Spatial econometric model of the Ecological Footprint

YN. Ramirez[1]

[1]*Faculty of Cadastral and Geodesy Engineering, Universidad Distrital Francisco José de Caldas, Bogotá, Colombia. chessika32@hotmail.com*

Abstract. *Sustainable development is an utopia within regions in Colombia, even so, we can talk about it to try to quantifying such development. The main purpose is quantify sustainable development through spatial econometric techniques, where the independent variables are the sustainable development constituents and the dependent variable is an indicator of strong sustainability: the ecological footprint for the CORPOCHIVOR region. Through of Lagrange Multipliers was identified that the best spatial model that explains the relation between the ecological footprint and the sustainable development constituents is the autoregressive model Durbin Spatial, it exposes that the sustainable development presents a structure of substantive spatial autocorrelation where the sustainable development constituents define the ecological footprint based on spatial lagged along all region.*

Keywords. *Spatial Econometrics, Lattice Data, Ecological Footprint, Sustainable Development*

1 Theoretical Framework

Sustainable Development: The concern for the conservation of natural capital of the planet has been stronger in recent decades given the poor land management to satisfy humans needs. This is why indicators appear on scene to help determine the environmental impact generated by the planet's citizens; one of these indicators is the ecological footprint, defined as a strong indicator of sustainability of inclusiveness Wackernagel (1996), which is needed to produce the resources used and to assimilate the waste produced by the population ecologically productive area.

Spatial Econometrics: Lattice approach It is defined as a branch of econometrics is concerned with the proper treatment of spatial interaction: autocorrelation, spatial and spatial structure in regression models with data and cross-cutting or grid lattice (Anselin, 1988). For the estimation of spatial econometric models are required to present information to estimate spatial autocorrelation schemes, whether this residual or substantive, this spatial autocorrelation is determined by tests based on Lagrange multipliers hypothesis Blommestein (1983). At the time that these models is to estimate the spatial autocorrelation model as a laggard in the dependent variable or as a parameter or as more model that explains the error term thereof.

2 Methodology

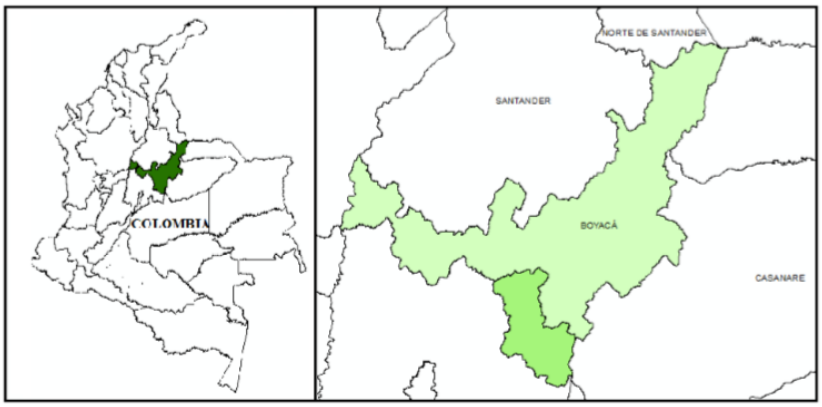

Figure 1: CORPOCHIVOR is a government agency under the Ministry of Development and Land Management, responsible for the management of natural resources of 25 municipalities in the department of Boyaca. It is located within the Republic of Colombia, the Andean region.

The value of the ecological footprint for each municipality in the CORPOCHIVOR region was calculated through consumption and production for 2010. After this, it was done an exploratory spatial data analysis to determine the best spatial weights matrix calculated by analyzing principal coordinates (Dray, 2006) and also was done the analysis of global visualization and spatial association local independent and dependent variables finding if the autocorrelation is given footprint globally or locally in the region. After a regression model was estimated using ordinary least squares with spatial variables that explain the ecological footprint. It then showed that the model residuals are spatially autocorrelated, an indication to begin the formulation and estimation of a spatial econometric model, so that, by spatial autocorrelation test based on the form of maximum likelihood estimation, called Lagrange multipliers confirms what the structure of spatial dependence shows the configuration of the ecological footprint in the region. Finally, applying the model make the relevant evidence in order to contrast the good estimates of the same specification.

3 Results

It is evident that the ecological footprint is not distributed linearly in the territory and that this is limited by economic destination of soils and location of the territory. Of the estimated regressions between ecological footprint and eigenvectors having positive eigenvalues, the best spatial weight matrix was chosen as one that AIC had the lowest ratio, this being the style tower array. According to ESDA, were chosen as independent variables to explain the ecological footprint, forest cover, aqueduct cover and the literacy rate; as alluding to these maps show spatial autocorrelation schemes, corroborating the above tests with global and local spatial association. SAR-LAG as the most appropriate model is identified, as reaches the highest value in the diagnosis of Lagrange multipliers. The value of Moran's I for the residuals of the regression model, confirms the problem of omitted variable that is corrected by the inclusion of the spatial lag model. Although the estimated coefficients were significant for the exogenous variables, as expected, the contrasts of dependence and spatial heterogeneity (based on the Lagrange multiplier) revealed the existence of a misspecification in the model, especially due to the presence of strong autocorrelation space in both the endogenous variable and the random disturbance.

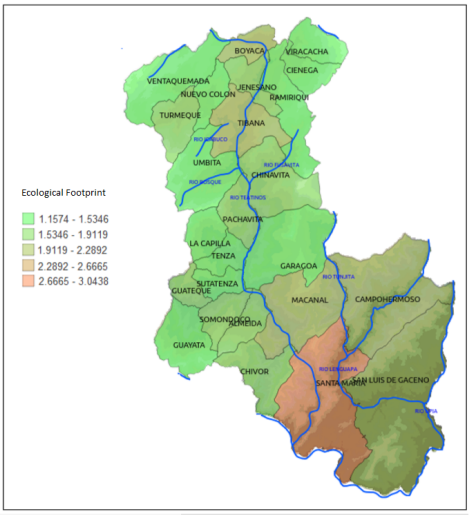

Figure 2: The green region refers to sustainable municipalities and the red region refers to municipalities that are not sustainable in the time based on ecological foot print value. It can see that this kind of development has an spatial autocorrelation. HE: Ecological footprint, BOS: Foresr cover, COBacu: aqueduct cover, ALF: Literacy

Independent Variable	Estimate	P-value	T-value	VIF	R	Durbin Watson	Breush Pagan
Intercep	3.4284	1.16e-07	7.828		0.6945	2.4137	1.1644
BOS	0.5726	0.0166	2.603	1.102		P-value	P-value
COBACU	-0.4583	0.0306	-2.319	1.075		0.8211	0.7615
ALF	-2.7576	9.87e-06	-5.775	1.029			

Table 1: Estimated linear regression model.

4 Analysis of results

According to exploratory spatial data analysis,the spatial relationships of the ecological footprint and the other sustainable development constituen, occur globally throughout the region (spatial autocorrelation global test); then, in the estimation linear model of the ecological footprint was evident that the residuals were spatially autocorrelated, so that, through the Lagrange multiplier test, it could be noticed the schema of the spatial autocorrelation refers to substantive spatial autocorrelation that has the ecological footprint in the whole space. Therefore a model Durbin Spatial is chosen to estimate the ecological footprint based on forest cover, the literacy rate and aqueduct cover; already that in this type of models, the dependence structure is given in general terms, extending the other regions of the system.

Test	LMlag	LMerror	RLMerror	RLMlag	Moran's I
Value	6.4703	2.0677	0.0220	4.4246	2.0345
P-value	0.0109	0.1504	0.8820	0.0354	0.0418

Table 2: Testing for spatial dependence for linear model

LMlag: Lagrange multiplier test where the spatial structure lags in the exogenous variables, LMerror: Lagrange multiplier test with spatial structure in the model errors, RLMerror: Robust Lagrange multiplier test in the model errors, RLMlag: Robust test lagged Lagrange multipliers and Moran's I test.

Independent Variable	Estimate	P-value	Z-value	ρ	R	LV	AIC
Intercep	5.2431	0.0000	12.4015	-0.5492	0.8515	28.3359	-38.7122
BOS	0.5711	0.0000	3.7831				
COBACU	-0.8827	0.0000	-6.2050			]	
ALF	-1.8320	0.0000	-6.1300				
Lag.BOS	0.8293	0.0000	4.2160				
Lag.ACU	-1.6989	0.0000	-5.8865				
Lag.OFH	-0.9920	0.0000	-5.9601				

Table 3: Estimated spatial econometric model Spatial Durbin

Lag.BOS: Spatial lag of forest cover, Lag.ACU: Spatial lag of the water supply coverage, Lag.OFH: Spatial lag of the water offering, ρ: Spatial autocorrelation coefficient, LV: Log-Likelihood and AIC: Akaike information criterion.

The ecological footprint in a region would be explained not only by the elements sustainable development for the region and other related to it, but by the proper value of existing ecological footprint in neighboring regions (variable this spatially delayed endogenous like any external variables). Found the ecological footprint and capabilities through loading each municipality shows will have environmental deficit, if it is positive, Municipalities were sustainable for 2010 (had the capacity to produce what consumed and thus have reserves for future years) while if is negative, the competent authorities should make plans for ensure that the environmental deficit is positive, this minds, are not sustainable municipalities. the map shown below is the map of environmental deficit agreement the ecological footprint in the municipalities of CORPOCHIVOR for 2010 .

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5 References

ANSELIN,L.,1988,Spatial Econometrics: Methods and Models. Kluwer Academic Publishers, TheNetherlands.

BLOMMESTEIN, H., 1983, "Specification and estimation of spatial econometric models: A discussion of alternative strategies for spatial economic modeling", Regional Science and Urban Economics, 13, 251-270.

DRAY, S., LEGENDRE, P., y P., PERES-NETO. Spatial Modelling: A comprehensive framework for principal coordinate analysis og neighbour matrices. Ecological Modelling 196(2006).

WACKERNAGEL, M., y W., REES, 1996. Our Ecological Footprint: Reducing Human Impact on the Earth. Philadelphia and Gabriola Island, Canada. New Society Publishers.