WHAT IS THE PROGRESS OF EU CIRCULAR ECONOMIES?

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Abstract
Circular economy is becoming an increasing concern for specialists due to the benefits it can have upon the environment and people. Although there are no well-defined indicators according to which the progress of a circular economy can be quantified, there is more and more concern in the specialised literature. This paper attempts to measure such progress within the EU member states via an aggregate indicator based on the indicators ones issued by the Eurostat in the EC monitoring framework. The indicator has been determined in two variants: one where the states missing some statistical data have been removed and another where the zero value has been attributed to all circumstances of unavailable data. The different determination methods have revealed different values of the circular economy aggregate indicator as well as different approaches of the states.

Key words: *circular economy, circular economy aggregate indicator, linear economy, progress, ranking*

JEL Classification: *F63, F64, O44, Q01, Q56*

I. INTRODUCTION

Nowadays, the scarceness of resources is becoming more intensely obvious. At the same time, it is becoming ever more understandable that people must live in harmony with nature. This is compulsory for the present which is marked by large ecological imbalances caused by the exaggerated use of resources in the perpetual struggle to obtain the highest profits. Man's alterations of nature, human activities in general have caused over time a lot of natural disasters and climate change, biodiversity decrease, environment pollution and the reduction of many natural resources. All those have led to the need to find solutions to protect the environment, to use natural resources more efficiently, to ensure sustainable development and to change the ways of approaching production and consumption systems.

The theoretical debates regarding circular economy (CE) are extremely numerous and ample in specialised literature. Yet, the attention of specialists is increasingly drawn by practical issues regarding measuring CE, including through certain attempts to build a specific synthetic indicator. It is extremely useful when it comes to knowing the progress of a CE implementation process or when resorting to international hierarchies or comparisons.

Although there is currently no set of functional CE indicators (Căutișanu, et al., 2018), an increasing number of attempts (theoretical and practical) to build an aggregate indicator at micro-, meso- and macroeconomic levels have been noticed lately. To many authors, both sustainable development and CE aim at the same (economic, social, environmental) dimensions meaning that some indicators of sustainable development are also indicators of the CE.

Azevedo, Godina, and Oliveira Matias (2017) developed a theoretical approach to building a circularity index at microeconomic level for manufacturing companies. Additionally, at the same microeconomic level, Yi and Liu (2016) presented an example of a composite indicator of circularity for construction companies.

Domestically, regarding the mesoeconomic level, Strat, Teodor and Săseanu (2018) built an aggregate indicator of Romanian counties in order to identify the areas where resources need to be focused for the development of a CE and for identifying good practice elements adapted to local specificity. Still in the autochthonous specialised literature, there is the work of Căutișanu and others (2018) where they analysed the CE issue at the macroeconomic level, thus building their own system of indicators in order to carry out a quantitative analysis of CE for the OECD countries.

Another macroeconomic approach of CE was conducted by D. Mitrovic (2018) who laid down an aggregate CE indicator, ranking EU member states in relation to three sub-indicators: Sustainable Resource Management Indicator, Societal Behaviour Indicator and Business Operations Indicator. The author used the

DEA (Data Envelopment Analysis) methodology and the results ranked the countries in the following order: Luxembourg, Finland, Sweden and Germany.

A further ranking of circular economies at EU level was conducted by the Politico publication in 2018 based on a synthetic indicator calculated as an arithmetic mean of 7 indicators (municipal waste, food waste; municipal recycling rate; the share of recyclable materials in new goods sold; material re-use rate, number of CE-related patents and CE sector investment). According to the analysis, Germany, the UK and France ranked high with the most robust recycling systems and a high innovation degree in the CE sectors in the EU. Nevertheless, the analysis mentions that the states ranking high are not the "greenest" as the practices of reducing the impact upon health or the environment do not necessarily contribute in economy circularity (http://cursdeguvernare.ro/).

The purpose of the present paper was to build an aggregate CE indicator (CEAI) based on the series of indicators issued by the EUROSTAT in its monitoring framework (even if the indicators do not fully cover all aspects of a CE). In order to track possible progress/regression, the calculations were made for four years (2010, 2012, 2014, 2016), the selection being made according to the criterion: the most statistical data available for the entire series of indicators. We also aimed to see if there are significant differences in the final ranking due to the two different ways of calculating the CEAI, namely if there are differences between our ranking and the similar rankings made for the EU.

The paper is made up of three parts: the first is aimed at bringing some theoretical CE issues to the reader's attention also trying to highlight the disadvantages of a linear economy, that is, the advantages of a CE; the second one presents the methodology and the results obtained in building the CEAI, and the last one includes the main conclusions of the paper.

II. CIRCULAR VS. LINEAR MODEL

In recent years, specialised literature has been increasingly debating the issue of CE, a term attributed to an economic model arising from the ecological imbalances during the last decades. Specialists' warnings on the need to move to a CE model are not very recent. Environmental economist Boulding introduced in 1966 the concept of a circular system economy regarded as a prerequisite for man's survival on earth. Geissdoerfer et al. showed that certain specialists (Andersen, 2007; Su et al. 2013; Ghiselinni et al. 2016) believe that Boulding's idea was taken over later in 1990 by economists Pearce and Turner. The latter explained at that time the need to move from a traditional economic system to a circular one as a result of the thermodynamic law.

Climate, economic and social changes generated as a result of the interaction of human activities with the environment have attracted the attention of many specialists in different fields over the years (Ghența & Matei, 2018). Although many of the theoretical and practical approaches are different, many authors argue that the CE must be implemented at both microeconomic, mesoeconomic and macroeconomic levels (Yuan et al., 2006; Geng & Doberstein, 2008; Banaitė, 2016). Basically, a CE is based on reducing the consumption of natural resources, increasing their use efficiency (Ghiselinni et al., 2016; Ness, 2008), applying the three principles (3 R's): re-use, recycling and reduction of waste.

Through a CE, humanity actually turns towards nature, getting inspiration from it, imitating processes that occur in the natural environment, where few resources are wasted and most are recovered by other species (Geng & Doberstein, 2008). At the same time, according to some specialists, a CE is an implementation model of the sustainable development concept (Zhu & Qiu, 2007; Geldron, 2014), an instrument (Sauve et al., 2016) and also a strategy of sustainable development (Mihai et al., 2018).

The reasons for moving from a linear economy (LE) to a CE are multiple. Yet, it is sufficient to address only the main drawbacks of LE, namely the main advantages of CE.

Thus, the most significant drawbacks of LE, as reported in specialised literature and beyond, are the following:

- LE matches the pattern of "take-produce-consume-throw" (CIRAIG, 2015; Lakatos et al. 2017; Câmpeanu, 2016);
- LE requires the use of large quantities of raw materials, energy (Banaitė, 2016) and depleting resources (Ellen MacArthur Foundation, 2013);
- LE requires a lesser use of renewable resources;
- LE is a model of economic development which is not environment-friendly, based on an excessive consumption of natural resources that does not allow the regeneration thereof in sufficient quantities (faster depletion of natural resources);
- LE places pressure on the resources, the environment and the planet (AEM, 2015; Orțan et al., 2016);
- LE involves scheduling the wear and tear - conceiving finished products with a limited lifetime in order to encourage the purchase of new products (www.europarl.europa.eu);
- Within the LE, resources leave the economic flow when they reach the end of their lifetime (Lakatos et al., 2017);

- LE is based on the generation of waste going to landfills or getting burnt;
- LE determines the volatility of resource prices (Ellen MacArthur Foundation, 2013; Câmpeanu, 2016);
- LE generates the increase of some resource-poor countries' dependency (Câmpeanu, 2016) on countries having a surplus of natural resources;
- LE leads to decreased competitiveness of dependent countries;
- LE causes the pollution of the environment due to the extraction and processing of raw materials as well as to the storage of waste in increasing quantities;
- LE produces climate changes (Câmpeanu, 2016).

Unlike LE, CE means:

- an alternative to the neoclassical/current economy (Strat et al.; 2018; Planing, 2015; Steffen, 2015);
- a new environment-friendly economic model that can ensure sustainable development (Zhu & Qiu, 2007; Geldron, 2014);
- protecting the environment by better waste management and reducing carbon emissions;
- reducing pressures on the resources and the environment (Andersen, 2007; Ellen MacArthur Foundation, 2013);
- decreasing the volatility of resource prices on the world market;
- prolonging the lifetime of products and natural resources by means of recycling, re-use, reprocessing (Comisia Europeană, 2014);
- turning waste into raw materials (Preston, 2012; Park & Chertow, 2014) and improving the security of raw material supply (Comisia Europeană, 2014);
- creating added value (Comisia Europeană, 2015; Lakatos et al., 2017);
- reducing production costs through waste prevention and recycling, ecological design, re-use (Ellen MacArthur Foundation, 2013; Comisia Europeană, 2015; Câmpeanu, 2016; Vuță et al., 2018);
- lowering the dependency of supplies to countries that do not have enough natural resources (Comisia Europeană, 2014);
- obtaining energy from renewable resources (Gallagher, et al. 2017);
- promoting innovations (Orțan et al., 2016) that will allow for the production of more sustainable and innovative products (Comisia Europeană, 2015);
- stimulating consumers' long-term saving process;
- creating new jobs (Stahel, 2016; Wijkman & Skanberg, 2015; Ellen MacArthur Foundation, 2015; WRAP, 2018);
- ensuring green economic growth (Ellen MacArthur Foundation, 2015).

CE has been in the EU's attention for several years now, as this type of economy involves a process by which there is a decoupling of economic growth from resource consumption (Ellen MacArthur Foundantion, CE, 2014; Ghiselinni et al., 2016; Elia at al., 2017; Căutișanu et al., 2018). A series of steps have been laid down aiming at implementing the new production and consumption patterns, covering all the lifecycle stages of a product - product design, material procurement, production and consumption, waste management and the development of secondary raw material market (Strat et al., 2018).

III. METHODOLOGY

In the calculation of the CEAI, we took into account the indicators issued by the EUROSTAT within the CE monitoring framework, grouped in the following areas: 1. production and consumption; 2. waste management; 3. secondary raw materials; 4. competitiveness and innovation.

The CEAI has been set using two different methods of approaching the lack of data: 1) by eliminating countries in such a situation; 2) by assigning the zero value for all unavailable data.

The steps taken while setting the CEAI were: I) selecting the indicators and determining the period under analysis; II) normalisation of indicators; III) aggregation of indicators; IV) CEAI calculation.

The indicators selected for building the CEAI are shown in table no. 1.

Table 1 Indicators in CEAI Calculation

CE Domain	Indicators / Type of Impact on CE	Partial Aggregate Indicators	Domain Aggregate Indicators
1. production and consumption	1.1. municipal waste generated per person / negative 1.2. generated waste, exclusively major mineral waste per unit of gross domestic product / negative 1.3. generated waste, exclusively major mineral waste per domestic material consumption / negative	-	**IA1** (arithmetic mean of indicators 1.1., 1.2. and 1.3)
2. waste management	2.1. municipal waste recycling rate / positive 2.2. total waste recycling rate without major mineral waste / positive	Ia1 (arithmetic mean of indicators 2.1. and 2.2.)	**IA2** (arithmetic mean of partial aggregate indicators Ia1 and Ia2)

	2.3. packaging recycling rate – total / positive 2.4. demolition and construction waste recycling rate / positive 2.5. electrical and electronic equipment waste recycling rate / positive 2.6. biomass recycling / positive	Ia2 (arithmetic mean of indicators 2.3., 2.4., 2.5. and 2.6.)	
3.secondary raw materials	3.1. rate of circular material use / positive 3.2. trade in recyclable raw materials / positive	-	**IA3** (arithmetic mean of indicators 3.1. and 3.2.
4. competitiveness and innovation	4.1. patents related to recycling and secondary raw materials per one million inhabitants / positive	-	**IA4** (arithmetic mean of indicator 4.1 and indicator Ia3)
	4.2. gross investment in tangible goods - percentage of GDP / positive 4.3. people in total employees / positive 4.4 value added to the cost of factors - percentage of GDP / positive	Ia3 (arithmetic mean of indicators 4.2. 4.3 and 4.4.)	
CIRCULAR ECONOMY AGGREGATE INDICATOR (CEAI) **CEAI = (IA1+IA2+IA3+IA4)/4**			

The minimum-maximum method was used to normalise data (Nardo et al., 2005; OECD, 2008; Azevedo, S.G. et al., 2017). When applying the data normalisation formula, the type of indicators was taken into account: positively impacting the CE (optimised by maximising) or negatively impacting the CE (optimised by minimising).

Thus, for positively impacting indicators, the formula used was:

$$I_{i,j}^{t} = \frac{I_{i,j}^{t} - minI_{i,j}^{t}}{maxI_{i,j}^{t} - minI_{i,j}^{t}} \quad (1)$$

where: $I_{i,j}^{t}$ = value of sub-indicator "i" of country "j" at time "t"

$minI_{i,j}^{t}$ = lowest value of sub-indicator "i" after country "j" at time "t"

$maxI_{i,j}^{t}$ = highest value of sub-indicator "i" after country "j" at time "t"

As to negatively impacting indicators, normalisation was based on the formula:

$$I_{i,j}^{t} = \frac{maxI_{i,j}^{t} - I_{i,j}^{t}}{maxI_{i,j}^{t} - minI_{i,j}^{t}} \quad (2)$$

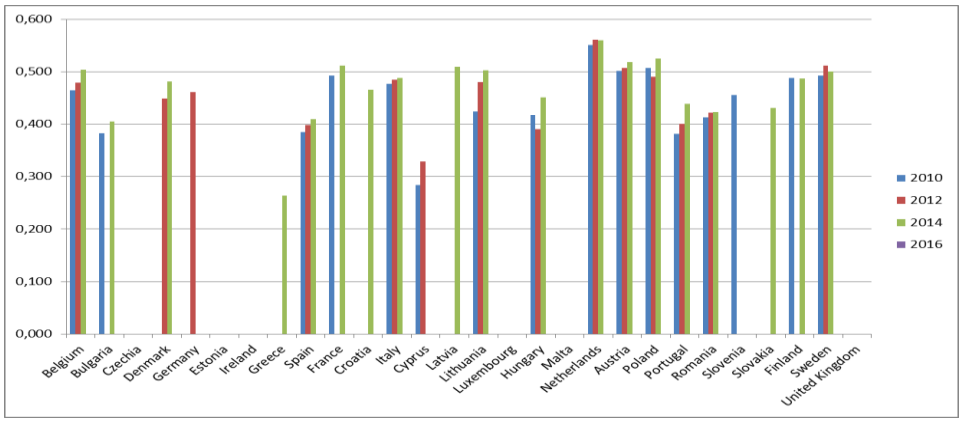
As a result of data normalisation, all indicators ranged between zero and one inclusively. Value 1 corresponded to the most favourable situations (countries with the highest value in terms of positively impacting indicators, namely countries with the lowest value in terms of negatively impacting indicators), while the zero-value corresponded to the least favourable situations (countries with the highest value in terms of negatively impacting indicators, namely, countries with the lowest value in terms of positively impacting indicators).

The arithmetic mean was used to aggregate the data. An aggregate indicator was built for each domain. The mode of aggregating indicators by domains is shown in Table no.1.

IV. RESULTS AND DISCUSSIONS

Following the calculations, the following results were obtained:

I) the situation of missing data



Graph 1. EU CEAI: Years 2010, 2012, 2014, 2016 (own calculations based on Eurostat data)

As shown in Graph 1, the unavailability of certain data has not allowed for the setting of all aggregate indicators by domains, namely of the CEAI, for each year and for each country. Additionally, data not available for all member states related to the year 2016 as to the "recycling and secondary raw material patents per 1 million inhabitants" indicator has made it impossible to measure the CEAI. This explains the lack of columns and values for 2016 for all member states both in Graph 1 and Table 2. The centralised status of the EU member states' ranking is shown in the table below:

Table 2 EU Member States' Ranking in Relation to the CEAI

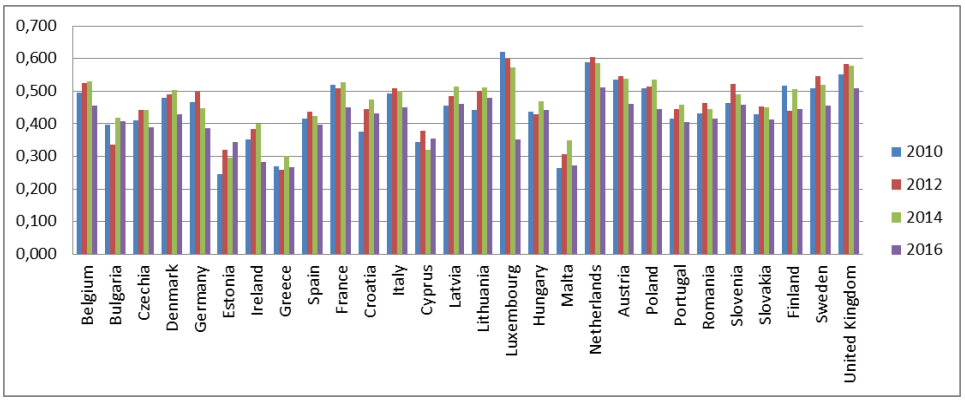
Place	Year 2010		Year 2012		Year 2014	
	Country	CEAI	Country	CEAI	Country	CEAI
1	Netherlands	0.551	Netherlands	0.560	Netherlands	0.559
2	Poland	0.507	Sweden	0.512	Poland	0.525
3	Austria	0.502	Austria	0.508	Austria	0.519
4	France	0.492	Poland	0.491	France	0.511
5	Sweden	0.492	Italy	0.485	Latvia	0.509
6	Finland	0.488	Lithuania	0.480	Belgium	0.504
7	Italy	0.477	Belgium	0.479	Lithuania	0.503
8	Belgium	0.464	Germany	0.461	Sweden	0.501
9	Slovenia	0.456	Denmark	0.449	Italy	0.488
10	Lithuania	0.425	Romania	0.422	Finland	0.487
11	Hungary	0.417	Portugal	0.400	Denmark	0.481
12	Romania	0.413	Spain	0.399	Croatia	0.466
13	Spain	0.385	Hungary	0.390	Hungary	0.451
14	Bulgaria	0.383	Cyprus	0.329	Portugal	0.438
15	Portugal	0.382	:	:	Slovakia	0.430
16	Cyprus	0.284	:	:	Romania	0.423
17	:	:	:	:	Spain	0.410
18	:	:	:	:	Bulgaria	0.405
19	:	:	:	:	Greece	0.264

Source: own calculations based on Eurostat data

The number of countries ranking according to the CEAI was different (Table 2). Only two countries, the Netherlands (I) and Austria (III), managed to keep their ranks in all three years, whereas other countries either rose steadily or dropped. Moreover, the ranking included countries with: fluctuating evolution (Poland, Romania, Spain, Sweden, Italy, Lithuania, Portugal); favourable evolution (Belgium); and unfavourable evolution (Hungary). At the same time, though, in terms of value over the three years, the CEAI grew for countries such as Romania, Portugal, Italy, Spain and Lithuania, that did not lead to a rise of those countries. That is not the case, however, for Belgium and Austria. Just like the aforementioned countries, they also reported increases in CEAI values. Unlike the former, however, Belgium managed to climb the ranking and Austria to hold its position. At the same time, it has also been noticed that there were some countries not appearing in the ranking of each year (France, Finland, Slovenia, Bulgaria, Cyprus, Germany, Denmark, Latvia, Croatia, Greece). The ratio of CEAI values between the first and the last country oscillated, namely 1.94:1 for 2010, 1.70:1 for 2012 and 2.11:1 for 2014.

As it turns out, the final situation in Table 2 does not allow comparisons with similar rankings in the EU, based on other groups of indicators.

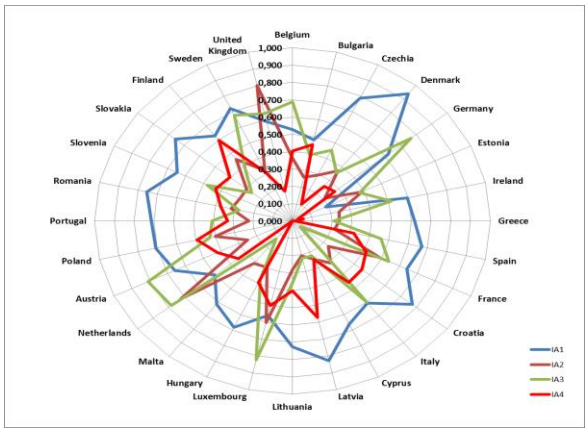
II) the situation of assigning the zero value for unavailable data



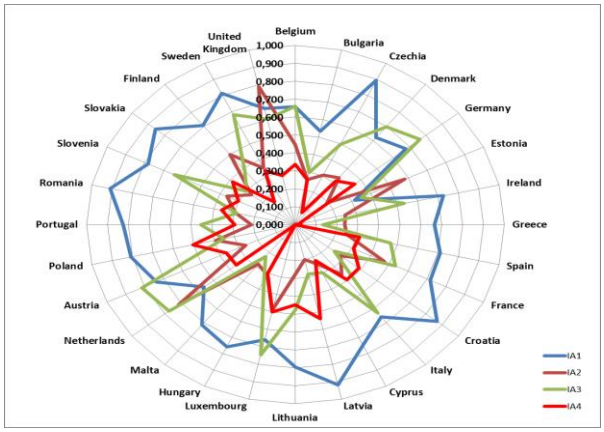
Graph 2. EU CEAI: years 2010, 2012, 2014, 2016 (own calculations based on Eurostat data)

As compared to the previous situation, the picture of the progress/regression reported by the EU member states during the CE implementation is much better outlined. Assigning the zero value for unavailable data has allowed the CEAI to be set for each country as well as for 2016.

The situation of aggregate indicators by domains (IA1, IA2, IA3 and IA4) is shown according to Graphs 3 and 4.

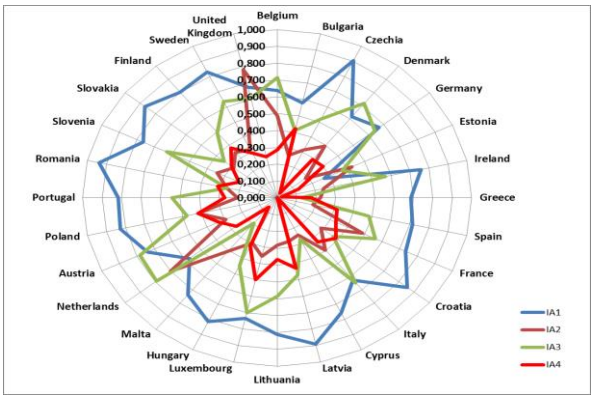


EU - year 2010

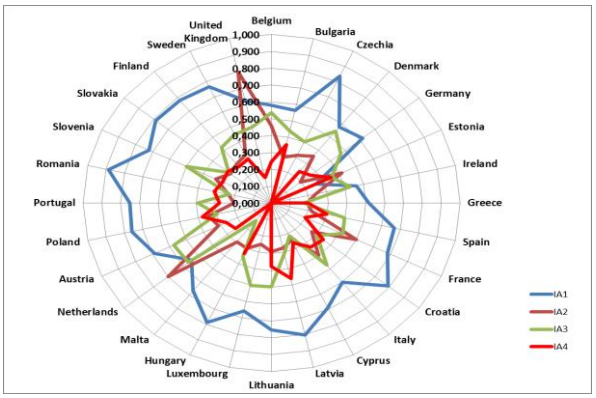


EU - year 2012

Graph 3 Aggregate Indicators by Domains (own calculations based on Eurostat data)



EU - year 2014



EU -year 2016

Graph 4 Aggregate Indicators by Domains (own calculations based on Eurostat data)

A comparison of the final situations in Tables 2 and 3 can show the following differences:

- CEAI values are different and higher in the latter situation. The explanation is based on assigning the zero value that generated higher normalised values for some indicators;
- against the former situation, in the latter, no country was able to rank the same throughout the analysed period;
- unlike the former situation, according to Table 3, in 2010, the Netherlands was not on top of the list and was outranked by Luxembourg. But it managed to top the rankings in the coming years;
- in the second situation, Luxembourg reported the most dramatic decrease in the CEAI, from 0.621 (2010) to 0.353 (2016). As a matter of fact, the country was experiencing a continuous decline in the CEAI.
- the United Kingdom, not present in the previous ranking (Table 2), ranked high in the latest hierarchy (II-III);
- Croatia, Lithuania and Latvia were steadily going up on the list (see Table 3);
- the calculations made based on Table 3 show the reduction of the CEAI ratio gap between the country ranking first and the one ranking last. It was due to the reduction of the CEAI for the country ranking first, and the rise of the CEAI (except for the year 2016) for the country ranking last. The ratio was: 2.53:1 (2010); 2.33:1 (2012); 1.97:1 (2014) and 1.92:1 (2016).

Table 3 EU Ranking against CEAI (years 2010, 2012, 2014 and 2016)

Place	Year 2010		Year 2012		Year 2014		Year 2016	
	Country	CEAI	Country	CEAI	Country	CEAI	Country	CEAI
1	Luxembourg	0.621	Netherlands	0.603	Netherlands	0.585	Netherlands	0.513
2	Netherlands	0.590	Luxembourg	0.599	United Kingdom	0.578	United Kingdom	0.509
3	United Kingdom	0.551	United Kingdom	0.584	Luxembourg	0.572	Lithuania	0.479
4	Austria	0.535	Austria	0.546	Austria	0.538	Latvia	0.461
5	France	0.521	Sweden	0.545	Poland	0.535	Austria	0.460
6	Finland	0.516	Belgium	0.526	Belgium	0.530	Slovenia	0.459
7	Sweden	0.508	Slovenia	0.523	France	0.528	Sweden	0.456
8	Poland	0.508	Poland	0.513	Sweden	0.520	Belgium	0.455
9	Belgium	0.496	Italy	0.510	Latvia	0.514	Italy	0.451
10	Italy	0.493	France	0.508	Lithuania	0.510	France	0.450
11	Denmark	0.480	Lithuania	0.500	Finland	0.505	Poland	0.444
12	Germany	0.467	Germany	0.499	Denmark	0.505	Finland	0.444
13	Slovenia	0.463	Denmark	0.491	Italy	0.501	Hungary	0.443
14	Latvia	0.457	Latvia	0.485	Slovenia	0.489	Croatia	0.430
15	Lithuania	0.442	Romania	0.463	Croatia	0.474	Denmark	0.429
16	Hungary	0.437	Slovakia	0.452	Hungary	0.470	Romania	0.415
17	Romania	0.431	Portugal	0.444	Portugal	0.458	Slovakia	0.413
18	Slovakia	0.430	Croatia	0.444	Slovakia	0.451	Bulgaria	0.409
19	Portugal	0.417	Czechia	0.443	Germany	0.449	Portugal	0.405
20	Spain	0.416	Finland	0.440	Romania	0.445	Spain	0.396
21	Czechia	0.410	Spain	0.436	Czechia	0.443	Czechia	0.388
22	Bulgaria	0.396	Hungary	0.429	Spain	0.425	Germany	0.387
23	Croatia	0.376	Ireland	0.385	Bulgaria	0.417	Cyprus	0.353
24	Ireland	0.352	Cyprus	0.378	Ireland	0.400	Luxembourg	0.353
25	Cyprus	0.344	Bulgaria	0.337	Malta	0.350	Estonia	0.344
26	Greece	0.268	Estonia	0.319	Cyprus	0.319	Ireland	0.282
27	Malta	0.265	Malta	0.307	Greece	0.302	Malta	0.273
28	Estonia	0.245	Greece	0.259	Estonia	0.296	Greece	0.268

Source: own calculations based on EUROSTAT data

As it was normal, our hierarchical situation differs from other similar ranks, the explanation being the different set of indicators selected to build the CEAI on the one hand, and the analysed period of time on the other. However, there are three countries ranking the same both in the hierarchy conducted by Politico and in ours. They are: Great Britain (ranking 2nd in the Politico top and our top); Belgium (ranking 8th in 2016 in both tops) and Malta (ranking 27th in both tops). It should also be said that our results best rank the Netherlands, not Germany, regarded as the highest-performing CE by the Politico publication. Indeed, according to our results, Germany's best ranking was only the 12th (2010 and 2012). Neither was the Czech Republic in our ranking among the first performing countries, but on the contrary, among the last eight. Moreover, our ranking also confirmed the last countries in the top, namely Greece, Ireland and Cyprus.

V. CONCLUSIONS

CE is only at the dawn of its implementation. There are differences at the EU level regarding the results of the implementation of CE specific steps. It is enough to relate only to the situations of the first and last countries in the ranking. Also, CEAI oscillating developments from one year to another have been noted for some countries, while others have reported positive development. As expected, as a result of the use of different indicators and different periods, there are differences in the ranking of the countries. Under such conditions, three countries still rank the same (Great Britain, Belgium and Malta). Surprisingly, there is also a West European country (Ireland) among the last 5. As far as Romania is concerned, it has experienced a fluctuating evolution of the CEAI, but it managed to rank 15th in 2012.

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