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CLUSTER GROUPING OF EU MEMBER STATES ACCORDING TO SOME ECONOMIC PERFORMANCE AND CIRCULAR ECONOMIC INDICATORS

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Abstract
In the next few years, the EU economy must go through a big change that will lead to a greener and more sustainable Europe. The goal is to use natural resources less, which will help protect biodiversity and cut down on waste, both of which are important parts of being sustainable. The EU Commission has been publishing reports, decisions and plans for the transition to a circular economy since 2015, with the primary aim of helping European countries to make the transition and accelerate progress. In 2020 the European Commission adopted a new Circular Economy Action Plan, and measuring the transition to a circular economy is part of the Sustainable Development Goals (SDGs) under SDG 12, Sustainable Production and Consumption. All EU Member States now aim to monitor their progress towards the SDG targets. After 2017, the problem of measuring the circular economy has also seen a surge in the literature, with an increasing number of experts exploring the issue. The circular economy concept covers many sectors, so it is clear that it cannot be captured by a single indicator. However, each country measures this using different national indicators, depending on the country's weaknesses and what it considers important to measure. Today, the issue of the transition to a circular economy (CE) in the EU has gained momentum. In recent years, the shift towards a circular economy has become increasingly visible in EU Member States. In their statistical records, they try to provide indicators to show the extent of this change. In other words, EU countries are increasingly focusing on measuring their progress at a macro level. At the same time, Member States are using different approaches to measuring sustainable consumption and production, and thus different indicators to measure the circular economy, and the shift towards the circular economy has become more pronounced in both less developed and developed EU Member States. The difference between Member States in this respect lies in their different levels of development and the fact that they have their own strategies and indicators. All the indicators under SDG 12 on achieving sustainable consumption and production measure the achievement of this objective. The difference between countries is that the indicators against which the SDGs are measured are not uniform. The indicators and their corresponding values can be found in the statistical systems of the Member States. The following study brings together the relevant information and aims to provide a general picture of the similarities and differences in this area, and to divide the EU countries into two distinct clusters using the indicators of the circular economy.
KEY WORDS: Circular economy, Indicators, Sustainable production and consumption, SDG, Cluster analysis.
JEL: O52, O57, Q01, Q59

Introduction

Several authors in the literature address the issue of measuring the transition to a circular economy. Moraga and co-authors (2019) and Pascale and co-authors (2021) also deal with the enumeration of circular economy indicators without counting the statistical office records of each country. In this paper, we enumerate sustainable consumption and production indicators from the statistical records of the EU-27 member states, in order to answer which indicators are most common in these countries and what the differences are between countries. Garcia-Bernabeu et al (2020) attempted to rank EU countries' performance using circular economic indicators, whereas in this paper we attempt to group EU countries into two distinct clusters using economic performance and circular indicators.

In the next few years, the EU economy must go through a big change that will lead to a greener and more sustainable Europe. The goal is to use natural resources less, which will help protect biodiversity and cut down on waste, both of which are important parts of being sustainable. In March 2020, the European Commission adopted a new Circular Economy Action Plan (COM, 2020), which forms the basis of the European Green Deal, Europe's sustainable agenda. In addition, the new action plan puts a strong emphasis on initiatives along the whole life cycle of products, from design to consumption and recycling. Promoting sustainable consumption and preventing waste are also very important. Measuring the transition to a circular economy is part of the Sustainable Development Goals (SDGs) under SDG 12, Sustainable Production and Consumption. All EU Member States now aim to monitor their progress towards the SDG targets. However, each country measures this using different national indicators, depending on the country's weaknesses and what it considers important to measure. In terms of measurement, the websites of the statistical offices of each country provide the indicators that the country considers important to examine and publish.

My research serves **a dual purpose**. On the one hand, I want to map, review, and aggregate the indicators for Objective 12 on the websites of the statistical offices of the EU Member States in order to get a comprehensive picture of the national indicators of the Member States that are relevant for the transition to a circular economy. The research question is how the SDG targets are mapped into the statistical systems of each country and how these can be used for EU-wide analysis. In recent years, EU countries have paid increasing attention to indicators at the macro level. Second, after the indicators have been enumerated, I have conducted a cluster analysis using the most commonly reported circular indicators (with 2020 and 2021 data).

The first hypothesis of my research was that the indicators of the circular economy appear in the statistical registers of the EU Member States in a nearly identical way. As a second hypothesis, I tested whether countries with more advanced economic performance also performed better in terms of indicators measuring the circular economy.

Theoretical Background

Several ways have been thought of so far to measure the change to a circular economy. At the moment, there are three main ways to measure the amount of change and progress: focusing on resources and material consumption, keeping track of energy consumption, and switching to a circular process in order to make less waste and find ways to deal with waste (Hoffer, 2021). Measuring progress towards the circular economy at the national level is also an objective set by EU Member States individually. The current, generally accepted understanding is that the extent of the transition to a circular economy can be measured primarily through resource and material use and waste management. Against this background, countries have developed different strategies, sometimes called action plans or roadmaps, to achieve the transition to a circular economy. These were published from 2016 onwards, with different timing from country to country, and most EU countries (with one or two exceptions) have now described concrete steps to take and targets to achieve in the coming period (Hoffer, 2021).

In 2007, the UNEP formulated the Life Cycle Management (LCM) model, which refers to the ability and attitude of economic actors to consider products or services from the design stage, through production, consumption, and use, to disposal, including their link to sustainability (UNEP, 2007). Life cycle management is a way of thinking about business that can provide a basis for companies, public authorities, and government decision-makers to take action for sustainable development and the sustainability of products. This can help, for example, to reduce CO_2 emissions from the production of products or the material and water footprint.

Moraga and co-authors (2019) also consider the classification of indicators in the circular economy, but also find that most indicators focus on measuring the conservation of materials. They classify the indicators they formulate into 4 categories: indicators focusing on functions (1), products and components (2), materials and energy (3), and composite indicators (4) (Moraga et al., 2019). ascale et al. (2021) have compiled a list of indicators used in the literature to measure the circular economy. They classified and analysed 61 CE indicators, categorising and analysing them at three geographical (micro, meso, and macro) levels based on the three dimensions of sustainability (economic, social, and environmental), taking into account the circular framework (3Rs; see below). Elia et al. (2017) have pointed out that, although several attempts to develop CE indicators have been made over the last two decades, the process is still in its infancy. Most studies focus mainly on macro-level analyses, with micro-level analyses being a very small slice of the subject (Elia et al., 2017), which is also a consequence of the complexity of the subject and the lack of methodology. Currently, the macro level is the most analysed area of CE intervention. In some extreme cases, authors equate the circular economy with recycling, but most authors interpret the concept as a combination of reduction, reuse, and recycling, which is best represented by the 3Rs framework (Kirchherr et al., 2017).

The R-frame system is a way to close material circles by loops, or levels. This is done in a hierarchical way. When there are fewer R-levels (lower R-frames), the process is shorter, less outside help is needed to finish it, and the strategy is more circular. Conversely, the more R levels, the less circular the strategy. In the past few years, many authors or pairs of authors have tried to come up with a single sign of a circular economy. Through their research, Saidani and co-authors (2019) and Potting and co-authors (2017) found that it is not easy to make a composite indicator that measures the transition. Interestingly, it is worth highlighting Potting's R-framework, which uses the most, i.e., 10 strategies to increase the circularity: reject, reconsider, reduce, reuse, repair, refurbish, remanufacture, recycle, reuse again, and reclaim (Potting et al., 2017).

Garcia-Bernabeu and co-authors (2020) tried to make a composite indicator of the circular economy, among other things. Their aim was to use the composite indicator to establish a ranking by comparing the performance of EU countries (Garcia-Bernabeu et al., 2020). They emphasise the importance of measuring the transition to a circular economy at the national level, as CE is a key driver of sustainable development, and in this respect, governments can play a crucial role in setting and implementing targets and measures in the future. Here again, we can see the idea, which is also partially reflected later in this article, that the indicators can be divided into 4 broad areas: production and consumption, waste management, secondary raw materials, competitiveness, and innovation.

Kozma et al. (2021) state that mapping the wide range of indicators does not yet give us a clear ranking of the EU Member States, and that it is not easy to rank them by the values obtained. Nonetheless, the aim is to use the indicators to identify the performance of individual Member States in the circular economy.

Methodology

Mapping the indicators of the EU Member States

Figure 1 shows that the indicators for measuring sustainable consumption and production vary a lot across EU Member States, from 2 to 25. The largest number of indicators, 25, is found in the Italian statistics, the smallest in the Croatian statistical statement (2).

Fig. 1. Distribution of sustainable consumption and production indicators by country, editing based on the database created using Tableau Public.

Based on statistical records and their online availability, I aggregated 107 indicators (Table 1). All EU countries except Cyprus and Latvia have statistical registers. Sustainability indicators are available, including indicators for sustainable consumption and production. According to Table 2, the indicators have been classified into six categories based on the literature reviewed. Indicators related to waste collection and treatment top the ranking with 35 indicators. The data also shows which categories each country considers important to measure and which group of indicators is the most relevant for them.

Table 1. Distribution of indicators by type

Indicators by type	Number of indicators	Number of countries, where it appears
Emissions of pollutants	10	9
Material use	19	27
Waste generation and treatment	35	25
Energy use	5	9
Businesses and tourism	30	17
Projects and education	8	8
Total indicators	107	

Source: own data collected and edited from the websites of the statistical offices of the EU Member States.

Figure 2 shows the indicators that are most frequently found in EU country statistics. These indicators come from two categories: waste management and material consumption. The leading indicators are recycling rates and total material consumption.

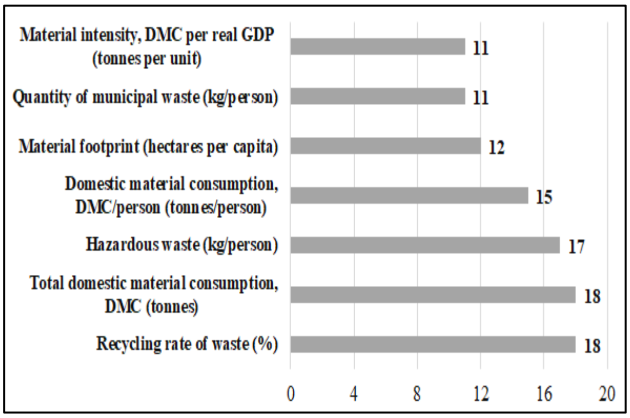

Fig. 2. Frequency of indicators (how many countries have the indicator in their statistics?) Data collected and edited from the websites of the statistical offices of the EU Member States.

Figure 3 clearly shows that in most countries, the majority of indicators focus on measuring material use and waste management. Indicators related to waste management are the least emphasized in Austria, while indicators related to material use are less emphasized in Hungary and Estonia. In Hungary, the indicators measuring emissions of pollutants stand out compared to the other countries, while indicators measuring the activity of companies are emphasized in Austria, Germany, and Italy. The indicators on energy use are dominated by Latvia, while the projects and grants category is most prominent in Croatia.

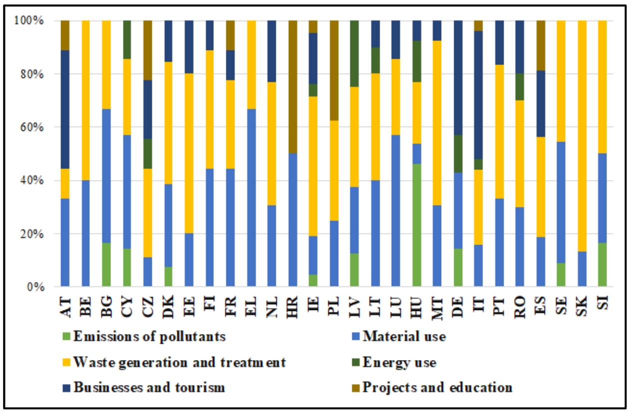

Fig. 3. Distribution of indicator categories in EU Member States. Data collected and edited from the websites of the statistical offices of the EU Member States.

The six groups of indicators are briefly described below.

One of the most important ways to measure the change to a circular economy is through the group of material use indicators. In Environment at a Glance 2020, the OECD summarizes key environmental trends in areas such as climate change, biodiversity, water resources, air quality, and the circular economy. In the circular economy section, indicators measuring resource use, such as resource productivity or domestic material use per capita, also play an important role in this study. The data show a slow downward trend in material use between 1990 and 2017, and the resource productivity of the world economy improved during the period under review, while material intensity decreased significantly (OECD, 2020). Nevertheless, the OECD's Global Material Resources Outlook to 2060 shows that after 2017, global material consumption, as a measure of material use, will increase in the coming years (OECD, 2019). Improving resource efficiency is a very important factor in mitigating global environmental problems (e.g., climate change, biodiversity loss), so systemic thinking and appropriate action by governments are important (Pomázi-Szabó, 2021). Indicators measuring material use and consumption are included in the statistics of all EU countries. In total, there are 19 such indicators, the most common being total domestic material consumption (18 countries), domestic material consumption per capita (15 countries), and ecological footprint (12 countries). Romania has the highest number of indicators in this category (6).

As for the indicators measuring emissions of pollutants, they appear in the statistics of nine countries: Bulgaria, Cyprus, Denmark, Ireland, Latvia, Germany, Hungary, Slovenia, Sweden, and the United Kingdom. Of the 10 indicators, six are reported for Hungary. The most frequently occurring indicator, which appears in 4 countries, is the average CO_2 emissions per kilometre of new passenger cars. Hungary has the most indicators in this category (6). The number of indicators measuring waste generation and treatment is 35, and they are to some extent present in the statistical records of all Member States except Croatia and Germany. The three most frequently occurring indicators are hazardous waste (21 countries), recycling rate (18 countries), and municipal waste (11 countries). The highest number of indicators in this category is found in Slovakia (13) and Ireland (11). Energy use indicators appear in the statistics of nine EU countries: Cyprus, the Czech Republic, and Ireland. Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Italy, Latvia, Lithuania, Hungary, Germany, Italy, Romania, Romania. In total, there are 5 indicators in this category, with the most frequent (6 countries) being the electricity capacity from renewable energy sources. Latvia, Hungary, and Romania have the most indicators in this category (2-2).

The number of indicators for business and tourism is 30, and they appear in the statistics of 17 EU countries. Three indicators stand out, which are also monitored in four other countries: employment in the environmental goods and services sector, the number of organisations operating EMAS (Eco-Management and Audit Scheme) and the use of standard accounting tools to monitor the economic and environmental aspects of tourism. Austria, Ireland, Romania, and Spain have the highest number of indicators in this category (4-4). In the category of projects and education, there are 8 indicators in the statistics of 8 EU countries (Austria, the Czech Republic, France, Croatia, Ireland, Poland, Spain, and Italy). The two most frequently occurring indicators, which appear in four countries, are the National Action Plan and the level of education for sustainable development. Poland has the most indicators in this category (3).

Discussion

Cluster analysis based on the most common circular indicators

The second aim of my research was to find out whether it is possible to organise EU countries into clusters using the most commonly used circular indicators. My analysis is based on two main sets of indicators: those assessing economic performance or development and those measuring the transition to a circular economy. The second hypothesis of my research was that countries with more advanced economic performance also perform better in terms of indicators measuring the transition to a circular economy. To make the clusters, I made a database of 22 indicators. Eleven of them measure the performance and growth of the economy, and the other eleven are the most common indicators of the circular economy. The database was compiled from statistics published by the European Union (2020 and 2021 data were used). The indicators reflecting economic performance were GDP per capita (euro), average net income (euro), income distribution (inequality rate, %), external trade balance (million dollars), extreme poverty rate (%), employment rate (%), long-term unemployment rate (%), R&D as a share of GDP (%), general government budget (million euros and as a percentage of GDP), and share of tertiary education (%).

Frequency played the largest role in the choice of circular indicators used. I compared the indicators for the countries that appeared in most countries at the time of enumeration. Following this logic, I selected 11 indicators: resource productivity, material use per capita, material use per GDP, circular material use rate, material footprint, greenhouse gas emissions per capita, share of renewable energy in gross final energy consumption, energy dependency, hazardous waste rate, municipal waste and recycling rate.

Below is a brief explanation of each indicator:

1. DMC: domestic material consumption: domestic extraction + import-export (tonnes).
2. Resource productivity: GDP/DMC.
3. DMC/capita: domestic material consumption per capita.
4. Circular material use rate (CMR, %) measures the proportion of materials recovered and recycled back into the economy as a share of total material use.
5. Material footprint, hectares per capita, or raw material consumption (RMC) within a geographical area: refers to the demand for the extraction of materials (minerals, metal ores, biomass, fossil fuels) generated by the consumption of goods and services.
6. Per capita greenhouse gas emissions measure the total national emissions of the so-called "Kyoto basket" of greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and the so-called F-gases (hydrofluorocarbons, perfluorocarbons, nitrogen trifluoride /NF_3/ and sulphur hexafluoride /SF_6/).
7. Share of renewable energy sources in gross final energy consumption, %: measures the share of renewable energy consumption in gross final

energy consumption according to the Renewable Energy Directive.

8. Energy dependence shows the extent to which an economy relies on imports to meet its energy needs. The indicator is calculated by dividing net imports by gross available energy.
9. Municipal waste in tonnes measures the total amount of waste generated per inhabitant per year in a country, excluding major mineral wastes.
10. Hazardous waste as a percentage of total waste generated.
11. Recycling rate measures the proportion of municipal waste recycled as a percentage of total municipal waste generation.

The compiled database was analyzed using the statistical data processing software Jamovi. I tried to support the formulated hypothesis by means of hierarchical cluster analysis. I opted for this method for two reasons; firstly, the database I have created has a small number of elements, and secondly, it is less sensitive to outliers. The cluster analysis was preceded by a correlation analysis for the indicators I selected, since cluster analysis treats all variables equally. If two variables are closely correlated (r absolute value is greater than 0.7), it is appropriate to exclude one of the variables. As a consequence, five economic indicators (GDP per capita, average net income, income distribution, long-term unemployment rate, and general government budget) and two circular indicators (hazardous waste rate and material use per capita) were excluded from further analysis, resulting in a total of 15 indicators (9 circular, 6 economic).

Results

To construct the clusters, I used standardised values for each variable to avoid the effect of differences in magnitude. Ward's hierarchical method is one of the most commonly used methods, combining the elements so that the increase in the internal standard deviation square after the merging is as small as possible. As with the K-means method, Ward's method minimizes the sum of the squared distances of the points from their cluster centres. Hierarchical clustering can be represented using a species diagram, or dendogram (Figure 4), which plots both the cluster-cluster relationships and the order of clustering (clustering viewpoint) or subdivision (subdivision viewpoint). The tree also gives us the order of mergers. The dendogram (Figure 4) shows which Member States are closest to each other in terms of the indicators analysed. Two clusters can be identified: the first cluster, consisting of 15 countries (brown), and the second cluster, consisting of 12 countries (blue) (Table 2).

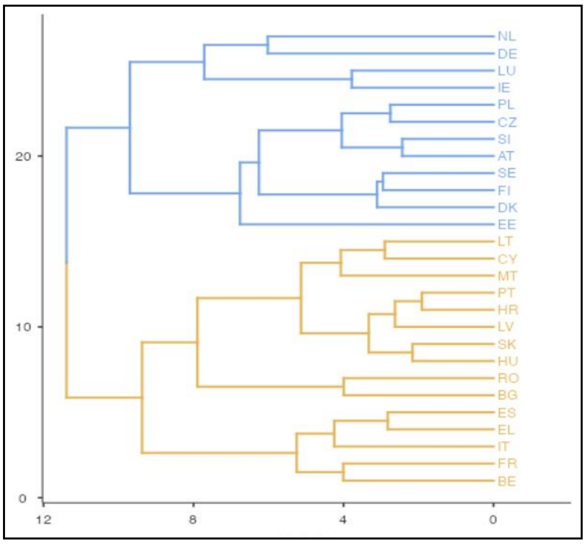

Fig. 4. Cluster dendrogram

After analysing the data, it was found that cluster 2 countries perform better overall, with an average score of 64% for 14 out of the 22 indicators examined. For the indicators measuring economic performance, 73% show better average scores compared to Cluster 1, and for the transition to a circular economy, the share is also above 50% (Table 2). In the following, I will describe in more detail the differences in economic performance and circular performance between the two cluster countries using average values.

Table 2. Countries in the two clusters

Cluster	**Number of countries**	**Countrie s**	**Indicators in which they perform better**
Cluster no.1	15 countries	BE, BG, SK, HU, PT, HR, LT, LV, IT, ES, FR, EL, CY, IT, RO	8 indicators: income distribution, general government budget in million euros, general government budget as a percentage of GDP, DMC/capita, CO_2 emissions, ecological footprint, hazardous waste, municipal waste
Cluster no.2	12 countries	NL, DE, SE, DK, FI, AT, IE, LU, PL, CZ, SI, EE	14 indicators: GDP/capita, external trade balance, average net income, R&D as a share of GDP, long-term unemployment rate, extreme poverty rate, employment rate, DMC, resource productivity, recycling rate, energy dependency, renewable energy rate, recycling rate

Source: own editing based on data from the cluster analysis.

If we look at the averages of the economic data for the countries in the two clusters, we can say that 8 of the 11 economic indicators in cluster 2 show better averages. For six of these indicators, there is a significant difference in the averages, and for two indicators, the averages are close between the two clusters (share of tertiary education and share of employed). As the average values for three indicators are lower for cluster 2 countries than for cluster 1, it can be said that the averages of the economic indicators for the two clusters do not give a clear answer as to which group the more or less developed countries belong to. Let us take the indicators in turn. Six economic indicators of the countries in cluster 2 have a much higher average value than those of the countries in cluster 1.
These indicators are:

1. The average trade balance value: the average of the countries in Cluster 2 is 75 times that of the countries in Cluster 1.
2. GDP per capita: the average for cluster 2 countries is two times higher than the average for cluster 1 countries.
3. Average net income is 80% higher in cluster 2 countries than in cluster 1 countries.
4. The share of GDP devoted to R&D is on average 70% higher in Cluster 2 countries than in Cluster 1 countries.
5. The deep poverty rate: on average, 1/3 as many people live in deep poverty in cluster 2 countries as in cluster 1 countries.
6. The long-term unemployment rate is on average 60% lower in cluster 2 countries than in cluster 1 countries.

Thus, cluster 2 countries perform better than cluster 1 countries on most, but not all, economic indicators (except for income distribution, the general government budget in millions of euros, and the percentage of GDP). Looking at the averages of the data for the circular economy indicators for the two cluster countries, six out of the 11 indicators analysed show better averages in cluster 2. Cluster 2 includes those countries with an average resource productivity 41% higher than that of Cluster 1. In terms of the recycling rate, the countries in cluster 2 recycle on average 40% more material back into the economy than those in cluster 1. The same surplus of over 40% is also reflected in the recycling rate for these countries.

However, Cluster 2 countries perform 20% better in terms of material use, renewable energy, and energy dependency. These are the six indicators in which Cluster 2 countries perform better in terms of recycling, while showing higher values for CO_2 emissions, waste, hazardous waste, material use per capita, and footprint compared to Cluster 1 countries. This is probably because we have seen from the economic data that these countries have a higher production rate, which results in a larger footprint, more waste, more CO_2 emissions, and more material use per capita for the time being. It can be said that Cluster 2 countries, although having better economic indicators, perform less well in terms of circular economy indicators and need further improvement in this respect.

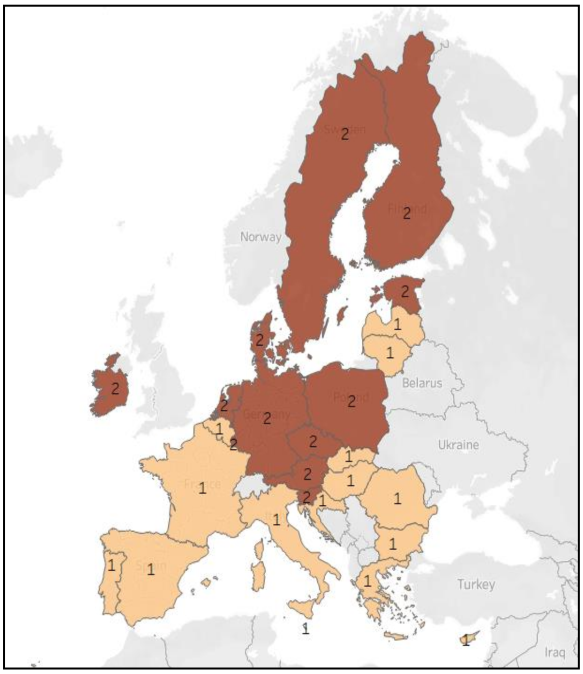

Fig. 5. Map of countries in the two clusters created by using Tableau Public.

Next, I performed the most important test of the relationship, the t-test, to find out whether the difference between the means of the two groups in my sample is due to existing differences (significant) or whether the difference is just a result of chance. [1] My null hypothesis was that the two means in the two samples are statistically identical, i.e., the difference between the means of the two groups is not significant for the factors under investigation. I was interested in the significance level of the t-tests. If the significance level is less than 0.05 ($p < 0.05$), then we can say with 95% confidence that the differences between the group averages calculated on my observed data are not due to chance. I complemented the analysis with a normality test and a homogeneity test. For those factors where one of these was violated, I used Welch's estimation, in the other cases, I used Student's estimation.

[1] The use of the t-test could be criticized for not being a simple random sampling. However, it is not my intention to draw conclusions for all the countries of the world, but only to characterise the countries included in the analysis as accurately as possible. For this reason, taking a random sample is not necessary. The other two conditions, normality and homogeneity, have been checked for each indicator. Whichever one is violated, in that case the Student's (S) t-test is not used, but the Welch' t (W) test is considered valid. I have indicated which test I used.

Table 3. Two independent samples T-test

Indicator	T	P	Mean of clusters		Cohen's d	Dif. ***
DMC/ capita	S	0.033*	1	14,55	-0.875	72,64
			2	20,03		
Recycling rate	S	0.004**	1	32,88	-1.217	68,33
			2	48,12		
CO_2 emissions	W	0,01**	1	6,69	-1.169	70,72
			2	9,46		
GDP/ capita	W	0,009**	1	18069,33	-1.234	48,61
			2	37169,17		
Average net income	W	0,004**	1	12255,67	-1.301	54,57
			2	22457,33		
Income distribution	S	0,016*	1	5,18	1	124,82
			2	4,15		
Extreme poverty rate	W	0,002**	1	9,27	1.374	329,89
			2	2,81		
Gover-nment budget as a share of GDP	S	0,004**	1	-7,53	-1.220	154,62
			2	-4,87		
Research and develop-ment as a share of GDP	S	0,004**	1	1,35	-1.226	58,70
			2	2,3		
Long-term unemploym ent rate	S	0,009**	1	70,97	-1.097	92,81
			2	76,47		
Unemploy-ment rate	W	0,01**	1	3,09	1.074	245,24
			2	1,26		
External trade balance	W	0,03*	1	661,67	-0.980	1,33
			2	49862,25		

*p < 0,05
**p ≤ 0,01
*** Difference in the mean of cluster no. 1 expressed as %

The null hypothesis says that there is no significant difference between the two groups of countries in the average value of the indicator. This is true for 10 indicators, which means that the differences between the two groups of countries are not significant, regardless of whether the countries are in two groups. For example, for DMC, the mean values for the two groups of countries are the same. Overall, there are no significant differences for 8 of the 11 indicators of the circular economy (material use, resource productivity, share of circular material use, material footprint, share of renewable energy in gross final energy consumption, energy dependency, and share of hazardous waste and municipal waste). According to the alternative hypothesis, there are some indicators for which there is a significant difference between the averages of the two groups of countries. For the variables under consideration, there are 12 indicators (Table 3) for which there is a significant difference between the average values of the two groups. As the p-value is less than 0.05, the null hypothesis is rejected in these cases. For the following 12 indicators, the strength of significance can be broken down into 2 categories depending on the p-value ($p < 0.05$ and $p \leq 0.01$): material use per capita, recycling rate, CO_2 emissions, GDP per capita, average net income, income distribution, R&D as a share of GDP, employment and extreme poverty rates, and the share of the public budget in GDP, unemployment rate, and external trade balance. The largest significant difference between the mean scores of the economic indicators of the countries in the two groups is found in the deep poverty rate, as p=0.002, thus providing strong evidence against the null hypothesis and allowing us to accept the alternative hypothesis that there is a significant difference between the two groups of countries in this respect.

This is followed by three more indicators with $p \leq 0.01$, all three with p=0.004 (average net income, research and development as a share of GDP, and public budget as a share of GDP), thus providing strong evidence against the null hypothesis and allowing us to accept the alternative hypothesis that there is a significant difference between the two groups of countries on these indicators as well. Cohen's effect size is large, as $d > 1$ for all four indicators mentioned above, suggesting a strong effect. The p-value of the recycling rate and CO_2 emissions indicators indicates a significant difference in the degree of transition to a circular economy, as the p-value is $p \leq 0.01$ in both cases, thus rejecting the null hypothesis and accepting the alternative hypothesis that there is a significant difference between the two groups of countries for these two indicators as well. The Cohen effect size is $d > 0.8$ in both cases, indicating a strong effect. However, because the p-value for the per capita material use indicator is p 0.05, we reject the null hypothesis and accept the alternative hypothesis that there is a significant difference in this indicator between the two groups of countries. The Cohen effect size is $d > 0.8$ in both cases, indicating a strong effect. The difference in the means of the differences between the two clusters in percentage terms is shown in the last column of Table 3. The difference between the means is calculated in % shows the percentage difference between the averages of the two groups of countries. It is clear that the averages for cluster 1 are below those for cluster 2.

Conclusions

Based on the analysis that was done, the move towards a circular economy has also become more noticeable in EU Member States. As a result, they are trying to use indicators in their statistical records to show how big this change is. In other words, EU countries are increasingly focusing on measuring their progress at the macro level. After taking stock of the indicators, it can be concluded that Member States are trying to demonstrate progress by measuring different indicators, but that there is no uniform measurement at Member State level. A review of their statistical data shows that Member States have different approaches to measuring sustainable consumption and production, and thus different indicators for measuring the circular economy. However, the analysis has revealed that, overall, there are some prominent and commonly used indicators that can be found in the statistics of several countries and that have been used as a basis for my cluster analysis. The cluster analysis allows the EU countries to be divided into two large groups, but it turns out that there is not yet a significant difference between the two for all circular economy indicators, with the exception of three indicators at present: the reuse rate, CO_2 emissions, and material use per capita. The analysis also showed that, currently, it is mainly the economic performance indicators that show a significant difference. It is an open question whether a significant difference will emerge between the two groups of countries by 2030, based on indicators measuring the circular economy in the coming years. However, based on the analysis carried out, the shift towards a circular economy has become more pronounced in both less developed and developed EU Member States.

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