Environmental performance index and economic welfare

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Abstract
This study relies in the proposed methodology by the Universities of Yale and Columbia for constructing an environmental performance index. Two different versions of the index are considered and compared having as reference point our country (Greece) and comparing it with other countries in the Mediterranean as well as in Northern Europe. Both versions (the one of 2014 and the other of 2016) of the index consists of two components, the environmental health and the ecosystem vitality. These two components are constructed with the help of nine variables (and nineteen indicators behind) relevant to the environment. These variables are health impact, air quality, water and sanitation, water resources, agriculture, forestry, fisheries, biodiversity and habitat and climate and energy. In the case of EPI 2016 the construction of the index has improved relying on the same two components and 9 variables but in twenty (in most cases different) indicators. Next the index is used with some socio-economic variables in order to model its behavior. The empirical findings and the associated policy implications are discussed together with future extensions.

Keywords: Environmental performance index; economic welfare.

JEL Codes: Q01; Q50; Q58; D60.

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1. Introduction

The natural environment covers all living and non-living things present as well as the interaction of living species, climate, weather, and natural resources that may influence the existence of humans and their economic activities. The environment offers its resources available to everyone as well as all those vital elements (among others, the air we breathe, ground, water) every living organism needs. All those elements that constitute the environment raise a great conflict about their availability and whether they assumed to be public goods or not. We tend to overuse them without wondering and caring about their future, or to be more specific our future and the one we are going to bequeath to the next generations. This raises the important issue of sustainability.

Economic systems consist of three main factors: households, corporations and the government. All three factors do pollute the environment with no one willing to pay for the possible degradation caused due to the fact that it is considered as public good. Although we can examine each factor independently, we already know that interlinkages do exist. The operations of one sector may negatively affect the existence of another. More specifically, the production of the corporations has two main outcomes: a) products and services and b) wastes and residuals. The supply of the first outcome satisfies the demand of households and other corporations while at the same time provides income sources to households and tax revenues to governments.

On the other hand, the second outcome has as a consequence the damage of the environment. In other words, the pollution caused by firms may adversely affect the viability of households and/or other firms (Evangelinos and Halkos, 2002). The overuse of natural resources limits their future availability; air and water pollution leads to endangerment of public health, while damage of the nature limits the recreation and amusement someone may enjoy on his/her leisure time. The government on the other hand, has as commitment to protect and overhaul the environment due to the fact that it is considered to be a public good.

The structure of this study is the following. Section 2 reviews the relevant existing literature, while section 3 discusses the methodology proposed by the Universities of Yale and Columbia in constructing the environmental performance indexes for the years 2014 and 2016. Using Greece and various other countries in the Mediterranean and in North Europe we will comment on the reliability and accuracy. Section 4 will model the index with various socioeconomic variables to model its behaviour. Finally, the last section will discuss the general findings, the associated policy implications and possible future extensions.

2. Literature Review

The majority of the literature is focused on firms' environmental performance indices (Ingram and Frazier, 1980; Azzone and Noci, 1996; Russo and Fouts, 1997; Stanwick and Stanwick, 1998; King and Lenox, 2001; Konar and Cohen, 2001; Patten, 2002; Al-Tuwaijri et al., 2004; Färe et al., 2004; Hassel et al., 2005; Zhou et al., 2007; Hermann et al., 2007; Zhou et al., 2008; Perotto et al., 2008; Clarkson et al., 2008; De Benedetto and Klemes, 2009). To our knowledge, the literature on national or international environmental performance is limited. Thus, although the research is restricted, some attempts have been made both by individuals and institutions.

Hammond et al. (1995) aimed to present the main characteristics of the environmental indicators claiming that successful indicators should be user driven, policy relevant and highly aggregated. As "user driven" they regard the indicators that utilitarian to the interested parties. Detlef (1998) used a comparative analysis focusing on four main categories. The first category refers to the degree of pollution having as main criteria the country's climate and size, population density, the size of industrial and service sectors and the changes in industrial production. The second hypothesis refers to the differentiation between the various pollution forms with richer countries tackling more easily environmental problems and usually polluting more. The next hypothesis refers to the political and institutional aspects of a country with arrangements established by governments affecting environmental performance. To that statement, Crepaz (1995) has mentioned that positive effects have been recorded on the neo-corporatist arrangements. Finally, we have the hypothesis connected to the political actors of each political system where the type of government and the influence a green party may have to the government is able to lead to significantly different environmental outcomes.

Smeets and Weterings (1999) emphasize the importance of environmental indicators for policy makers. Environmental indicators should complete the demand for information necessary to policy makers; at the same time they may boost policy development and observe the outcomes of the policy responses. Apart from the useful role environmental indicators have to policy makers, they may also raise public's attentions regarding environmental issues and environment's sustainability. In 2000, two of the most known universities, Yale University and Columbia University, joined their forces in order to build a composite indicator called *"Environmental Sustainability Index, (ESI)"* that includes all different influences environment faces.

After improvements, ESI included 76 variables in total, which constructed 21 indicators in order to determine the 5 main components which will create the final value of ESI. Although that attempt was promising, 2 main obstacles forced Yale and Columbia University to redefine the variables, decide which of all are most important to policy makers and create a more concrete index that will contain less but more essential variable. The new attempt was made in 2006, and the new index was called *"Environmental Performance index, (EPI)",* which, after improvements, has only 19 indicators that create 9 issues. These 9 issues are divided into 2 main categories which finally create the EPI.

The main motivating power for that new attempt was the *"Millennium Development Goals, (MDGs)"* which were established by the United Nations and included the 8 major fields of population and sustainability. Since then, a lot of attempt have been recorded in order to estimate indicators that can be used as policy-making tools. These attempts mainly include regression analysis and other more advanced statistical approaches (Panayotou, 1997; Dasgupta et al. 2001, 2002; York et al. 2003, Esty and Porter, 2005). Other more advanced attempts were made by Kuosmanen and Kortelainen (2005) and Kortelainen (2007), where dynamic approaches on national level were used in both cases. The first paper by Kuosmanen and Kortelainen (2005) used a Data Envelopment Analysis (DEA) in order to specify endogenous weightings for the estimations of the Environmental indicators. Similar efforts can be fount in Halkos and Tzeremes (2012, 2014), Halkos et al. (2015) and Halkos and Skouloudis (2016a, b).

On the other hand, Kortelainen (2007) and Halkos and Tzeremes (2015) preferred another dynamic approach known as Malmquist Index. The main issue that the majority of authors mentioned is the narrow data availability (Porter and van der Linde, 2000; Jaffe et al., 1995; Esty and Porter, 1998; Esty and Porter, 2005). Due to all the statements above, the most common approach nowadays is the EPI estimation by Yale and Columbia, and is the one that the authors are willing to use in this paper.

3. Methodology

As already mentioned above, the methodology proposed by the Universities of Yale and Columbia in 2000 and described in ESI (Esty et al., 2000) and later on in EPI (Esty et al., 2006), known as *Environmental Performance Index* (hereafter EPI), will be used in our analysis. Starting with data availability we should mention that all variables are available at Yale website since 1990 for most of the variable, while there are some exception like agriculture subsidies and pesticide regulations that are available since 1955 and fish stocks and trawling catch that are available since 1950. Figure 1 illustrates that the EPI is constructed relying on two main categories coming from 9 issues, which in turn include 19 different variables with proposed weightings. All environmental variables in Figure 1 are inspired from the Millennium Development Goals set up by the United Nations.

Let us mention at this point that Yale and Columbia Universities report EPI every 2 years. In Table 1 we clarify and present a full description of the issue categories refering to Greece for the years 2014 (Hsu et al., 2014) and 2016 (Hsu et al., 2016). The aim of this table is to show the differences in the individual variables used in the construction of the indexes. For instance, in the case of Health Impact the EPI in 2014 (Hsu et al., 2014) was constructed relying on child mortality while in 2016 (Hsu et al., 2016) on environmental risk exposure.

Similarly, Table 2 presents the performance in the 9 issues for 2014 and 2016 in the case of Mediterranean (Italy, France, Spain, Morocco, Egypt, Turkey) and sampled Northern-West European countries (Finland, Norway, Denmark, the UK). The rankings are in parenthesis and the percentage change in brackets. As can be seen there are many differences in the rankings due to the different indicators used in 2016. A full reference to all countries and for both EPIs for 2014 and 2016 can be fount in the Appendix.

Apart from the variables proposed by Yale and Columbia University methodology, we are going to use some determinant variables so as to observe if there is a relation between the EPI and the economic level of each country. Such variables will be GDP/capita, population density, infant mortality and industrialization.

Figure 1: Environmental Performance Index Structure & Weightings

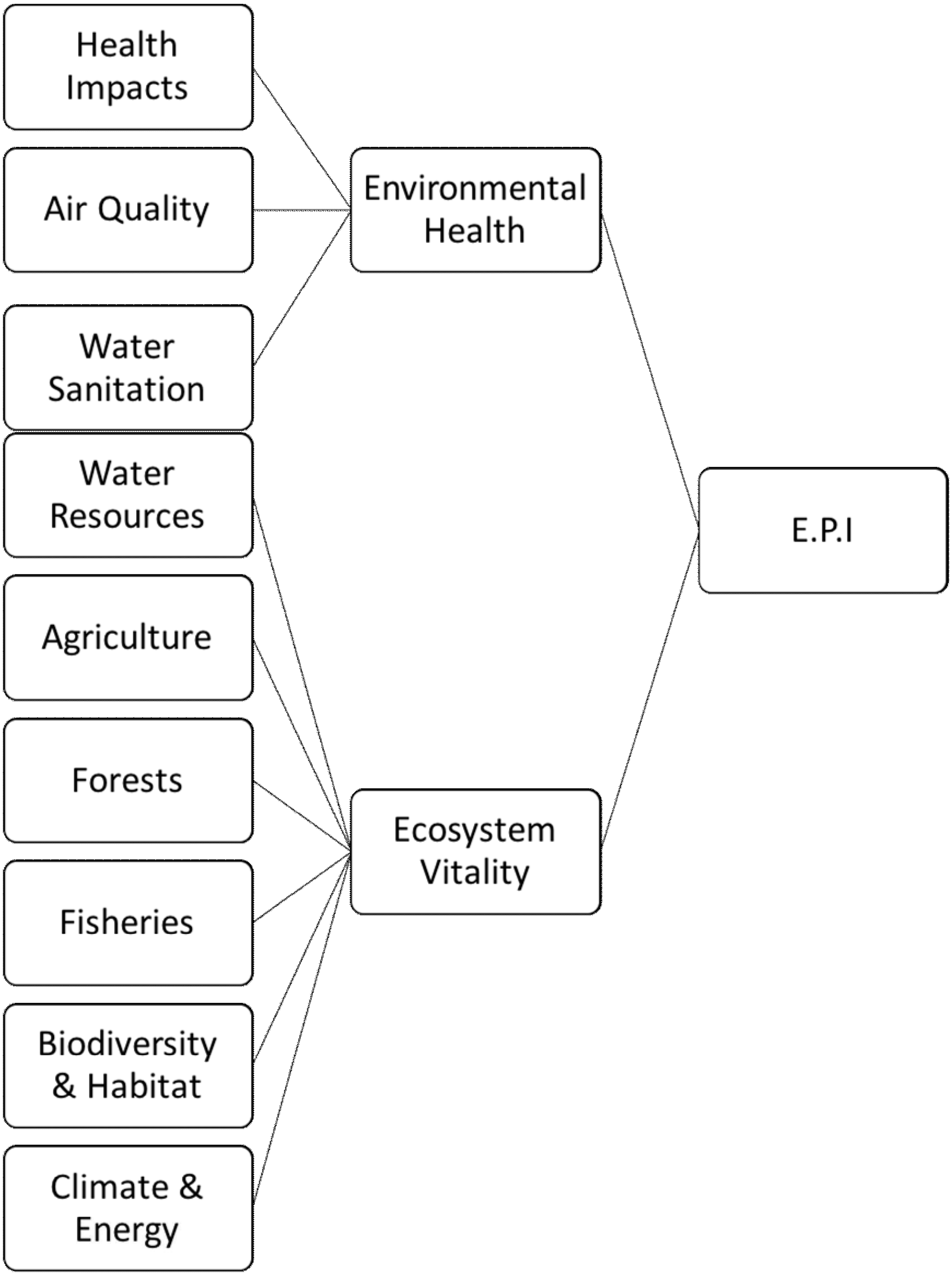


Table 1: Performance in the 9 issues and 20 indicators for 2014 and 2016 in the case of Greece

Greece							
Issue Categories		EPI 2014		EPI 2016		Change	
2014	2016	Score	Rank	Score	Rank	Score	Score (%)
Health Impact		**100**	**17**	**80,89**	**61**	**-19,11**	**-0,1911**
Child Mortality		100	17				
	Environmental Risk Exposure			80,89	61		
Air Quality		**85,88**	**66**	**87,01**	**56**	**1,13**	**0,013157895**
Household Air Quality		95	54	95	20	0	0
Air Pollution - Average Exposure to PM2.5		91,05	126	100	17	8,95	0,098297639
Air Pollution - Average PM2.5 Exceedance		71,58	125	84,69	111	13,11	0,183151718
	Household Air Quality - Risk Exposure			100	21		
	Air Pollution - Average Exposure to PM2.5 - Risk Exposure			70,77	92		
	Air Pollution - Average Exposure to NO2			67,42	129		
Water & Sanitation		**87,76**	**35**	**99,36**	**19**	**11,6**	**0,132178669**
Access to Sanitation		80,71	42	97,43	29	16,72	0,207161442
Access to Drinking Water		94,81	36	100	17	5,19	0,054741061
	Unsafe Sanitation- Risk Exposure			100	18		
	Unsafe Drinking Water Quality -Risk Exposure			100	18		
Water Resources		**87,33**	**14**	**92,03**	**22**	**4,7**	**0,053818848**
Wastewater Treatment		87,33	14	92,03	22	4,7	0,053818848
Agriculture		**61,01**	**111**	**100**	**4**	**38,99**	**0,639075561**
Agricultural Subsidies		38,01	116				
Pesticide Regulation		84	66				
	Nitrogen Use Efficiency			100	4		
	Nitrogen Balance			100	14		
Forests		**22,83**	**88**	**62,66**	**49**	**39,83**	**1,744634253**
Change in Forest Cover		22,83	88				
	Tree Cover Loss			62,66	49		
Fisheries		**25,86**	**46**	**42,96**	**85**	**17,1**	**0,6612529**
Fish Stocks		21,49	19	42,96	85	21,47	0,999069335
Coastal Shelf Fishing Pressure		30,23	61				
Biodiversity & Habitat		**66,49**	**77**	**94,82**	**26**	**28,33**	**0,42607911**
Terrestrial Protected Areas (National Biome Weights)		95,73	35	100	12	4,27	0,044604617
Terrestrial Protected Areas (Global Biome Weights)		96,11	38	100	12	3,89	0,040474456
Marine Protected Areas		74,1	58	74,12	78	0,02	0,000269906
Critical Habitat Protection		0	55				
	Species Protection (National)			100	6		
	Species Protection (Global)			100	12		
Climate & Energy		**59,79**	**42**	**69,64**	**75**	**9,85**	**0,164743268**
Trend in Carbon Intensity		60,38	55	68,1	82	7,72	0,127856906
Change of Trend in Carbon Intensity		33,91	75				
Trend in CO_2 Emissions per KWh		61,66	37	80,72	126	19,06	0,309114499
Access to Electricity		100	22	100	21	0	0

Table 2: Performance in the 9 issues for 2014 and 2016 in the case of Mediterranean and sampled Northern European countries (rankings in parenthesis and percentage change in brackets)

Country	Italy		France		Spain		Egypt		Morocco		Turkey		United Kindom		Norway		Sweden		Finland		Denmark	
Issue	2014	2016	2014	2016	2014	2016	2014	2016	2014	2016	2014	2016	2014	2016	2014	2016	2014	2016	2014	2016	2014	2016
Health Impact	100	76.1	100	88.3	96.2	92.5	66.8	65.2	65	65.6	66.1	74.4	100	95.26	100	100	100	99	100	99.4	100	96.2
	(16)	(76)	(19)	(37)	(31)	(24)	(97)	(105)	(103)	(104)	(100)	(81)	(10)	(16)	(8)	(2)	(7)	(5)	(14)	(4)	(11)	(140)
	[-23.91%]		[-11.75%]		[-3.8161%]		[-2.4839%]		[0.9082%]		[12.6702%]		[-4.7399%]		[0%]		[-0.9699%]		[-0.6500%]		[-3.81%]	
Air Quality	80.9	72.8	89.4	82.4	97.4	91.3	68	58	98.9	89.6	84.1	79.3	95.82	86.78	98.3	94.6	97.1	93.3	98.3	93.8	92.8	87
	(81)	(124)	(56)	(84)	(32)	(33)	(144)	(164)	(14)	(46)	(74)	(98)	(45)	(62)	(17)	(12)	(33)	(22)	(20)	(18)	(52)	(57)
	[-10.0185%]		[-7.8376%]		[-6.2647%]		[-14.6639%]		[-9.3879%]		[-5.6738%]		[-9.4343%]		[-3.8035%]		[-3.9843%]		[-4.6374%]		[-6.2917%]	
Water & Sanitation	63.5	99.6	100	99.2	99.3	99.9	73.6	86.7	26.2	67.7	71.4	85.1	100	99.5	100	98.9	100	99.6	100	98.6	100	99.7
	(64)	(14)	(15)	(21)	(23)	(9)	(50)	(65)	(134)	(119)	(53)	(71)	(10)	(17)	(8)	(24)	(7)	(16)	(13)	(26)	(11)	(12)
	[56.8886%]		[-0.7800%]		[0.6040%]		[17.8420%]		[158.0792%]		[19.0816%]		[-0.5%]		[-1.14%]		[-0.4300%]		[-1.4300%]		[-0.2900%]	
Water Resources	91.4	92.8	83.8	92.4	92.8	97.5	49.5	78.5	39.4	60.8	48.9	79	97.93	98.94	77.1	93.9	87.9	96.1	84.3	93.5	93.4	95.7
	(10)	(20)	(17)	(21)	(8)	(8)	(41)	(54)	(47)	(83)	(42)	(53)	(3)	(40)	(23)	(17)	(12)	(12)	(16)	(18)	(7)	(13)
	[1.4654%]		[10.2744%]		[5.0522%]		[58.6666%]		[54.4046%]		[61.4347%]		[1.0313%]		[21.8559%]		[9.3557%]		[11.0029%]		[2.4345%]	
Agri-culture	58.9	88.2	65.6	98.8	65.2	78	73	51.7	46.4	100	56.7	7.04	66.03	61.28	46.6	63	65.2	100	67	85.9	66.1	96.6
	(116)	(82)	(89)	(42)	(96)	(103)	(74)	(139)	(161)	(8)	(125)	(86)	(87)	(130)	(159)	(128)	(97)	(1)	(82)	(87)	(86)	(56)
	[49.7536%]		[50.7093%]		[19.6809%]		[-29.1329%]		[115.7497%]		[-87.5772%]		[-7.1936%]		[35.2145%]		[53.4212%]		[28.2131%]		[46.2761%]	
Forests	55.4	80.9	37.9	55.1	45.1	41.5	na	na	100	na	52.4	68.5	43.06	30.36	32.5	66.9	14.4	16.3	11.8	17.4	18.5	28.1
	(35)	(24)	(54)	(60)	(45)	(79)	na	na	(14)	na	(38)	(40)	(50)	(94)	(67)	(43)	(107)	(107)	(113)	(106)	(97)	(96)
	[46.0566%]		[45.0975%]		[-7.8801%]		na				[30.8118%]		[-29.4937%]		[105.5658%]		[13.7282%]		[47.5785%]		[51.6198%]	
Fisheries	24.9	29.2	0	60.8	23.2	45.1	23.8	30.6	19.4	71	21.9	57.8	0	2.91	20.9	93.9	25.3	50.8	32.9	72.9	8.66	23.1
	(52)	(117)	(101)	(31)	(63)	(81)	(58)	(115)	(78)	(10)	(70)	(35)	(100)	(129)	(72)	(1)	(50)	(63)	(24)	(8)	(93)	(128)
	[17.0878%]				[93.8468%]		[28.5954%]		[266.6494]%		[164.0182%]				[349.6647%]		[100.8695%]		[121.5567%]		[166.2817%]	
Bio-diversity & Habitat	79.8	99	54.5	99.5	56.6	96.7	65.3	72.8	31.2	91.1	32.6	22.5	70.11	98.98	71.7	82.2	62.4	88.8	61.9	96.9	67.7	97.6
	(52)	(14)	(105)	(10)	(101)	(20)	(81)	(116)	(134)	(42)	(133)	(177)	(70)	(12)	(65)	(80)	(89)	(57)	(90)	(19)	(73)	(17)
	[24.0566%]		[82.7731%]		[71.0219%]		[11.4771%]		[191.9871%]		[-30.9319%]		[41.1781%]		[14.6763%]		[42.2891%]		[56.6925%]		[44.0803%]	
Climate & Energy	63.4	79.4	49.8	80.1	81.8	81.8	61.1	50.9	49.4	59.6	46.5	47.8	54.24	84.53	75.7	57.1	77.3	92.7	62.2	90.2	67.2	8.67
	(25)	(49)	(67)	(47)	(4)	(40)	(37)	(99)	(67)	(87)	(76)	(101)	(56)	(30)	(10)	(91)	(8)	(10)	(32)	(18)	(16)	(24)
	[25.1379%]		[60.7866%]		[-0.0122%]		[-16.6912%]		[20.6680%]		[2.6870%]		[55.8443%]		[-24.4943%]		[19.8991%]		[44.9228%]		[-87.1020%]	

4. Modelling the EPI: some empirical findings

In this section we will propose two model specifications. The first proposed model specification is of the form

$$Y = X\beta + \varepsilon$$

With Y being a (nx1) vector and X an (nxk) matrix; β and ε are (kx1) and (nx1) vectors respectively. Our dependent variable Y is the EPI in the years 2014 or 2016 and X is the matrix including the explanatory variables of GDP and its powers in a polynomial specification, life expectancy, population density and unemployment.[1] That is

EPI=f(GDP/c, GDP/c^2, GDP/c^3, life expectancy, population density, unemployment)

Apart of these variables we have also considered in a second stage the proposed by cultural dimensions proposed by Hofstede. Hofstede (1980, 2001, 2010) established the differences between cultures by allocating each dimension and country a score on a scale between 0-100. The following cultural dimensions are considered:

- *Power distance (PDI)*, referring to the degree to which the less powerful members of institutions and organizations within a country anticipate and recognize that power is distributed unequally. The basic matter here is the way a society tackles inequalities among its members.
- *Uncertainty avoidance (UAI)*, concerns the degree to which members of a culture feel uncertain or ambiguous with uncertain situations. The primary matter here is the way a society tackles the actuality that future is unknown. Countries with high UAI scores sustain strict policies on belief and behaviour and are intolerant of unconventional actions and

[1] It is worth mentioning that we have also considered the Human Development Index (HDI), a statistic consisting of the indicators of life expectancy, education, and per capita income and helping in the ranking of countries into four levels of human development. A country with high HDI has high lifespan, education level and GDP per capita and low fertility and inflation rates. In our case the correlation coefficient between EPI2014 and HDI is 0.892 and between EPI2016 and HDI 0,792. Let us also indicate that the correlation coefficient between EPI2014 and EPI2016 is 0.836.

ideas. Low UAI scores refer to societies sustaining a more relaxed way with practice counting more than principles.

- *Individualism versus collectivism (IDV)*, ranging from societies where the ties between individuals are loose to societies in which people are integrated into strong, solid groups.
- *Masculinity versus femininity (MAS)*, ranging from societies where social gender roles are clearly discrete to societies in which social gender roles tend to overlap.
- *Long-term orientation versus short term orientation (LTO)*, referring to societies' time horizon with long-term oriented societies to give more importance to the future while short-term oriented societies share values related to the past and the present.
- *Indulgence versus restraint (IVR)*, describing the extent to which societal members try to control their desires and impulses with indulgent societies to retain a tendency to allow relatively free gratification of basic and natural human desires while restrained societies to be characterized by a conviction that such gratification needs to be curbed as well as regulated by sets of rigid norms.

That is, in this case the model specification is

$$EPI = f\,(GDP/c, PDI, UAI, IDV, MAS, LTO, IVR)$$

Table 3 presents the descriptive statistics of the variables considered in the first stage of analysis while Table 4 presents the descriptive statistics for a sample of 63 countries[2] representative of all parts of the Globe. Similarly Figure 2 present the probability graphical presentations of the cultural aspects and the EPI 2014 and EPI 2016.

[2] The countries considered are the one with full record. Namely: Morocco, Tunisia, Argentina, Brazil, Chile, Colombia, Peru, Uruguay, Venezuela, Canada, Mexico, USA, Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, Australia, China, Indonesia, Japan, South Korea, Malaysia, New Zealand, Philippines, Singapore, Thailand, Viet Nam, Bangladesh, India, Pakistan, Bahrain, Iran, Kuwait, Oman, Qatar, United Arab Emirates

Table 3: Descriptive statistics of the variables considered

Total sample (n=178)	**EPI Score**	**GDP/c**	**Life expectancy**	**Population density**	**Unemployment**
Mean	61.22844	14281.31	75.86443	219.8077	8.532468
Median	59.31000	5453.281	76.15861	86.54949	6.800000
Maximum	87.67000	116612.9	83.58780	7736.526	28.00000
Minimum	18.43000	286.0023	52.75427	3.054305	0.500000
Std. Dev.	14.47675	20593.26	6.229514	876.7777	5.556704
Skewness	-0.311265	2.341856	-1.553358	8.342092	1.670111
Kurtosis	2.569884	9.017929	6.017537	72.01623	6.004085
Jarque-Bera	1.836909	409.4914	60.17938	16175.14	64.74932
Probability	0.399135	0.000000	0.000000	0.000000	0.000000

Table 4: Descriptive statistics of the variables considered

Total sample (n=63)	EPI2014	EPI2016	IDV	IVR	LTO	MAS	PDI	UAI
Mean	63.84429	78.40841	46.49206	45.20635	47.44444	49.46032	60.58730	66.92063
Median	66.61000	82.03000	39.00000	42.00000	47.00000	52.00000	64.00000	68.00000
Maximum	87.67000	90.68000	91.00000	100.0000	100.0000	110.0000	104.0000	112.0000
Minimum	25.61000	41.77000	12.00000	0.000000	13.00000	5.000000	11.00000	8.000000
Std. Dev.	14.35562	10.58262	22.54091	20.95630	22.57731	20.05462	21.35464	21.81099
Skewness	-0.590624	-1.260284	0.285439	0.412101	0.329709	0.118027	-0.207506	-0.404306
Skewness	2.577903	4.352253	1.912363	2.790584	2.056326	3.756811	2.378393	2.713897
Kurtosis	4.130471	21.47736	3.960746	1.898302	3.479051	1.649769	1.466404	1.931237
Jarque-Bera	0.126788	0.000022	0.138018	0.387069	0.175604	0.438286	0.480368	0.380748
Probability	12777.21	6943.493	31501.75	27228.32	31603.56	24935.65	28273.27	29494.60
Observations	63	63	63	63	63	63	63	63

Table 5 presents the regression results for the full sample in quadratic and cubic specifications, for Europe, for Sub-Saharan and for East Asia and Pacific regions. Specifically, all model formulations have as explanatory variables the per capita output (GDP/c) as an approximation of prosperity together with life expectancy, population density and unemployment. The output and its powers are statistically significant in all cases. In the first two models and in the analysis of the Globe we end up to an N-shape behaviour of the index with the variables of the final model being significant in all levels of significance while the Akaike Information Criterion in lower in the second model. In the third and fourth models and in the cases of Europe and Sub-Saharan we end up to quadratic specifications while in the last model we have a positive monotonic relationship. The turning points in the case of Sub-

Saharan are well within the sample while the one for Europe is quite high although lower than the maximum value of income for the European countries considered. Looking at the diagnostic tests we may see that we very view exceptions we face no problem of heteroskedasticity, normality and specification error.

Figure 2: Theoretical probability graphical presentations of EPI2014 and EPI2016 and Cultural aspects (assuming Normality)

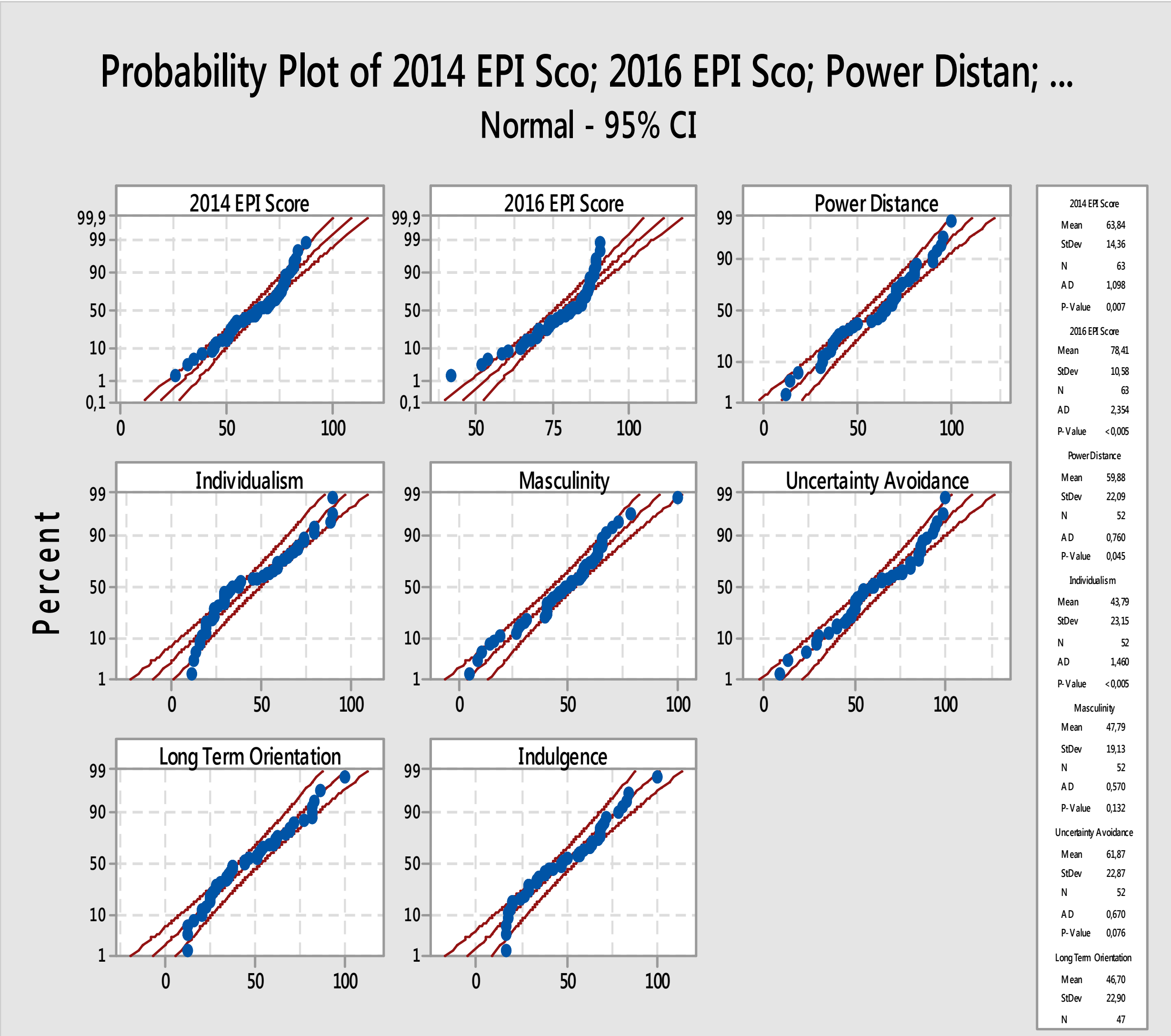


Table 5: OLS model results and diagnostics tests (P-Values in brackets).

	All (n=178)		Europe **(n=31)**	Sub-Saharan **(n=46)**	East Asia – Pacific **(n=24)**
Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	-21.3675***	-15.889**	61.8984***	28.8689***	43.065***
GDP/c	0.000718***	0.001205***	0.000412***	0.0042***	0.00069***
$(GDP/c)^2$	-4.75E-09***	-1.82E-08***	-2.10E-09*	-1.81E-07***	
$(GDP/c)^3$		8.81E-14***			
Life Expectancy	0.91534***	0.80742***			
Turning Points	75579	55346.6 and 82375.7	98095	11602	
R-square	0.77	0.78	0.48	0.49	0.80
Akaike Information Criterion	7.0263	6.9957	6.5155	6.8192	6.7831
Schwarz criterion	7.101	7.0892	6.6543	6.9409	6.8823
Normality test (Jarque-Bera)	0.6206 [0.7331]	0.26164 [0.8774]	1.2615 [0.5322]	0.01625 [0.9919]	0.9933 [0.6086]
Heteroscedasticity White test	1.4979 [0.1619]	1.1848 [0.3018]	1.1196 [0.3687]	1.0155 [0.4113]	0.9098 [0.4194]
Heteroscedasticity test (Harvey)	1.4614 [0.2271]	3.7312 [0.0062]	2.9326 [0.0698]	0.32089 [0.7273]	2.9998 [0.1111]
Heteroscedasticity test (Glejser)	1.8148 [0.1465]	1.2744 [0.2822]	2.9273 [0.0701]]	1.2711 [0.2914]	2.086 [0.1642]
ARCH effect test	0.12299 [0.7263]	0.04276 [0.8364]	1.5925 [0.2178]	1.9913 [0.1617]	2.003 [0.1802]
Ramsey RESET (linear)	0.020037 [0.9840]	0.6167 [0.4334]	1.5862 [0.1243]	0.1197 [0.7311]	1.1902 [0.2486]
Ramsey RESET (quadratic)	3.148 [0.0456]	0.7891 [0.4560]	2.26867 [0.1236]	0.8936 [0.9147]	1.3401 [0.2867]
Ramsey RESET (cubic)	3.335 [0.0210]	1.71699 [0.1657]	1.7184 [0.1888]	0.14114 [0.9347	1.0386 [0.4007]

*P<0.1; **P<0.05; ***P<0.01

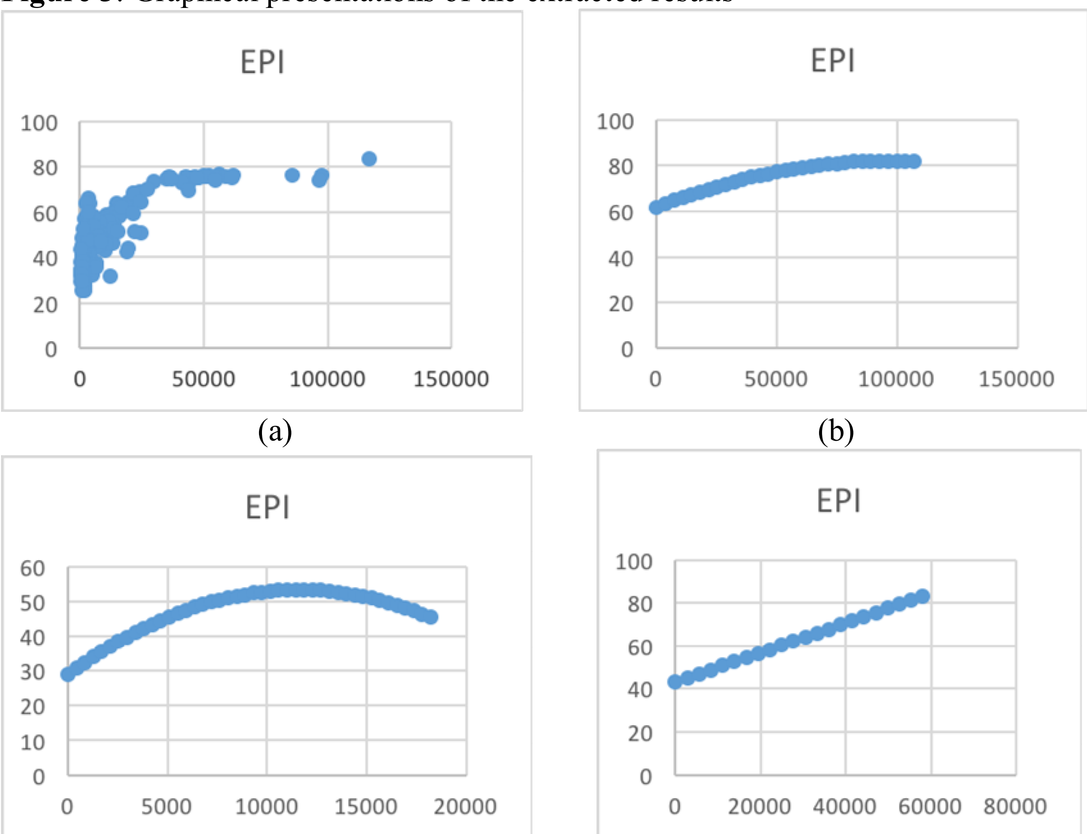
Moving to the second stage of regression analysis and relating the index with the cultural dimensions we may see from Table 6 that the magnitudes of IDV, LTO and IVR are high while, on the other hand, PDI has a negative and statistically insignificant effect. MAS also has a negative effect. In this respect, holding constant the effect of the other variables and considering each variable in turn, a unit increase in IDV, IVR, LTO and UAI will result to a 0.27, 0.204, 0.17 and 0.11 increase in EPI 2014 and 0.24, 0.18, 0.13 and 0.126 in EPI 2016 respectively. That is the changes are almost of the same magnitude although the indexes differ considerably. Likewise, holding constant the effect of the other variables and considering each variable in turn, a unit increase (decrease) in MAS will reduce (increase) EPI 2016 by approximately 0.092.

Table 6: OLS model results and diagnostics tests (P-Values in brackets).

	All (n=69)	
Variables	EPI2014	EPI2016
Constant	32.71***	48.889***
PDI	-0.105	
IDV	0.2762***	0.2432***
IVR	0.2039**	0.1805***
LTO	0.1723**	0.1299**
UAI	0.1085*	0.1258***
MAS		-0.0916*
R-square	0.50	0.51
Normality test (Jarque-Bera)	0.457 [0.7957]	8.584 [0.0138]
Heteroscedasticity test (White)	0.7792 [0.4545]	1.4028 [0.1748]
Ramsey RESET	1.0856 [0.1465]	1.1113 [0.1312]

*P<0.1; **P<0.05; ***P<0.01

Figure 3: Graphical presentations of the extracted results



(a) (b)

(c) (d)

Finally, Figure 3 presents the extracted relationships between EPI and per capita income in the case of all countries considered (Figure 3a), Europe (Figure 3b), Sub-Saharan Africa (Figure 3c) and East Asia and Pacific (Figure 3d) countries.

5. Discussion and conclusions

During the last decades, a great awareness is raised on environmental issues. In this study we have considered the EPI for the years 2014 and 2016. These indexes are constructed around two components with the help of nine variables (and nineteen indicators behind) all relevant to the environment. We may say that the construction of EPI_2016 is improved relying on the same two components and 9 variables but in the case of the twenty indicators we have some substantial differences towards a more reliable representation of the environmental degradation. Greece's rank is not so much different compared with other countries (23rd in 2014 and 21st in 2016) but this is not the case for the majority of countries. Finland ids ranked 1st from 18th, Iceland 2nd from 14th, Sweden 3rd from 9th, South Korea 80th from 43rd,Thailand 91st from 78th, with Somalia remaining in the last position.

Specifically, EPI 2016 in the case of health impacts relies on environmental risk exposure and not on child mortality. In this way it captures health metrics across various ages and genders and not only children's mortality. In terms of air pollution we have also an extension in the indicators used with the addition of household air quality and risk exposure as well as to exposure to nitrogen dioxide NO_2 which may represent toxic pollutants to humans. Long term exposure to this pollutant causes respiratory effects and health problems to people like asthma while NO_2 produces ozone causing irritation to eyes.

In terms of water and sanitation we have the addition of risk exposures in unsafe sanitation and drinking water quality. In agriculture we have a different concentration between the two years with attention to nitrogen in the recent index and to subsidies and regulations in agriculture and pesticides respectively in 2014. In forests we have as indicator the change in forest cover in 2014 and tree cover loss in 2016. Even this small difference in the construction leads to a change in rankings in this category (Greece is ranked 88th and 49th in 2014 and 2016 respectively). In the case of Climate and Energy the exclusion of the change of trend in carbon intensity in EPI 2016 leads again to differences in the rankings with Greece ranked from 42nd in 2014 to 75th in 2016. A significant number of countries scored in this indication are decreasing their carbon intensity and this is ignored in the new constructed index. In terms of Biodiversity and Habitat we have the addition of species protections in national and global levels.

This requires a further investigation on what determines the efficiency of countries on this analysis and under these components. For instance, in the case of Greece the inclusion of environmental risk exposure and the omission of the change of trend in carbon intensity worsen a lot its ranks while the inclusion of the new indicators in air quality, water sanitation and species protection improves a lot its rankings. Special reference has to be done in the case of the inclusion of nitrogen use efficiency and nitrogen balance with Greece ranked from 111th in 2014 to 4th in 2016. This analysis shows that individual consideration is necessary in getting a general idea of the positive and negative components.

As the EPI relies on environmental components we have related in two stages this index first with some socio-economic variables in order to model its behavior and then with some cultural dimensions. It seems that income is an important determinant with different turning points or relationships in the samples considered. In the analysis of the Globe we end up to an N-shape of the index while in the cases of Europe and Sub-Saharan we end up to quadratic specifications and in the last model of East Asian and Pacific we have a positive monotonic relationship. The turning points in Sub-Saharan Africa are within the sample while in the case of Europe they are high. Finally, in the examination of the cultural dimensions the magnitudes of IDV, LTO and IVR are high while PDI has a negative and insignificant effect and MAS a negative effect.

The policy implications when dealing with the environment are important. Based on Ostrom (2009), environment is no one's property, it can be used by anyone but no one is the owner. Halkos (2013) defines the separate meanings between *"public good"* and *"common pool resources"*, while illustrates their meaning by giving real examples. More specifically, *"public good"* is the material or immaterial good that someone can use without having to pay for it and at the same time without excluding other users. Conversely, *"common pool resources"* are those material or immaterial goods that can someone use without having to pay for, yet the one user excludes another. In general, the air we breathe, the water in a lake or the ocean is a public good, however, the fishery, the forestry, the fossil fuels, the clear air and water are common pool resources (Ostrom et al., 1994).

As common pool resources are usually freely available individuals tend to consume more units than the optimal point of their utility maximization. The overuse of one individual minimizes the availability to other users (Halkos, 2013)[3]. That phenomenon is nowadays called *"the tragedy of the commons"*. Although it is a ordinary conditions in modern societies, especially on environmental issues, the term *"the tragedy of the commons"* is not such a modern one. The phenomenon was initially mentioned by William Forster Lloyd in 1833, however, Hardin (1968) was the one that introduces it on the environmental field of studies. Since then, great attention was raised about this condition. As Hardin (1968) mentioned, when rationality on individuals exists, the preferable option is to ignore the pollution caused to the common pool resources instead of purifying their wastes due to the cost-benefit analysis. As already mentioned, government is main authority which is responsible to observe the commons and solve the abnormalities with regulatory interventions (Halkos, 2013). Ostrom (1999, 2009)

[3] On social aspects see Halkos and Jones (2012); Halkos and Matsiori (2012); Halkos and Salamouris (2003).

has investigated the methods that a government can use in order to tackle with the tragedy of the commons. One of her findings was the fact that usually the efforts that have been done by the governments do not seem to succeed. The three main options a government can use are: a) purifying waste methods, b) taxation, c) privatization (Ostrom, 2009), however, not all of them is applicable to all causes. Such an example can be the privatization. In that case the specific resource does not belong to the public property but becomes private and in such way it obtains an owner who now is responsible for its protection. The most common method is the taxation either to the polluter, "Polluter Pays Principle, PPP" or to the victim, "Victim Pays Principle, VPP" (Halkos, 2013).

According to what has already mentioned, the government should be able to observe and protect both public goods and common pool resources. Government's policy makers do need some trustable indicators that can provide information about the levels of environmental danger, or even worse environmental damage. In that way, they will be able to notice the possible danger, indicate the source of the potential damage and propose the method of confrontation

Obviously various variables may be used in the future in improving even more the reliability of this index, namely, among others, freshwater quality, toxic chemical exposures, solid (apart from wastewater) waste management, wetlands loss, agricultural soil quality and degradation, levels of recycling, adaptation and exposure to climate change and desertification.

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Appendix

	Country	2014 EPI Score	2014 EPI Rank	2016 EPI Score	2016 EPI Rank	Increase / Decrease
1	Afghanistan	21,57	174	37,5	176	↓
2	Albania	54,73	67	74,38	61	↑
3	Algeria	50,08	92	70,28	83	↑
4	Angola	28,69	160	51,32	145	↑
5	Antigua and Barbuda	48,89	96	62,55	122	↓
6	Argentina	49,55	93	79,84	43	↑
7	Armenia	61,67	48	81,6	37	↑
8	Australia	82,4	3	87,22	13	↓
9	Austria	78,32	8	86,64	18	↓
10	Azerbaijan	55,47	63	83,78	31	↑
11	Bahamas	46,58	105	69,34	93	↑
12	Bahrain	51,83	82	70,07	86	↓
13	Bangladesh	25,61	169	41,77	173	↓
14	Barbados	45,5	108	54,96	140	↓
15	Belarus	67,69	32	82,3	35	↓
16	Belgium	66,61	36	80,15	41	↓
17	Belize	50,46	88	73,55	68	↑
18	Benin	32,42	150	43,66	166	↓
19	Bhutan	46,86	103	64,99	110	↓
20	Bolivia	50,48	87	71,09	76	↑
21	Bosnia and Herzegovina	45,79	107	63,28	120	↓
22	Botswana	47,6	100	70,72	79	↑
23	Brazil	52,97	77	78,9	46	↑
24	Brunei Darussalam	66,49	37	67,86	98	↓
25	Bulgaria	64,01	41	83,4	33	↑
26	Burkina Faso	40,52	126	43,71	165	↓
27	Burundi	25,78	167	43,37	168	↓
28	Cambodia	35,44	145	51,24	146	↓
29	Cameroon	36,68	141	57,13	136	↑
30	Canada	73,14	24	85,06	25	↓
31	Cape Verde	44,07	113	51,98	143	↓
32	Central African Republic	42,94	119	46,46	159	↓
33	Chad	31,02	156	37,83	175	↓
34	Chile	69,93	29	77,67	52	↓
35	China	43	118	65,1	109	↑
36	Colombia	50,77	85	75,93	57	↑
37	Comoros	31,39	153	49,2	152	↑

38	Congo	39,44	130	59,56	128	↑
39	Costa Rica	58,53	54	80,03	42	↑
40	Cote d'Ivoire	39,72	129	59,89	127	↑
41	Croatia	62,23	45	86,98	15	↑
42	Cuba	55,07	64	79,04	45	↑
43	Cyprus	66,23	38	80,24	40	↓
44	Czech Republic	81,47	5	84,67	27	↓
45	Dem. Rep. Congo	25,01	170	42,05	171	↓
46	Denmark	76,92	13	89,21	4	↑
47	Djibouti	28,52	161	45,29	164	↓
48	Dominica	47,08	102	73,25	70	↑
49	Dominican Republic	53,24	75	75,32	58	↑
50	Ecuador	58,54	53	66,58	103	↓
51	Egypt	61,11	50	66,45	104	↓
52	El Salvador	43,79	115	68,07	97	↑
53	Equatorial Guinea	41,06	123	69,59	90	↑
54	Eritrea	25,76	168	36,73	179	↓
55	Estonia	74,66	20	88,59	8	↑
56	Ethiopia	39,43	131	45,83	163	↑
57	Fiji	53,08	76	75,29	59	↑
58	Finland	75,72	18	90,68	1	↑
59	France	71,05	27	88,2	10	↑
60	Gabon	46,6	104	67,37	100	↑
61	Gambia	29,3	159	52,09	142	↑
62	Georgia	47,23	101	64,96	111	↓
63	Germany	80,47	6	84,26	30	↓
64	Ghana	32,07	151	58,89	130	↑
65	Greece	73,28	23	85,81	21	↑
66	Grenada	35,24	147	63,28	120	↑
67	Guatemala	48,06	98	69,64	88	↑
68	Guinea	28,03	162	55,4	139	↑
69	Guinea-Bissau	35,98	144	48,2	155	↓
70	Guyana	38,07	137	71,14	75	↑
71	Haiti	19,01	176	43,28	169	↑
72	Honduras	48,87	97	69,64	88	↑
73	Hungary	70,28	28	84,6	28	-
74	Iceland	76,5	14	90,51	2	↑
75	India	31,23	155	53,58	141	↑
76	Indonesia	44,36	112	65,85	107	↑
77	Iran	51,08	83	66,32	105	↓
78	Iraq	33,39	149	63,97	116	↑
79	Ireland	74,67	19	86,6	19	-

80	Israel	65,78	39	78,14	49	↓
81	Italy	74,36	22	84,48	29	↓
82	Jamaica	58,26	55	77,02	54	↑
83	Japan	72,35	26	80,59	39	↓
84	Jordan	55,78	60	72,24	74	↓
85	Kazakhstan	51,07	84	73,29	69	↑
86	Kenya	36,99	140	62,49	123	↑
87	Kiribati	55,82	59	60,48	125	↓
88	Kuwait	63,94	42	64,41	113	↓
89	Kyrgyzstan	40,63	125	73,13	71	↑
90	Laos	40,37	127	50,29	148	↓
91	Latvia	64,05	40	85,71	22	↑
92	Lebanon	50,15	91	69,14	94	↓
93	Lesotho	20,81	175	47,17	157	↑
94	Liberia	23,95	172	43,42	167	↑
95	Libya	42,72	120	63,29	119	↑
96	Lithuania	61,26	49	85,49	23	↑
97	Luxembourg	83,29	2	86,58	20	↓
98	Madagascar	26,7	166	37,1	178	↓
99	Malawi	40,06	128	49,69	151	↓
100	Malaysia	59,31	51	74,23	63	↓
101	Maldives			57,1	137	
102	Mali	18,43	177	41,48	174	↑
103	Malta	67,42	34	88,48	9	↑
104	Mauritania	27,19	165	46,31	160	↑
105	Mauritius	58,09	56	70,85	77	↓
106	Mexico	55,03	65	73,59	67	↓
107	Moldova	53,36	74	76,69	55	↑
108	Mongolia	44,67	111	64,39	114	↓
109	Montenegro	55,52	62	78,89	47	↑
110	Morocco	51,89	81	74,18	64	↑
111	Mozambique	29,97	158	41,82	172	↓
112	Myanmar	27,44	164	48,98	153	↑
113	Namibia	43,71	116	70,84	78	↑
114	Nepal	37	139	50,21	149	↓
115	Netherlands	77,75	11	82,03	36	↓
116	New Zealand	76,41	16	88	11	↑
117	Nicaragua	50,32	90	64,19	115	↓
118	Niger	36,28	142	37,48	177	↓
119	Nigeria	39,2	134	58,27	133	↑
120	Norway	78,04	10	86,9	17	↓
121	Oman	47,75	99	60,13	126	↓

122	Pakistan	34,58	148	51,42	144	↑
123	Palau	51,96	80			
124	Panama	56,84	58	78	51	↑
125	Papua New Guinea	41,09	122	48,02	156	↓
126	Paraguay	39,25	133	70,36	82	↑
127	Peru	45,05	110	72,95	73	↑
128	Philippines	44,02	114	73,7	66	↑
129	Poland	69,53	30	81,26	38	↓
130	Portugal	75,8	17	88,63	7	↑
131	Qatar	63,03	44	69,94	87	↓
132	Romania	50,52	86	83,24	34	↑
133	Russia	53,45	73	83,52	32	↑
134	Rwanda	35,41	146	50,34	147	↓
135	Samoa			70,2	85	
136	Sao Tome and Principe			48,28	154	
137	Saudi Arabia	66,66	35	68,63	95	↓
138	Senegal	40,83	124	63,73	117	↑
139	Serbia	69,13	31	78,67	48	↓
140	Seychelles	55,56	61	64,92	112	↓
141	Sierra Leone	21,74	173	45,98	162	↑
142	Singapore	81,78	4	87,04	14	↓
143	Slovakia	74,45	21	85,42	24	↓
144	Slovenia	76,43	15	88,98	5	↑
145	Solomon Islands	31,63	152	46,92	158	↓
146	Somalia	15,47	178	27,66	180	↓
147	South Africa	53,51	72	70,52	81	↓
148	South Korea	63,79	43	70,61	80	↓
149	Spain	79,79	7	88,91	6	↑
150	Sri Lanka	53,88	69	65,55	108	↓
151	Sudan	24,64	171	42,25	170	↑
152	Suriname	53,57	71	68,58	96	↓
153	Swaziland	37,35	138	60,63	124	↑
154	Sweden	78,09	9	90,43	3	↑
155	Switzerland	87,67	1	86,93	16	↓
156	Syria	54,5	68	66,91	101	↓
157	Taiwan	62,18	46	74,88	60	↓
158	Tajikistan	31,34	154	73,05	72	↑
159	Tanzania	36,19	143	58,34	132	↑
160	Thailand	52,83	78	69,54	91	↓
161	Timor-Leste	39,41	132	55,79	138	↓
162	Togo	27,91	163	46,1	161	↑
163	Tonga	61,68	47	66,86	102	↓

164	Trinidad and Tobago	52,28	79	74,34	62	↑
165	Tunisia	58,99	52	77,28	53	↓
166	Turkey	54,91	66	67,68	99	↓
167	Turkmenistan	45,07	109	70,24	84	↑
168	Uganda	39,18	135	57,56	135	-
169	Ukraine	49,01	95	79,69	44	↑
170	United Arab Emirates	72,91	25	69,35	92	↓
171	United Kingdom	77,35	12	87,38	12	-
172	USA	67,52	33	84,72	26	↑
173	Uruguay	53,61	70	73,98	65	↑
174	Uzbekistan	43,23	117	63,67	118	↓
175	Vanuatu	45,88	106	57,74	134	↓
176	Venezuela	57,8	57	76,23	56	↑
177	Viet Nam	38,17	136	58,5	131	↑
178	Yemen	30,16	157	49,79	150	↑
179	Zambia	41,72	121	66,06	106	↑
180	Zimbabwe	49,54	94	59,25	129	↓