

## The Relation between Environmental Quality Indices and Energy Consumption in the Selected Countries

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**Abstract:** This study is regarded as an applied research in terms of objective and an ex post facto research in terms of data collection, because past data of the research variables is used. Also it is a descriptive- correlative research. Data is gathered by using the library method. Also a major part of data pertaining to the research variables has been derived from time series data of the World Bank and Yale University. To determine the relation between environmental quality indices and energy consumption, data pertaining to the research variables namely, energy consumption based on oil consumption (ENERGY), under-5 children mortality (CHMORT), agricultural subsidies (AGSUB), access to drinking water (WATSUP), access to sanitation (ACSAT), CO<sub>2</sub> per capita (CO<sub>2</sub>CAP) during 2007 to 2011 was used. The statistical universe of this study comprises high energy-consuming countries namely, America, China, Japan, India and Russia. Panel data and Chow Test (constrained F test) have been applied to select the fixed effects. The main result of this study indicates that there is a significant relation between life quality indices (Agricultural subsidies, access to sanitation, under-5 children mortality, CO<sub>2</sub> per capita, access to drinking water) and energy consumption. The effect of this relation for agricultural subsidies, access to sanitation, under-5 children mortality, CO<sub>2</sub> per capita, access to drinking water indices are 17.8, 68.57, 21.16, 129.77, 4.03, respectively.

**Keywords:** Environment performance index, environment sustainability index, panel data

### INTRODUCTION

Multiple environmental indices have been raised by the United Nations and universities for monitoring the environmental degradation processes. Among these indices, the UN sustainable development indices, the seventh Millennium Development Goals (MDG) and the World Bank development indices reports can be mentioned. The World Bank publishes reports regarding some macro environmental indices of the countries. At the present juncture, development of these indices is regarded as the criterion of environmental developments in the countries regarding environment protection. These indices include jungles area, percentage of agricultural land, the annual decline in sweet waters, improvement of water resources, excretory system in the urban areas, energy consumption per capita, CO<sub>2</sub> per capita and electrical energy consumption per capita (Violeta-Maria, 2012). The most important indices that are now regarded as the criteria for comparing the countries and are published regarding environment protection annually are Environment Sustainability Index (ESI) and Environment Performance Index (EPI) published annually by Yale University and Colombia University with cooperation of the World Economic Forum (Francesco, 2012). From 1999 to 2005, four annual ESI reports have been published. Since 2006, a major

change occurred in preparation of these indices and environment performance index was considered instead of sustainability index; by present, two EPI reports have been published for 2006 and 2008 (José-María *et al.*, 2010). When experts and scholars of all over the world particularly developing countries criticized the environment sustainability report in 2005, the indices and variables were reviewed and the related report was published based on new variables and indices in 2006 titled as environment performance index report. The difference of this index with environment sustainability index is in restricting variables and underscoring the countries performance in the environment sector (Alison *et al.*, 2008). The environment performance index was reviewed again in 2008 and indices were changed. The difference of this index with the environment performance index 2006 is in increasing the number of indices from 16 to 25 in different classes. Environment performance index 2008 is focused on two goals namely, reduction of environmental pressures on human health and improvement of ecosystems vitality and proper management of natural resources. These two components are measured through 25 indices in six areas namely environmental health, air quality, water resources quality, biodiversity, quality of productive natural resources and climate changes (Natacha and Christian, 2006).

Environment protection is now regarded as one of the main issues at the global level and has drawn attention of the international community. This study seeks to investigate the relation of environmental quality indices with energy consumption in Iran and present a proper model to be used in the related organizations.

**LITERATURE REVIEW**

**Theoretical bases:** Table 1 presents theoretical bases of this study. As shown, indicator definition, indicator code, indicator weight in EPI, target and transformed low performance benchmark are presented.

**Research Background:** Violeta presents the phenomenon of institutional change through the implementation of sustainable strategies of medium-term budgeting, having as an effect the growth of opportunity to attract proper resources for social and environmental programs. The study analyzes green budget practices and suggests several ways to use them in order to ensure consistency in implementing key elements of sustainable economy. They conducted an empirical study to explain the decisive factors impact (greenhouse gas emissions and national income) on health expenditure and they obtained statistically significant positive relationship, suggesting that green budgeting is an important factor for sustainable economy. The reasons behind the introduction of a sustainable perspective for budgeting in any country are important since they will dictate, to a large extent, the way the medium term budgeting will be institutionalized (Violeta-Maria, 2012). Nicolli tests the presence of convergence in the main municipal solid waste-related indicators across Italy. In the last decade the waste sector has experienced a profound transformation, both at a European and an Italian level, a transformation in which landfill is losing its primary role as the main means of waste disposal and other activities, like recycling and incineration, are becoming increasingly important. Environmental policies, as well as social polarization and organized crime, may play an extremely relevant role in this scenario, which may influence waste management performances and render the policy environment less stable and less secure (Francesco, 2012). Montero explains that one of the

main tasks of regional and environmental economics is to construct Environmental Quality Indexes for big cities in his article. A standard method is to generate a single measure as a linear combination of several contaminants by applying Principal Component Analysis. Spatial interpolation is then carried out to determine pollution levels across the city. They innovate on this method and propose an alternative approach. First, they combine a set of noise and air pollutants measured at a number of monitoring stations with data available for each census tract. This yields a mixed environmental index that is socioeconomically more complete. Finally, they construct a composite pollution index using the Pena Distance method (DP2), which proves more robust than traditional approaches (José-María *et al.*, 2010). Donnelly applied the completed checklist to 10 environmental reports from Ireland, Wales, England, Malta and Germany and proposed a grading system for comparative purposes. The results showed varying quality among the ERs from Ireland, UK and Malta. In addition, they found that the checklist did not directly apply to the German ERs because of the different approach taken to SEA whereby environmental targets and indicators were used in a more implicit manner than elsewhere. However, as environmental objectives and the monitoring programs were similar for all ERs they concluded that different approaches still resulted in a manageable and focused monitoring system (Alison *et al.*, 2008). Boutaud has examining different criticisms that can be addressed to studies that validate this hypothesis (environmental data which concern mostly restricted and/or local phenomenon, development indicators which offer a too limited vision of human development), this study proposes a representation that confronts two aggregated indicators: ecological footprint and human development index. This confrontation contradicts the EKC hypothesis. Different visions concerning the meaning of the term environment (local environmental quality versus global ecological carrying capacity) might partially explain our conclusions and reveals a pernicious phenomenon. While developed nations tend to improve the quality of their 'local' environment, they also tend to consume more and more 'global' resources, which might often come from developing nations (Aurelien, 2008).

Table 1: The selected criteria from among indicators used in EPI 2008

Indicators	Indicator codes	Indicator weight in EPI %	Transformed target	Targets	Transformed low performance benchmark
Agricultural subsidies	AGSUB	3.89	-7.48	0 subsidies	0.34
Access to sanitation	ACSAT	3.75	0.00	100% of population with access	4.48
Child mortality	CHMORT	15.00	-6.91	0.0007 probability (between age 1 and 5)	-2.18
CO2 per capita	CO2CAP	6.13	7.16	1262 kg CO <sub>2</sub> eq	9.88
Access to drinking water	WATSUP	3.7	0.00	100% of population with access	4.17

**RESEARCH METHODOLOGY**

This study is regarded as an applied research in terms of objective and an ex post facto research in terms of data collection, because past data of the research variables is used. Also it is a descriptive-correlative research which seeks to describe the relation of variables (dependent and independent) by using statistical tests. In this study, data pertaining to the theoretical literature is gathered by referring to the related papers, books, studies, theses and so on. So, data is gathered by library research method. Also a major part of data pertaining to the research variables is derived from time series data of the World Bank and Yale University. So here data is collected through documentary library method.

To determine the relation between environmental quality indices and energy consumption, data pertaining to the research variables namely, energy consumption based on oil consumption (ENERGY), under-5 children mortality (CHMORT), agricultural subsidies (AGSUB), access to drinking water (WATSUP), access to sanitation (ACSAT) and CO2 per capita (CO2CAP) during 2007 to 2009 is applied.

This study defines the environment quality indices and then tests the relation of these indices with the energy consumption. To analyze the results panel data method is used. With regard to the model reliability indices in the regression (like t-statistics for determining significance of variables, F statistic for determining total significance of the regression, Durbin-Watson statistic for determining homogeneity variance, R<sup>2</sup>), this model is suggested.

**Statistical universe, sample and sampling method:** The statistical universe of this study comprises high energy-consuming countries namely America, China, Japan, India and Russia, respectively.

**Data analysis methods:** Chow test is carried out to select the fixed effects. Moreover, Levin, Lin and Chu test is used to examine variables reliability.

**Research findings:**

**Chow test:** Chow test determines whether it is better to use a mixed model or a fixed effects model. Below hypotheses are formulated for such a test:

- H0 :** All intercepts are equal ⇔ fixed effects model
- H1 :** At least one of the intercepts is different from others ⇔ mixed model

The test statistic equals:

$$F = \frac{(R_{LSDV}^2 - R_{Pooled}^2) / (T-1)}{(1 - R_{LSDV}^2) / (NT - T - K)}$$

Or:

$$F = \frac{(RSS_{Pooled} - RSS_{LSDV}) / (T-1)}{RSS_{LSDV} / (NT - T - K)}$$

Table 2: The results of Chow test

Redundant fixed effects tests			
Pool: Untitled			
Test period fixed effects			
Effects test	Statistic	d.f.	Prob*
Period F	0.354014	(4,15)	0.8372
Period Chi-square	2.255242	4	0.6889

Table 3: The results of Levin, Lin and Chu test of variables reliability

Variable	Critical value	Prob*	Cross-sections	Result	Degree
AGSUB	-10.5156	0.0000	10	Reliable	I(0)
ACSAT	-4.50406	0.0000	7	Reliable	I(0)
CHMORT	-7.29998	0.0000	8	Reliable	I(0)
CO2CAP	-6.13781	0.0000	10	Reliable	I(0)
WATSUP	-3.77591	0.0001	8	Reliable	I(0)

where,  $R_{LSDV}^2$  and  $RSS_{LSDV}$  denote, respectively coefficient of determination and sum squared residuals of the unconstrained model (FEM),  $R_{Pooled}^2$  and  $RSS_{Pooled}$  represent, respectively coefficient of determination and sum squared residuals of the constrained model (pooled). Number of periods is shown by N and length of period (i.e., years) is shown by T. Table 2 presents the results of Chow test.

As shown in the above table, prob. values are greater than 0.05 and H0 is not rejected. So this study uses the fixed effects model.

**Unit root test (panel data):** If time series variables used in estimating the model parameters are not reliable, it is very likely that the obtained regression is Spurious, so using F and t statistics will be misleading. Thus to prevent Spurious regression, first data reliability is tested. Levin, Lin and Chu test has been applied in this study to test variables reliability. Table 3 presents the results of unit root test for all variables to reduce number of tables.

As it is seen, prob. values are less than 0.05 and so reliability of test variables is approved.

**Fixed effects model estimation:** Table 4 presents the results of fixed effects model estimation by Eviews software.

The results of model estimation indicate that:

- Value of model determination coefficient (R<sup>2</sup>) reveals that 0.98 of changes in the dependent variable (energy consumption) can be explained by the explanatory variables (selected indices of life quality).
- By one unit increase in CHMORT, energy consumption is increased by 21.16434 units.
- By one unit increase in AGSUB, energy consumption is increased by 17.77777 units.
- By one unit increase in WATSUP, energy consumption is increased by 4.027975 units.
- By one unit increase in ACSAT, energy consumption is increased by 68.56885 units.
- By one unit increase in CO2CAP, energy consumption is increased by 129.7684 units.

Table 4: Fixed effects model estimation

Variable	Coefficient	S.E.	t-Statistic	Prob.
C	-921.1194	57.68032	-15.96939	0.0000
CHMORT	21.16434	6.259681	3.381057	0.0031
AGSUB	17.77777	3.549396	5.008673	0.0001
WATSUP	4.027975	8.994530	0.447825	0.6593
ACSAT	68.56885	6.320792	10.84814	0.0000
CO2CAP	129.7684	5.190434	25.00146	0.0000
R-squared	0.983669	Mean dependent var	222.5271	
Adjusted R-squared	0.979371	S.D. dependent var	79.18172	
S.E. of regression	11.37277	Akaike info criterion	7.905884	
Sum squared resid	2457.458	Schwarz criterion	8.198414	
Log likelihood	-92.82355	Hannan-Quinn criter.	7.987020	
F-statistic	228.8797	Durbin-Watson stat	1.923875	
Prob (F-statistic)	0.000000			

- Durbin-Watson statistic with a value (1.923875) less than 2.5 shows that the assumption of auto-correlation among the model components is rejected.

### CONCLUSION

Having studied the indices related to the environmental quality, research method, goals and data, this study investigates the relation of selected environmental quality indices with respect to the available statistics of five high energy-consuming countries. The method of this study and some of its findings are consistent with some prior studies like (Mehrara *et al.*, 2011; Arman and Zare, 2005; Najarzadeh *et al.*, 2004) and (Deilaminejad and Reza, 2010). The main result of this study indicates that there is a significant relation between life quality indices (agricultural subsidy, access to sanitation, under-5 children mortality, CO2 per capita, access to drinking water) and energy consumption. The effect of this relation for agricultural subsidies, access to health, under-5 children mortality, CO2 per capita, access to drinking water indices are 17.8, 68.57, 21.16, 129.77, 4.03, respectively.

### Suggestions:

- The results of coefficients between dependent variable (energy consumption) and life quality indices represent the rank of each selected variable for improvement of EPI in the selected countries. The related organizations may use these coefficients to allocate resources if long term planning is needed.
- Quick response to some results is regarded among requirements governing the selected countries. As per the results, CO2 per capita coefficient value equals 129.77. Its higher coefficient indicates the

importance of the authorities' attention to the dissemination of environmental pollutants. High energy-consuming countries have the maximum CO2 production and they must pay particular attention to these environmental pollutants.

- The second index that must be investigated is access to drinking water with the coefficient 68.57. Attention to this need in the selected countries is a matter of great magnitude.

### Suggestions for future research:

- Modeling this study to study the relation between energy consumption in Iran in gasoline, gas and oil sectors and EPI indices separately and comparatively.
- Studying the relation of life quality indices with low energy-consuming countries (selected based on minimum consumption).
- Making a regression model for EPI indices based on data of at least 30 selected countries and developing the model for other countries and comparing the results.

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