SPATIAL ANALYSIS OF THE DETERMINANTS ASSOCIATED TO THE CHANGES OCCURRED IN THE MUNICIPAL HUMAN DEVELOPMENT INDEX IN THE STTE OF MINAS GERAIS. 1991-2000[*]

Julio Racchumi Romero[*]

ABSTRACT

The purpose of this work is to analyze the spatial relationship of the determinants that influenced the changes produced in the Municipal Human Development Index of (MHDI) in the State of Minas Gerais between 1991 to 2000. The method to be used to check the association of the explanatory variables is the spatial statistical analysis. For this spatial analysis it was used the test of spatial auto-correlation determined by the Moran's Index and spatial regression Conditional Auto Regressive. With the methodology applied, some explanations are found for the changes of the human development in the period being studied. Besides, this technique possibility awards a higher explanatory potential of the analysis MHDI, allowing identifying population groups, risk areas that permit to guide policies for better conditions of the municipalities. Finally, the study shows that it is possible to make use of the progresses obtained in the area of geo-processing in the areas socials.

[*] Centro de Desenvolvimento e Planejamento Regional (Cedeplar)/UFMG

SPATIAL ANALYSIS OF THE DETERMINANTS ASSOCIATED TO THE CHANGES OCCURRED IN THE MUNICIPAL HUMAN DEVELOPMENT INDEX IN THE STTE OF MINAS GERAIS. 1991-2000[*]

Julio Racchumi Romero[*]

1. INTRODUCTION

Along the years, several works have invested in the improvement of obtainment and interpretation of indicators that have described, in a closest way, the social problems. In this sense, the techniques of spatial analysis are contributing significantly to the improvement of the works that study the economical and social problems, mainly in the regions under development in which the geographical location is important (Heninger e Snel, 2002).

The regions of the third world, during the last decade, although having presented progresses in the economical and social indicators, these have not been homogeneous in their geographical space and it is still observed that economical difficulties persist in a large portion of this region. As a consequence of these difficulties, the United Nations Development Program (UNDP), starting from the paradigm of the Human Development, has insisted about the need to privilege the social dimension of the economical processes in which the population is immersed (Güel, 2001).

The Human Development, a focus spread through the UNDP via the creation of the Human Development Index (HDI), emphasizes that the population is the means and the conclusion of the development of the countries. This is one of the synthetic indicators most used to measure the degree of development of the population. Although the perspective of the human development has been broadly studied, there are still some discussions about the determinants or mechanisms of their development. Therefore, it is an indicator of results, which helps to establish what the structural capacity of a society is, but that is not able to indicate which the factors that determine these results are. (Lacerna, et al, 1995). When analyzing the changes occurred with the human development, the main results show that it is necessary to consider other factors and mainly to analyze the articulation and the interdependence that exist among them.

In face of this context, a statistical analysis that explains the relationship between the MHDI and the determinants of these is of utmost importance to understand the behavior presented by the human development in the last decade. One of the models that is frequently used in this case is the so called multiple regression. A statistical tool that studies the relationship between two or more variables. However, when it is assessed the social-economical relationship among the agents and sometimes their relation with their geographical location, this is, the less developed population is concentrated in specific spaces. (Pérez, 2005).

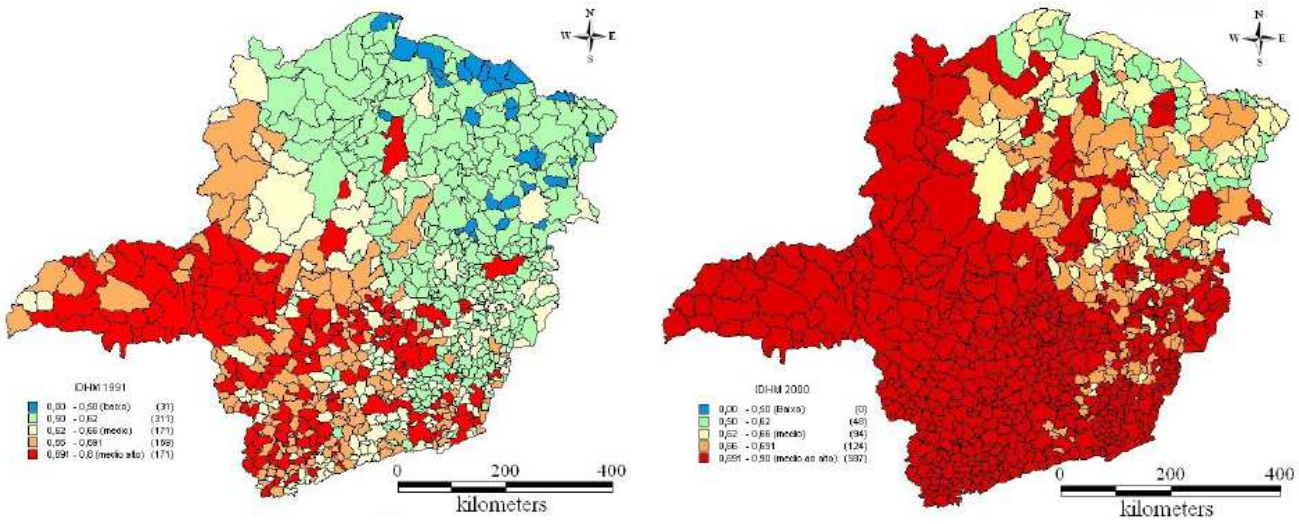
To perform these estimates the model of regression generally used does not respond to the problems of auto-correlation that foreseeable will be present in the estimation of the models. Thus, with the intent to diminish this problem in the past years many studies have appeared using techniques of spatial regression models (Alañón A. 2002, Chasco C. 2003). The estimates of these spatial models incorporate the spatial structure, once the dependence among the observations alters the explanatory capacity of the model. Specifically, the spatial regression consists of the realization of an econometric estimate at an upper municipal, state or regional geographical level (Lopes, *et al*., 2005).

[*] Doctorate in Centro de Desenvolvimento e Planejamento Regional (Cedeplar)/UFMG

In our case the study will be carried out for the State of Minas Gerais, a State that represents around 7% of the Brazilian territory, that is, it is the fourth state with larger area in the country, having the main reserves of metallic and non-metallic minerals of the country, which jointly with the existing hydrographic basis favor the construction of several hydroelectric plants of strong impact on the generation of wealth (statistical year book of Minas Gerais 2000-2001). Besides, the studies carried out for the State of Minas Gerais confirm the differences marked in some regions of the State, such as the studies of João Pinheiro Foundation: Gross Product of Minas Gerais per Municipality and Region (1999-2002), Social-economical differences of the regions of Minas Gerais 1991 – 2000. Other works have also been carried out to explain the differences; Helger Marra Lopez (2003), which performs an analysis of the poverty in the State of Minas Gerais per micro-regions using multi-dimensional indicators.

Graph 1
Distribution of Municipal Human Development Index
1991 to 2000. Minas Gerais.

1991 **2000**



Source: Elaboration of data the Atlas of Human Development in Brazil (PNUD, IPEA and FJP) and database IPEA (IPEADATA).

2. Data and Methodology

For the study of the human development, as the analysis is made at municipal level, the Municipal Human Development Index (MHDI) was used as a dependent variable, mainly because it is available at municipal level in 1991 and 2000 and due to the easiness to interpret the results. The data correspond to the 853 municipal cities of the State of Minas Gerais and were obtained from the program of human development carried out by João Pinheiro foundation in 2001. The independent variables named in the work as determinants of the Municipal Index of Human Development were: Gini's index, inequality of Theil's index, per capita income familiar, average income of the chief of the family, poverty index (percent of people of age 10 of more, per classes of monthly nominal income below one minimum salary), rate of analphabetism (percent of people at age 15 and more who are not capable of reading or writing) and demographic density. These indicators have as source the Map Book of Human Development of João Pinheiro foundation and of the IPEADATA of IPEA (2007). The cartographic basis that was used is dated 1996, obtained by the Instituto de Ciências Aplicadas (IGA) and Fundação Centro Tecnológico de Minas Gerais (Cetec), who integrate the GeoMINAS organization.

In the work it was first carried out an exploratory analysis of the independent variables, using the matrix of correlation and the Moran's Index was used to measure the relationships the spatial correlation. Secondly, with the purpose of verifying the relationships between the dependent and the independent variables, it were tested models of multi-varied linear regression; and in the case of the spatial analysis it was used the Condicional Auto Regressive (CAR) model, which captures the spatial dependence of the variables. The quality of the adjustment of the spatial regression model is similar to the one of multiple regression model, verified by means of the analysis of residues based on the Moran' Index. The software's used were: SPSS-13.0, Geoda 0.9.5i, e R. 2.6.2.

3. Results

The results of Moran's I for the test of spatial autocorrelation are shown in TAB 1, the results detected the presence of significant spatial autocorrelation in most indicators for 1991 and 2000 ($p < 0.05$), except in the Gini's index and the number of doctor inhabitants. Thus, the MDHI, poverty rate and per capita income showed strong spatial autocorrelation. The rural population and occupied, however significant ($p < 0.05$), show a weak correlation. These results suggest the formation of clusters of municipality in the state by MHDI. This spatial dependence is only a limited vision, because the clusters of MHDI in 2000 may only be reflecting the distribution of the explanatory variables of this indicator, but it is also possible, the presence of other phenomena that contribute to the formation of clusters of MHDI in 2000. To examine is spatial dependence controlling for other relevant characteristics, we can implement the regression models, which can result of great importance for the study of MHDI in 2000.

Table 1.
Result of local spatial autocorrelation. 1991 to 2000. Minas Gerais

Variables	Moran's I	
	1991	2000
MHDI	0,7088	0,7206
Per capita Income	0,5838	0,7006
Gini's index,	0,0885	0,3473
poverty index	0,7701	0,8049
Occupied population	0,1146	0,1504
Rural Population	0,1953	0,2201
Life expectancy at birth	0,5723	0,4909
Doctor per thousand inhabitants	0,0794	0,0619
Children 7 to 14 years illiterate	0,7925	0,6852
Adults 25 years and more illiterate	0,7913	0,8020

Source: Elaboration of data the Atlas of Human Development in Brazil (PNUD, IPEA and FJP) and database IPEA (IPEADATA).
*significant 5% ($p<0.05$)

The application of spatial regression in this work, not really intended to be exhaustive, but illustrative of the type of analysis to be carried out with these regressions, and to show how far our data suggest autocorrelation substantive or noise, and how the estimates change implementing the regression space.

In Table 2 presents the results for a model that estimates the IDHM according to selected independent variables (through the method "Stepwise Forward" to reduce the number of variables second Charterjee & Price, (1977)). First, to compare results with different models, a regression of least squares (MCO). The results for this model, suggest that per capita income, poverty (to a lesser extent) and life expectancy at birth in 2000, increase the level of municipal development, on the other hand, the growth rate of income per capita, the percentage of illiterate adults 25 years or older and life expectancy at birth between 1991 - 2000 reduces the levels of development. The results are in agreement with other work, but draws attention to the fact that the Gini's index and the descend between 1991 and 2000, the percentage of children aged 7 to 14 illiterate and their reduction, the decrease of poverty and decrease the percentage of adults 25 and older illiterate were not significant for the model.

According to the results of estimation of spatial regressions SAR and CAR, the coefficients do not change significantly with those of the least squares regression (MCO) and the SAR and CAR, but not to estimate the standard error improvement.

In the diagnosis of model MCO indicate: absence of normality of residuals (Jarque-Bera test), not homocedasticity with the Breusch-Pagan test, but with a test homocedasticity more robust (White). These results advise of a diagnostic model divergent. Analyzing the spatial dependence, the *Moran's I* test and the Lagrange Multiplier (Lag), showed spatial autocorrelation and spatial dependence of the waste data ($p <0.05$), respectively (see Chart 3), suggesting the need to adjust the spatial regression models: the auto-regressive spatial (SAR) and spatial error (CAR).

Table 2
Results and estimates of the coefficients of regression model and models by MCO and SAR, CAR and CAR without trend. Minas Gerais. 1991 -2000

Índice de Desenvolvimento Humano Municipal (IDHM) 2000	Regresión de mínimos cuadrados (MCO)	Modelo Espacial Lag (SAR)	Modelo Espacial do Error (CAR)
Modelo			
Constante	0,0081*	0,0328*	0,0022*
Logaritmo da renda familiar per capita em 2000	0,1517*	0,1518*	0,1521*
Intensidade da pobreza em 2000	0,0005*	0,0004*	0,0002*
Esperança de vida ao nascer em 2000	0,0058*	0,0059*	0,0059*
Porcentagem de adultos de 25 anos e mais em 2000	-0,0017*	-0,0018*	-0,0017*
Taxa de crescimento da renda familiar per capita 1991- 2000	-0,0085*	-0,0001*	-0,0001*
Taxa de crescimento da esperança de vida ao nascer 1991 - 2000	-0,0041*	-0,0042*	-0,0042*
Coeficiente Espacial			
coeficiente espacial autoregressivo (ρ)	-	-0,0397*	-
Lambda (λ)	-	-	0,6180*
Bondad del Ajuste			
R2-Ajustado	0,9866	-	-
Log-Likelihood (LIK)	3085,47	3092,99	3150,39
Akaike info criterion (AIC)	-6154,94	-6169,98	-6286,77
Schwarz criterion (SC)	-6116,95	-6131,99	-6253,53
Diagnósticos de Dependencia Espacial			
I de Moran (erro)	0,2297*	0,2631*	-0,0551
Multiplicador de Lagrange (lag)	17,9110*	-	-
Multiplicador de Lagrange Robusto (lag)	39,6266*	-	-
Multiplicador de Lagrange (erro)	119,3686*	-	-
Multiplicador de Lagrange Robusto (erro)	141,0842*	-	-
Likelihood Ratio	-	16,4753*	131,2662*
Diagnóstico da Hetereodasticidade			
Breusch-Pagan test	10,3009**	10,4578**	12,5642**
White (Teste robusto)	50,741**	-	-
Diagnóstico de Normalidade			
Jarque-Bera	26,080**	-	-

*significant 1% (p<0.01)
*significant 5% (p<0.05)
Source: Elaboration of data the Atlas of Human Development in Brazil (PNUD, IPEA and FJP) and database IPEA (IPEADATA).

In the SAR model, the spatial autoregressive coefficient (ρ) and the other parameters were significant. In the diagnosis of adjustment of this model, considering the statistics LIK, AIC and SC, the model is better adjusted to data. The result of the Breusch-Pagan test was not significant (p> 0.05), suggesting accept the hypothesis of homocedasticity, while the test of the Likelihood Ratio (Likelihood Ratio) also suggests the existence of spatial dependence. This confirms that in spite of, improves the fit of the model, there are some sources not specified and may invalidate assintotically the properties of the estimator of spatial dependence.

For the CAR model, the value λ (lambda) and regression coefficients were significant. The fit of the model improved, the value of LIK and increase of AIC and SC decreased, compared with the two models previously adjusted. The test of Breusch-Pagan still not showing the rejection of homocedasticity and the test of the Likelihood Ratio (VR), the existence of spatial autocorrelation (p <0.05). However, when analyzing the graph of dispersion of residuals of the CAR model e *Moran's I* statistic is -0.0551, or approximately equal to zero (p> 0.05) indicates that the inclusion of the term of the error spatial autoregressive in the model has removed the autocorrelation

Finally, the diagnosis of errors confirmed the presence of spatial autocorrelation, suggesting both, spatial dependence found between the interaction of IDHM 2000 and with the neighboring units, and the error term. The results of the goodness of fit of the model indicated that the tests and analyzed the values of LIK, AIC and SC, are satisfactory for the three models, but these values were higher than the model previously adjusted. Thus, the hypothesis that the inclusion of indicators of spatial dependence between variables improves the predictive power was confirmed by the CAR model.

4. Conclusions

The main contribution of the study is to show that the spatial regression is applicable to the studies in the area social, just as the poverty and human development, with the purpose of analyzing the determiners associated to the improvements of the social indicators such as the MHDI. Besides, during the past years the analysis of spatial auto-correlation has become an important tool in the studies of social and economical problems (Hawkins et al., 2003a).

The results found in the spatial correlation of the MHDI do not permit to warn that the "contagion" among the municipalities or structural forces, originate the concentration of the human development by themselves. However, there are more evidences to believe that the spatial dependence is the result of the geographical distribution of the explanatory variables and of the auto-correlation of the expression error; that is, the spatial correlation is due to flows of interchange among neighboring municipalities, which produce in the sea moment or time interval in which the process is analyzed. A result that helps to consider these evidences was observed in the graphic of clusters of Moran, in which the CAR model has shown the largest number of areas grouped in regions with low residues (negative) and with high residues (positive).

The regression models have also indicated that the per capita income, the intensity of poverty and the expectation of life when Born in the year 2000 presented a positive association with the levels of municipal human development and, as a consequence, in its spatial structure. On the other hand, the rate of growth if the per capita family income, of the percentage of analphabet adults with age 25 and more and of the expectation of life when born between 1991 and 2000 reduce the levels of development. These results were expected. Besides, the results that called attention were the fact that the Gini index and its diminishing between 1991 and 2000, the percentage of analphabet children from age 7 to age 14 and their diminishing, the decrease of poverty and the diminishing of the percentage of adults from age 25 and more were not significant for the model; better saying, do not contribute to the explanation of the clusters of the MHDI observed in the exploratory analysis.

Finally, it is appropriate to emphasize that in our case the work with the spatial models does not intend to be actually exhaustive, but is merely illustrative, of the type of analysis to be carried out with spatial regressions and it is intended to show to what extent our data suggest a substantive auto-correlation or noise, and when the estimations change implementing the spatial regression.

REFERENCES:

ALAÑÓN A. (2002): Estimación de la Renta de los Municipios Españoles en 1991 Mediante Técnicas de Econometría Espacial. *XXVIII Reunión de Estudios Regionales. Murcia Noviembre 2002*.

ANSELIN L. (1988): *Spatial Econometrics: Methods and Models.* Edit. Kluwer Academic Publishers.

ANSELIN L. (1996). Luc, "The Moran Scatterplot as an ESDA Tool to Asses ocal Instability in Spatial Asociation", en *Spatial Analytical Perspectives on GIS in Enviromental and Socio- Economic Sciences*, London, 1996.

ANSELIN. **L.** (2005)., *Exploring Spatial Data with GeoDaTM : A Workbook.* Spatial Analysis Laboratory Department of Geography University of Illinois, Urbana-Champaign Urbana, IL 61801.

ASSUNÇÃO, R Apostila da matéria de "Estatística Espacial dados de área",. LESTE - Departamento de Estatística, UFMG, MG, 2005.

CHARTTERJEE, S e PRICE, B. (1977). Regression Analysis by Example. Johm Wiley e sons, New York, 1977.

CHASCO C. (2003): *Econometría espacial aplicada a la predicción-extrapolación de datos microterritoriales*. Consejería de Economía e Innovación Tecnológica, Comunidad de Madrid. Madrid, abril de 2003.

GÜELL, PEDRO E. (2001). Crecimiento Económico y Desarrollo Humano: ¿aliados, enemigos o qué?, 10.10.2001, PNUD .

HENNINGER, N.; SNEL, M., (2002). *Where are the Poor? Experiences with the Development and Useof Poverty Maps*, World Resources Institute, Washington, DC.

LASERNA, R.; CORTÉS, J.; LEDO, C; RAMIREZ, A.; VALDIVIESO, R.; HURTADO, W.;CASAZOLA, J. (1995). Sostenibilidad y Desarrollo Humano: La calidad de vida em Cochabamba. PNDU. Cordeco. Cochabamba. Bolívia.

LIMA MLC, SOUZA ER, XIMENES RAA, ALBUQUERQUE MFPM, BITOUN J, BARROS MDA. (2005). Análise espacial dos determinantes socioeconômicos dos homicídios no Estado de Pernambuco. Rev Saúde Pública 2005;39(2):176-82.

LOPES, H. M. ; LOPES, H. M. ; MACEDO, P. B. R. ; MACHADO, A. F. (2003). Indicador de pobreza: aplicação de uma abordagem multidimensional ao caso brasileiro 2003 (Texto Para Discusão 223).

LOPES, S. B.; BRONDINO, N. C. B.; SILVA. (2005) Análise do desempenho de modelos de regressão espacial na Previsão de demanda por transportes. USP. SP.Brasil.

OLIVEIRA S. V. (2000). Regressão ponderada geograficamente para os dados do censo IBGE 2000 de São Paulo. Divisão de Engenharia Civil do ITA, Instituto Tecnológico de Aeronáutica.

PEREZ, G. (2005) Dimensión espacial da pobreza en Colombia, Cartagena de Indias.

RANIS, GUSTAVO e STEWART, FRANCES. (2002b). Crecimiento económico y desarrollo humano en América Latina. Revista de la CEPAL, no. 78, pp. 7-24.

ROMERO, J. (2006) Análise Espacial da Pobreza Municipal no Estado de Minas Gerais - 1991 – 2000. Trabalho apresentado no XIV Encontro Nacional de Estudos Populacionais, ABEP. Caxambú-MG – Brasil.

SÁNCHEZ P., L. (2006). Métodos para el análisis espacial. Una aplicación al estudio de la geografía de la pobreza. Trabajo presentado en el II Congreso de la Asociación Latinoamericana de Población. Guadalajara, México.

APPENDIX 1

MODELING SPATIAL DEPENDENCIES

Spatial Autoregression (SAR) Model

In the SAR model, the spatial dependencies of the error term or the dependent variable, are directly modeled in the regression equation. If the dependent values Y are related to each other, then the regression equation can be as

$$Y = \rho WY + XB + \varepsilon$$
$$\varepsilon \sim N(0, \sigma^2 I)$$

Here, W is the neighborhood relationship contiguity matrix and ρ is a parameter that reflects the strength of spatial dependencies between the elements of the dependent variable. After the correction term ρWY is introduced, the components of the residual error vector are then assumed to be generated from independent and identical standard normal distributions.

Conditional Auto Regressive (CAR) Model

This model assumes that the spatial dependency in the dependent variable is the result of the geographical distribution of the explanatory variables and the autocorrelation of the error term:

$$Y = X\mathrm{B} + \mu \quad \mu = \rho W\mu + \varepsilon$$
$$\varepsilon \sim N(0, \sigma^2 I)$$

Here, μ is the component of error in spatial effects, ρ is the autoregressive coefficient e ε is the component of error variance constant and not correlated. The null hypothesis for non-existence of autocorrelation is that $\rho = 0$, i.e. the error term is spatially correlated.

APPENDIX 2

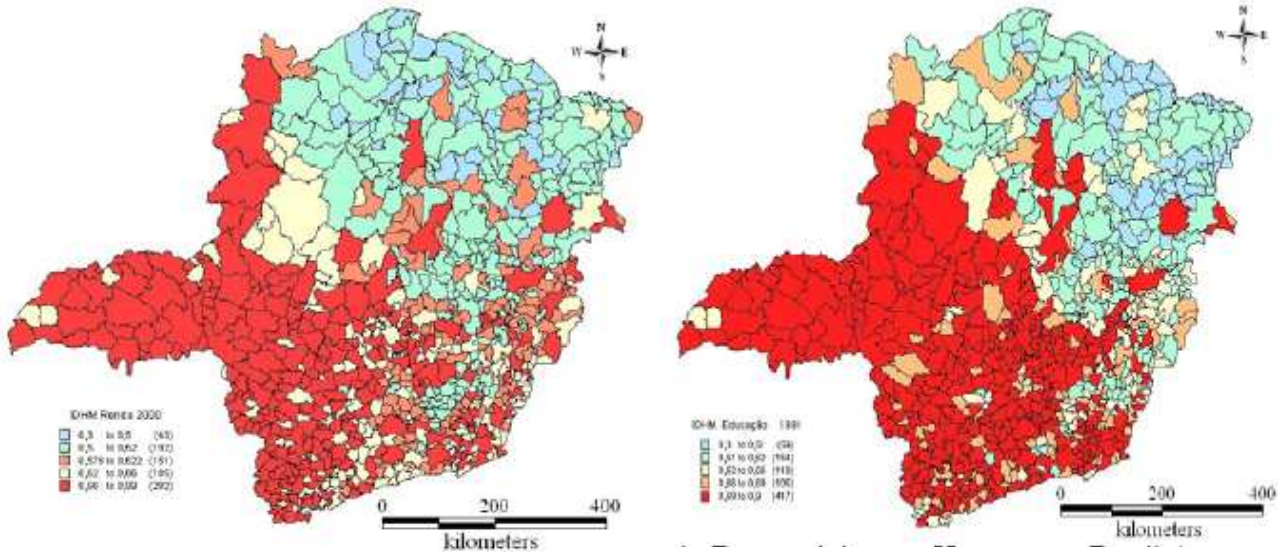
Table 3 Correlation matrix of variables used in the analysis of determinants of MHDI 2000. Minas Gerais.

	IDHM 2000	Renda per capita 2000	Índice de Gini 2000	Taxa da pobreza 2000	População ocupada 2000	População rural 2000	Esperança de vida ao nascer 2000	Médicos X mil habitantes 2000	% criança Analfabetas de 7 a 14 2000	% Pessoas Analfabetas de 25 > 2000	Δ Renda per capita 1991 - 2000	Δ Índice de Gini 1991 - 2000	Δ Taxa da pobreza 1991 - 2000	Δ População ocupada 1991 - 2000	Δ População rural 1991 - 2000	Δ Esperança de vida ao nascer 1991 - 2000	Δ Médicos por mil habitantes 1991 - 2000	Δ Analfabetas de 7 a 14 1991 - 2000	Δ % Pessoas Analfabetas de 25 > 1991 - 2000
IDHM	1																		
Renda per capita	0,898	1																	
Índice de Gini	-0,316	-0,136	1																
Taxa da pobreza	-0,814	-0,751	0,557	1															
População ocupada	0,213	0,338	0,060	-0,050	1														
População rural	-0,134	-0,055	0,343	0,275	0,103	1													
Esperança de vida ao nascer	0,768	0,627	-0,272	-0,564	0,121	-0,066	1												
Médicos X mil habitantes	0,450	0,563	0,104	-0,274	0,400	0,174	0,288	1											
% criança Analfabetas de 7-14	-0,780	-0,643	0,416	0,732	-0,089	0,238	-0,530	-0,261	1										
% Pess Analfabetas de 25 >	-0,911	-0,762	0,411	0,792	-0,165	0,220	-0,629	-0,346	0,837	1									
Δ Renda per capita	0,085	0,150	0,091	-0,170	-0,057	0,000	0,002	0,007	-0,151	-0,094	1								
Δ Índice de Gini	-0,375	-0,258	0,613	0,542	-0,030	0,158	-0,236	-0,116	0,397	0,434	0,231	1							
Δ Taxa da pobreza	-0,266	-0,202	0,408	0,640	0,131	0,180	-0,134	-0,020	0,344	0,328	-0,415	0,549	1						
Δ População ocupada	0,294	0,305	-0,123	-0,208	0,130	0,013	0,230	0,130	-0,117	-0,279	-0,020	-0,044	0,051	1					
Δ População rural	0,344	0,345	-0,237	-0,365	0,073	-0,078	0,295	0,087	-0,231	-0,354	0,192	-0,122	-0,204	0,543	1				
Δ Esperança de vida ao nascer	0,001	-0,008	-0,086	-0,030	-0,035	0,019	-0,005	-0,045	-0,011	-0,032	-0,011	-0,074	-0,051	0,265	0,204	1			
Δ Médicos por mil habitantes	-0,055	-0,005	0,039	0,067	0,062	0,016	0,378	0,020	0,048	0,009	-0,064	0,042	0,114	0,088	0,052	0,050	1		
Δ Analfabetas de 7 a 14	0,309	0,363	0,109	-0,174	0,087	0,127	0,181	0,615	-0,210	-0,221	0,092	0,125	0,035	0,145	0,101	-0,062	-0,045	1	
Δ % Pess. Analfabetas de 25 >	-0,348	-0,296	0,170	0,296	-0,074	0,087	-0,200	-0,102	0,370	0,449	-0,157	0,151	0,157	-0,209	-0,228	-0,036	0,005	0,008	1

Correlação significativa ao 0,01
Correlação significativa ao 0,05
Correlação não significativa

APPENDIX 3

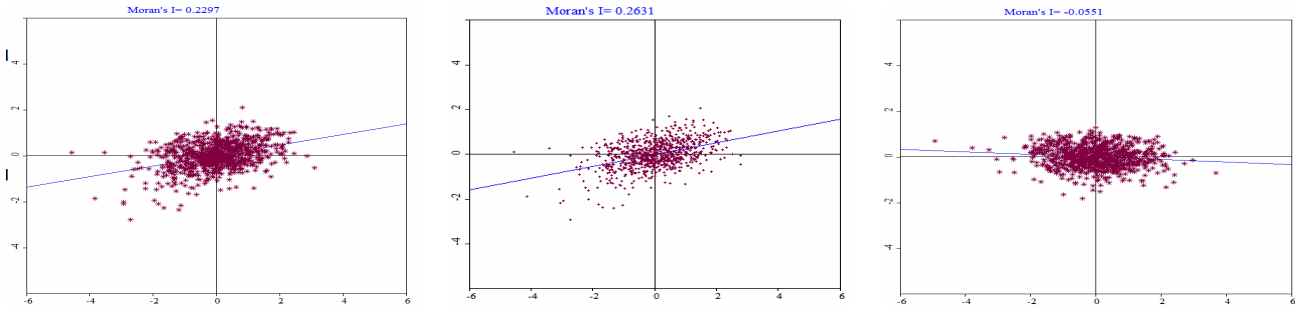
Graph 2
Distribution of Municipal Human Development Index.
Dimension Income and Education 1991 to 2000. Minas Gerais.



Source: Elaboration of data the Atlas of Human Development in Brazil (PNUD, IPEA and FJP) and database IPEA (IPEADATA).

Graph 3
Dispersion of Moran's index of residuals of the regression model.
Municipalities of Minas Gerais. 2000.

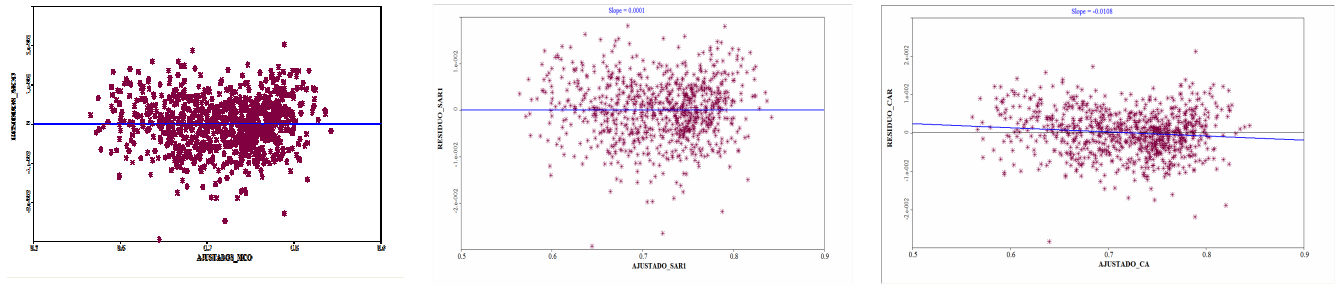
Regression Multiple | Regression SAR | Regression CAR



Source: Elaboration of data the Atlas of Human Development in Brazil (PNUD, IPEA and FJP) and database IPEA (IPEADATA).

Graph 4 Dispersion residuals of the regression model, for adjusted values
Municipalities of Minas Gerais. 2000.

Regression Multiple | Regression SAR | Regression CAR



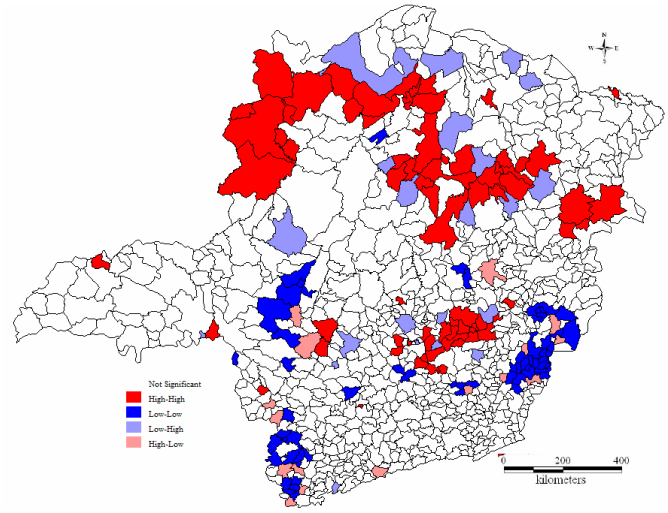
Source: Elaboration of data the Atlas of Human Development in Brazil (PNUD, IPEA and FJP) and database IPEA (IPEADATA).

APPENDIX 4

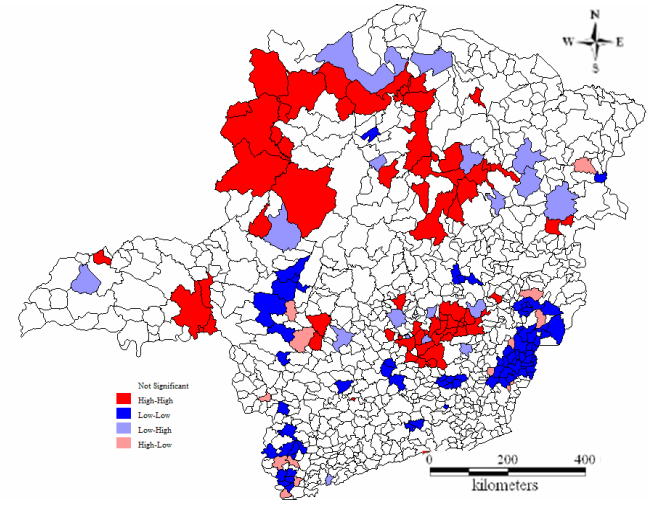
Graph 5

Spatial distribution of residues of the estimates with the adjusted models.
Municipalities of Minas Gerais. 2000.

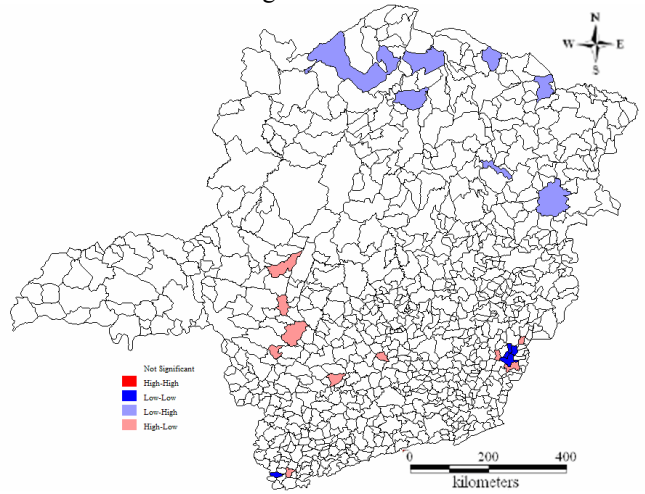
Regression Multiple



Regression SAR



Regression CAR



Source: Elaboration of data the Atlas of Human Development in Brazil (PNUD, IPEA and FJP) and database IPEA (IPEADATA).