VALUATION OF PROPERTIES IN RIO GRANDE DO SUL: AN ANALYSIS FROM SPATIAL REGRESSION

Luis Fernando Braga*
Tiago Wickstrom Alves**

ABSTRACT: This work aims to determine the influence which the socioeconomic factors, along with the usual constructive variables, cause in the valuation of property in the state of Rio Grande do Sul. The real estate is an asset with distinctive features, different from others, and many researchers are pursuing different elements to explain this different behavior. In this regard, stands a very important factor, the neighborhood. The traditional inferential methods hinder the suitable modeling of the multiple factors that influence the value of the properties of a particular region. Thus, the spatial regression models were used to estimate the value of the same unit (VU). But the LAG regression model was used to standardize the sample data that showed heterogeneous properties. Nevertheless, the estimate of the kriging has demonstrated the value of a property to a particular region. The implementation of the methods was carried out to a database obtained from the Federal Savings Bank, containing properties traded in the state of Rio Grande do Sul, from 2005 to 2008. Moreover, applied regression methods indexes have confirmed significant indexes in the models obtained for all properties of a region. Thus, the spatial structure of indexes minimized the autocorrelation existing in the residuals of the regression model, improving the reliability of the assessment.

KEYWORDS: Econometric, Evaluations of flats, Spatial Regression

1 INTRODUCTION

The value of a property depends on a wide range of variables such as: constructive attributes, structural work factors, material quality, location factors, poles of attraction, neighborhood effects, accessibility, public policies, direct credit for certain ranges of income, investments in infrastructure, tax levy, among others. These elements combined create a complexity in the process of establishing the market price of a particular property.

This complexity has generated in recent years, an increase of methodological procedures for determining the value of the property, for example, use of spatial regression and data envelopment analysis. In Brazil, the first published work of engineering assessments were technical journals in 1918 and 1919, but it was during the 1970 evaluation that the subject began to arouse more attention from the professionals. Since then, property evaluation, and resourceful techniques, started using deterministic factors, homogenization and empirical formulas, but nevertheless remained difficult to establish the value of property.

Dantas et al. (2007), suggest that property valuation must take into account: i) attributes derived from its physical aspects such as: area, building standard, number of parking spaces, etc. ii) location, such as property location, distance from poles of influence, etc.. iii) economic aspects such as payment terms of the property, nature of the event, that is, on offer or actually sold, etc. As for Gonzalez and Formoso (2000), properties have a different behavior from other economic goods, due to the effects of their specific attributes, especially: high cost, heterogeneity, immobility and durability. The issue of heterogeneity arises from the fact that each property has different amounts of each of the attributes valued by the market. Therefore, they are called "composite goods", and the comparison between them requires balancing the various attributes of interest (BALCHIN; KIEVE, 1986; ROBINSON, 1979).

In short, to these authors, the microeconomic aspects, that is, those related to the budget constraint of the consumer are the determinants of value since the real estate market is atomized and uncoordinated, therefore these elements can explain a large portion of price variation.

* Mestre em Economia pela PUC/RS e Professor da Universidade Católica de Pelotas.
* Professor da Universidade Do Vale do Rio dos Sinos/UNISINOS

Holly, Pesaran e Yamagata (2006) conducted an empirical investigation of regional dependency in the states of the U.S., working with data on income and real growth in house prices and concluded that there is significant spatial effect in determining the value of the property.

Another problem is the definition of the model, which affects the assumptions of linearity of the equation and that important variables have been included. Which variables to include and in what format is a non-trivial statistical problem. Literature review indicates these difficulties through the lack of uniformity in texts on urban economy (BALL, 1973; SMITH et al., 1988). In this sense, for White (1992), the assumption that the actual format of the model under analysis is known is not correct, and in this case, the parameter estimates are inconsistent, leading to suspicion about the inferences made with the equation.

This work is proposed, given the complexity of the evaluation process and advances in methods of inference, and that they still disregard the effect demand and economic variables in the model. The goal is to estimate the effect of space and variable in determining the socioeconomic value of the property. This analysis was performed in the State of Rio Grande do Sul, Brazil, using spatial econometrics.

2 THEORETICAL REFERENCE

The valuation of real estate has generated various modeling procedures for the determination of market values given the complexity derived from the characteristics of the property. The goal of this article is to describe the evolution of the techniques most used by researchers, focusing on spatial regression, which will be used in this study.

In Gonzalez (1997), "to evaluate" is to seek value, and the value of goods is essentially determined by the market segment where it can be transacted. Although there are many interpretations, the market value of a property can be defined as the most likely value that a given property can achieve in a normal transaction, under certain economic conditions. Ultimately, the market value is a momentary micro balance, under the conditions of supply and demand.

In the evaluation, in case where there is no transaction information (of a reasonable likeliness and minimum quantity for the analysis), the analyst can use the so-called methods of income and the cost of reproduction. If there is available information the econometric models can be used for inferring the value of the property. In evaluations, the use of this procedure is widespread, although the models, in their overwhelming majority, are restricted to the multiple regressions by the method of ordinary least squares using cross section data. According to Hayashi (2000), these models have as their preposition the no- correlation between the explanatory variables and the regression error. However, the properties are highly correlated in terms of value in space. For example, identical properties located in different districts have high probability of having different values and these values are derived from the existing property in the neighborhood. This aspect is what has been the cause for searching methods to estimate the value of the property.

To Belsley et al. (1980) and Daniel & Wood (1980), the other aspects concerning the assumptions of regression and the characteristics of the housing market would not be limiting factors for the use of classical regression analysis, as in the case of the occurrence of outliers, there are treatments documented and the solution is fairly easy. The multicolinearity caused by inter-relationships of the explanatory variables can be eliminated by the use of techniques that transform the data, according to Gonzales (1993), Harmann (1976) and Maddala (1988), using the factor analysis. The heteroscedasticity can be bypassed, according to Judge et al. (1985) and Neter et al. (1990), with the use of generalized least squares, since estimates are obtained for the weight matrix. However, according to Gonzalez and Fair (2000), as for the autocorrelation of the error term, some difficulties still remain, including restrictions to the regression analysis by the lack of a theoretical model that defines the functional form of the regression function for the property.

On the basis of these elements there have been several attempts to estimate the value of properties with the support of other methodologies. For instance, Baptistella (2005) used techniques of Artificial Neural Networks as an alternative to Multiple Linear Regression to estimate the selling price of urban property in the city of Guarapuava / PR, concluding they are both efficient, however, with greater precision to the model with neural networks. Novaes and Paiva (2003) applied the Data Envelopment Analysis (DEA) in order not only to conduct the evaluation of real estate, but also to compare the results with those obtained using the multiple linear regressions. In their study, they concluded that the use of DEA may be particularly advantageous when the evaluator faces a population of market data or when the scope of work is the determination of intervals for the final value of the property and present attributes next to the extreme observed in the sample.

Despite the different instruments used, recently, the method which has been used more is the spatial regression. This method, which Luc Anselin thrust , from the 90's, allows you to include in the regression models the influence of space, and thus, it eliminates the autocorrelation of the explanatory variables with the error of the regression function, which according to Trivellone (2005), among all the variables that influence the value of the properties, the variables or factors referred to the location of the property are the most complex to analyze and model, and it is of great importance according to the author.

However, Zietz, Zietz and Sirmans (2008) in performing a quantile regression, considering spatial effects, found a dominance of the quantile effects on the other regressors. According to the author this is an interesting result and needs to be validated in other samples.

Recently, there have been significant advances in statistical procedures to estimate the model inference. Perhaps, the most important has been the inclusion of spatial analysis. This, according to Trivelloni (2006), demonstrated the deficit of the traditional inference techniques of mass evaluation, leading to the development of spatial statistical techniques for the treatment of real estate data, which the process of real estate appraisal can be done by two methods for the data spatial treatment: spatial econometric and their regression models on the one hand, and the use of geostatistics on the other.

Braulio (2005) investigated a procedure to build a statistical model to evaluate property according to their characteristics, using Multivariate Analysis in support of traditional statistical techniques, applying the Cluster Analysis on the data of real estate to obtain homogeneous classes. He built a model of Multiple Linear Regression of each class of items for each type of property (44 flats, 51 houses and 24 lots) from Campo Mourão - Paraná State, concluding that each class of these three types of real estate was a good fit to the data, has good predictive ability and also that the multivariate methodology is feasible, bringing excellent accuracy and correct treatment of the differences.

Resende and Cypriano (2010) investigated the appreciation of the urban lots in the city of Toledo-PR, from 1998 to 2008, using an econometric model through the ordinary least squares method (OLS), estimating the elasticity of the variables referred to the influence of per capita income of the municipality, distance from urban lots to the area of college / university, distance from urban lots to the city center, the lot size in square meters, and the variable trends, where one of them is a variable representing the time on the price of land in urban areas. The results indicated that these variables significantly influence the prices of the lots.

Canan (2005) aimed to develop factors for homogenizing finishing standards and conservation state for homes located in the central city of Cascavel - Paraná State. Qualitative variables (finishing standards and conservation state) positively influenced the final value of the property, by the method of comparative market data, enabling the estimation of value, taking into account the various trends and fluctuations in the real estate market.

Therefore, it can be stated that the problem of generalization of a model results from the complexity of the dynamics of locational factors such as the proximity to shopping, education, public health and safety, as well as the structural characteristics standards and desirable or undesirable environmental poles, caused by the urban dynamics, producing a continuous change in the effects of these factors on the value of the property such as: public investments in the region, changes in local business activities, real estate undertakings, among others.

Even seemingly simple, issues related to housing prices have not been fully worked out. For instance, the matter of whether home prices converge or not, according to The Law of One Price (LOOP) has been discussed and controversial, to the example of the results of Burger and Rensburg (2008) and of Da, Gupta and Kaya (2010).

On the whole, almost all urban change affects the value of the property nearby, transforming the location in the most dynamic factor of its appreciation. Emerge, then, the neighborhood variables, spatial or locational. Many of these factors are in fact demand changes which are reflected in the real estate prices and these, in their large majority, are not considered in the current models, thus start from the analysis that the demand is given for a specific period.

3 SPATIAL REGRESSION

Analyses using the spatial regression had a significant increase in social sciences from the 90s. These models allow the inclusion in the regression, the locational effect in the regression, giving an extensive allotment in urban and regional economics, among other areas. Anselin (1996) defined as Exploratory Spatial Data Analysis (ESDA) - considered a continuation of Exploratory Data Analysis (EDA) - the analysis that considers three basic elements:

- Spatial proximity matrix (W): square matrix that defines the spatial variation of the area data, where each element W_{ij} is an equivalent measure of proximity between A_i and A_j, where A_i and A_j are the areas analyzed;
- Deviation vector (Z): obtained from the mean (μ),where each component is calculated by subtracting the value μ of the attribute value (y_i) for each region;
- Weighted mean vector (Wz): is defined by the spatial trends. Also known as average values of the neighbors or spatial moving average.

According to Câmara et al. 2002 the estimate of the spatial average is obtained by the equation

$$\hat{\mu}_i = \frac{\sum_{j=1}^{n} W_j \times y_i}{\sum_{j=1}^{n} W_j} \tag{1}$$

Where:

$\hat{\mu}_i$ = weighted average;

$\sum_{j=1}^{n} W_j$ = spatial proximity matrix.

According to Câmara et al. (2002), an essential aspect of the exploratory analysis is to characterize the spatial dependence, which shows how the values are correlated in space.

3.1 GLOBAL INDEX OF SPATIAL ASSOCIATION: MORAN INDEX: I

The Moran index provides a common measure of spatial association between the data set. Its value ranges from -1 to 1. If these values are close to zero, they indicate the absence of spatial autocorrelation. Thus, positive values for the index indicate positive spatial autocorrelation, that is, the attribute values of an object are related in a similar way to the values of their neighbors and the opposite if negative (ANSELIN, 1996).

According to Florax and Graaff (2004), the Moran Index is indicated by:

$$I = \frac{n}{S_o} . \frac{\hat{\varepsilon}' W \hat{\varepsilon}}{\hat{\varepsilon}' \hat{\varepsilon}} \quad (2)$$

Where:

n: is the number of observations

S_o: is the sum of the spatial weight matrix W in case the values are not normalized.

$\hat{\varepsilon}$: is the vector $nx1$ of residues resulting from the method of Ordinary Least Squares (OLS)

W: is the spatial weight matrix

According to Monastério and Ávila (2004), the value of a uniform variable on each axis, as well as the average of the standardized value of the same variable with the neighbors, is represented by the Moran's scatterplot graph (Figure 1)

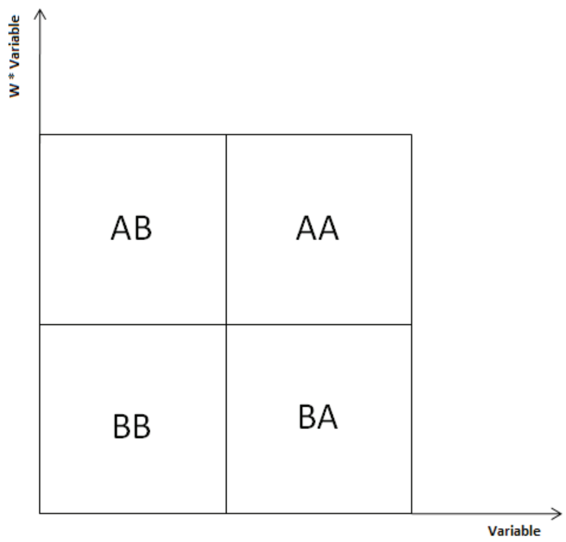

Figure 1. Moran's scatterplot graph.
Source: Elaborated by author

Figure 1 is divided into four quadrants, and correspond to four different patterns of local association between the regions and their neighbors. The first quadrant HH - High-High, has regions of high values for the variable in the analysis as well as the average of its neighbors, that is, it has a positive autocorrelation. The second quadrant LH - Low-High represents regions with low values surrounded by neighbors that have high values. The third quadrant (LL) Low-Down: is opposite to the first and HL - High-Low is made up of regions with high values for the variables in question surrounded by regions of low values.

To indicate areas where the local correlation is extremely different from other data, with a significance level above 95%, maps of the type: LISA Map and Moran Map are used, because such regions have their own spatial dynamics with strong similarity in relation to their neighborhood.

The maps and the Moran index indicate whether or not there is autocorrelation. If there is, the regression should be done with spatial models. If not, the classical regression is the best alternative for not demonstrating specification error.

3.2 SPATIAL REGRESSION MODELS

When performing a regression analysis, the goal is to obtain a match between the values suggested by the model and the observed values of the dependent variable. Also, the intention to find the explanatory variables contributes significantly to the linear relationship. The standard hypothesis is that observations are not correlated, therefore, in the model εi, the residuals will be independent and not correlated with the independent variable, also showing normal distribution with zero mean and constant variance.

There is little chance that the standard hypothesis of non-correlated observations is true in case of data, where there is the presence of spatial dependence. Generally, residuals tend to keep the observed spatial autocorrelation established in the data, and can be verified by systematic regional differences, or also by a continuous spatial trend.

Thus, the analysis of regression residuals, the search for occurrences of spatial structure, can inform the need of a spatial model. Graphical analysis tools and mapping residuals may provide the first indication that the observed values are more correlated than would be expected under a degree of freedom (FOTHERINGHAM et al., 2000). Besides the graphical analysis, statistical tests can help verify the existence of spatial autocorrelation in regression residuals, which can be used for the analysis of Moran's index I.

The regression analysis in spatial data unifies, in the modeling, the spatial dependence among data, helping in choosing the best model to be used. When carried out an exploratory data analysis, the goal is to define the dependence structure in the data, defining how to incorporate this dependence to the regression model. There are two basic types of modeling that take into account the spatial effect: the Global and the Local form (ANSELIN, 2002; CÂMARA et al., 2002 and FOTHERINGHAM et al., 2000).

The Global models, assessed in this study, were tested using the software GeoDA, of public domain and available at (http://geodacenter.asu.edu). The models are: Spatial Lag Model and the Spatial Error Model.

3.3 SPATIAL LAG MODEL

Anselin (2002) defines that in the model LAG, the spatial autocorrelation mask is attributed to the dependent variable Y. Analyzing the spatial dependence by addition, to the regression model, from a new term in the form of a spatial relationship with the dependent variable, and represented by the following equation:

$$y = \rho WY + X\beta + \varepsilon \tag{3}$$

Where:

Y = dependent variable;

X = independent variables;

β= regression coefficient;

ε = random errors with zero mean and variance s2;

W = spatial neighborhood matrix or special weight matrix;

ρ= spatial autoregressive coefficient.

The null hypothesis for the absence of autocorrelation is that ρ = 0. The minimum goal is to embed the autocorrelation as part of the spatial model.

3.4 SPATIAL ERROR MODEL

The same author defines the second type of spatial regression model through global parameters, also referred to as Spatial Error Model, and considers that the spatial effects are a noise, that is, need to be excluded. Thus, the effects of the spatial autocorrelation are associated with the error term Wε and the model is represented by the equation:

$$y = X\beta + \varepsilon, \varepsilon = \lambda W\varepsilon + \xi \quad (4)$$

Where:
Wε = spatial errors;
ξ = random errors with zero mean and variance s2;
λ= autoregressive coefficient.
The null hypothesis for the absence of autocorrelation is that λ= 0, therefore, the error term is not spatially correlated.

Câmara et al. (2002a) show that, in practice, the definition of use between the two types of spatial regression models with global parameters is complex, because, despite the difference in their motivations, they have been very close in form.

4 METHODOLOGICAL PROCEDURES

This chapter discusses the methodological procedures necessary to obtain the desired results. Describes the attainment of the data analyzed in this work, since its treatment, selection of significant variables, centroid calculation of the cities studied, kriging techniques and the attainment of spatial weight matrix.

The software OpenGeoDa was used for the realization of tested spatial regression and the attainment of the spatial weight matrix. For the mapping of isovalue curves and kriging generation the software ArcGis 9.3 was used.

4.1 REGRESSION MODEL

The special model can be expressed as follows:

$$VU = \rho W_{VU} + X\beta + \lambda W\varepsilon + \varepsilon \quad (5)$$

Where:
VU is the vector of the dependent variable, defined as the ratio between the total values of the property by its corresponding area;
ρ is the coefficient of the spatial autocorrelation;
W the spatial weight matrix, defined by the method *Queen*;
X is the matrix of observations of the independent variables;
β is the vector of the parameters that need to be estimated;
λ is the coefficient of spatial autocorrelation;
u is the vector of non-correlated residuals;
ε is the vector of the model residuals that it is expected to be: $\varepsilon \sim N(0,\sigma^2 I)$.
Matrix ***X*** was composed by significant variables, according to table 1.

It is noteworthy that several economic variables were tested to evaluate the ability of explaining the value of the property. It was an exploratory process in which the model was composed with a large number of variables and variable tests were carried out, redundant to the ones in the model, and omitted variables, among those who were not selected, using the test of maximum likelihood ratio (LR), while evaluating the stability of parameters estimated by the Wald test[1]. The variables used in this process and that were not included in the final model, because they were not significant, are shown in Table 3.

Table 1 - Independent variables, symbolism used and the desired effect

Symbolism	Variables	Desired effect
ACAB_POND	**Finishing** –refers to the standard of finishing as the materials used in construction.	$\partial(VU)/\partial(ACAB\_POND) > 0$
ACONST_POND	**Built-up area** - is the amount measured in square meters of the total area of the property.	$\partial(VU)/\partial(ACONST\_POND) < 0$
AG_CAIXA	**Caixa Econômica** - is a financial institution that aims to stimulate public savings by applying the deposits received and other resources in loans for the promotion and the social welfare of the population.	$\partial(VU)/\partial(AG\_CAIXA) > 0$
BANH_POND	**Bathrooms** - number of bathrooms in the existing houses.	$\partial(VU)/\partial(BANH\_POND) > 0$
CONSERV_PO	**Conservation** - corresponds to the conservation status of the property according to the conditions present there.	$\partial(VU)/\partial(CONSERV\_POND) > 0$
DEN_DEM	**Population density** - corresponds to the value obtained by the relationship between population and area of the municipality. Measured by inhabitants per square kilometer	$\partial(VU)/\partial(DEN\_DEM) > 0$
DOMIC	**Domicile**- structurally separate and independent sites that are intended to serve as housing one or more persons, or that is being used as such.	$\partial(VU)/\partial(DOMIC) < 0$
FROTA	**Vehicles fleet** - with respect to all motor vehicles, electric, articulated, semi-trailer or trailer registered with the executive body of the transit of the State or the Federal District, in the municipality of domicile or residence of its owner, according to the law.	$\partial(VU)/\partial(FROTA) > 0$
HOMIC	**Homicide** – is the number of homicides happened and registered.	$\partial(VU)/\partial(HOMIC) < 0$
HOSPITAIS	**Hospital –** is an institution providing medical services, outpatient hospital, with beds and appropriate facilities for carrying out its activities, and which has at least one physician and nursing staff.	$\partial(VU)/\partial(HOSPITAIS) > 0$
PAV_POND	**Paving** - corresponds to the type of flooring used in place of the property.	$\partial(VU)/\partial(PAV\_POND) > 0$
PIB_PER	**GDP per capita** - is the Gross Domestic Product at market prices divided by population.	$\partial(VU)/\partial(PIB\_PER) > 0$
TERR_POND	**Lot** - is the amount measured in square meters of the total area of the land.	$\partial(VU)/\partial(TERR\_POND) > 0$

[1] The test Rl is given by LR = 2(lir-lr) $\sim \chi 2$ (mgl). Where LR is the test of maximum likelihood ratio ; l is the logo of the function of the restricted likelihood function (r) and unrestricted (ir); LR follows a chi-square with the number of degrees of freedom equal to the number restrictions imposed to the model (Gujarati, 2006). The Wald test (Wt), tests restrictions on the estimated parameters and is calculated assuming $y = X\beta +$, with linear restrictins $R\beta = r$, by:

$$W = \frac{(R\hat{\beta}-r)'[R(X'X)^{-1}R']^{-1}(R\hat{\beta}-r)/q}{(e'e)(n-k)} \sim F(q,n-k)$$

The Wt follows an F distribution and the definition of degrees of freedom given in the equation depend on q, the number of restriction, and n-k, the number of observations minus the number of estimated parameters (SOARES; CASTELAR, 2003).

4.2 TESTS USED FOR THE VALIDATION OF SPATIAL REGRESSION MODEL AND THE SPATIAL OVERFLOW

The test used to evaluate the use of the spatial regression was I-Moran. The tests used to verify which effects in the model, if delay or error, or both, were the Lagrange multipliers (*LM*).

The Moran test confirms whether there is the presence or not of spatial autocorrelation. If the probability of the p-value of the I-Moran is significant, that is, less than or equal to 5%, no spatial effect is involved, since it is a test conducted under the null hypothesis of no spatial autocorrelation, according to Graaff and Florax (2004).

The definition regarding the choice of the model, that is, spatial lag or spatial error is accomplished through the Lagrange multipliers (LM), which are: Lagrange Multiplier spatial lag (LM-lag) and the Lagrange Multiplier spatial error (LM-error). These have two statistics that are the LM and LM-robust. Thus, when LM-lag (simple or robust) is significant, that is, less than 5%, there is an indication for the spatial lag model (*WVU*) and if the LM-error (simple or robust) is also significant, that is, less than 5%, there is an indication for the spatial error model (W) (ANSELIN, 2005).

4.3 SAMPLE, SOURCE AND DATA TREATMENT

In this section, we describe the sample used in the research and the data processing performed. Thus, initially there is the region of analysis, which describes the region and the composition of this analysis in terms of observations. After, there are variables studied in the model, which were not significant, as well as their data sources. Finally, there is the structuring of data for the model described in section 4.1.

4.3.1 **Region of Analysis**

The region of analysis was the state of Rio Grande do Sul, which has 496 municipalities (IBGE, 2000) and is located in the extreme south of Brazil, as shown in Figure 2.

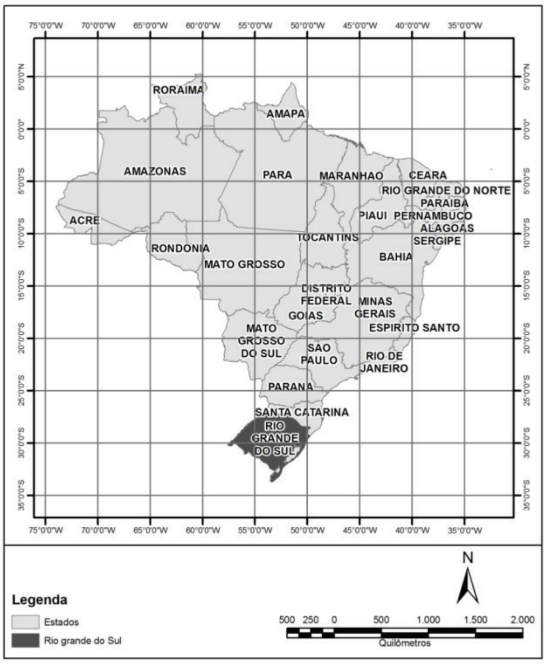

Figure 2. Brazil Political
Source: elaborated by the author

From the 496 municipalities of Rio Grande do Sul, Porto Alegre was taken out from the sample because it is the state capital, and because of its size, the buildings have significantly increased degree of variability in the values due to the internal location of the property in the city. Certainly, properties in other cities have their values influenced by the neighborhood where they are located, but it is expected that on average, these values are distinguished from other municipalities in terms of macroeconomic variables and location. If this average is considered to Porto Alegre, it is believed that would generate a distortion of such magnitude that it would reflect unrealistic values. This view is from Caixa Economica Federal (CEF), through the Office of Urban Development (GIDUR / CEF), because when it analyzes the same data values and real estate financing, it works with two databases, one only for Porto Alegre, and another for the other municipalities of the state. This is already recognition of the existence of differences in values in the variables analyzed.

It should be emphasized that the sample provided by CEF did not contain data from all municipalities of Rio Grande do Sul, basically due to the absence of a transaction financed by CEF. There were 206 municipalities from which there was no information. Thus, from the 496 municipalities of the State, the study remained with 290. After reviewing the initial results, cities like Canoas and Triunfo were withdrawn, because there is an oil refinery in the first and a petrochemical complex in the latter. These activities generate a much higher added value to others and are not values that remain significantly in the city, generating unrealistic values for GDP per capita. Due to these specific activities in these municipalities, the value added is far superior to the others. These values end up not staying substantially in the municipality, generating unrealistic GDP values per capita. Because of this distortion, they were opted-out. In all, 288 municipalities were analyzed. Its spatial distribution can be seen in Figure 3.

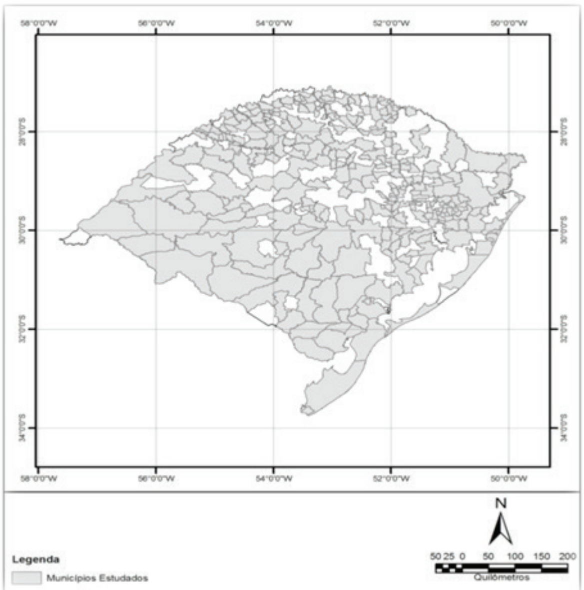

Figure 3. Location of the municipalities studied
Source: Elaborated by the author

In observing Figure 3, it can be seen that the sample used in this study contains a significantly large spatial coverage of Rio Grande do Sul and is not concentrated in a specific region.

4.3.2 **Data Source**

The research used data from real estate financed by Caixa Econômica Federal, assigned by the Management of Urban Development in Rio Grande do Sul - GIDUR in the period between 2006 and 2008. This database contained 20,698 buildings distributed by municipalities in the state of Rio Grande do Sul, as explained above. Annex A contains the municipalities and the number of observations in each, as well as the average value of property in each municipality.

Subsequently, the data were cataloged and an analysis of the logical coherence was carried out, and several inconsistencies were found, such as: exorbitant areas in relation to the number of bedrooms and the total value, excessive values in relation to the area of the property, lack of dormitories in some data, etc.

Thus, these anomalous observations were removed, so that from the 20,698 properties, it remained 19,203, comprised by 7,457 flats and 11,746 houses.

Table 2 - Sample base composition by type of property

Type	Occurrence	% over the total
Flat	7.457	38,83
House	11.746	61,17
Total	19.203	100%

Source: Elaborated by the author based on the research data.

To have information about the properties, latitude and longitude data were added to enable the linkage of constructive and socioeconomic information in the geographic region of origin. Figure 4 shows the distribution of these properties in spatial terms in the state of Rio Grande do Sul

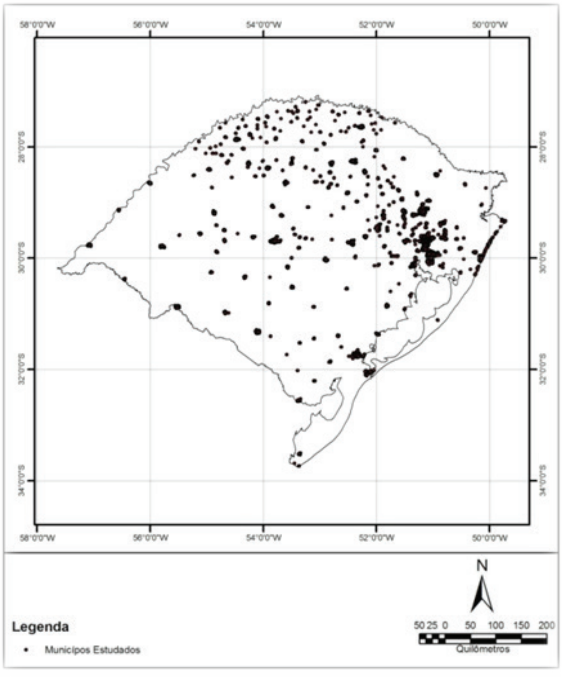

Figure 4. Location of the municipalities studied
Source: Elaborated by the author

As mentioned earlier (in the presentation of the explanatory variables given in Table 1), the socioeconomic variables, evaluated as possible factors in determining the value of the property and that were not significant, can be seen in Table 3. These were tested in the regression model, composing the matrix ***X***, and their exclusion from the final model happened, as described before, by the maximum likelihood test and the Wald test. In Table 3, in addition to the variable, there is the denomination used and the desired signal when it was included in the model. Because these variables were not relevant, they were removed from the final model, considering a significance level of 5%. The data source is at end of table.

Table 3 - Independent variables, symbols used and without desired effect

(continua)

Variables	Description	Desired signs
AGEN_BANC	**Commercial Bank -** a banking financial institution, private or public, constituted as a corporation specialized in short and medium term operations.	$\partial(VU)/\partial(AGEN\_BANC) > 0$
CASAM	**Marriage** - is the process by which constitutes a legal relationship between man and woman, which can be civil or religious to civil effects. Data refer to the place of registration.	$\partial(VU)/\partial(CASAM) > 0$
COMBUS	**Fuel** - value referring to the amount in liters of the total automotive fuels of any kind.	$\partial(VU)/\partial(COMBUS) > 0$
DIVORC	**Divorce –** it is the legal dissolution of marriage, which the parties the right to a new civil or religious marriage. The data refer to the place of process action.	$\partial(VU)/\partial(DIVORC) < 0$
DORM_POND	**Dormitories –** it is the number of dormitories in the property.	$\partial(VU)/\partial(DORM\_POND) < 0$
ED_SUP	**Higher education** - is a higher education institution, private or public, specialized in undergraduate or postgraduate courses.	$\partial(VU)/\partial(ED\_SUP) > 0$
ELEITORES	**Voters** - Brazilians over 18, both sexes, who are obliged to exercise the vote, and those over 16 , who can opt to exercise his voting	$\partial(VU)/\partial(ELEITORES) > 0$
EXP_VIDA	**Life Expectancy -** average number of years you would expect people to live from birth	$\partial(VU)/\partial(EXP\_VIDA) > 0$
EXPOR_R$	**Export -** refers to the sale value of goods exported, plus all expenses incurred by the exporter to ship the merchandise, including port taxes, Social Security, the Committee on Merchant Marine and others added to the freight.	$\partial(VU)/\partial(EXPOR\_R\$) > 0$
ICMS	**Tax on goods and on services of transport and communication –** it is a state tax, levied on the entry or exit of goods ,and on the beginning of interstate or intercity transport, communications and the supply of food and drinks and other goods, including services.	$\partial(VU)/\partial(ICMS) > 0$
IDESE_GERAL	**Index of socioeconomic development (IDESE)** - is a synthetic indicator that covers a wide range of social and economic indicators in order to measure the degree of development of municipalities in the state. IDESE is the result of aggregation, with equal weighting (0.25), of four blocks of indicators: Household and Sanitation, Education, Health and Income. Each block in turn, results from the aggregation of different variables.	$\partial(VU)/\partial(IDESE\_GERAL) > 0$
INDUST	**Industry –** value referring to the level of Industrial Production of the municipality.	$\partial(VU)/\partial(INDUST) > 0$

(conclusão)

IPI	**Tax on Manufactured Products -** is the tax on industrialized products, domestic and foreign, subject to the constant specifications in the Table of the Incidence of the Industrialized Products Tax - TIPI (Law No. 4502 of November 30, 1964, art. 1, and Decree Law No. 34, November 18, 1966, art. 1).	$\partial(VU)/\partial(IPI) > 0$
IPTU	**Property and urban land tax -** is a municipal tax, levied on the property over the domain or the possession of real estate located in the urban area of the municipality.	$\partial(VU)/\partial(IPTU) < 0$
IPVA	**Taxes on property for motor vehicles -** is a state tax, and has as generating factor the ownership of motor vehicles.	$\partial(VU)/\partial(IPVA) > 0$
IRPJ	**Corporate income tax -** the collection is classified according to the municipality of the company. It includes all forms of taxation of Corporations: taxable income, deemed income and arbitrated profit.	$\partial(VU)/\partial(IRPJ) > 0$
ISSQN	**Tax services of any kind -** is a municipal tax, levied exclusively on services and activities related to work and to activities legally considered to be service companies or by independent professionals.	$\partial(VU)/\partial(ISSQN) > 0$
ITBI	**Tax on transfer of real estate-** is a state tax, levied on the transfer of real estate and rights related thereto. It is generated by the purchase and sale, donation and auction or act of transmission by death. The 1988 Constitution abolished the tax, creating the ITCD at the state and ITIBI at municipal levels. The presence of ITBI at the state after 1988 is explained by the existence of values related to events prior to that change.	$\partial(VU)/\partial(ITBI) > 0$
ITIBI	**Tax transmission "*inter vivos*" of real estate and of real rights over property -** is a municipal tax, levied on the transmission in any capacity, for consideration, of real estate and real rights over them, except for collateral, as well as the assignment of rights, from one living person to another.	$\partial(VU)/\partial(ITIBI) > 0$
LEITOS	**Bed -** refers to the maximum number of admissions a hospital can meet, offering basic accommodation for the patient.	$\partial(VU)/\partial(LEITOS) > 0$
OBITOS	**Death -** concerns the disappearance of signs of life at any time after birth. The record refers to the place of residence of the deceased.	$\partial(VU)/\partial(OBITOS) < 0$
PIB	**Gross Domestic Product at market price -** is equal to the value added at basic prices, less the financial intermediation services indirectly measured and added taxes on products net of subsidies.	$\partial(VU)/\partial(PIB) > 0$
POP_RURAL	**Rural population -** covers people who live outside the boundaries of urban areas, including rural settlements (villages, nuclei, etc.).	$\partial(VU)/\partial(POP\_RURAL) > 0$
POP_URBANA	**Urban population -** represents people living in cities, towns and isolated urban areas, whose boundaries are defined by municipal law.	$\partial(VU)/\partial(POP\_URBANA) > 0$
POPUL_TOTAL	**Total population –** corresponds to the scope of the population of the municipality, and the result is the sum of urban and rural population.	$\partial(VU)/\partial(POPUL\_TOTAL) > 0$
SEP_JUD	**Legal separation -** is the legal dissolution of the conjugal partnership, without allowing the parties the right to a new civil or religious marriage. The data refer to the place of process action.	$\partial(VU)/\partial(SEP\_JUD) < 0$

Source: FEE – Fundação de Economia e Estatística

The criminal variables related to municipalities that were added to the database in the following Table 4 can be seen below:

Table 4 - Variables crime rates by municipality

Variable	Description	Desired signal
ARMA_MUNI	Weapons and Ammunition robbery	$\partial(VU)/\partial(ARMA\_MUNI) < 0$
CORRUPC	Corruption	$\partial(VU)/\partial(CORRUPC) < 0$
ENTOR_POSSE	Narcotics – Possession	$\partial(VU)/\partial(ENTOR\_POSSE) < 0$
ENTOR_TRAF	Narcotics – Drug dealing	$\partial(VU)/\partial(ENTOR\_TRAF) < 0$
ESTELIO	Embezzlement	$\partial(VU)/\partial(ESTELIO) < 0$
EXT_M_SEQ	Extortion through kidnapping	$\partial(VU)/\partial(EXT\_M\_SEQ) < 0$
EXTOR	Extortion	$\partial(VU)/\partial(EXTOR) < 0$
FUR_VEIC	Vehicle Theft	$\partial(VU)/\partial(FUR\_VEIC) < 0$
FURTOS	Thefts	$\partial(VU)/\partial(FURTOS) < 0$
LATROC	Murder with intent to rob	$\partial(VU)/\partial(LATROC) < 0$
ROUB_VEIC	Vehicle Robbery	$\partial(VU)/\partial(ROUB\_VEIC) < 0$
ROUBOS	Robbery	$\partial(VU)/\partial(ROUBOS) < 0$
TT_DELITOS	Total Offenses	$\partial(VU)/\partial(TT\_DELITOS) < 0$

4.3.3 **Data approach**

From the 19,203 real estate filtered, divided into 7,457 flats and 11,746 houses, it became apparent the restriction of the software Open Geode, in relation to the volume of data. This software has a processing capacity of only 999 observations, using the spatial weight matrix. Given this limitation, it was built information for each municipality based on the weighted average of the properties sold in that municipality. This information is called property representative. With this procedure, it became the sample of 288 observations. At the same time the procedure is limited by containing average values by region, losing some freedom, it has, on the other hand, the advantage of eliminating distorted values.

From the representative property, in each municipality analyzed there is data representing the unique values of a property in a central municipality, that is, a property that presents weighted data for all variables and can represent the average weighted of these buildings in a single georeferenced point.

4.4 KRIGING

This section is based on Landim (2003), all other citations will be identified in the relevant section. This process has begun in South Africa, where some researchers, especially the mining engineer D. G. Krige and the statistician H. S. Sichel developed empirically an estimation technique for the calculation of mineral reserves. This methodology is named Geostatistics for the study of regionalized variables, that is, variables with spatial conditioning.

The geostatistical analysis is concerned with understanding, through mathematical analysis, the genesis and natural laws that govern the phenomena construed as regional, estimation of the regional variables, or some of its spatial characteristics, using information and relationships from a set of discrete samples. It also focuses on the assessment of estimation errors, in order to establish the degree of safety provisions and high standards of sampling, ensuring that a maximum error estimate is not exceeded.

Initially, its application was only for situations in mining geology and mining exploration, but later extended to other fields, especially in recent years, with application in climatology, spatial econometrics, environmental geology, hydrogeology, among others. Currently, almost all of the latest software versions for Map Making or Georeferenced Information Systems have geostatistical methods.

The term geostatistics is a special topic of applied statistics that deals with issues related to the truly random variables and those completely deterministic, because they present a seeming continuity in space, are represented by ordinary numerical functions that take a definite value in each point in space, and mathematically describe a natural phenomenon.

The provided geographical continuity is expressed by the property that the variable needs to have very close values in two neighboring points, and gradually more different as the points become more distant. Although the regionalized variable is continuous in space, it is generally not possible to know their values at every point, but only in some that were sampled.

When studying the behavior of a regionalized variable it is necessary to use two basic tools of geostatistical methods: the semivariogram and kriging.

The semivariograms express the spatial behavior of the regionalized variable or its residues showing:

- the size of the zone of influence around one sample;
- the anisotropy, when semivariograms show different behaviors for different directions of sampling lines and study of the variable;
- continuity, the shape of the semivariogram, a situation known as the nugget effect, which measures the measurement error or the fact that data were not collected at intervals small enough to show the behavior of the underlying spatial phenomenon under study.

The Kriging is an estimation process of variable values distributed in space, and / or time from adjacent values, while considered as interdependent by the semivariogram, being an estimation method for moving average. The term comes from the French *krigeage*, and from the English Kriging, a term used in honor of a mining engineer, a pioneer in applying statistical techniques in mining assessment, Daniel G. Krige, from the French School of geostatistics.

With this, it is possible to find the best possible estimate for non-sampled locations, by minimizing the variance of the error, unless there is total assurance that the map obtained by kriging has the same semivariogram and the same variance of the original data, therefore it is by the very nature of the method, a map with smoothed values.

According to Cressie (1990), the kriging can be used to meet various ends. The method provides, in addition to estimated values, the error associated with such estimate, distinguishing it from other algorithms available, viewed as an estimator that is based on a series of regression analysis techniques, whether linear or nonlinear transformations, seeking to minimize the estimated variance from a previous model that takes into account the stochastic dependence between the data distributed in space. With it, it is possible to improve the estimate for non-sampled locations, by minimizing the variance of the error.

There are several forms of kriging, the most common: ordinary kriging, universal kriging, indicator kriging and cokrigagem.

According to Jakob (2002), traditional methods of data analysis use geo-referenced data in vector form with points, lines and polygons trying to represent the physical / geographical area of study. When using software such as ArcView to analyze tabular data, the entire unit of analysis assumes the same value. Thus, if the analysis is at the municipal level, the entire city will take a single value, and the neighbor another single value, which can generate enormous contrast between them, making the final map have large distortions. To work around this problem it is better to use a method of analysis based on interpolation of data, preserving the values in between, creating a continuous surface as a result of data smoothing and minimizing the contrasts between the polygons. In this case, the Kriging method is considered a good interpolation of data.

4.5 SPATIAL WEIGHT MATRIX

The spatial weight matrix is a crucial aspect in the study of the spatial effect of the housing market. According to Anselin (2005), this matrix is usually based on the rooke queen or distancedecay. These matrices have in each cell of the main diagonal, values equal to zero and each cell **Wij** equals to zero if **i is not a neighbor of j**; otherwise takes the value 1.

According to Anselin (1999), the spatial lag operator is considered as a weighted average of random variables related to neighboring geographic units, where it is fundamental the definition of the set of neighbors for each geographical unit. This author recommends that the elements of the matrix W be not stochastic and exogenous (from outside the model) to avoid problems in model identification and assisting in obtaining consistent and asymptotically normal estimators.

The *wij's* are designed based on the relationship of contiguity between the geographical units, referring to the following definitions: "rookcotiguity", "bishopcontiguity", "double linear", "doublerook" and "queencontiguity". There are also other alternatives of spatial weights based on inverse distance or inverse squared distance.

The spatial weight matrix has been generated by the "queen" method from the weighted unit values in order to choose the model that best results would demonstrate by the neighborhood of contiguous municipalities.

It is known that the municipalities have very different areas, and the neighboring cities might be located in close or distant borders, disadvantaging the use of distance-based methods. The method "queen" can detect all counties that have the border with the existent boundary in all directions, like the movement of the queen in chess game.

4.6 ANALYSIS

Analyzing, in spatial terms, the distribution of unit value of the properties (VU), which is the dependent variable of the model to be estimated, it is clear that there is concentration of values in certain regions and these are reduced from these points of concentration. This distribution, carried out from kriging, where the isovalue curves were established, can be seen in Figure 5.

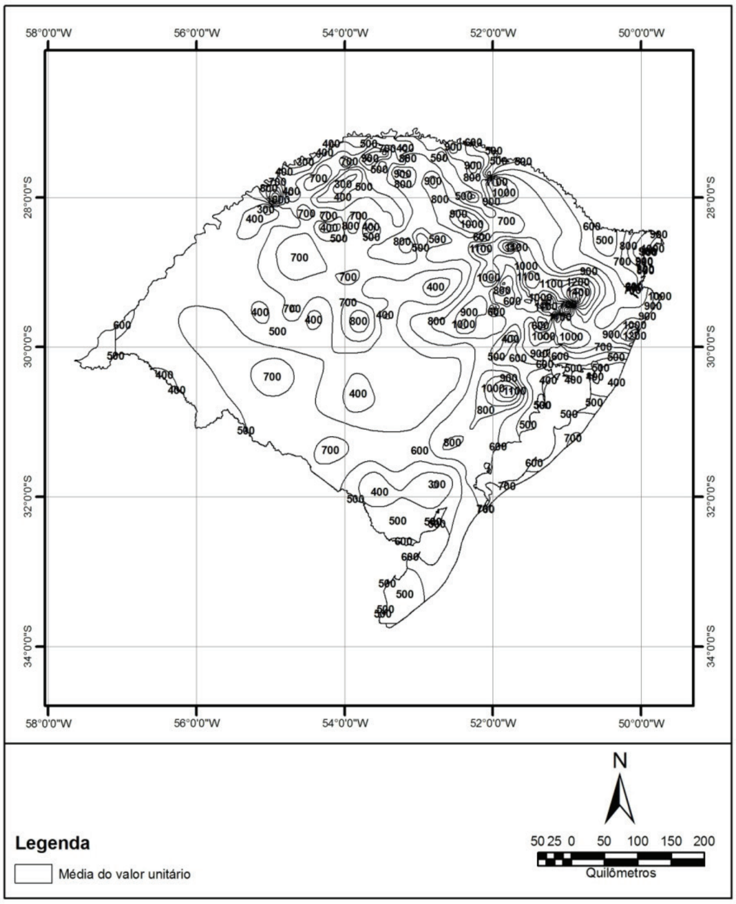

Figure 5. Curves for the dependent variable: the Unit Value Curves (VU)
Source: elaborated by the author

By observing the Figure 5, it is clear that the highest values are found in the mountain region, confirming the expected, because that is a tourist region known nationally as Gramado and Canela, and heavily industrialized as Caxias do Sul and Bento Gonçalves. From these sources of high value, there is a VU reduction generating well-defined and not uniform borders, in which the VUs are reducing. It moves toward the southern part of the state, until the border areas.

Areas with 700 and 500 VUs are quite large in the southern half and narrow when you look at its implications for the central and northern part of Rio Grande do Sul. In adjacent areas to those in or adjoining, focuses of value depression as VU 400 can be perceived.

The analysis of the shapes of the isovalue curves for the VU can anticipate that the hypothesis of spatial autocorrelation should be confirmed by I- Moran. However, this assumption may be unrealistic, if the variables maintain the same constructive pattern of spatial distribution. In this sense, one of the most significant elements, in terms of cost and valuation of the property is its built-up area. Therefore, the construction of isovalue curves was done for this variable and the Figure 6 was obtained.

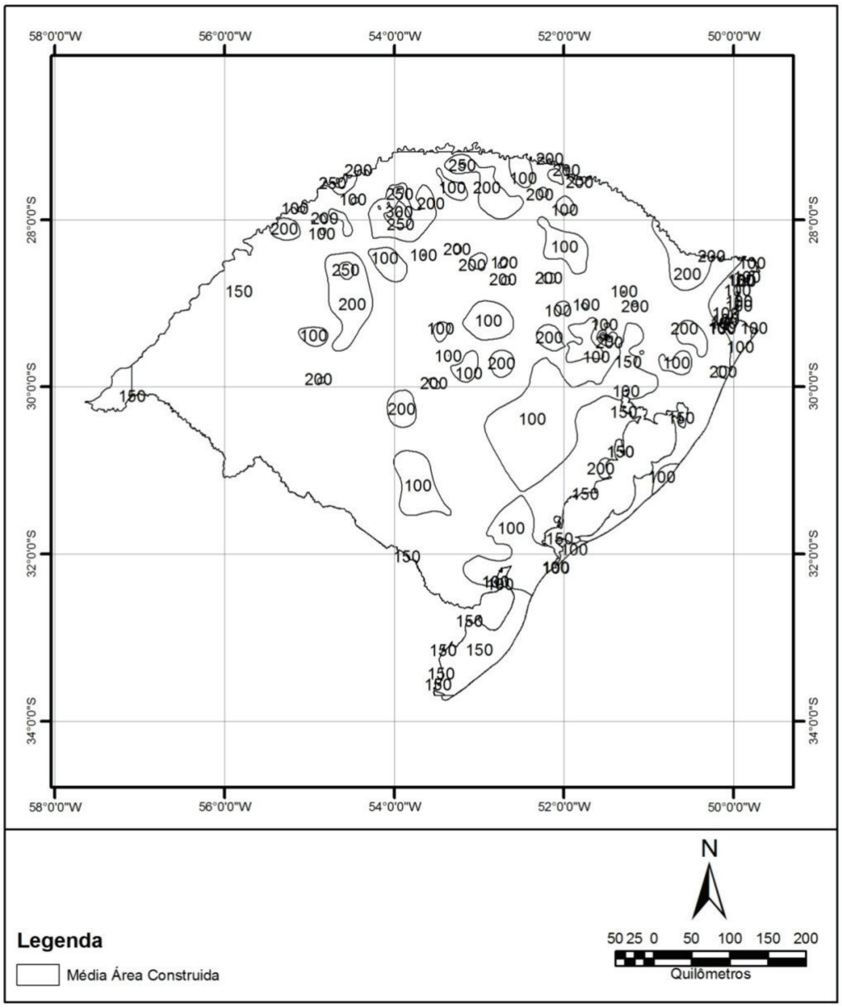

Figure 6. Isovalue curves for the independent variable: Built-up Area
Source: elaborated by the author

By analyzing the Figure 6, it is clear that the highest values are in the Northwestern part of the state. The mountain region of Rio Grande do Sul, showed no prominence in the average of build-up area. This information supports the strengthening of the hypothesis of spatial autocorrelation, once the values of the area built-up have a significantly different format in the space of unit values. Thus, the VU will influence the region's location, once the control of other explanatory variables is maintained.

Table 4 - Best adjustment of the regression model by ordinary least squares regression - model I

DEPENDENT VARIABLE	VU
R^2	0.453701
R^2A	0.427782
F	17.5044
PROB (F)	<0.0001
LOG LIKELIHOOD	-1863.75
AKAIKE CRITERIA	3755.5
SCHWARZ CRITERIA	3806.78
STANDARD ERROR OF REGRESSION	156.399

Table 5 - Autocorrelation test of the spatial regression model – model 1

TEST	PROBABILITY
I-MORAN (ERROR)	0.0000539
LM (LAG)	0.0000533
LM ROBUST (LAG)	0.0643163
LM (ERROR)	0.0001729
LM ROBUST (ERROR)	0.2734961

Table 6 - Significance of the independent variables regression - model I

VARIABLE	COEFFICIENT	STANDARD ERROR	ESTATISTICS-T	PROBABILITY
CONSTANTE	-117.7098	95.22571	-1.236113	0.2174757
ACAB_POND	171.8044	32.50796	5.284994	0.0000003
ACONST_PON	-1.34712	0.3949554	-3.410816	0.0007453
AG_CAIXA	61.73802	25.57798	2.413717	0.0164468
BANH_POND	81.41429	32.73306	2.487219	0.0134699
CONSER_PO	128.4538	30.31026	4.237966	0.0000309
DEN_DEM	0.03477071	0.03192862	1.089014	0.2771035
DOMIC	-0.008704205	0.003300537	-2.637209	0.0088365
FROTA	0.006476919	0.002085742	3.10533	0.0021000
HOMIC	3.348134	2.55062	1.31267	0.1903916
HOSPITAIS	7.69578	25.177	-0.3056671	0.7600898
PAV_POND	44.18212	31.03985	1.4234	0.1557576
PIB_PER	0.005387097	0.002251402	2.392774	0.0173952
TERR_POND	0.180552	0.0575395	3.13788	0.0018874

Analyzing the results of the regression, two elements are relevant. The first refers to the value of the I-Moran. Its p-value is highly significant, lower than 1%. Therefore, the classical regression will generate obliquous results, since the error will not have normal distribution, because a relevant variable was omitted from the model. Thus, the spatial regression may contribute when inserting the effect in the same neighborhood. Thus, it did not analyze the regression results for this model, but to the one with spatial regression.

The second result concerns the testing of Lagrange Multipliers. For these, both models are significant with a p-value more significant for spatial lag model. Thus, there is an indication that both models are viable, but a smaller indication in favor of the spatial lag model.

Thus, to re-estimate the previous regression, it was used the spatial weight matrix relative unit values of neighborhood, that is, WVU. It was observed, then the p-value of the parameter variable and indicators of Akaike and Schwarz. The model that resulted in a better estimate, containing only significant variables, estimated by spatial regression (Appendix C), is found in Table 8, taken from Annex C.

Table 7 - Results of the regression on the model LAG - Model II

DEPENDENT VARIABLE	VU
R^2	0.495306
LOG LIKELIHOOD	-1853.73
AKAIKE CRITERIA	3737.46
SCHWARZ CRITERIA	3792.41
STANDARD ERROR OF REGRESSION	150.325

Table 8 - Significance of explanatory variables in the regression on the model LAG - model II

VARIABLE	COEFFICIENT	STANDARD ERROR	VALUE	PROBABILITY
W_VUN_POND	-1.216643	0.005993549	-202.992	0.0000000
CONSTANTE	487.2929	153.8812	3.166682	0.0015420
ACAB_POND	237.4804	52.53094	4.520771	0.0000062
ACONST_PON	-1.910317	0.6386188	-2.991327	0.0027778
AG_CAIXA	139.0533	41.35365	3.362541	0.0007724
BANH_POND	87.2119	52.92876	1.647722	0.0994096
CONSER_PO	138.0597	48.98461	2.818431	0.0048260
DEN_DEM	0.1317794	0.05159465	2.554129	0.0106454
DOMIC	-0.0211343	0.005333374	-3.962651	0.0000742
FROTA	0.01159433	0.003370483	3.43996	0.0005819
HOMIC	16.13492	4.121771	3.914561	0.0000906
HOSPITAIS	77.32497	40.68569	-1.900545	0.0573616
PAV_POND	84.57635	50.15796	1.6862	0.0917573
PIB_PER	0.01108821	0.003638073	3.047825	0.0023052
TERR_POND	0.1917788	0.09297919	2.0626	0.0391506

The R^2 improved in comparison with the classical spatial model, from 0.45 to 0.50. Similarly, the Akaike and Schwarz criteria were reduced, indicating a better model for spatial regression data, as shown in Table 8, originated in Annex C.

4.6.1 **Number of relevant constructive variables**

From the "7" constructive variables analyzed, the most significant were: standard of finishing, built-up area, number of bathrooms, conservation state, paving and urban land area.

Of these, only the built-up area behaved inversely proportional to the unit value, confirming the expected correlation for the same. The others had a behavior directly proportional to the unit value, as expected.

The constructed area is inversely related to the unit value, different from the total area that has a direct relationship.

The other variables have a direct constructive relationship, because better finishing, more bathrooms, better conservation, more land area and paving, increases the property value.

4.6.2 **Number of relevant socioeconomic variables**

From "45" socioeconomic variables analyzed, the significant were: number of branches of CEF, population density, number of households, urban motor vehicle fleet, number of homicides, number of hospitals and GDP per capita.

Of these, only the number of households behaved inversely proportional to the unit value, confirming that a greater supply of real estate on the market causes a reduction in unit value.

The others had a directly proportional behavior to the unit value.

GDP per capita was expected, since higher income should lead to higher costs for home, and evaluation of marginal spending on property values should be valued higher than in those with lower incomes.

Greater urban fleet is due to the development of the municipality and, consequently, real estate valuation reflected in the VU. The same occurs with the population density.

The presence of hospitals in the cities works as urban pole of attraction, resulting in increased demand for housing and causing a direct relationship with the VU.

The number of homicides showed a direct relationship with the VU, possibly due to increased insecurity in some public places, causing an increase in demand for properties in safer areas, valuing them.

The existence of branches of Caixa Economica Federal is related directly to the VU; it is believed that this occurs, primarily, due to the increased availability and easiness of mortgage lending. This is very relevant information to the assessment of housing public policies carried out by the Federal Government

4.6.3 **Residue Analysis**

In the representative graph of the isolines of the variable VU_Pond, , it can be proved that the expected values for each region suffer proportional variations to changes of the VU itself, when confronted with the analysis of residues, and you can identify places where there are major discrepancies between the expected values and the observed values.

Therefore, it is observed that the properties located in areas where residues do not occur, the proximity between isolines represent the expected value of VU and its observed value.

On the contrary, it is possible to find multiple islands with positive and negative residues, where the observed and estimated values are distant from the VUs. It is concluded that the properties in these regions were commercialized with values above or below expectations, as for instance in the Serra Gaucha.

Notice that the isolines represent the observed value of properties transacted in the region and the color scale represents the residue analysis, as Figure 7.

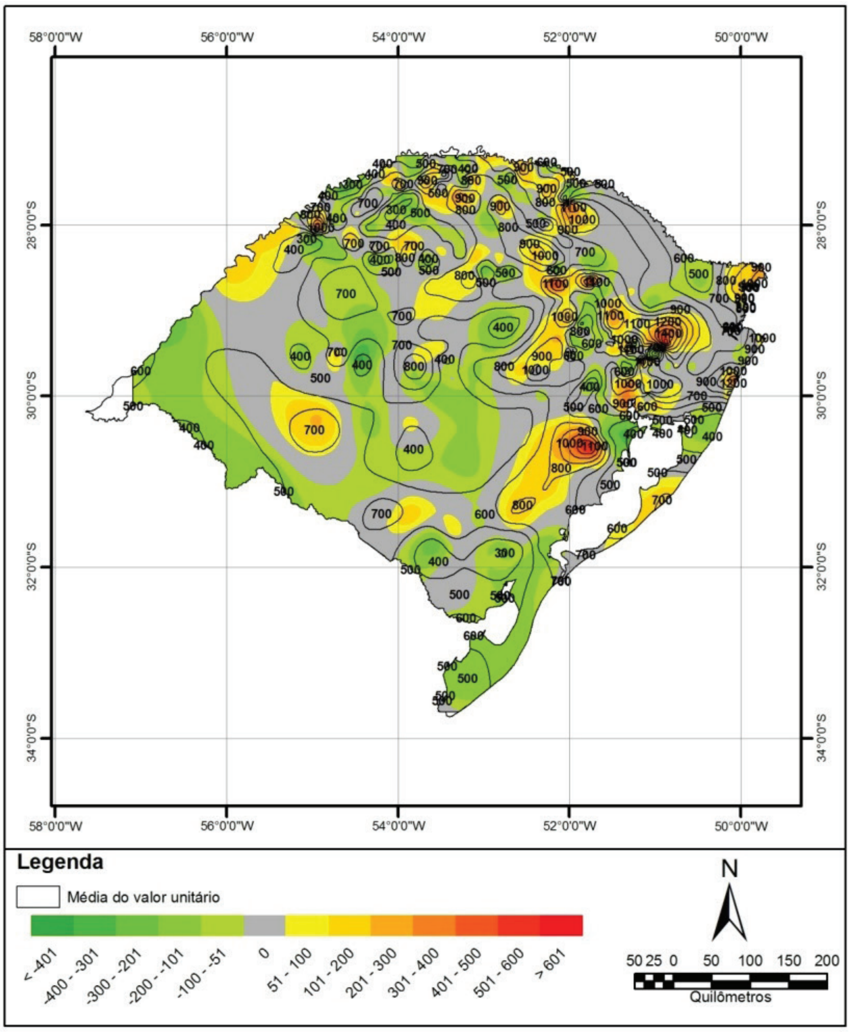

Figure 7. Residue Analysis of the variable VU.
Source: elaborated by the author

Figure 8 refers to the analysis of residues compared to the unit value and the built-up area. The Y-axis shows three ranges of Unitarian values, with its extremes extracted from the database, while the central values have been configured to better understand the graphics conditioned. The same occurs in the X-axis, just changing the variable to built-up area.

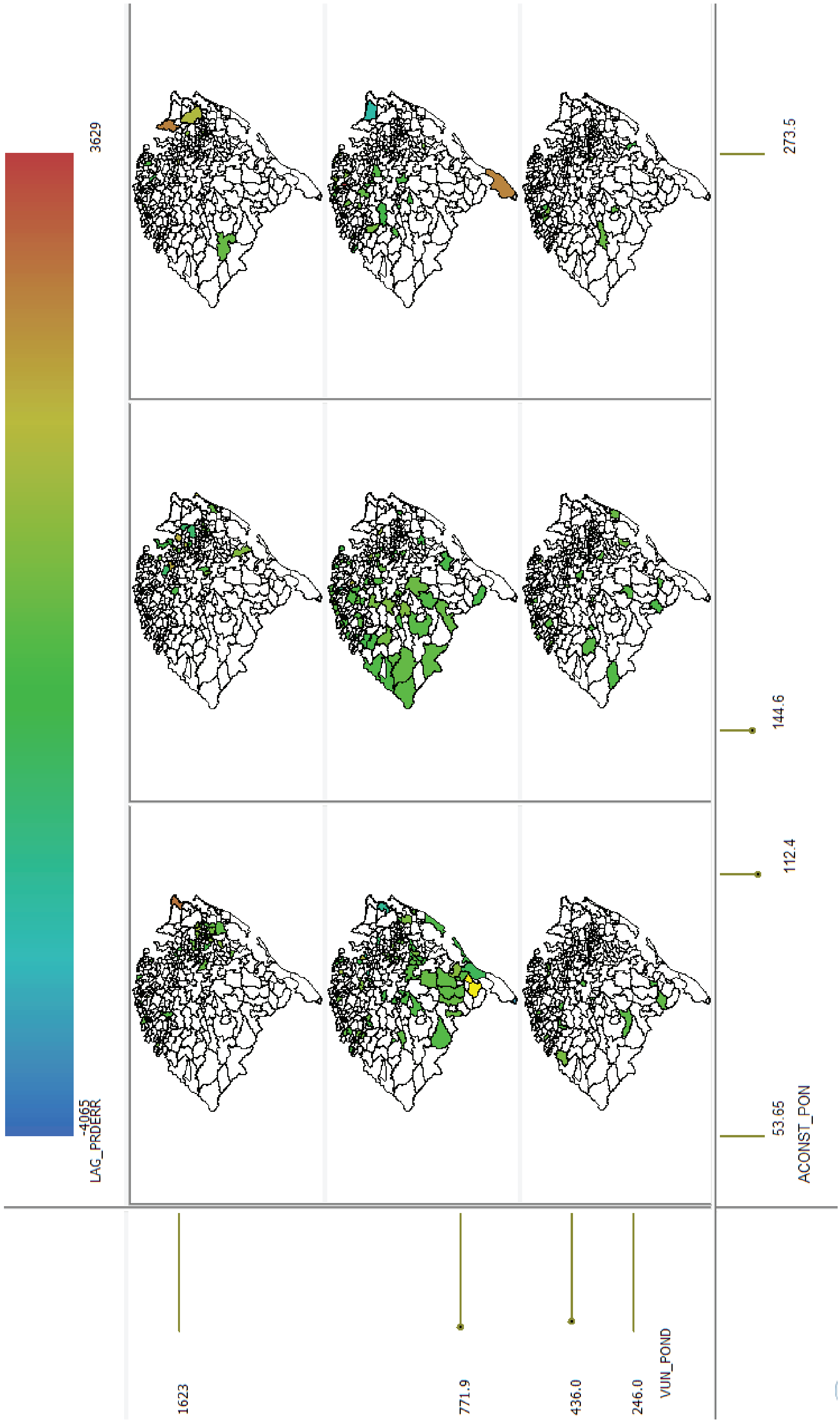

Figure 8. Residue Analysis in Conditioned Maps
Source: elaborated by the author

The cities outlined in the areas of analysis demonstrate the value of the residues to the data- crossing comparison between VU and a built area. The overflow occurred are indicated by the extremes of the range of colors represented on maps.

It is observed that the municipalities in the Southern End of the state had a positive spillover for the upper range of the built area and middle range of unit values.

There was also negative spillover in the Northwest Region, in the same range of values

5 CONCLUSION

This study aimed to measure the improvement of traditional models of valuations by introducing socio-economic variables. This improvement provides increased reliability to the evaluation of these properties on the property market, as it goes beyond the basic assumptions of multiple regression and advances in the spatial methodology.

It is concluded, based on the results of econometric models, the variables that showed a statistically significant correlation with the unit value of the property were constructed area, land area, urban paving, finishing standards and conservation state, GDP per capita, urban fleet, number of branches of Caixa Economica Federal, the number of households, number of bathrooms, number of hospitals, demographic density and homicides. It is noticed that the variables, building area and number of homicides, are negatively associated with the VU, while the others are positively associated with it.

It was also observed that the spatial regression was favorable for the improvement of the statistical indices of the model.

It is known that the valuation of real estate, based on data that show spatial autocorrelation, when performed by multiple regression models, may provide biased or conflicting results, with no consistency.

To provide greater reliance on evaluative work, you should use the Methodology of Spatial Regression, because it avoids the breach of the main characteristics of the estimators. Therefore, it will be always tested the possibility of using spatial regression.

REFERÊNCIAS

ABUNAHMAN, S.A., 2000. Engenharia Legal e de Avaliações. São Paulo: PINI.

ALMEIDA, E. S., 2004. Curso de Econometria Espacial Aplicada. Piracicaba.

ANSELIN, L. 1988. Spatial Econometrics: Methods and models. DORDRECHT: Kluwer Academic.

ANSELIN, L., 2001. Spatial Externalities, Spatial Multipliers and Spatial Econometrics. Specialist Meeting on Spatial Externalities, Santa Barbara, Califórnia.

ANSELIN, L., 2000. Exploring Spatial data with GeoDa™: A Workbook. Center for Spatially Integrated Social Science, University of Illinois, Urbana-Champaign, Illinois.

ANSELIN, L., 1999. Spatial econometrics. Bruton Center, School of Social Sciences, University of Texas, Dallas, Richardson.

ANSELIN, L.; BERA, A., 1997. Spatial dependence in linear regression models with an introduction to spatial econometrics. Orgs.: ULLAH, A. Handbook of Applied Economic Statistics, Giles: Marcel Dekker.

ANSELIN, L., 1996. The Moran scatterplot as ESDA tool to assess local instability in spatial association. In: Fisher, M.; Scholten, H. J.; Unwin, D. Spatial Analytical Perspectives on GIS. London: Taylor & Francis, p. 111-126.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. NBR 5676, 1989. Avaliação de Imóveis Urbanos. Rio de Janeiro.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. NBR 14653-1, 2001. Avaliação de Bens. Parte 1: Procedimentos gerais. Rio de Janeiro.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. NBR 14653-2, 2004. Avaliação de Bens. Parte 2: Imóveis urbanos. Rio de Janeiro.

BALCHIN, P.N.; KIEVE, J.L., 1986. Urban land economics. 3. ed. London: McMillan.

BALL, M.J., 1973. Recent empirical work on the determinants of relative house prices. Urban Studies, v.10, p.213-233.

BAPTISTELLA, Marisa, 2005. O uso de redes neurais e regressão linear múltipla na engenharia de avaliações: determinação dos valores venais de imóveis urbanos. Universidade Federal do Paraná Tese mestrado. Disponível em http://www.repositorio.seap.pr.gov.br/arquivos/File/material_didatico_PDC/Avaliacao_de_Imoveis_Publicos/area_urbana/materiais/artigos_teses_dissertacoes/uso_de_redes_neurais.pdf.

BELSLEY, D.A.; KUH, E.; WELSCH, R.E. , 1980. Regression diagnostics: Identifying influential data and sources of co linearity. New York: John Wiley.

BRAULIO, S. N. , 2005. Proposta de uma Metodologia para Avaliação de Imóveis Urbanos baseado em Métodos Estatísticos Multivariados. Curitiba: Universidade Federal do Paraná, Tese de Mestrado. Disponível em http://www.ppgmne.ufpr.br/arquivos/diss/112.pdf

BROWN, G.R., 1985. Property Investment and Performance Measurement: A Reply. Journal of Valuation 4: 33-44.

BURGER, Philippe; RENSBURG, Lizelle Janse Van, 2008. Metropolitan house prices in south Africa: do they converge? South African Journal of Economics. Volume 76, Issue 2, pages 291–297, June.

CÂMARA, Gilberto et al. Análise espacial de áreas, 2010. Disponível em http://www.dpi.inpe.br/gilberto/livro/analise/cap5-areas.pdf.

CANAN, K. A. , 2005. Determinação Científica de Fatores de Homogeneização para Padrão de Acabamento e Estado de Conservação analisando Residências Localizadas no Centro da Cidade de Cascavel- PR.. Cascavel: Faculdade Assis Gurgacz – FAG,Especialização em Perícias Judiciais e Avaliações em Engenharia.

CRESSIE, N. , 1990. The Origins of kriging. Math. Geology, v.22, p.239-52.

DANIEL, C.; WOOD, F.S., 1980. Fitting equations to data. 2. ed. New York: John Wiley.

DANTAS, R. A., 1998. Engenharia de Avaliações: Uma Introdução à Metodologia Científica. São Paulo: PINI.

FOTHERINGHAM, A.S. et al., 2000. Quantitative Geography. London: Sage.

FLORAX, R.J.G.M.; GRAAFF, T. The Performance of Diagnostic Tests for Spatial Dependence in Linear Regression Models: A Meta-Analysis of Simulation Studies. Free University Amsterdam, Orgs.: ANSELIN, L.; FLORAX, R.J.G.M.; REY, S.J. ,2004. Advances in Spatial Econometrics: Methodology, Tools and Applications. New York: Springer, 29-65.

GONZALEZ, M.A.S., 1993. A formação do valor de aluguéis de apartamentos residenciais na cidade de Porto Alegre. Porto Alegre: UFRGS. Dissertação de Mestrado em Engenharia.

GONZALEZ, M.A.S., 1997. A Engenharia de Avaliações na visão inferencial. São Leopoldo: Editora da UNISINOS.

GONZALEZ, M.A.S.; FORMOSO, C.T., 2000. Análise conceitual das dificuldades na determinação de modelos de formação de preços através de análise de regressão. Engenharia Civil – UM – nº8, UFRGS.

GUJARATI, D., 2006.Econometria Básica. 4. ed. Rio de Janeiro: Elsevier Campus.

DA Sonali; GUPTA, Rangan; KAYA, Patrick A., 2010. Convergence of metropolitan house prices in south Africa: a re-examination using efficient unit root tests. Applied Econometrics and International Development, vol. 10, issue 1, pages 173-188.

HARMANN, H.H., 1976. Modern factor analysis. 3. ed. Chicago: University of Chicago.

HAYASHI, F., 2000. Econometrics. New Jersey: Princenton University Press.

HOLLY, S.; PESARAN, M.H.; YAMAGATA. T., 2006.A Spatio - Temporal Model of House Prices in the US, Cambridge Working Papers in Economics 0654, Faculty of Economics, University of Cambridge.

JAKOB, A.A.E., 2002. Krigagem como Método de Análise de Dados Demográficos. UNICAMP/NEPO. XIII Encontro da Associação Brasileira de Estudos Populacionais, Ouro Preto, Minas Gerais, Brasil.

JUDGE, et al., 1985. Introduction to the theory and practice of econometrics. 2. ed. New York: John Wiley.

LANDIM, P.M.B., 2003. Análise Estatística de Dados Geológicos. 2 ed. São Paulo: UNESP.

LIZIERI, C.; VENMORE-ROWLAND, P., 1991.Valuation Accuracy: A Contribution to the Debate. Journal of Property Research 8-2: 115-122.

MADDALA, G.S., 1988. Introduction to econometrics. New York: McMillan.

MATYSIAK, G.; WANG, P. Commercial Property Market Prices and Valuations: Analysing the Correspondence. Journal of Property Research 12: 181-202, 1995.

McALLISTER, P., 1995. Uncertainties in Property Performance Measurement: The Problem of Valuation Error. International Conference on Financial Management of Property and Construction. Newcastle. Northern Ireland: 185-199.

MONASTERIO, Leonardo M.; ÁVILA, Rodrigo Peres de, 2004. Uma Análise Espacial Do Crescimento Econômico Do Rio Grande Do Sul (1939-2001), Anais do XXXII Encontro Nacional de Economia [Proceedings of the 32th Brazilian Economics Meeting] 113, ANPEC - Associação Nacional dos Centros de Pós-Graduação em Economia [Brazilian Association of Graduate Programs in Economics], 2004.

MORCELLI, A. T. G., 2006. Construção de Modelos de Regressão para estimar o Valor dos Lotes Urbanos do Setor 11 de Santa Maria-RS. Santa Maria: Universidade Federal de Santa Maria.Dissertação de Mestrado em Engenharia da produção.

MOREIRA, A.L., 1984. Princípios de Engenharia de Avaliações. São Paulo: Pini / Escola Nacional de Habitação e Poupança.

NETER, J.; WASSERMANN, W.; KUTNER, M.H., 1990. Applied linear statistical models. 3. ed. Burr Ridge: Richard D. Irwin.

NOVAES, L.F.; PAIVA, S.A., 2003. Situações onde a aplicação da Análise Envoltória de dados (DEA) apresenta vantagens sobre o uso da regressão linear múltipla. (avaliação de imóveis). XII COBREAP – Belo Horizonte/MG.

PINDYCK, R.S.; RUBINFELD, D.L., 2004. Econometria. Modelos & Previsões. 4. ed. Rio de Janeiro: Elsevier Campus.

RESENDE, T. G; CYPRIANO, L.A., 2010. Valorização dos lotes urbanos na cidade de Toledo: uma análise econométrica no período de 1998-2008. Revista Brasileira de Gestão Urbana, v.2, n.1, p. 107-116, jan/jun.

ROBINSON, R., 1979. Housing economics and public policy. London: McMillan.

SMITH, L.B.; ROSEN, K.T.; FALLIS, G., 1988. Recent development in economic models of housing markets. Journal of Economic Literature, v.26, p.29-64, Mar.

SOARES, Ilton G. e CASTELAR, 2003. Ivan. Econometria Aplicada com uso do Eviews. Fortaleza: UFC/CAEN.

TRIVELLONI, C.A.P., 2005. Método para Determinação do Valor da Localização com Uso de Técnicas Inferenciais e Geoestatísticas na Avaliação em Massa de Imóveis. Tese de Doutorado, Universidade Federal de Santa Catarina.

TRIVELLONI, C.A.P., 2006. Utilização de Métodos de Análise Espacial na Avaliação em Massa de Imóveis. Congresso Brasileiro de Cadastro Técnico Multifinalitário. UFSC, Outubro.

WHITE, H., 1992.Artificial neural networks. Approximation and learning theory. Cambridge (USA): Blackwell.

WOOLDRIDGE, J.M., 2006. Introdução à Econometria. Uma Abordagem Moderna. 2. ed. São Paulo: Pioneira Thomson Learning.

ZIETZ, Joachim; ZIETZ, Emily Norman; SIRMANS, G. Stacy., 2008, Determinants of House Prices: A Quantile Regression. The Journal of Real Estate Finance and Economics. Volume 37, Number 4, pages 317-333.