal Unit Problem (MAUP) (Openshaw and Taylor, 1981).

The choice of the Brazilian micro-regions and GB’s UALADs has a major impact on our analysis of the spatial structure of the health services supply and must not be forgotten by no means throughout this paper. As for the definition of the neighbourhood, the spatial influence between different areas of analysis was restricted to the 10 closest neighbouring regions.

Estimation Strategy

In order to evaluate the spatial interaction of the health services supply between the spatial units for Brazil and GB the following equation was defined:

$$Health = W\_Health + \ln\_Population + elderly\_ratio \qquad (1)$$

The equation defined relates the ratio of health service professionals in relation to all professionals in any location (*Health*) to this ratio in the neighbouring area (*W_Health*).

Hence, the *W_Health* variable captures the spatial influence on the share of health workplaces. Its coefficient indicates whether a location with a high ratio of health professionals is surrounded by locations also with a high ratio of health professionals or by locations with low ratio or even if there is no spatial relationship on the share of health professionals across the regions. On its turn, the *ln_Population* captures the Central Place effect over the supply of health services. *ln_Population* is defined as the total population in each localities. Usually, the more central the place, the more population it presents. The amount of population also captures the offer of urban amenities in each locality, which makes any place more attractive to professionals with high qualifications. Following Jacobs (1969), one may argue that a higher population is also related to a bigger diversity of economic activities and, therefore, the ratio of health professionals would be smaller. However, the same one must consider that the bigger diversity also applies to the health services. As presented by the Central Place Theory, more complex – i.e. more central – services are more spatially concentrated. Hence, if the advanced health professionals tend to be concentrated in space, and in central spaces, this shall be captured by the ratio of health professionals according to the amount of population. The last variable *elderly_ratio* captures a demand side effect over the health services supply. Localities with a higher share of aged people tend to present a higher demand for health services.

Surely these are very few variables to explain such a complex subject as the supply of health services. However, the relationship between the ratio of health professionals and any other missing variable is controlled by the chosen methodology through the estimation residuals.

The investigation of the spatial structure of the health services supply in Brazil and Great Britain in this paper is based on the GMM estimator for a spatial panel model with an endogenous spatial lag and spatial moving average errors proposed by Fingleton (2008). The modelling is an extension of the GMM estimation procedure to allow a spatial moving average error process along with an endogenous spatial lag. Therefore, the spatial dependence can be accounted also as a spatial lag, in addition to the error process. The moving average suits better to the purpose of this paper since it implies local shock-effects rather than global as in autoregressive processes.

Fingleton (2008) presents a model of panel data with spatial lag and components of the error correlated in space as well as in time. The model presented by Fingleton (2008) is closely related to the spatial panel model presented by Kapoor et al (2007). Fingleton (2008) main innovations lie in two different assumptions regarding the spatial interaction for panel data. Kapoor et al (2007) assume a spatial autoregressive (AR) error process, which implies a complex interdependence between locations, so that a shock in any location is transmitted to all other – global effect. However, Fingleton (2008) assumes a moving average (MA) error process, which implies that a shock in any location is transmitted only to its neighbours.

The second main difference between the two models is that Fingleton (2008) extends the methodology in order to incorporate an endogenous spatial lag. Therefore, the spatial dependence is not restricted to the error process, but may occur via the dependent variable as well.

The analysis of panel data allows us to control the time-invariant effects specific to each region, mainly those that we omit in our model. Therefore, the regional heterogeneity is modelled by this methodology as random effects. Besides, with the spatial interaction – whether it is in the error or the dependent variable – we try to identify the effect of the possible spillover that can happen between the regions throughout the period analyzed.

The spatial panel model presented by Fingleton (2008) is based on the generalizations of the Generalized Moments Method (GMM) proposed by Kapoor et al. (2007) and Kelejian and Prucha (1999). The modelling proposed by the author considers a linear regression of panel data that allows for disturbance correlation throughout space and time and for spatial interaction of the dependent variable. Fingleton (2008) assumes that in each period of time *t* the data is generated in accordance with the following model:

$$Y(t) = \lambda WY(t) + H(t)\gamma + u(t) \quad (2)$$

in which $Y(t)$ is a N x 1 vector of observations of the dependent variable in time *t*, W is a N x N matrix of constant weights independent of *t* which defines the spatial interdependence across areas, $H(t)$ is a N x K matrix of regressors with full column rank that can contain the constant term, γ is the K x 1 vector correspondent to the parameters of the regression and $u(t)$ denotes the N x 1 vector of the disturbances generated by a random error process.

Usually, to model the spatial dependence of the disturbances, it is considered the spatial first order auto-regressive (AR) process for each period of time:

$$u(t) = \rho Wu(t) + \varepsilon(t) \quad (3)$$

where W is a N x N matrix of constant weight independent of *t*, ρ is a scalar auto-regressive parameter and $\varepsilon(t)$ is a N x 1 vector of innovation in the period *t*.

Solving the disturbance vector in terms of the innovation vector, equation 3 results in:

$$u(t) = (I - \rho W)^{-1}\varepsilon(t) \quad (4)$$

In contrast, the moving average (MA) error process which considers local rather than global shock-effects is:

$$u(t) = (I - \rho W)\varepsilon(t) \quad (5)$$

Stacking the observations for the *T* time periods, we have:

$$\begin{aligned} Y &= \lambda(I_T \otimes W)Y + H\gamma + u = X\beta + u \\ X &= ((I_T \otimes W)Y, H) \\ \beta' &= (\lambda, \gamma') \end{aligned} \quad (6)$$

in which *Y* is a TN x 1 vector of observations of the dependent variable, *X* is a TN x (1+*k*) matrix of regressors, comprising the endogenous spatial lag $(I_T \otimes W)Y$, *H* is a TN x *k* matrix of exogenous regressors, I_T is a T x T identity matrix and *u* is a NT x 1 vector of disturbances given by the MA process:

$$u = [I_{TN} - \rho(I_T \otimes W)]\varepsilon = \varepsilon - \rho\bar{\varepsilon} \quad (7)$$

To allow for the innovations ε to be correlated over time, we assume the following error component structure for the innovation vector:

$$\varepsilon = (e_T \otimes I_N)\mu + v \quad (8)$$

in which e_T is a T x 1 vector of 1s, μ is the N x 1 vector of unit specific error components of each locality and v is the TN x 1 vector of error components which vary in space and time.

In this way, the innovations are correlated in time, but not in space. However, as presented in (7), the disturbance of any locality is affect by the weighted disturbances of its neighbours. Hence, even the innovations, i.e. the spatial heterogeneities, spillover. We consider that this approach is more suitable to our analysis of the Brazilian municipalities because the interactions at this level are very high.

In such a way, for areas *i*, *j* and times *t*, *s*:

$$\mathrm{E}[\varepsilon'\varepsilon] = \begin{bmatrix} (\sigma_\mu^2 + \sigma_v^2) & if\ i = j, t = s \\ \sigma_\mu^2 & if\ i = j, t \neq s \\ 0 & if\ i \neq j, t \neq s \end{bmatrix} \quad (9)$$

The estimation procedure involves three stages. In the first, considered here as Estimation 1 for Brazil and Estimation 3 for GB, we used the instrumental variables model to estimate the residuals from equation (2). In the second, those residuals were used to estimate, through a non-linear optimization routine, a moments equation that gave us estimates for the parameters ρ , σ_v^2 e σ_1^2 , and hence to the covariance matrix Ω_ε :

$$\hat{\Omega}_{\varepsilon} = \mathrm{E}(\varepsilon\varepsilon') = \hat{\sigma}_{\mu}^{2}\left(J_T \otimes I_N\right) + \hat{\sigma}_{v}^{2} I_{TN} = \hat{\sigma}_{v}^{2} Q_0 + \hat{\sigma}_{1}^{2} Q_1 \tag{10}$$

in which $\sigma_1^2 = \sigma_v^2 + T\sigma_\mu^2$, J_T is a T x T unity matrix and Q_0 and Q_1 are standard transformation matrices, symmetrical, idempotent and orthogonal between themselves.

The third stage uses the estimated values of ρ, σ_v^2 and σ_1^2. With another instrumental variables estimation we can finally reach the estimated values of the parameters and their standard deviations. In this stage, the data is transformed via a Cochrane-Orcutt type of procedure in order to consider the spatial dependence of the residuals.

Usually, the AR error process implies a pre-multiplication of the variables by $I_T \otimes (I_N - \hat{\rho}W)$ to account for the spatial dependence in the residuals. In contrast, the MA error process implies a pre-multiplication by the inverse:

$$\begin{aligned} Y^* &= (I_T \otimes (I_N - \hat{\rho}W))^{-1} Y \\ X^* &= (I_T \otimes (I_N - \hat{\rho}W))^{-1} X \end{aligned} \tag{11}$$

As our model presents heteroscedasticity and correlated errors, we cannot follow the standard assumption of a spherical errors structure. Therefore, we adopted the estimation of an instrumental variables model with non-spherical disturbances (Bowden and Turkington, 1990). In both the first and third stages, a set of linearly independent exogenous variables were used as instruments. Considering Z as the matrix of instruments, we have:

$$P_z \equiv Z(Z'\hat{\Omega}Z)^{-1} Z'$$

Thus:

$$\hat{b}^* = (X^{*\prime} P_z X^*)^{-1} X^{*\prime} P_z Y^* \tag{12}$$

The estimated variance-covariance matrix of the parameter is given by:

$$\hat{C} = (X^{*\prime} P_z X^*)^{-1} \tag{13}$$

In this way, the square root of the constant values in the main diagonal line of the variance-covariance matrix is equivalent to the standard errors of the estimated parameters. However, this methodology does not provide the standard error of $\hat{\rho}$, the statistical significance of which can be tested by Bootstrap methods (Fingleton, 2006).

As instruments for the endogenous spatial lag, we follow Kelejian and Prucha (1998) and use the exogenous variables H and their first spatial lag $(I_T \otimes W)H$, so $Z = (H, (I_T \otimes W)H)$ It is important to emphasize that, as in stage 1 we assume that $\rho = 0$, in this case, we have $Y^* = Y$ and $X^* = X$. Besides, we also assume that $\sigma_v^2 = 1$ and

$\sigma_1^2 = \sigma_v^2 + T\sigma_\mu^2 = 1$, then, in stage 1, the estimation with non-spherical disturbances corresponds to the estimation by standard instrumental variables.

Under these considerations, if we go back to our equation 1, which defines our approach to the spatial structure of the health service supply, we have:

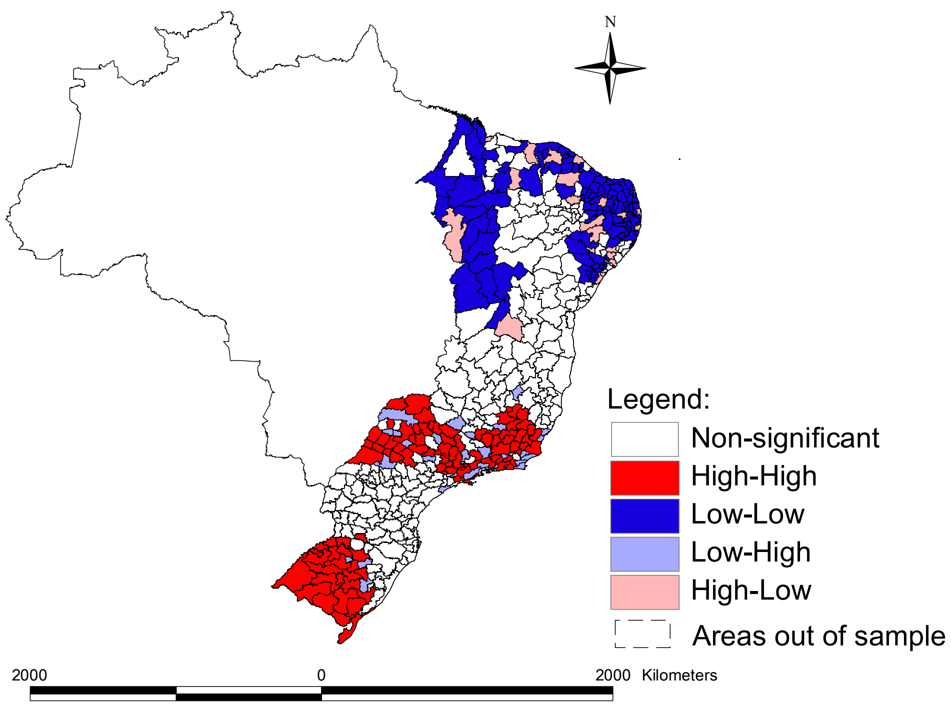
$$\begin{aligned} Health &= \lambda(W\_Health) + \gamma_0 + \gamma_1(\ln\_Population) + \gamma_2(elderly\_ratio) + u \\ u &= (I - \rho W)\varepsilon \end{aligned} \qquad (14)$$

Exploratory Analysis

Figure 1 shows the local Moran's I for the ratio of health professionals in Brazil in 2007. There is a predominance of non-significant areas or micro-regions belonging to clusters of positive spatial association. The north-eastern region concentrates all the micro-regions in Low-Low clusters. These micro-regions present a low ratio of health professionals and are surrounded by neighbours also with a low ratio. There are some High-Low outliers amongst the Low-Low cluster, which probably acts as central places providing health services of higher hierarchy.

Figure 1

Local Moran's I – Ratio of Health Professionals in Brazil, 2007

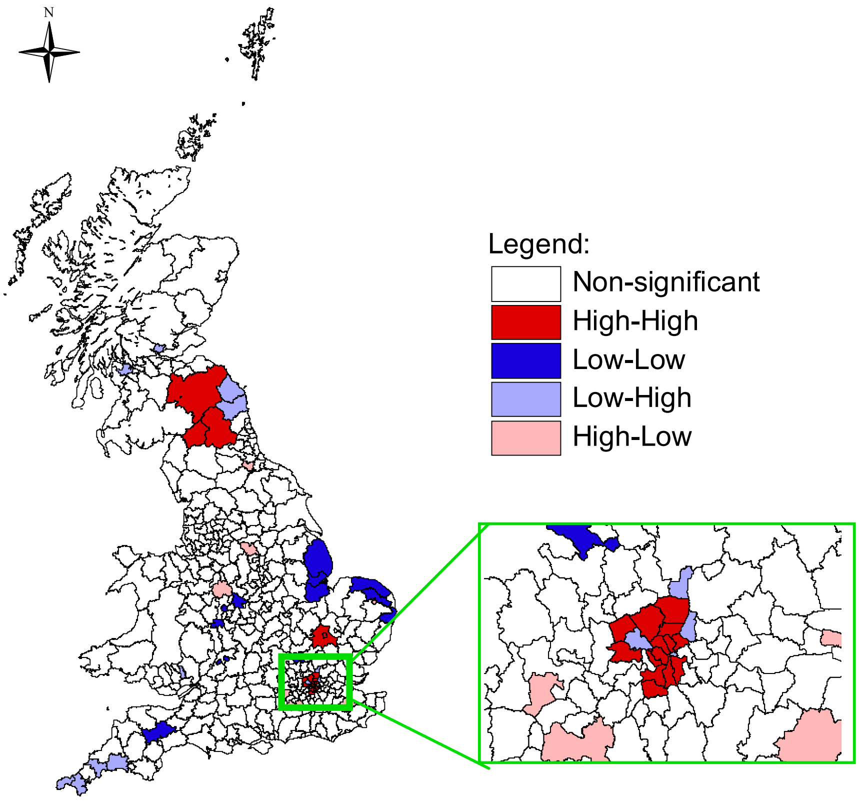


The central and southern regions present High-High clusters, indicating that these areas have a higher concentration of health professionals. Therefore, different from what would be expected from the Central Place Theory, there is no regular urban network or a well defined structure of central places and their hinterlands. The spatial structure of the provision of health professionals in Brazil presents several gaps and absences in the north-eastern region and juxtapositions or redundancies in the central and southern region.

Looking at the Britain's local indicators, a very different spatial pattern can be seen. There is a small High-High cluster at the south of Edinburgh and close to Glasgow and another next to London to the west. Some Low-Low areas appear around Norwich and Grimsby. Roughly, we can say that there is not a well defined spatial pattern in the Great Britain and the distribution of the health professionals does not appear to be spatially concentrated.

Figure 2

Local Moran's I – Ratio of Health Professionals in Great Britain, 2007



In order to further investigate the spatial structure of the health services in Brazil and Great Britain, the results of the spatial panel regression can be more elucidative.

Estimates and Inferences

Table 1 presents the results of the estimation of equation 1 using standard IV regression (estimations 1 and 3) and the spatial panel model with moving average errors proposed by Fingleton (2008). The IV estimations serve only as a reference to our analysis. As would be expected, the coefficient estimations do not change much whereas the estimation is done by standard IV or by the spatial panel model. However, there are some changes in the standard deviations which will be addressed later on.

Estimation 2 presents the results for the Brazilian data. As indicated by the Moran's I, there is a positive spatial correlation in the ratio of health professionals in Brazil. A micro-region surrounded by areas with 1 additional percentage point of health professionals tends to have further 0.42pp of health professionals. Hence, there is a spatially concentrated distribution of health professionals in Brazil, resulting in the formation of regions over attended comparing to the average and regions with low levels of health service in commission. There is also a high correlation between the ratio of health professionals and the size of the region. A micro-region with an additional 1% of population tends to have 0.77pp further in its ratio of health professionals. Therefore, not only there is a spatial concentration of the health professionals, but they also tend to concentrate in the more populated areas, where there is a higher offer of central goods and services, urban amenities and equipments.

The elderly ratio also presents a positive correlation with the ratio of health professionals. An increase of 1pp in the elderly ratio is related to an increase of 0.27pp in the ratio of health professionals. However, the causality of this relationship is fuzzy. It could be the case of a higher ratio of health professionals in response to the bigger demand of health services or the case of a higher ratio of elders as a result of the availability of health services, which would increase the life expectancy. The causality between these two variables is not addressed in this paper, but shall be focused in a future research. The variables omitted in the model also present positive spatial correlation, as presented by the estimated *rho*. The negative estimation suggests a positive spatially correlated regional heterogeneity.

The results for the Great Britain's data are very different. As was also indicated by the Moran's I, there is no significant spatial correlation in the ratio of health services professionals among the GB's UALADs, which might indicate a very structured regional network of health services supply in which the UALADs are self-contained supply regions and only the very central services are spatially concentrated, which would not cause imbalances to ratio of health professionals amongst the UALADs.

The only similarity with the results for Brazil is the positive correlation of the ratio of health professionals with the size of the regions. An increase of 1% in the population is related to an increase of 0.35pp in the ratio of health professionals, which could once again be explained by the presence of urban equipments and amenities. The elderly ratio seems to be negatively correlated to the ratio of health professionals by the results of Estimation 3. However, the spatial panel model, which brings greater efficiency to the estimations, shows that the correlation between these two variables is not statistically different from zero. The *rho* estimation of 0.037 suggests a very light positive spatially correlated heterogeneity. However, this estimation should have its statistical significance tested by bootstrap methods, which will appear in a future version of this paper.

Table 1 - Estimations over *Health*

	Estimation 1	**Estimation 2**	**Estimation 3**	**Estimation 4**
	Brazil	*Brazil*	*GB*	*GB*
Intercept	-9.5524 (0.6606)**	-9.5410 (0.9987)**	-2.9027 (0.6818)**	-2.9916 (0.9071)**
W_Health	0.4180 (0.0822)**	0.4184 (0.1401)**	0.0961 (0.1945)	0.1060 (0.2652)
Ln_Pop	0.7554 (0.0488)**	0.7655 (0.0719)**	0.3419 (0.0470)**	0.3471 (0.0636)**
Elderly_%	0.2698 (0.0384)**	0.2495 (0.0603)**	-0.0144 (0.0064)*	-0.0136 (0.0082)
rho		-0.2525		-0.0367
σ ν		0.7689		0.3885
σ 1		4.8220		1.2726
R^2	0.2781	0.2781	0.0746	0.0752

Instruments: Ln_Pop, Elderly_%, W_Ln_Pop, W_Elderly_%.
Note: Sigficant at *** 1%, ** 5%, * 10%.

Final Remarks

This paper aimed at the verification of the spatial structure in the distribution of health services, searching for any spatial pattern or correlation, under the light of the Central Place Theory. To address this subject, this paper is based on a model of panel data with spatial lag and components of the error correlated in space as well as in time proposed by Fingleton (2008).

The comparison of the results for Brazilian and Great Britain's data is brings out some very interesting results. The positive estimated coefficient for the spatial lag of the ratio of health professionals indicates that there is a spatially concentrated distribution of health professionals in Brazil, resulting in the formation of over attended regions and regions with low levels of health service in commission. As shown by the exploratory Moran's I, the spatial structure of the provision of health professionals in Brazil presents several gaps and absences among the north-eastern micro-regions and juxtapositions among the central and southern micro-regions.

The results for the Great Britain's data are very different. There is no significant spatial correlation in the ratio of health services professionals among the GB's UALADs, which might indicate a very structured regional network of health services supply in which the UALADs are self-contained supply regions and only the very central services are spatially concentrated, which would not cause imbalances to ratio of health professionals amongst the UALADs.

Therefore, in the case of developed regions such as the Great Britain, the spatial distribution of health services can be understood under the concepts of complementarity and interdependence, as described by the Central Place Theory and its derivations. In the case of peripheral countries such as Brazil – which has a very unequal income distribution, presents regional imbalances in terms of physical, economic and social infrastructure and shows an erratic pattern of social public spending – the notions of complementarities and interdependencies in the supply of services are harder to define and describe.

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