

SPATIAL DISTRIBUTION AND RELATIONSHIP BETWEEN SUSTAINABLE DEVELOPMENT MEASURES IN EU COUNTRIES

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Abstract

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Since the Rio Earth Summit sustainable development involving environmental, economic or human issues has been set as an important goal. There are a lot of measures that try to reach the Summit aim, among others Environmental Sustainability Index (ESI) and Human Development Index (HDI). The aim of presented article is to bring more light into the spatial distribution of ESI and HDI in EU countries and find relevant relationship between these two indices.

environmental sustainability index, human development index, EU, quantitative methods

Whether environmental conditions improve as a direct result of improvements in economic or human development or whether economic or human development put pressure on the environment, or whether there are even more complicated relationships between economic, human and environmental outcomes are questions that lie at the heart of major policy debates.

Since the 1992 Rio Earth Summit, sustainable development involving environmental, economic or human issues has been embraced as an important goal. In order to measure sustainable development, many scientists and researchers have made efforts to establish measurement systems comprising, among others, Environmental Sustainability Index (ESI) or Human Development Index (HDI).

ESI and HDI differ in included data sets. Both of them, nevertheless to reach the same aim, have different priorities described below. Moreover, there are few authors demanding to make these indices more general. For example, Sagar and Najam (1999) indicated the basic concept of human development seems to have become stagnant and need changes evolving

and improved conception of human development that better reflects current global realities and future global aspirations. Ogwang and Abdou (2003) paper suggested an alternative weighting scheme how should all the three components of HDI retained. In addition, Morse (2003) asked for modifying existing HDI to take on board wider issues of sustainability, concrete to include environmental and resource-consumption dimensions.

ESI, for example, was used to measure the sustainable development of Shandong in China; resulting Shandong is still far from a position of sustainable development (Cui et al, 2004).

Qizilbash (2001) in his article recognized two values of human development, involving equity and well-being, which can according to her conflict. The potential conflict suggests that countries, which are doing well in terms of well-being may perform badly on environment concerns. He monitored linkages between human development and environmental protection. Moldan (1996) analysed the main dimensions of sustainable development, among others HDI, rela-

tionships between ecology and economy, eco-efficiency, or ecosphere and its services.

We have decided to bring more light into that dispute and therefore, to evaluate relationship between composed indices of ESI and HDI in view of space.

MATERIAL AND METHODS

ESI is a project conducted jointly by Yale University, Columbia University, and the World Economic Forum started with the Pilot report formally released in Davos (Switzerland) at the annual meeting of the World Economic Forum in 2001. ESI 2002 measures overall progress toward environmental sustainability for 142 countries in total. Environmental sustainability is measured through 20 indicators, each of which combines two to eight variables, for a total of 68 underlying data sets. The ESI tracks relative success for

each country in five core components (Table I): (1) the state of the Environmental Systems, such as air, soil, ecosystems, and water; (2) the Stresses on those systems, in the form of pollution and exploitation levels; (3) the Human Vulnerability to environmental change in the form of loss of food resources or exposure to environmental diseases; (4) the Social and Institutional Capacity to cope with environmental challenges; and, (5) the ability to respond to the demands of Global Stewardship by cooperating in collective efforts to conserve international environmental resources such as the atmosphere. Environmental sustainability is defined as the ability to produce high levels of performance on each of these dimensions in a lasting manner. These five dimensions are referred as the core "components" of environmental sustainability.

I: *ESI core components*

Component	Logic
Environmental Systems	A country is environmentally sustainable to the extent that its vital environmental systems are maintained at healthy levels, and to the extent to which levels are improving rather than deteriorating.
Reducing Environmental Stresses	A country is environmentally sustainable if the levels of anthropogenic stress are low enough to engender no demonstrable harm to its environmental systems.
Reducing Human Vulnerability	A country is environmentally sustainable to the extent that people and social systems are not vulnerable (in the way of basic needs such as health and nutrition) to environmental disturbances; becoming less vulnerable is a sign that a society is on a track to greater sustainability.
Social and Institutional Capacity	A country is environmentally sustainable to the extent that it has in place institutions and underlying social patterns of skills, attitudes, and networks that foster effective responses to environmental challenges.
Global Stewardship	A country is environmentally sustainable if it cooperates with other countries to manage common environmental problems, and if it reduces negative transboundary environmental impacts on other countries to levels that cause no serious harm.

Source: 2002 Environmental Sustainability Index Main Report, p. 5

Each indicator, in turn, has associated with it a number of variables that are empirically measured. The choice of variables was driven by a consideration of a number of factors including: country coverage, the recency of the data, direct relevance to the phenomenon that the indicators are intended to measure and quality. To calculate the Environmental Sustainability Index we averaged the values of the 20 indicators and calculated a standard normal percentile for each country. Higher ESI means better environment conditions.

The ESI combines measures of current conditions, pressures on those conditions, human impacts and social responses because these factors collectively constitute the most effective metrics for gauging the prospects for long-term environmental sustainability. The ESI permits cross-national comparisons of environmental sustainability in a systematic and quantitative way. ESI 2002 data were obtained from the 2002 Environmental Sustainability Index Report.

Human development is about creating an environ-

ment in which people can develop their full potential and lead productive, creative lives in accord with their needs and interests. The most basic capabilities for human development are to lead long and healthy lives, to be knowledgeable, to have access to the resources needed for a decent standard of living and to be able to participate in the life of the community.

Composite measures of economic development The Human Development Report has been published by the United Nations each year since 1990. It is an independent report that is commissioned by the United Nations Development Programme (UNDP). The report contains detailed statistical information on economic and social development indicators for almost every country in the world. One of them is the Human Development Index (HDI), a summary composite index scaled between 0 and 1 that measures a country's average achievements in three basic aspects of human development: longevity, knowledge, and a decent standard of living. Longevity is measured by life expectancy at birth; knowledge is measured by a combination of the adult literacy rate and the combined primary, secondary, and tertiary gross enrolment ratio; and standard of living by GDP per capita. Higher index value means better HDI performance. HDI 2002 data were obtained from the Human Development Report 2004.

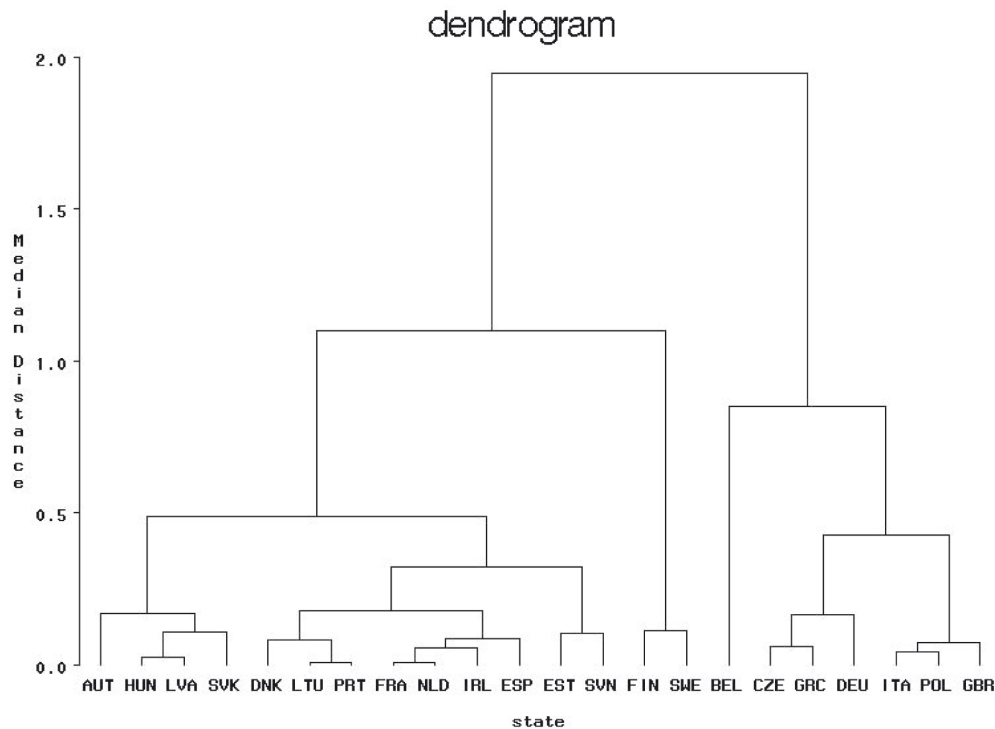
We will focus on 22 EU countries and year 2002

in our analysis; Cyprus, Luxemburg and Malta were dropped because of missing ESI data. To help facilitate relevant comparisons across countries with similar profiles, we have undertaken cluster analysis median method (Brian, 1993). Cluster analysis provides a basis for identifying similarities among countries across multiple heterogeneous dimensions. The result is not only to calculate exact number of clusters containing similar countries, but also dendrogram that depict process of clustering. Data has the spatial character what facilitates to use methods of spatial statistics, such as spatial autocorrelation and it's two most common Moran and Geary measures (Stehlíková, 2002). The relationship between ESI and HDI was proved by regression analysis. Model applicability was supported by Ramsey and White test, R Square or by testing of hypothesis about normal residuum distribution.

Software package SAS and ArcView were used for the computations and picture depicting.

RESULTS AND DISCUSSION

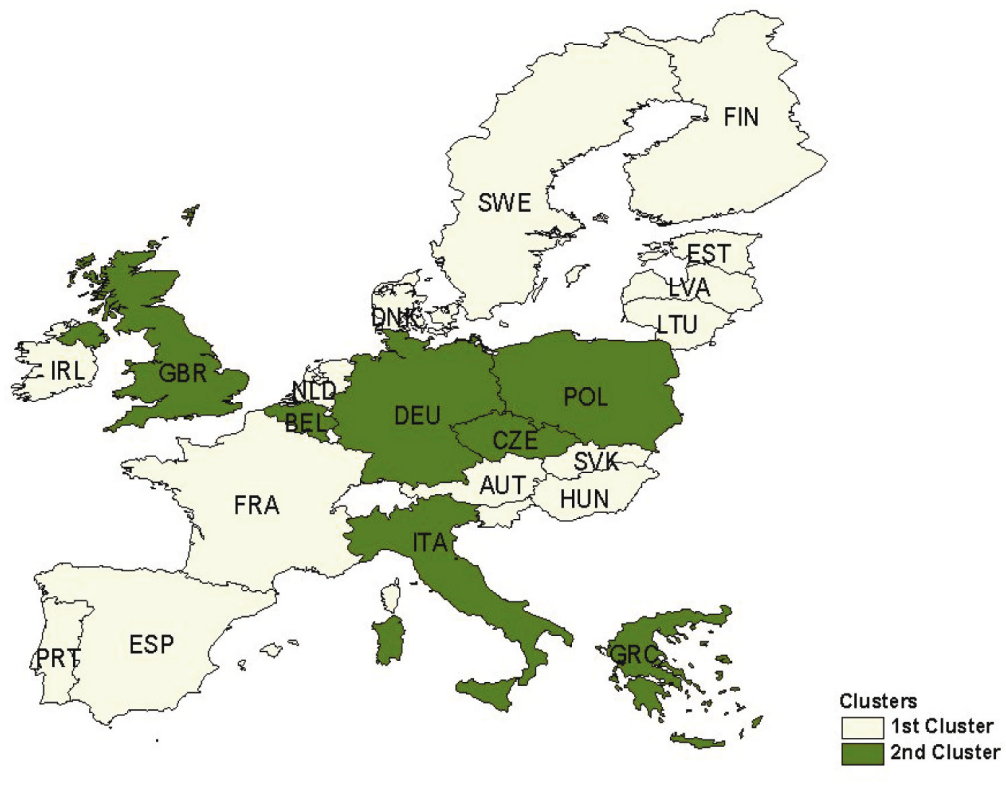
The cluster analysis performed on the ESI 2002 data set revealed 2 groups of countries that had distinctive pattern of result. The sharp jump in measure of median distance from 1,10 to 1,95 arises for two clusters; the optimal number of clusters is two (Fig. 1). That means there are two types of EU countries having similar ESI values.



1: ESI 2002 dendrogram

Figure 2 depicts EU countries that belong to these clusters. According to the results, countries Austria, Hungary, Slovakia, Latvia, Denmark, Lithuania, Portugal, France, Netherlands, Ireland, Spain, Estonia, Slovenia, Finland and Sweden create cluster that perform better in terms of ESI. Countries such as Belgium, Czech Republic, Greece, Germany, Italy, Poland and Great Britain create the second cluster that involves countries reaching lower ESI.

Spatial autocorrelation test, using Moran and Geary coefficients, proved statistically significant positive spatial autocorrelation based on ESI data set. Positive spatial autocorrelation was also proved by test of spatial autocorrelation coefficients based on Monte Carlo simulations. The results submit there are continuous areas of countries that belong to particular clusters (Table II).



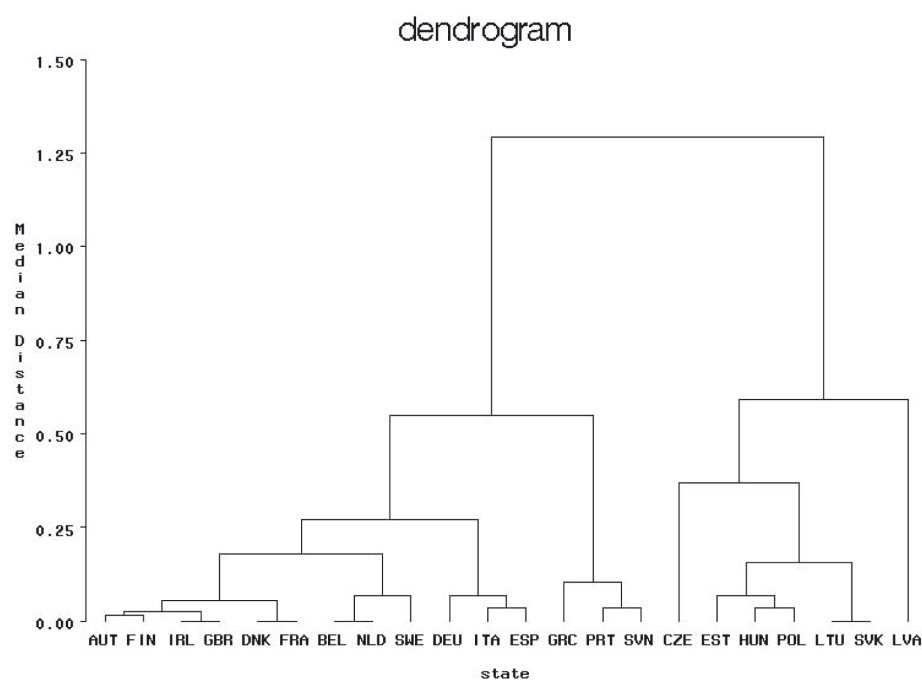
2: EU countries related to identified clusters according to ESI 2002

II: Spatial autocorrelation results for ESI and HDI

Indicator	I Moran coefficient	C Geary coefficient	Test based on randomisation $P > Z $ I	Test based on randomisation $P > Z $ C
ESI 2002	0,2513	0,5923	0,0349	0,0472
HDI 2002	0,5804	0,4029	0,0001	0,0104

In case of HDI 2002 the cluster analysis also revealed 2 groups of countries having similar pattern. The biggest jump in measure of median distance from

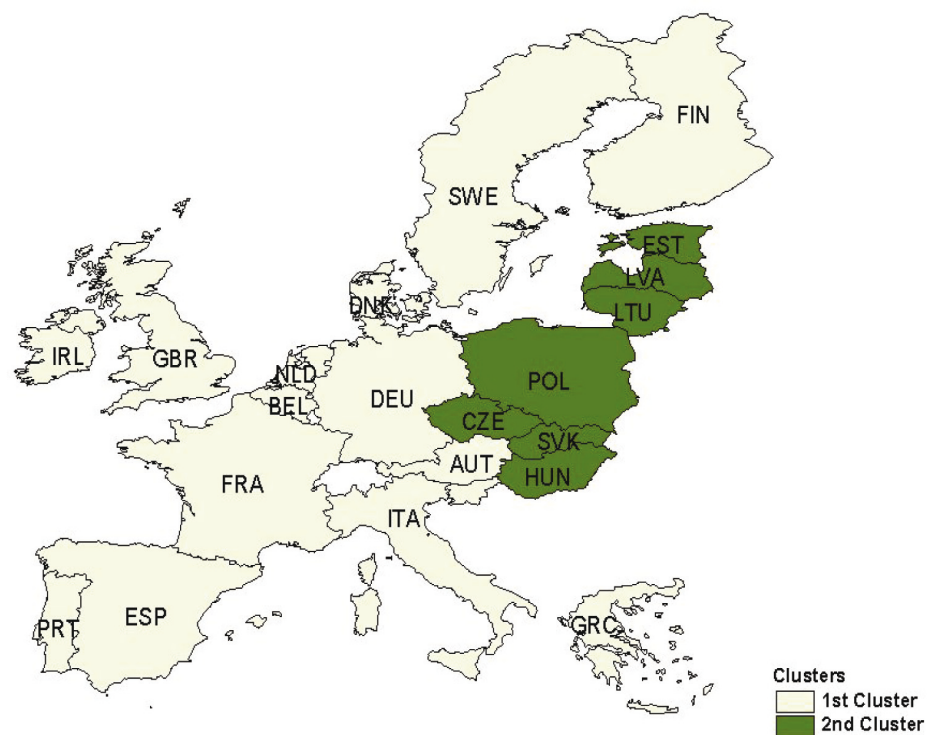
0,59 to 1,29 occurred for two clusters; the optimal number of clusters is also two (Fig. 3).



3: HDI 2002 dendrogram

Countries Austria, Finland, Ireland, Great Britain, Denmark, France, Belgium, Netherlands, Sweden, Germany, Italy, Spain, Greece, Portugal and Slovenia create the first cluster that reach the higher HDI values.

On the other hands, countries as Czech Republic, Estonia, Hungary, Poland, Lithuania, Slovakia and Latvia belong to the second cluster where the HDI values are significantly lower (Fig. 4).



4: EU countries related to identified clusters according to HDI 2002

Also the spatial autocorrelation test, using the same Moran and Geary coefficients and Monte Carlo simulations as mentioned above, proved statistically significant positive spatial autocorrelation based on HDI data set. That means there are continuous areas of countries that belong to particular clusters (Table II).

Both indices should reach the same measurement aim – to evaluate sustainability development from the environmental, economic or human perspective. As we already mentioned these indices have different

variables involved into calculation of their composite forms. Some authors (Moldan, 1996; Qizilbash, 2001) have already monitored linkages between human development and environmental sustainability variables. Regression analysis admitted there is a positive correlation between ESI and HDI, pointing out increase in HDI returns better ESI values. Table III shows regression result as well as results of other tests that prove the model suitability.

III: Regression analysis

Dependent Variable ESI Ordinary Least Squares Estimates			
SSE	1654.36398	DFE	21
MSE	78.77924	Root MSE	8.87577
SBC	160.567186	AIC	159.476144
Regress R-Square	0.9768	Total R-Square	0.9768
Normal Test	0.1997	Pr > ChiSq	0.9050
Durbin-Watson	2.1797		

Q and LM Tests for ARCH Disturbances				
Order	Q	Pr > Q	LM	Pr > LM
1	0.5309	0.4662	0.3728	0.5415
2	1.7067	0.4260	3.0938	0.2129
3	1.7891	0.6173	4.4341	0.2182
4	4.7456	0.3144	4.8001	0.3084
5	5.9308	0.3130	6.3208	0.2762
6	6.0044	0.4227	6.4968	0.3699
7	6.0996	0.5282	7.2686	0.4015
8	6.2898	0.6148	7.9101	0.4423
9	6.6983	0.6685	8.1335	0.5207
10	6.8039	0.7438	8.2635	0.6031
11	7.1880	0.7837	8.3107	0.6852
12	7.2278	0.8422	8.3648	0.7560

Ramsey's RESET Test		
Power	RESET	Pr > F
2	3.0533	0.0959
3	2.4120	0.1166
4	1.5254	0.2421

The Equation to Estimate is

$$ESI = F(c1(HDI))$$

Nonlinear OLS Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > t
c1	62.38785	2.0982	29.73	<.0001

Heteroscedasticity Test					
Equation	Test	Statistic	DF	Pr > ChiSq	Variables
ESI	White's Test	6.10	2	0.0573	Cross of all vars

CONCLUSION

Sustainable development comprising of environmental, economic or human variables is the matter of today's world discussions. There are various approaches how to measure sustainable development, depends on what is the primary focus of designed index. Presented article evaluated two measures of sustainable development - Environmental Sustainability Index (ESI) and Human Development Index (HDI). Spatial character of analysed data facilitated to use spatial statistics methods such as cluster analysis or spatial autocorrelation. According to the results there

are two groups of EU countries for both monitored indices showing different pattern of similarity. Spatial autocorrelation indicated distribution of clusters comprising EU countries is not accidental. There was proved positive spatial autocorrelation suggesting there are continuous areas of countries that belong to particular clusters. Relationship between ESI and HDI observed positive correlation showing increase in HDI returns increase in ESI values. We can conclude ESI and HDI are mutually connected and improvement in human development also brings improvement in environmental area.

SOUHRN

Priestorová distribúcia a vzťah medzi ukazovateľmi trvaloudržateľného rozvoja v krajinách EU

V súčasnosti sa venuje značná pozornosť otázkam trvaloudržateľného rozvoja, zahrňujúce ako aj environmentálne tak aj ekonomické či demografické premenné. Existujú viaceré miery trvaloudržateľného rozvoja, medzi ktoré patria aj Index environmentálnej udržateľnosti (ESI) či Index ľudského rozvoja (HDI), ktorých analýza je predmetom predkladanej práce. Cieľom práce je priestorové zhodnotenie oboch analyzovaných mier ako aj určenie ich vzájomné vzťahu. Priestorový charakter dát umožnil použiť metódy priestorovej štatistiky, regresnou analýzou sme hľadali definovanú závislosť ESI a HDI. Zluková analýza oboch mier trvaloudržateľného rozvoja potvrdila existenciu dvoch vyhranených zhlukov krajín EU. Priestorová autokorelácia ako aj samotná simulácia Monte Carlo potvrdila, že zhlukovanie krajín EU nie je náhodné. Jej pozitívny charakter naznačuje že kontinuálne územia zahrňujúce viacero krajín EU tvoria konkrétny zhluk. Regresná analýza preukázala pozitívnu závislosť medzi ESI a HDI. Obe miery sú navzájom prepojené a platí, že vyššie hodnoty v oblasti ľudského rozvoja podporujú aj lepšie výsledky v oblasti environmentálneho rozvoja.

index environmentálnej udržateľnosti, index ľudského rozvoja, EU, kvantitatívne metódy

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