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Eco-Innovativeness of European Union Member Countries in the Light of Public Sector Innovation

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ABSTRACT

XXI century stand out progressive processes of globalization, changing socio-economic conditions, degradation of natural environment and leveling of this problem. One of the major challenges faced by the economies of the progressive degradation of the environment. Important prove innovations, namely eco-innovations, which carry a lot of valuable ideas and solutions with one hand, meet the constantly changing demands of customers and constantly progressive degradation of the environment.

The purpose of article is to emphasize the essence of what eco-innovation play in the contemporary world and analyze of eco-innovativeness of European Union member countries. Some of the attention will also be devoted to accentuating the worthy to follow, activities of innovation leaders in this field.

Eco-innovation analysis was done using one of the tools - the Hellwig model. It should be added that the creation of the innovative capacity of a national economy is conditioned by many determinants. Among them an important place is human capital and investment.

Key words: eco-innovation, eco-innovativeness, European Union, public sector innovation

Introduction

XXI century stand out progressive processes of globalization, changing socio-economic conditions, degradation of natural environment and leveling of this problem. To persevere in this turbulent environment, the regions, the economy, functioning of these entities and governments must demonstrate a continuous vigilance and flexibility to what chances, and refrain from attacking from everywhere dangers.

Innovations today are ubiquitous and the same range of attempts to define oh notion is extremely broad. Worth mentioning is the precursor of innovation approach, which introduced them to the concept of economic sciences, J. Schumpeter. In his opinion, innovation is the introduction of a new product, modifying existing, introduction of new production methods, obtaining new sources and opportunities to use intact so far areas and markets, or new ways of organizing business. (Schumpeter, 1932, p. 66)

Innovations are ubiquitous today and the frequency of innovation activity is rising in both the private and the public sectors. Unlike the public finance sector, the private sector has already been fairly in-depth in terms of innovation. The situation is definitely different in the case of the public sector and worth to analyse it depper.

One of the challenges of the 21st century is the progressive degradation of the environment. For this reason, the aim of this article will be to try to identify the eco-innovativeness of EU Member States, using the annual reports produced by, among others, the World Bank, the Global Innovation Index, Eurostat or the Global Competitiveness Index of the World Economic Forum.

Ecoinnovation analysis was done using one of the tools - the Hellwig model. It should be added that the creation of the innovative capacity of a national economy is conditioned by many determinants. Among them an important place is human capital and investment.

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1. The essence of public sector innovation and eco-innovativeness

Innovations are present today practically at every level of life and are an important solution to many of the problems and challenges of the modern world. They are sort of an "idea for a better tomorrow".

It is not only firms who innovate; public sector entities also innovate by introducing new approaches to provide quality public services and better respond to society's needs. The public sector includes all public corporations and general government at central, state and local levels. Its duties cover administration, ensuring public order and safety, education, health and social care, and a variety of other functions for citizens and business. (*Public Sector Innovation …*)

In the midst of a fragile economic recovery across the European continent and stressed public finances, many governments are faced with long-term issues such as ageing societies, mounting social security and healthcare costs, high youth unemployment and an outdated public service infrastructure that lags behind the needs of modern citizens and businesses. The ICT driven explosion of new business models, geographical dispersion of production and social media are also challenging the way governments operate and, above all, how they are perceived. (*Powering …*, p. 7)

Innovation is ubiquitous today. In the case of the private sector, the problem seems to be examined very carefully. When it comes to innovation, the public sector, also known as the public finance sector, the situation is somewhat different. In contrast to the private sector, there is no one specific definition of its innovation, but we can find some common aspects in the case of private sector innovation.

The innovativeness of public sector can be identified a number of forms by which innovation may take place within the public sector, either at the service level or at the policy level: (Cunningham, Karakasidou, 2009, p. 1)

- Service level:

- new characteristics or design of service products and production processes;

-new or altered ways of delivering services or interacting with clients or solving tasks;

- new or altered ways in organising or administrating activities;

- new or altered ways of interacting with other organisations and knowledge bases;

- new world views, belief systems, missions and strategies;

- Policy level:

- new or altered policies and policy instruments;

- new or altered ways in organising or administrating activities;

- new or improved ways of interacting with other organisations and knowledge bases;

- new world views, belief systems, missions and strategies.

One of the innovatie way of public sector might be eco-innovation. More precisely, it is environment area, like:

- optimization of energy consumption;
- renewable energy sources;
- reduction of CO2 emissions.

More and more programs and strategies for the development of various business entities, as well as public sector budgets, take into account the area of environmental activity, eco-innovation.

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2. Eco-innovation of European Union member countries

Eco-innovations are all forms of innovation aiming at sustainability by reducing the environmental impact or more efficient and responsible use of natural resources, including energy.

More precisely eco-innovation can be any form of innovation resulting in or aiming at significant and demonstrable progress towards the goal of sustainable development, through reducing impacts on the environment, enhancing resilience to environmental pressures, or achieving a more efficient and responsible use of natural resources. (*Innovatio for …*, p. 2)

In response to the mammoth challenges of the economic crisis, increased demand for natural resources, ageing and globalisation, in 2010 the European Union launched its Europe 2020 strategy to put the EU economy on a sustainable trajectory. The transformational changes proposed in the strategy are underpinned by five headline targets4 and three priority themes, namely smart growth, sustainable growth and inclusive growth. The themes are supported by seven 'Flagship Initiatives'5 that give the framework conditions for action to be taken at both member state and EU level in support of the Europe 2020 objectives. Among these flagship initiatives is 'Innovation Union', which cautions that the major challenges faced by the EU cannot be resolved without a major push towards embracing innovation and research. (Rizos, Behrens, Taranic, 2015**,** pp. 1-2)

The most distinguished types of eco-innovation: (Węgrzyn, 2013, p. 138-148)

- eco-innovation in the field of products and production processes;
- social eco-innovations, such as behavior, consumption habits;
- organizational eco-innovations, for example eco-projects;
- institutional innovation, such as cooperation platforms, informal groups, networks established to address environmental issues;
- eco-innovation marketing, for example eco-labels, eco-packaging.

Ecoinnovation Observatory shows that eco-nnovativeness of the European Union, generally is connected within the framework of implemented projects, the following areas:

construction and structures, food and drink, ecological business, recycling and water**.** It is worth adding that the most popular eco-innovation activity company is this eco-friendly business and recycling.

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Table 1. Eco-innovativeness of EU member countries in 2016

Rank	Country
1	Germany
2	Luxembourg
3	Finland
4	Denmark
5	Sweden
6	United Kingdom
7	Italy
8	Austria
9	Slovenia
10	Czech Republic

Table 1. Eco-innovativeness of EU member countries in 2016 - continued

Rank	Country
11	**France**
12	**Ireland**
13	**Spain**
14	**Greece**
15	**Portugal**
16	**Netherlands**
17	**Lithuania**
18	**Latvia**
19	**Slovakia**
20	**Croatia**
21	**Belgium**
22	**Estonia**
23	**Poland**
24	**Cyprus**
25	**Romania**
26	**Malta**
27	**Hungary**
28	**Bulgaria**

Source: own elaboration on the basis of: *ECO-INNOVATION at the heart of European policies*, https://ec.europa.eu/environment/ecoap/scoreboard_en, 01.10.2017.

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Table 1 shows eco-innovative ranking of EU member countries. Notable eco-innovations introduced in Europe include: vertical farms in the Netherlands (Eindhoven), solar powered ships in Norway, nearly fully self-sufficient city district of Stockholm - Hammarby Sjöstad, energy produced from confiscated narcotics at the incinerator in Ponte Malnome near Rome and many, many others.

3. Analysis of eco-innovativeness of member countries of EU in 2015

Table 2. Eco-innovation indicators (Eco-Innovation Scoreboard 2015)

Indicator type	The dimension of innovation	Indicator number	Indicator
INPUTS	**Eco-innovation inputs**	1.1	Government support measures for R&D in the field of environment and energy [% of GDP
		1.2	R&D employment [% of total employment]
		1.3	The total value of investments in early-stage ecological investments (USD/per capita)
	Eco-innovation activities	2.1	Number of enterprises introducing eco-innovations to improve material efficiency [% of total companies]

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Table 2. Eco-innovation indicators (Eco-Innovation Scoreboard 2015) - continued

Indicator type	The dimension of innovation	Indicator number	Indicator
INPUTS	**Eco-innovation activities**	2.2	Number of enterprises introducing eco-innovations improving energy efficiency [% of total companies]
		2.3	Number of organizations with ISO 14001 certificate
OUTPUTS	**Eco-innovation outputs**	3.1	Patents for eco-innovation
		3.2	Publications about innovation (per mln population)
		3.3	Information about innovation in the media (per numbers of electronic media)
	Resource efficiency outcomes	4.1	Material Efficiency (GDP / consumption of materials in the national economy)
		4.2	Water efficiency (GDP / Water Footprint)
		4.3	Energy efficiency (GDP / energy consumption in the national economy)
		4.4	Greenhouse gas emissions [CO2 / GDP emissions]

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Table 2. Eco-innovation indicators (Eco-Innovation Scoreboard 2015) - continued

Indicator type	The dimension of innovation	Indicator number	Indicator
OUPUTS	**Socio-economic outcomes**	**5.1**	**Export of environmental technology sector production [% of total export value]**
		5.2	**Employment in the environmental technology sector [% of total employment]**
		5.3	**Turns in the industry of environmental technologies**

Source: *ECO-INNOVATION at the heart of European policies*, https://ec.europa.eu/environment/ecoap/scoreboard_en, 04.08.2017.

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Analysis by development pattern (Hellwig):

Table 3. Value of eco-innovation indicators (INPUTS)

Country	**INPUTS**					
	Eco-innovation inputs			**Eco-innovation activities**		
	1.1	1.2	1.3	2.1	2.2	2.3
	STYM	STYM	STYM	STYM	STYM	STYM
(AT) Austria	89,49	129,60	73,82	156,31	160,68	61,68
(BE) Belgium	74,50	120,05	73,79	136,94	163,75	48,59
(BG) Bulgaria	5,44	50,88	0,00	50,53	53,58	108,82
(CY) Cyprus	6,71	36,41	2,24	62,11	70,94	29,71
(CZ) Czech Republic	82,89	103,36	170,30	165,32	172,32	205,78
(DE) Germany	172,06	120,05	801,34	223,24	220,81	42,73
(DK) Denmark	135,73	167,40	16,19	-	-	71,21
(EE) Estonia	145,25	73,94	100,55	159,48	61,53	167,41
(ES) Spain	90,76	91,43	207,83	-	-	133,51

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Table 3. Value of eco-innovation indicators (INPUTS) - continued

Country	INPUTS					
	Eco-innovation inputs			Eco-innovation activities		
	1.1	1.2	1.3	2.1	2.2	2.3
	STYM	STYM	STYM	STYM	STYM	STYM
(FI) Finland	172,06	167,40	66,63	172,81	159,93	124,19
(FR) France	137,29	130,39	0,00	143,26	131,63	56,44
(GR) Greece	58,66	97,00	15,83	-	-	37,25
(HR) Croatia	5,07	50,88	8,48	-	-	100,26
(HU) Hungary	139,84	72,35	3,80	95,13	97,75	101,13
(IE) Ireland	25,32	104,15	801,34	164,98	176,41	64,75
(IT) Italy	91,75	88,25	43,80	71,53	82,02	200,20
(LT) Lithuania	44,00	68,38	16,28	91,77	82,67	107,54
(LU) Luxembourg	77,78	163,78	76,86	139,23	148,86	57,02
(LV) Latvia	59,07	51,68	18,47	50,53	53,58	74,72
(MT) Malta	5,07	69,17	0,00	88,82	94,12	31,58
(NL) Netherlands	64,86	118,46	14,92	79,09	88,07	64,14
(PL) Poland	63,70	52,47	2,80	67,71	65,91	29,71
(PT) Portugal	149,06	83,48	4,54	223,24	220,81	56,72
(RO) Romania	79,18	36,41	0,00	107,73	101,75	205,78
(SE) Sweden	137,21	139,14	86,45	133,08	142,81	185,22
(SI) Slovenia	93,12	128,80	0,00	-	-	92,32
(SK) Slovakia	53,86	58,83	0,00	75,23	79,50	149,30
(UK) United Kingdom	78,67	100,97	198,56	-	-	116,09

Source: own elaboration.

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Table 4. Value of eco-innovation indicators (OUTPUTS)

Country	OUTPUTS									
	Eco-innovation outputs			Resource efficiency outcomes				Socio-economic outcomes		
	3.1	3.2	3.3	4.1	4.2	4.3	4.4	5.1	5.2	5.3
	STYM	STYM	STYM	STYM	STYM	STYM	DEST	STYM	STYM	STYM
(AT) Austria	160,61	150,99	94,92	79,85	119,82	105,61	121,90	117,55	68,34	33,27
(BE) Belgium	42,71	108,03	181,21	115,81	95,96	83,68	98,08	55,42	71,32	85,03
(BG) Bulgaria	16,06	26,38	39,99	35,24	28,53	63,98	55,07	23,46	100,44	119,48
(CY) Cyprus	8,56	237,52	150,13	75,30	48,72	104,62	79,62	17,41	14,56	17,80
(CZ) Czech Republic	45,15	78,13	18,86	72,29	67,44	65,43	57,67	99,21	183,40	159,36
(DE) Germany	230,37	88,08	101,40	105,07	123,10	103,90	95,31	147,47	50,14	64,27
(DK) Denmark	195,60	227,17	49,68	80,19	116,58	120,78	113,11	141,95	54,64	61,69
(EE) Estonia	16,23	122,02	19,91	33,96	41,90	59,30	55,07	49,63	131,52	120,03
(ES) Spain	45,65	101,44	160,00	148,98	59,40	117,99	120,63	53,10	136,79	126,36
(FI) Finland	230,37	284,32	56,14	43,22	119,20	59,30	85,56	100,84	143,00	116,78
(FR) France	164,80	66,54	92,90	121,61	96,72	89,43	126,22	101,72	181,80	129,97
(GR) Greece	38,24	141,86	123,54	81,38	53,52	107,99	69,83	34,02	74,47	74,15
(HR) Croatia	18,87	85,79	162,44	81,40	45,33	99,65	93,74	48,76	-	-
(HU) Hungary	8,56	54,39	18,86	87,57	35,84	98,03	102,26	112,83	162,89	102,07
(IE) Ireland	25,66	146,16	22,12	64,30	140,41	125,45	87,75	41,05	94,35	53,35
(IT) Italy	53,54	107,80	189,23	147,28	73,33	120,65	121,74	105,80	101,45	96,36
(LT) Lithuania	17,01	69,23	89,58	63,18	42,68	118,81	97,79	52,06	110,98	97,53
(LU) Luxembourg	141,87	284,32	189,23	170,47	137,28	103,29	114,80	147,47	14,56	17,80
(LV) Latvia	64,53	120,33	99,58	43,06	32,59	94,95	109,14	50,54	125,03	151,22
(MT) Malta	12,88	26,38	124,72	116,77	55,24	125,45	118,96	17,41	-	74,42

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(NL) Netherlands	65,33	144,21	108,65	170,47	131,92	98,92	96,45	70,97	93,94	159,36

Table 4. Value of eco-innovation indicators (OUTPUTS) - continued

Country	OUTPUTS									
	Eco-innovation outputs			Resource efficiency outcomes				Socio-economic outcomes		
	3.1	3.2	3.3	4.1	4.2	4.3	4.4	5.1	5.2	5.3
	STYM	STYM	STYM	STYM	STYM	STYM	DEST	STYM	STYM	STYM
(PL) Poland	71,07	32,65	71,60	53,14	50,76	86,84	58,90	84,65	33,67	111,37
(PT) Portugal	15,98	182,41	50,54	71,74	47,01	116,16	107,58	60,70	118,31	116,64
(RO) Romania	34,26	56,04	70,13	33,96	28,53	107,64	86,64	54,56	168,65	136,40
(SE) Sweden	170,23	269,56	39,43	74,74	128,72	79,85	126,22	88,53	93,43	97,20
(SI) Slovenia	55,47	182,77	55,49	90,67	60,35	77,22	83,25	87,28	183,40	155,87
(SK) Slovakia	14,10	93,50	46,92	89,46	59,49	80,08	83,96	50,15	105,95	106,00
(UK) United Kingdom	56,93	113,72	50,23	152,62	140,41	107,09	105,19	104,51	72,24	84,92

Source: own elaboration.

The ordering of n objects of Oi (i = 1.5, ..., n), which are characterized by m features, is ordered. Characteristic values (Xj) in the examined group of objects are standardized according to the formula:

$$z_{i,j} = \frac{x_{i,j} - \overline{x_j}}{S_j}$$

Wherein:

$\overline{x_j}$ - arithmetic mean of the j- characteristic

S_j - standard deviation j-characteristic

Then the abstract object (development pattern) with coordinates (z01, z02, ..., z0m) is defined, where:

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$z_{0j} = \max_i z_{i,j}$ - for stimulant

$z_{0j} = \min_i z_{i,j}$ - for destimulant

In the next step, the similarity of objects to the pattern is calculated by calculating the Euclidean distances in accordance with the formula:

$$D_{i,0} = \sqrt{\sum_{j=1}^{m} (z_{i,j} - z_{0j})^2}$$

Then the value of the synthetic measure is determined:

$$d_i = 1 - \frac{D_{i0}}{D_0}$$

Wherein:

$$D_0 = \overline{D_0} + 2S_0$$

$$\overline{D_0} = \frac{1}{n}\sum_{i=1}^{n} D_{i0}$$

$$S_0 = \sqrt{\frac{1}{n}\sum_{j=1}^{m} \left(D_{i0} - \overline{D_0}\right)^2}$$

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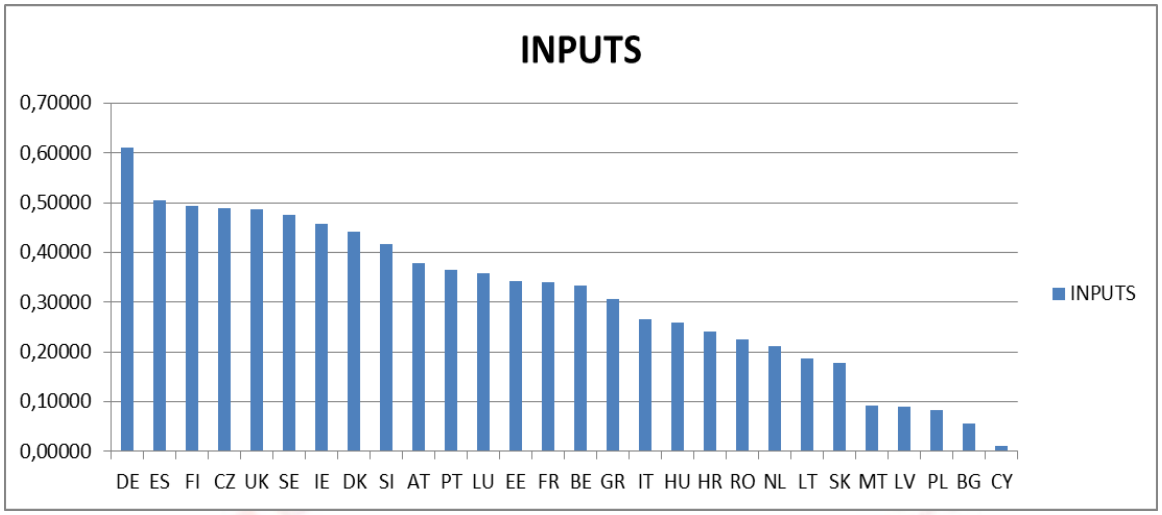

Figure 1. Ordering EU countries on the basis of INPUTS indicators

Source: own elaboration.

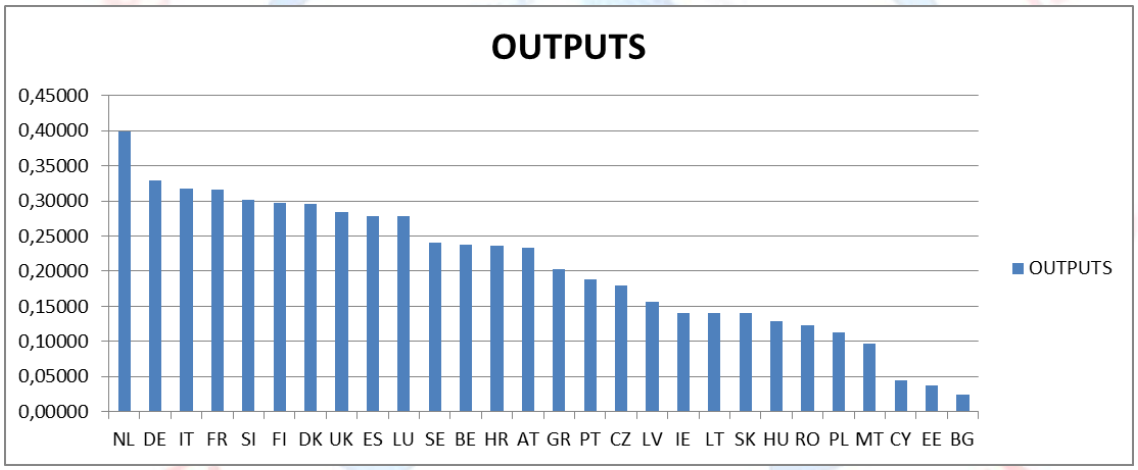

Figure 2. Organizing EU countries on the basis of indicators from the OUTPUTS group

Source: own elaboration.

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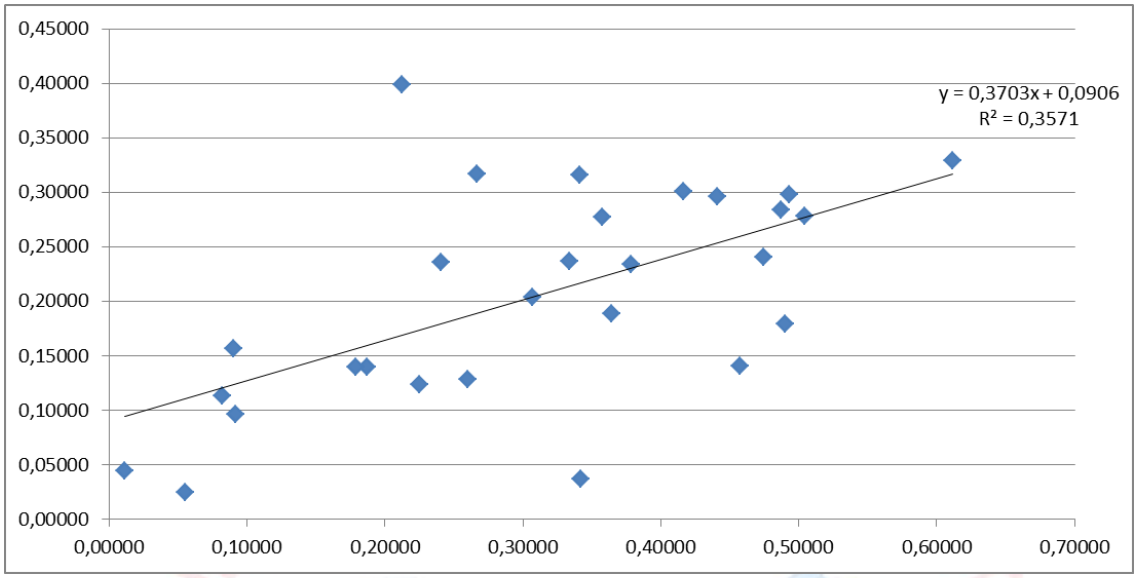

Figure 3. Dependence of synthetic measures in INPUTS and OUTPUTS groups

Source: own elaboration.

Table 5. Dependence of synthetic measures in INPUTS and OUTPUTS groups – continued

Correlation factor r = 0,5975			
Guilford's scale		Stanisz's scale	
0<r≤0,2	poor correlation	r=0	no correlation
0,2<r≤0,4	low correlation	0<r≤0,1	little correlation
0,4<r≤0,7	moderate correlation	0,1<r≤0,3	poor correlation
0,7<r≤0,9	high correlation	0,3<r≤0,5	average correlation
0,9<r≤1	very high correlation	0,5<r≤0,7	high correlation
		0,7<r≤0,9	very high correlation
		0,9<r≤1	correlation is almost certain

Source: own elaboration.

Attempt to interpret**:**

- shortcomings in the interrelation of the range of indicators between the INPUTS and OUTPUTS groups

=> efects measured with indicators from the OUTPUTS group do not depend directly on inputs in the INPUTS range

=> need to improve the set of indicators

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- disproportionate state of achievement of individual countries measured by individual indicators in the INPUTS and OUTPUTS groups

  => The need for a proper adjustment of the policy of some countries to promote eco-innovation

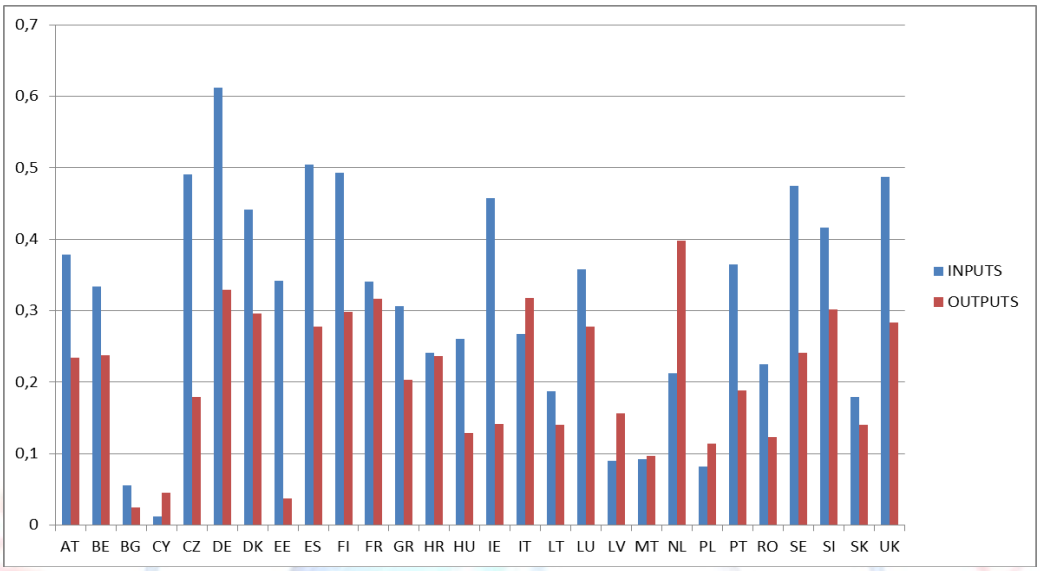

Figure 4. A comprehensive illustration of synthetic measures for INPUTS and OUTPUTS

Source: own elaboration.

The biggest disparities with respect to the rest:

- CZ, EE, IE (INPUTS => OUTPUTS)
- NL (OUTPUTS => INPUTS)

Classification of EU states in terms of innovation level

== > based on synthetic measures

partition scheme based on arithmetic mean and standard deviation:

group 1: innovation leaders $\bar{d} + S_d > d_i \geq \bar{d}$

group 2: good eco-innovators $\bar{d} + S_d > d_i \geq \bar{d}$

group 3: weak eco-innovators $\bar{d} > d_i \geq \bar{d} - S_d$

group 4: eco-innovation outsiders $d_i < \bar{d} - S_d$

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where:

$\bar{d}$ average value of synthetic measure

S_d Standard deviation of the synthetic measure

	INPUTS	OUTPUTS
Group I	**CZ, DE, ES, FI, SE, UK**	**DE, FR, IT, NL**
Group II	**AT. BE, DK, EE, FR, IE, LU, PT, SI**	**AT, BE, DK, ES, FI, GR, HR, LU, SE, SI, UK**
Group III	**GR, HR, HU, IT, LT, NL, RO, SK**	**CZ, HU, IE, LT, LV, PL, PT, RO, SK**
Group IV	**BG, CY, LV, MT, PL**	**BG, CY, EE, MT**

Legend:

Grading of INPUTS and OUTPUTS

Slight discrepancy in inputs and outputs

High level of discrepancies in inputs and outputs

Conclusions

It is obvious that innovation are very important motor strength. Bearing in mind the above results you will notice that due to the problems and challenges of the modern world, innovations of all kinds are becoming increasingly important. Among them increased attention (especially in the EU Member States) is attributed to eco-innovations.

The Eco-Innovation Scoreboard can be a useful tool in monitoring eco-innovation and policy-making. Analysis of eco-innovation in the EU Member States, broken down by INPUTS (measures/outlays) and OUTPUTS (effects), showed that the actions/outlays undertaken in all countries do not adequately reflect the effects.

On the one hand - this indicates the need for necessary adjustments to some countries' policies in support of eco-innovation. On the other hand, this can also be seen as a signal indicating the need for a proper modification of the set of indicators for monitoring the level of eco-innovation.

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