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This is an **author produced version** of a paper published in:

International Journal of Sustainable Development & World Ecology 26.8 (2019): 708 – 720

DOI: <https://doi.org/10.1080/13504509.2019.1666754>

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ANALYSIS OF THE RELATIONS BETWEEN CIRCULAR ECONOMY AND SUSTAINABLE DEVELOPMENT GOALS

ABSTRACT

Since the United Nations approved the eight Millennium Development Goals in 2000 and, 15 years later, the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs), the highest political institutions in the world have not stopped worrying about achieving the sustainability of the planet. Also in 2015, the European Commission prepared the European Union Action Plan for the Circular Economy, seeking a transition towards a less linear economy, in which products, materials, and resources are kept in the system for as long as possible and in which the generation of waste is minimized.

Since then, the European Union has continued issuing reports and communications to accelerate this process in search of a circular economy, making continuous references to the fact that, through circular economy initiatives, the SDGs would be fulfilled. In this context, the objectives of this paper are 1) to determine, through exploratory factor analysis and correlation analysis, whether there is a statistically significant relationship between circular economy initiatives undertaken in the EU and compliance with the SDGs; 2) to check, through a cluster analysis, if there are homogeneous groups of countries worldwide in terms of compliance with the SDGs; and 3) using this same technique, to check whether the countries that make up the EU achieve similar results in terms of compliance with the SDGs.

Keywords: circular economy, Sustainable Development Goals, 2030 Agenda, sustainability, European Union, indicators

1. INTRODUCTION

The Resolution of the General Assembly of the United Nations 55/2, called the “Declaration of the Millennium”, published on September 8, 2000 (<http://www.un.org/spanish/milenio/ares552.pdf>), considers that international relations in the 21st century should be based on a series of fundamental values, such as freedom, equality, solidarity, tolerance, respect for nature, and common responsibility, which, to be operative, should translate into actions that were materialized in the so-called Millennium Development Goals. These objectives aimed to a) eradicate extreme poverty and hunger; b) achieve universal primary education; c) promote gender equality and the empowerment of women; d) reduce child mortality; e) improve maternal health; f) combat HIV/AIDS, malaria, and other diseases; g) guarantee the sustainability of the environment; and h) develop global partnership for development. These eight objectives, oriented to human development, have to do with peace, security and disarmament, development and the eradication of poverty, the protection of our common environment, human rights, democracy and good governance, protection of vulnerable people, attention to the special needs of Africa, and the strengthening of the United Nations. On September 25, 2015, the General Assembly of the United Nations approved the “2030 Agenda for Sustainable Development” (<https://undocs.org/en/A/RES/70/1>), which is an action plan in favor of people, the planet, and prosperity. Its objective is to strengthen universal peace and eradicate poverty, as an indispensable requirement for sustainable development, and it is specified in 17 Sustainable Development Goals (SDGs) and 169 objectives that aim to be part of the Millennium Development Goals and achieve the ends that the Declaration of the Millennium did not achieve, focusing on the three dimensions of sustainable development: economic, social, and environmental.

In line with this global approach, on December 2, 2015, the European Commission prepared a report entitled “Close the Circle: An Action Plan of the European Union for the Circular Economy”, whereby it sought a transition towards a more circular economy (CE), in which products, materials, and resources are kept in the system for as long as possible and in which the generation of waste was minimized. This report focused on production, consumption, waste generation, waste transit to new products, innovation, investment, other horizontal measures, and measures to monitor the progress made towards a CE, setting as priority areas plastics, food waste, critical raw materials, construction and demolition, and biomass and bioproducts. The report also indicated that, although its scope of action was confined to the EU, the CE should be implemented globally. Furthermore:

“The circular economy will also need to develop globally. Increased policy coherence in internal and external EU action in this field will be mutually reinforcing and essential for the implementation of global commitments taken by the Union and by EU Member States, notably the U.N. 2030 Agenda for Sustainable Development and the G7 Alliance on Resource Efficiency. This action plan will be instrumental in reaching the Sustainable Development Goals (SDGs) by 2030, in particular Goal 12 of ensuring sustainable consumption and production patterns.” (https://eur-lex.europa.eu/resource.html?uri=cellar:8a8ef5e8-99a0-11e5-b3b7-01aa75ed71a1.0012.02/DOC_1&format=PDF pg 3)

Consequently, in the minds of the European Commission, the relationship that would exist between the CE and the SDGs was already present (Rodríguez-Antón 2019).

Thus, there seems to be a very close relationship between the CE and the SDGs. The CE can be considered as a tool that can be used by different countries, social agents, and institutions to achieve some SDGs. In fact, as mentioned, the European Union Action Plan for the Circular Economy of 2015 indicated that it was intended to contribute to the achievement of some SDGs, specifically objective 12, consisting of guaranteeing modalities of sustainable consumption and production. The importance of this objective is unquestionable. As indicated on the United Nations website (<https://www.un.org/sustainabledevelopment/en/sustainable-consumption-production/>), if the population of the planet reaches 9.6 billion inhabitants by 2050, it would need resources that would be equivalent to three Earth planets in order to maintain the lifestyle that we currently enjoy. On the other hand, humans are polluting the water faster than nature recycles and purifies water from rivers and lakes, causing more than one billion people to still have no access to drinking water. From the point of view of consumption, following the same source, if all humanity were to use low-energy bulbs, they would save USD \$120 million a year. Households have a decisive influence on the environmental impacts related to food due to eating habits that affect the environment through the consumption of energy related to food — which represents around 30% of the total energy consumption, as well as 22% of the total emissions of greenhouse gases — and the generation of waste.

From the study of the agreements reached within the scope of the United Nations and the recommendations, reports, and regulations issued by the EU, [three research questions can be formulated, as follows:](#)

[RQ1. Is there a direct relationship between initiatives undertaken at the EU level aimed at the effective implementation of a CE model in its member states and compliance with the SDGs defined by the United Nations in those member states?](#)

[RQ2. Are there homogeneous groups of countries worldwide in terms of compliance with the SDGs?](#)

[RQ3. Do the countries that make up the EU achieve similar results in terms of compliance with the SDGs?](#)

In order to answer these research questions and to compare the [hypothesis](#) that will be formulated later, the present research work will follow the following structure. After the present introduction, the following section will detail the research method used; next, the relationship between the CE and the SDGs will be analyzed using an international legislative approach. Finally, the results will be presented and discussed, and the conclusions of the research will be explained.

2. RESEARCH METHODS

In order to answer the three research questions presented and to compare the [hypothesis](#) that are subsequently formulated, the following research method was defined:

a) The relationship between CE and SDGs was analyzed in depth, based on the recommendations, reports, and international legislation issued by the United Nations and the EU, respectively, with the SDGs and with the CE.

b) For the 156 countries worldwide for which the Index and Dashboards Report 2018 offers information, the level of achievement for the year 2017 of the 17 SDGs was

analyzed. Based on these data, exploratory factor analysis (EFA) was carried out to determine the level of relationship between them and how many factors or main components these 17 SDGs have.

c) Next, a cluster analysis was carried out to determine how the 156 countries analyzed are grouped with respect to compliance with the SDGs.

d) In parallel, and at the level of the EU with 28 members (EU28), EFA was carried out with the main CE indicators offered by Eurostat (2019) in order to determine how many factors or main components these nine indicators have and, on the other hand, to elaborate a ranking of EU28 countries by degree of adjustment to the CE model.

e) Next, the correlations between all the selected CE indicators and the 17 SDGs were calculated.

f) Based on the results achieved, a discussion was presented, the research questions were answered, and the [hypothesis](#) formulated were contrasted, reaching interesting conclusions.

Once the research method that has been used is presented, the relationships between the CE and the SDGs are presented from the perspective of European legislation.

3. RELATIONSHIP BETWEEN THE CE AND THE SDGs

Before defining the relationships between CE and SDGs, it is necessary to clarify the concept of CE and further develop what makes it different from other related concepts.

According to Alonso-Almeida and Rodriguez-Anton (2019) the concept of CE is still developing. In fact these authors (p. 69) asserted that “The circular economy (CE) is considered a possible solution to problems such as the increasing global demand for resources, price volatility for raw materials, and the growing population and consumption worldwide”. In this sense, Kirchherr et al. (2017, p. 225) defined CE as “an economic system that is based on business models which replace the ‘end-of-life’ concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations”. Some features of the CE model which have previously been identified, overlap with some features of the sustainable development definition, for which some authors (Whalen et al., 2018) have stated that both concepts are interrelated. Thus, Kirchherr and Piscicelli (2019) reinforced this idea and explained that CE offers a novel pathway to sustainable development because the main emphasis of CE is put on the role of businesses and economic performance while sustainable development is focused on environmental and social issues to the benefit of current and future generations.

Bioeconomy is also an open concept (McCormick and Kautto, 2013). McCormick and Kautto (2013, p. 2590) enunciated bioeconomy as “an economy where the basic building blocks for materials, chemicals and energy are derived from renewable biological resources, such as plant and animal sources”. Maciejczak and Hofreiter (2013, p. 247) analysed the different definitions of bioeconomy and concluded that “the core of this concept lies sustainable transformation of renewable biological resources based on life

science's innovations into products and processes that aim to meet both private and public expectations".

Moreover, Hetemäki et al (2017) stressed that bioeconomy seeks to replace fossil-based and non-sustainable biological products and non-renewable materials as well as enhance natural capital with renewable and bio gradable solutions.

Thus, the aforementioned authors (p. 14) concluded that "The concepts of bioeconomy and circular economy clearly reinforce each other. However, so far, they have been developed mostly in parallel and they need to be strategically combined". Therefore, circular bioeconomy "increases the use of renewable non-fossil raw materials and products in sustainable, resource-efficient and circular way".

D'Amato et al. (2017) support these ideas. They compared CE and bioeconomy concept usage on published research and found that CE is the concept most popular in academic research. These authors concluded that differences are mainly based on 1. Geographical reasons. China is the leading country when it comes to CE, although Europe has been making a strong bet on CE development over the past years and is now moving closer to China (D'Amato et. 2019). Moreover, Europe is the pioneer in bioeconomy, 2. CE is focused on the use of inputs, industrial processes and use of end-life products and bioeconomy is focused on the use of biological resource-based and land practices. In other words, how resources should be managed (D'Amato et al. 2019).

Nevertheless, D'Amato et al. (2019) reckon that CE is mainly growing from governments support and legislation, first in China and after in Europe. Therefore, CE is a key driver to move EU towards more sustainable development and at some time achieve SDGs through strategies connecting CE with SDGs.

As indicated in the introduction, since the European Commission prepared the report Closing the Loop: An EU Action Plan for the Circular Economy in 2015, the subsequent reports and directives issued by the EU in the field of the CE have focused on compliance with the SDGs.

In fact, on November 22, 2016, the European Commission prepared the communication entitled "Next Steps for a Sustainable European Future: European Action for Sustainability" (2016), which was forwarded to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions {SWD (2016) 390 final} (<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016DC0739&from=EN>). This communication reaffirms the commitment that the EU has always made to sustainable development and highlights the role it played in the preparation of the 2030 Agenda, for which it assumes the commitment to be a pioneering space in its application and in the achievement of the SDGs set, integrating them into the European political framework as one of the priorities of the Commission. Moreover, the communication describes the measures that the EU is carrying out to achieve each of the 17 SDGs. Regarding SDG 12, the CE is cited on page 5, stating that "resource efficiency and circular economy actions aim to decouple economic growth from resource use and environmental degradation. Sustainable consumption will also require consumer policies that raise awareness and allow consumers to make informed choices contributing to sustainability."

In the same way, in Priority 1, defined as "a new boost to employment, growth and investment," the Investment Plan for Europe is mentioned, closely related to SDGs 8, 9, 12, and 13, which set aside 500 million euros for additional investments in strategic

sectors, such as education, health, water, energy, transport and other infrastructures, industry, and agriculture, and the promotion of forward-looking initiatives, such as renewable energies, CE, and climate change mitigation and adaptation, through the European Fund for Strategic Investments.

In this same area, it is indicated that the CE is directly involved in the achievement of SDGs 6, 8, 9, 11, 12, 13, 14, and 15 (page 10 of the communication) and that the EU has designed a "reform agenda with significant growth potential and the creation of new jobs and the promotion of sustainable models of consumption and production." Seeking greater efficiency of available resources and minimizing the generation of waste can offer the EU a significant competitive advantage. The new CE model can offer the EU the possibility of modernizing its economy, making it more competitive and, at the same time, more ecological and with a guarantee for the future. The start-up of the CE will also contribute to reducing the levels of carbon dioxide emissions, saving energy, and reducing air, soil, and water pollution. The EU's commitment to the CE has been reflected in the communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions of January 16, 2018, entitled "A European Strategy for Plastics in a Circular Economy" {SWD (2018) 16 final} (https://eur-lex.europa.eu/resource.html?uri=cellar:2df5d1d2-fac7-11e7-b8f5-01aa75ed71a1.0001.02/DOC_1&format=PDF), through which it aims to achieve a vision of a CE of plastic, which helps European industry to develop the plastic of the future, less dependent on fossil fuels, which will facilitate the reduction of marine pollution, fulfilling objective 14.

The communication also indicates that the reuse of water will be promoted through the establishment of minimum clearance requirements, an action that is aimed at achieving objective 6. In addition, actions are being taken on sustainable food systems and prevention of food waste, again related to objective 12 regarding sustainable consumption, relying on the European platform against food losses and waste, whose mission, in line with the United Nations, is to reduce the food waste per inhabitant by half worldwide by 2030.

The EU, through the communication sent on October 11, 2018, from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions entitled "A Sustainable Bioeconomy for Europe: Strengthening the Connection between Economy, Society and the Environment" (COM(2018) 673 final) (<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0673&from=EN>) aims to update the Bioeconomy Strategy of 2012, addressing the challenges outlined in a set of 14 specific actions to be implemented by 2019. The introduction to the communication states that "In order to be successful, the bioeconomy European Union should be articulated around sustainability and circularity. This will boost the renewal of industries, the modernization of primary production systems and the protection of the environment, and will also enhance biodiversity." After this clear statement of intentions, the communication is replete with references to the CE, beginning with the statement that "A sustainable bioeconomy is the renewable segment of the circular economy" (pg 3 of the Document), until defending the concept of bioeconomy circular and indicating that, in addition to the possible existing subsidies under Horizon 2020 for research and innovation, the EU will provide a specific financial instrument such as the thematic investment platform in circular bioeconomy, which will be equipped with 100 million euros aimed at reducing or eliminating the risk assumed by private companies in sustainable solutions.

There are other indications of the relationship between the CE and the SDGs besides this communication of the European Commission. On January 30, 2019, the European Commission published a reflection paper entitled “Towards a Sustainable Europe by 2030” (https://ec.europa.eu/commission/sites/beta-political/files/rp_sustainable_europe_30-01_en_web.pdf), in which it makes a diagnosis of how the EU is addressing the issue of sustainability and presents a series of scenarios on how the EU and its member states should act to lead the transition towards sustainability and achieve the SDGs by 2030. This document indicates that seven EU states are among the top 10 in the world and that all members of the EU-27 are among the top 50 in terms of compliance with the SDGs. However, there are significant differences in terms of compliance with each of these SDGs, although in the last five years it can be said that the EU has made significant progress in practically all of them. As extreme situations, the document indicates that the member states of the EU-27 achieve, on average, the highest score with respect to SDG 1 (end poverty in all its forms everywhere) and the second highest score in terms of compliance with SDG 3 (ensure healthy lives and promote well-being for all at all ages). But they are, on average, at the lowest compliance levels with respect to SDG 12 (ensure sustainable consumption and production patterns) and SDG 14 (conserve and sustainably use the oceans, seas, and marine resources for sustainable development), two of the SDGs most closely related to the CE.

Moreover, in this reflection paper, express mention is made that if the EU does not want to endanger its economic prosperity, social level, and environment, it must reinvent itself and be oriented towards sustainable economic growth through four challenges: a) achieve the sustainability of the farm to the table; b) betting on energy, buildings, and mobility prepared for the future; c) guarantee a socially just transition; and the challenge most directly related to this work, d) move from the linear economy to the EC, then, currently, the planet is consuming resources equivalent to 1.7 planets like ours. The implementation of a CE model could generate a net economic benefit of 1.8 billion euros in Europe between now and 2030, contribute to creating more than one million new jobs in this same time horizon, and play a fundamental role in reducing greenhouse gas emissions.

Faced with these challenges, the European Commission considers three possible scenarios to achieve compliance with the SDGs. The first scenario would be for the EU to adopt a global strategy in relation to the SDGs. The second would be based on continuing to integrate the SDGs in all policies issued by the EU, but without obliging the member states to comply with the collective commitments on SDGs. The third scenario would be to pay more attention to external action, helping the rest of the world to comply with the SDGs.

From all the above, there is no doubt that the European institutions consider that there is a direct relationship between the CE and the SDGs, considering the former as a tool or lever that contributes to the fulfillment of the latter. Consequently, and with the support of the communications presented by the European Commission in this area that were previously detailed, the following *hypothesis* are presented:

H1. The CE is related to SDG 6.

H2. The CE is related to SDG 8.

H3. The CE is related to SDG 9.

H4. The CE is related to SDG 11.

H5. The CE is related to SDG 12.

H6. The CE is related to SDG 13.

H7. The CE is related to SDG 14.

H8. The CE is related to SDG 15.

4. RESULTS

When the General Assembly of the United Nations adopted the 2030 Agenda, 17 SDGs that focus on various types of objectives were defined. They are summarized as a plan of action for people, the planet, and prosperity, while universal peace and the eradication of poverty are strengthened. Most of these goals are not independent, but are related to each other. As can be seen in Table 1, for the 156 countries for which information on compliance with the SDGs is available, there is a high correlation between all these ends, which is significant at the 0.01 level (two-tailed) in most cases. Only SDG 13 (take urgent action to combat climate change and its impacts), SDG 14 (conserve and sustainably use the oceans, seas, and marine resources for sustainable development), SDG 15 (protect, restore, and promote sustainable use of terrestrial ecosystems; sustainably manage forests; combat desertification; halt and reverse land degradation; and halt biodiversity loss), and, especially, SDG 17 (strengthen the means of implementation and revitalize the global partnership for sustainable development) appear not to be significantly correlated, neither with others nor with the average.

When the General Assembly of the United Nations adopted the 2030 Agenda, 17 SDGs that focus on various types of goals were defined. They are summarized as a plan of action for people, the planet, and prosperity, while universal peace and the eradication of poverty are strengthened. Most of these aims are not independent, but are related to each other. As can be seen in Table 1, for the 156 countries for which information on compliance with the SDGs is available [in Sachs, J. et al 2018, page 69 and the following pages, Table 15 Overall country scores by SDG](#) -the SDG score shows a country's position between the worst (0) and the best or target (100) outcomes- where missing values were replaced by the average, there is a high correlation between all these goals, which is significant at the 0.01 level (two-tailed) in most cases. Only SDG 13 (take urgent action to combat climate change and its impacts), SDG 14 (conserve and sustainably use the oceans, seas, and marine resources for sustainable development), SDG 15 (protect, restore, and promote sustainable use of terrestrial ecosystems; sustainably manage forests; combat desertification; halt and reverse land degradation; and halt biodiversity loss), and, especially, SDG 17 (strengthen the means of implementation and revitalize the global partnership for sustainable development) appear not to be significantly correlated, neither with others nor with the average.

Insert Table 1

Within these high significant correlations, all of them positive, it is necessary to emphasize that in the case of SDG 12 (ensure sustainable consumption and production patterns), the sign is negative. The correlation between SDG 12 and the average of the 17 SDGs is -0.606 (**), and the correlation with 13 of 16 objectives is meaningful and negative. This correlation of negative sign is due to the fact that of the seven indicators that define the fulfilment of this objective, six are moving in the opposite direction to the usual. That is, the higher the value of the indicator, the worse the degree of compliance with said objective. In particular, for several indicators — a) electronic waste generated

(kg/per capita), b) emissions of SO₂ based on production (kg/per capita), c) net emissions of imported SO₂ (kg/per capita), d) production footprint of reactive nitrogen (kg/per capita), e) net emissions imported from reactive nitrogen (kg/per capita), and f) municipal solid waste not recycled (kg/person/day) — the higher their values, the worse a country's behavior is in order to fulfill the aim of guaranteeing sustainable consumption and production. Only the indicator anthropogenic wastewater receiving treatment (%) moves in the traditional sense.

In order to determine if the 17 SDGs are homogeneous and explain the same concept, EFA was carried out by the method of maximum likelihood. A Kaiser–Meyer–Olkin (KMO) sample adequacy measure of 0.894 and a Bartlett's sphericity test were obtained, with a chi-square of 2032.9, 136 degrees of freedom, [significance of 0.000 and determinant of the correlation matrix of 0.00000113 -which was smaller than the necessity value of 0.00001 and it could be a problem of multicollinearity-](#); therefore, the EFA was adequate. The existence of four factors with eigenvalues greater than one was initially verified, which explained 71.2% of the variance. However, after analysis of the sedimentation graph, it was found that the first factor was the significant one, given that there was a sharp drop between its value, 7.646, and the others — 1.768, 1.336, 1.187, 0.939, 0.834, 0.607, 0.506... — which were reducing in value smoothly. Then, after the analysis of the factorial matrix, especially considering this first factor as well as the values of the communalities after the extraction, it was observed that the highest loads were linked to the SDGs between 1 and 12 (with a negative factorial load, with the explanation already formulated in the previous correlation matrix) and to SDG 16; however, the loads of SDGs 13, 14, 15, and 17 had values close to zero, which would not be aligned with the previous ones. Consequently, 13 goals would explain a high percentage of what is contained in the 2030 Agenda. Only the last four mentioned above seem to have divergent aims.

Next, a cluster analysis was carried out to determine how the 156 countries analyzed are grouped with respect to compliance with the 17 SDGs. [In this analysis, the data of 17 SDGs indexes from Sachs, J. et al 2018 were used as segmentation criteria.](#) Furthermore, the usual stages and procedures were followed: i) First, a hierarchical cluster analysis was performed using the method of Ward, choosing as a measure of the Euclidean distance squared. After analysing the dendrogram, at a distance of 10, four groups of countries were detected; ii) based on the previous results (initial centers), a cluster analysis was carried out using the k-means optimization method. With this, the list of grouped countries that are included in Annex 1 was obtained. As can be seen, four different groups of countries were obtained based on the degree of compliance with the SDGs. The first group consists of 42 countries, including all of the EU28, except Bulgaria and Romania, plus a number of advanced countries, such as Australia, Canada, Norway, the United States, China, Japan, South Korea, and Switzerland. In the second group, made up of 72 countries, were the two countries of the EU28 that were not in group 1; most of the Latin American countries, such as Brazil, Argentina, Chile, Colombia, Costa Rica, Cuba, Ecuador, Honduras, Mexico, Peru, Venezuela, Uruguay, and Paraguay; and a diverse group of countries from other continents, such as Russia, Serbia, Iran, Malaysia, Egypt, Indonesia, Morocco, Ukraine, and Thailand. In the third and smallest group were only eight countries, all located on the African continent: Botswana, Swaziland, Lesotho, Namibia, South Africa, Kenya, Rwanda, and Zimbabwe. Finally, in the fourth group, the remaining 34 countries are located, almost exclusively in Africa and Asia. Table 2 shows the average value of the 17 SDGs for each of the four cluster groups and the total average value of the whole SDG (SCORE). As can be seen in this table, most of the developed countries — including 26 of the 28 countries that make up the EU — which are those in group 1, achieve compliance values of most of the 17 SDGs better than the average (as well as higher socio-economic indicators). The group of developing countries is group 2, which is able to meet some SDGs above the average. On the

contrary, groups 3 and 4, formed mostly by underdeveloped countries of Africa, Asia, and Latin America, achieve values of compliance with the SDGs well below the global average values.

Insert Table 2

In order to analyze the structure of the indicators of the degree of implementation of the CE in the EU28 countries, an analysis of its correlation matrix was initially carried out to then carry out an EFA with the nine indicators of the CE selected from those included in the Eurostat Monitoring Framework. This choice sought to consider indicators that contemplated a wide spectrum of variables related to the CE and its compliance. The selected indicators were the following:

I) Production and consumption indicator:

- Generation of municipal waste per capita (kg per capita) (GRM)

II) Waste management indicators:

- Recycling rate of municipal waste (percentage) (TRRM)
- Recycling rate of general packaging (percentage) (TREG)
- Recycling rate of electrical and electronic waste (percentage) (TRREE)
- Recycling of biological waste (kg per capita) (RRB)
- Recovery rate of construction and demolition waste (percentage) (TRRCD)

III) Secondary raw materials indicator:

- Rate of use of circular material (percentage) (TUMC)

IV) Competitiveness and innovation indicators:

- Gross investment in tangible goods (percentage of GDP) (IBBM)
- People employed in the CE (percentage of total employment) (PE)

These nine selected indicators, for which the data available for 2017 were used, or estimates [by the authors](#), in the cases that existed only up to 2016, are intended to reflect the diversity of concepts contained in the CE and the different manifestations that it contemplates. If the content of Table 3 is analyzed, it can be verified that of the 36 existing correlations between these indicators, only seven are significant at the 0.01 level (two-tailed), and one is significant at the 0.05 level (two-tailed), which validates the broad spectrum of selected indicators.

Insert Table 3

With these indicators, an EFA was carried out by the principal component method (due to the small sample size) and a Varimax rotation. A KMO measure of 0.694 and Bartlett's sphericity test were obtained, with a chi-square of 86.7, 36 degrees of freedom, and a significance of 0.000; therefore, the EFA was again adequate. Initially, the existence of two factors with eigenvalues greater than one was verified, which explained 56.0% of the variance. Analysis of the sedimentation graph corroborated the existence of these two eigenvalues.

Of the two factors, the first has been selected — which we could name the Circular Economy Index — which explains 37.479% of the variance and is considered the main representative index of the implementation of the CE in the EU28 (it has been denominated IEC2017). This factor would be composed of the following indicators: recycling rate of municipal waste, recycling rate of general packaging, recycling of biological waste, rate of use of circular material, and people employed in the CE. The second factor would explain 18.548% of the variance and would be composed of the following indicators: generation of municipal waste per capita, e-waste recycling rate,

recovery rate of construction and demolition waste, and gross investment in tangible goods. The relatively low variance explained by these two factors demonstrates the heterogeneity and diversity of contents of the selected indicators.

Then, if the correlation is calculated between the first of these representative factors of the implementation of the CE in the EU28 and the values obtained for the 17 SDGs of these countries, it can be verified that the statistically significant correlations are greater with SDGs 2, 3, 5, 8, 9, 10, 11, and 16. In contrast, the second factor is significantly correlated with SDGs 3, 12, 15, and 16 (see Table 4).

Insert Table 4

If a ranking of countries belonging to the EU28 were established using a weighted average of the two factors obtained from the EFA (the so-called IEC2017 and the so-called second factor). (see Table 5).

Insert Table 5

Finally, the direct correlations between the nine selected CE indicators and the 17 SDGs were calculated. As can be seen in Table 6, there are many statistically significant correlations between both concepts. In order to systematize the analysis, we will detail the significant correlations between the selected CE indicators, which measure and reflect the actions undertaken in these countries aimed at closing the economic circle, and each of the SDGs. In other words, we will try to determine whether the fact that the EU countries are making efforts to implement a CE model will have an impact on the degree of compliance with the SDGs proposed by the United Nations.

Insert Table 6

If we start with the indicator municipal waste generation per capita (GRM), it appears that it is significantly correlated with SDG 1, 3, 9, 10, 12 (with a negative sign), and 16. The municipal waste recycling rate (TRRM) indicator is correlated with SDGs 1, 2, 3, 5, 8, 9, 10, 11, and 16, many of them at level 0.001. The general packaging recycling rate (TREG) is correlated with SDGs 2, 5, and 9. Recycling rate of electrical and electronic waste (TRREE) is correlated only with SDG 14. On the other hand, recycling of biological waste (RRB) is correlated with nine SDGs, specifically 2, 3, 5, 8, 9, 10, 11, 12 (with a negative sign), and 16. On the contrary, the rate of construction and demolition waste recovery (TRRCD) is not correlated with any SDG. The indicator for the use of circular material (TUMC) is correlated with SDGs 2, 5, 9, and 13, with a negative sign. Gross Investment in tangible goods (IBBM) is correlated with SDGs 3, 9, 16 (all of them with a negative sign), and 12. Finally, the indicator people employed in CE (PE) is correlated with SDGs 2, 3, 9, 16 (all of them with a negative sign), and 12.

When the correlation between each CE indicator and the total of the 17 SDGs is analyzed, not with each of them in particular, it turns out that five of the nine indicators used have a statistically significant correlation with the set of said SDGs. In particular, the municipal waste recycling rate (TRRM) indicator has a correlation of 0.652 (**); the general packaging recycling rate (TREG) has a correlation of 0.425 (*); the recycling of biological waste (RRB) has a correlation of 0.528 (**); the rate of use of circular material (TUMC) has a correlation of 0.406 (*); and the people employed in CE (PE) has a negative correlation of -0.387 (*) (see Table 6).

5. DISCUSSION

From the results achieved, the three proposed research questions can be treated. It could be asserted that there are multiple correlations between the nine chosen indicators of the CE defined in the Monitoring Framework of Eurostat and the 17 SDGs. This is asserted through the analysis of the established correlations between the proposed initiatives in the UE focused on transforming the linear economy model, which, nowadays, exists in a CE model and through the defined SDG fulfillment by the United Nations. Specifically, the indicator generation of municipal waste per capita (GMW) is correlated significantly with six SDGs; recycling rate of municipal waste (RRMW) is correlated with nine SDGs; recycling rate of overall packaging (RROP) is correlated with three SDGs; recycling rate of e-waste (RReW) is correlated with one SDG; recycling of biowaste (RB) is correlated with nine SDGs; circular material use rate (CMUR) is correlated with four SDGs; gross investment in tangible goods (GITG) is correlated with four SDGs; and persons employed (PE) is correlated with five SDGs. Only recovery rate of construction and demolition waste (RRCDW) is not correlated with any SDG. Furthermore, it has been shown that five of the nine used indicators of CE — recycling rate of municipal waste (RRMW), recycling rate of overall packaging (RROP), recycling of biowaste (RB), circular material use rate (CMUR), and persons employed (PE) — have a global correlation that is statistically significant with the set of 17 SDGs.

Under other approach, all the SDGs, except SDG 4, 6, 7, 15, and 17, are significantly correlated with some initiatives of the CE. Specifically, SDG 1 is correlated with two indicators of CE, SDG 2 with 5, SDG 3 with 5, SDG 5 with 4, SDG 8 with 2, SDG 9 with 7, SDG 10 with 3, SDG 11 with 2, SDG 12 with 4, SDG 13 with 1, SDG 14 with 1, and SDG 16 with 5.

All this allows answering accurately the first research question (RQ 1). Therefore, it could be asserted that there is a direct relationship between the undertaken initiatives in the EU scope. These initiatives tend to the effective implementation of a CE model in member states and the fulfillment of the SDGs.

After the cluster analysis, it could be deduced that there are four homogeneous groups of countries related with the fulfillment of the 17 SDGs. In the first cluster, most countries of the EU28 and many developed countries would be included. In the second, which is very large, would be the developing countries, two countries that were not in the first group, most Latin American countries, and a diverse group of countries from other continents. In the third group, the smallest, there would be only eight African countries. In the fourth group would be the rest of the countries, almost exclusively developing African and Asiatic countries. In these last groups, the values of compliance with the SDGs would be seriously below the world mean values. These data allow to determine that, as an answer to the second research question (RQ 2), there are groups of countries that can be considered homogeneous in terms of fulfillment of the SDGs.

Also, the cluster analysis allowed to determine that 26 of the 28 countries that form the EU, which are under the recommendations of the European Commission through its communications, obtain similar results in the fulfillment of the SDG scope. Except for Bulgaria and Romania, the EU28 countries would be grouped in the first cluster. This allows answering the third research question affirmatively (RQ 3).

Consequently, European institutions can continue to believe that there is a direct relationship between CE and SDGs. The first is considered as a tool that helps to fulfill the second. [In order to accept, partially accept or reject the hypotheses formulated, the following criteria have been followed: a\) when there was no significant correlation between a specific SDG and none of the nine selected CE indicators, the existence of](#)

correlation was rejected; b) when only one of the nine selected CE indicators had a significant correlation with a specific SDG, it was partially accepted; and c) when there were two or more selected CE indicators with significant correlations with a specific SDG, the hypothesis formulated was accepted. Then, the eight established hypothesis in this research were contrasted:

H1. The CE is related to SDG 6. Rejected.

H2. The CE is related to SDG 8. Accepted.

H3. The CE is related to SDG 9. Accepted.

H4. The CE is related to SDG 11. Accepted.

H5. The CE is related to SDG 12. Accepted.

H6. The CE is related to SDG 13. Partly accepted.

H7. The CE is related to SDG 14. Partly accepted.

H8. The CE is related to SDG 15. Rejected.

It is possible to confirm a strong relationship between the CE and SDGs 2, 3, 5, and 16, which do not appear collected, specifically, in the community legislation.

6. CONCLUSIONS

Since the European Commission issued its report titled Close the Circle: An Action Plan of the European Union for the Circular Economy, the EU has not stopped making its member states, regions, enterprises, institutions, and citizens aware of the importance of transitioning to the CE in a faster and more effective way.

Although previous Communications from the European Commission did not mention the Millennium objectives, since the United Nations General Assembly approved the 2030 Agenda, the EU has revised its recommendations to fulfill some SDGs approved in this agenda.

Through this study and the use of statistical methods, it can be asserted that there is a clear relationship between the CE and SDGs. This relation is statistically significant between some indicators of the CE and SDGs and between some indicators of the CE and the average value of the fulfillment of SDGs. This shows that the EU can achieve the desired SDGs, implementing initiatives that tend to make an economy more circular. It would allow to assert that if any multinational group or country practiced specific initiatives of CE, the SDGs could be achieved.

Another conclusion is that there are groups of countries that can be considered homogeneous in the fulfillment of SDGs. The origin of their high homogeneity could be in aspects of a political nature, as in the EU, or just geographic, as is the case of Latin America and Africa. In the case of the EU, there is evidence that 26 of the 28 member countries have achieved similar results according to the fulfillment of SDGs.

The following recommendations to public bodies could be expressed from the results achieved.

The first, refers to the significant relationship that has been found between the CE and some SDGs. In this regard, it has been shown that some EC indicators are highly correlated with some SDGs. Consequently, if public agents were to follow these indicators, the SDGs could achieve better values. Specifically, public measures designed to reduce the generation of municipal waste per capita, to increase the recycling rate of municipal waste, the recycling of biological waste, the rate of use of circular material and, to a lesser extent, to increase the gross investment in tangible goods and the percentage of People employed in the CE, the next six SDGs would significantly improve their results: 1) Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all; 2) Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation; 3) Make cities and human settlements inclusive, safe, resilient and sustainable; 4) Ensure sustainable consumption and production patterns; 5) Take urgent action to combat climate change and its impacts and 6) Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

The second is aimed at advanced countries supporting, through development support measures, those developing countries, which are grouped in clusters 2, 3 and 4, to implement urgent initiatives aimed to support those countries, in a more effective way, in their path towards a CE model that, as demonstrated, will facilitate the fulfilment of, at least, some SDGs.

With regard to limitations, the main one is the absence of a homogeneous global database, such as that elaborated by Eurostat for countries that belong to the EU. This causes the study not to be global, but only applicable to the EU.

For subsequent researches, it would be interesting to conduct a temporary analysis, considering certain years and analyzing the evolution of the implementation of CE initiatives and the achievement of the 17 SDGs in the EU countries and the rest of the countries worldwide. Starting from this study, the time that must elapse since the CE is implemented and the SDGs are achieved could be determined.

ACKNOWLEDGMENT

This work was supported by the Ministry of Science, Innovation and Universities of Spain within its National Program for Research Aimed at the Challenges of Society under grant ECO2016-79659-R (Ecoinnovation and Circular Economy in Services Industries).

DECLARATION OF INTEREST STATEMENT

The authors declare that there is no conflict of interest.

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ANNEXES

ANNEX 1. CLUSTER OF COUNTRIES FOR SDG COMPLIANCE

COUNTRIES	CLUSTER	COUNTRIES	CLUSTER	COUNTRIES	CLUSTER	COUNTRIES	CLUSTER
Australia	1	Mauritius	2	Botswana	3	Malawi	4
Bahrain	1	Saudi Arabia	2	Eswatini	3	Mozambique	4
Canada	1	Brazil	2	Lesotho	3	Djibouti	4
Kuwait	1	Chile	2	Namibia	3	Iraq	4
Norway	1	Colombia	2	South Africa	3	Afghanistan	4
Qatar	1	Costa Rica	2	Kenya	3	Angola	4
United Arab Emirates	1	Cuba	2	Rwanda	3	Benin	4
United States	1	Ecuador	2	Zimbabwe	3	Burkina Faso	4
Singapore	1	Georgia	2			Burundi	4
Croatia	1	Guyana	2			Cameroon	4
Estonia	1	Honduras	2			Chad	4
Austria	1	Mexico	2			Congo	4
Belgium	1	Montenegro	2			Ivory Coast	4
China	1	Peru	2			Democretic Republic of Congo	4
Cyprus	1	Suriname	2			Ethiopia	4
Denmark	1	Trinidad and Tobago	2			Gambia	4
Finland	1	Venezuela	2			Guinea	4
Germany	1	Iran	2			Haiti	4
Island	1	Kazakhstan	2			Liberia	4
Ireland	1	Oman	2			Madagascar	4
Israel	1	Turkmenistan	2			Mali	4
Italy	1	Jordania	2			Mauritania	4
Japan	1	Malaysia	2			Niger	4
South Korea	1	Turkey	2			Nigeria	4
Luxemboug	1	Azerbaijan	2			Pakistan	4
Netherlands	1	Bhutan	2			Senegal	4
Slovakia	1	Bosnia and Herzegovina	2			Sierra Leone	4
Switzerland	1	Lebanon	2			Sudan	4
United Kingdom	1	Albania	2			Tanzania	4

Czech Republic	1	Algeria	2			Togo	4
France	1	Argentina	2			Uganda	4
Greece	1	Armenia	2			Zambia	4
Latvia	1	Bangladesh	2			Central African Republic	4
Lithuania	1	Belarus	2			Yemen	4
Malta	1	Belize	2				
New Zealand	1	Cape Verde	2				
Poland	1	Cambodia	2				
Portugal	1	Egypt	2				
Slovenia	1	El Salvador	2				
Spain	1	Gabon	2				
Sweden	1	Ghana	2				
Hungary	1	Guatemala	2				
		India	2				
		Indonesia	2				
		Jamaica	2				
		Kyrgyzstan	2				
		Laos	2				
		Moldavia	2				
		Mongolia	2				
		Marruecos	2				
		Myanmar	2				
		Nepal	2				
		Nicaragua	2				
		Panama	2				
		Filipinas	2				
		Russia	2				
		Serbia	2				
		Sri Lanka	2				
		Syria	2				
		Tajikistan	2				
		Thailand	2				
		Ukraine	2				
		Uzbekistan	2				
		Vietnam	2				
		Bolivia	2				
		Bulgaria	2				
		Dominican Republic	2				
		Macedonia	2				
		Paraguay	2				
		Romania	2				
		Tunisia	2				
		Uruguay	2				

TABLES

Table 1. Correlation Matrix between SDGs

	SDG1	SDG2	SDG3	SDG4	SDG5	SDG6	SDG7	SDG8	SDG9	SDG10	SDG11	SDG12	SDG13	SDG14	SDG15	SDG16	SDG17
SDG1	1																
SDG2	.590(**)	1															
SDG3	.758(**)	.784(**)	1														
SDG4	.620(**)	.737(**)	.847(**)	1													
SDG5	.361(**)	.623(**)	.621(**)	.733(**)	1												
SDG6	.413(**)	.554(**)	.478(**)	.519(**)	.639(**)	1											
SDG7	.765(**)	.689(**)	.873(**)	.793(**)	.496(**)	.449(**)	1										
SDG8	.581(**)	.762(**)	.742(**)	.694(**)	.657(**)	.482(**)	.545(**)	1									
SDG9	.539(**)	.788(**)	.820(**)	.706(**)	.573(**)	.343(**)	.674(**)	.754(**)	1								
SDG10	.339(**)	.390(**)	.335(**)	.173(*)	0.110	0.109	.209(**)	.321(**)	.386(**)	1							
SDG11	.485(**)	.602(**)	.711(**)	.702(**)	.717(**)	.615(**)	.659(**)	.602(**)	.613(**)	0.093	1						
SDG12	-.420(**)	-.614(**)	-.686(**)	-.575(**)	-.444(**)	-.258(**)	-.557(**)	-.613(**)	-.777(**)	-.286(**)	-.486(**)	1					
SDG13	-0.099	-0.110	-.197(*)	-.164(*)	-0.069	-.186(*)	-0.100	-.198(*)	-.260(**)	-0.019	-0.030	.441(**)	1				
SDG14	0.055	0.069	0.088	0.132	.177(*)	0.066	0.090	0.121	0.132	-0.074	.174(*)	-0.063	0.008	1			
SDG15	-.187(*)	0.054	-0.093	-0.021	0.031	0.047	-0.097	-0.035	-0.014	0.101	-0.050	0.112	.241(**)	.225(**)	1		
SDG16	.486(**)	.588(**)	.689(**)	.523(**)	.333(**)	0.102	.499(**)	.610(**)	.768(**)	.425(**)	.430(**)	-.633(**)	-.310(**)	0.066	-0.044	1	
SDG17	-0.067	-0.018	-0.008	0.015	0.123	0.097	0.004	-0.133	-0.070	-0.059	0.066	0.037	-0.061	0.080	-0.071	-0.087	1
AVERAGE	.753(**)	.860(**)	.921(**)	.866(**)	.733(**)	.629(**)	.840(**)	.791(**)	.828(**)	.425(**)	.774(**)	-.606(**)	-0.041	-.201(*)	0.063	.654(**)	0.059

** . The Correlation is significant at the 0.01 level (2-tailed).

*. The Correlation is significant at the 0.05 level (2-tailed)..

N=156 countries

Table 2. Analysis of the averages of the groups of countries based on compliance with the SDGs

Cluster	SDG1	SDG2	SDG3	SDG4	SDG5	SDG6	SDG7	SDG8	SDG9	SDG10	SDG11	SDG12	SDG13	SDG14	SDG15	SDG16	SDG17	AVERAGE
1	99.5	70.1	91.6	90.5	76.2	81.0	87.1	82.6	68.5	74.9	81.4	54.4	77.0	49.8	63.2	79.3	58.0	75.7
2	96.6	54.0	74.2	77.9	64.6	81.0	76.0	64.2	28.9	53.5	73.6	72.5	84.3	48.7	57.3	61.2	63.3	66.5
3	59.6	42.6	51.7	64.7	74.4	69.1	37.8	51.6	24.9	15.0	74.3	73.4	75.0	51.7	60.5	54.2	80.6	56.5
4	54.0	38.8	43.4	34.4	46.1	58.9	25.4	47.7	10.2	55.7	51.0	79.7	86.5	46.4	63.4	52.7	60.1	50.2
Total	86.2	54.4	71.0	71.1	64.2	75.6	66.0	64.9	35.3	57.8	70.8	69.2	82.3	48.7	60.4	63.8	62.1	64.9

Table 3. Correlation Matrix between the selected CE indicators

	GRM	TRRM	TREG	TRREE	RRB	TRRCD	TUMC	IBBM	PE
GRM	1	0.262	0.148	-0.241	.535(**)	-0.082	0.065	-.609(**)	-0.288
TRRM	0.262	1	.619(**)	-0.013	.810(**)	0.177	.556(**)	-0.185	-0.252
TREG	0.148	.619(**)	1	-0.146	.563(**)	0.073	0.351	-0.239	-0.349
TRREE	-0.241	-0.013	-0.146	1	-0.188	0.157	-0.082	0.214	0.090
RRB	.535(**)	.810(**)	.563(**)	-0.188	1	0.049	.489(**)	-0.339	-0.336
TRRCD	-0.082	0.177	0.073	0.157	0.049	1	0.098	0.261	-0.073
TUMC	0.065	.556(**)	0.351	-0.082	.489(**)	0.098	1	-0.049	-0.364
IBBM	-.609(**)	-0.185	-0.239	0.214	-0.339	0.261	-0.049	1	.439(*)
PE	-0.288	-0.252	-0.349	0.090	-0.336	-0.073	-0.364	.439(*)	1

*. The Correlation is significant at the 0.05 level (2-tailed).

** . The Correlation is significant at the 0.01 level (2-tailed).

Table 4. Correlations between the rates of implementation of the EC in the EU28 and the SDGs

Correlations

	IEC2017 (1 st Factor)	2 nd Factor
SDG1	0.303	-0.238
SDG2	.698(**)	-0.067
SDG3	.495(**)	-.604(**)
SDG4	0.252	-0.229
SDG5	.649(**)	-0.109
SDG6	0.235	-0.177
SDG7	0.083	-0.262
SDG8	.469(*)	-0.048
SDG9	.719(**)	-0.366
SDG10	.477(*)	-0.240
SDG11	.397(*)	-0.140
SDG12	-0.239	.629(**)
SDG13	-0.335	0.153
SDG14	-0.358	0.304
SDG15	0.040	.455(*)
SDG16	.486(**)	-.422(*)
SDG17	0.272	-0.079
AVERAGE	.613(**)	-0.142
IEC2017	1	0.000
FAC2_1	0.000	1

Table 5. EU28 countries ranking by level of implementation of the EC

Country	Weighted average
Belgium	1.69
Netherlas	1.37
Bulgaria	0.84
United Kingdom	0.62
Germany	0.55
Austria	0.52
Italy	0.46
Slovenia	0.4
Lithuania	0.29
Denmark	0.24
Finland	0.21
France	0.2
Czech Republic	0.13
Luxembourg	0.08
Poland	0.01
Estonia	-0.12
Sweden	-0.19
Ireland	-0.22
Hungary	-0.24

Latvia	-0.26
Spain	-0.31
Croatia	-0.38
Portugal	-0.42
Slovak Republic	-0.52
Romania	-0.53
Greece	-1.04
Malta	-1.64
Cyprus	-1.75

Table 6. Correlation between the selected CE indicators and the SDGs

	GRM	TRRM	TREG	TRREE	RRB	TRRCD	TUMC	IBBM	PE
SDG1	.446(*)	.395(*)	0.054	-0.020	0.265	0.014	0.336	-0.320	-0.067
SDG2	0.210	.708(**)	.470(*)	0.018	.614(**)	-0.011	.525(**)	-0.124	-.412(*)
SDG3	.568(**)	.493(**)	0.363	-0.307	.555(**)	-0.149	0.366	-.656(**)	-.475(*)
SDG4	0.363	0.344	0.279	-0.228	0.184	-0.192	0.280	-0.123	0.052
SDG5	0.214	.633(**)	.584(**)	-0.014	.542(**)	0.075	.409(*)	-0.256	-0.317
SDG6	-0.028	0.260	0.153	-0.168	0.360	-0.278	0.170	-0.113	-0.272
SDG7	0.069	0.041	0.152	-0.118	-0.010	-0.191	0.148	-0.306	-0.338
SDG8	0.318	.507(**)	0.104	-0.156	.513(**)	0.129	0.344	0.082	-0.249
SDG9	.469(*)	.703(**)	.537(**)	-0.090	.715(**)	-0.059	.494(**)	-.450(*)	-.503(**)
SDG10	.423(*)	.526(**)	0.312	-0.060	.396(*)	-0.009	0.358	-0.261	-0.308
SDG11	0.246	.410(*)	0.216	-0.031	.405(*)	0.013	0.225	-0.118	-0.355
SDG12	-.648(**)	-0.199	-0.129	0.255	-.395(*)	0.062	-0.070	.590(**)	.467(*)
SDG13	-0.174	-0.191	-0.331	0.106	-0.251	-0.017	-.379(*)	0.234	0.236
SDG14	-0.249	-0.330	-0.351	.541(**)	-0.350	0.077	-0.319	0.191	0.227
SDG15	-0.350	0.020	0.159	0.231	-0.264	0.187	0.106	0.346	0.162
SDG16	.591(**)	.473(*)	0.297	-0.209	.555(**)	0.084	0.221	-.391(*)	-.461(*)
SDG17	0.245	0.280	0.151	0.171	0.272	0.054	0.075	-0.089	-0.284
AVERAGE	0.326	.652(**)	.425(*)	0.046	.528(**)	0.010	.406(*)	-0.199	-.387(*)
GRM	1	0.262	0.148	-0.241	.535(**)	-0.082	0.065	-.609(**)	-0.288
TRRM	0.262	1	.619(**)	-0.013	.810(**)	0.177	.556(**)	-0.185	-0.252
TREG	0.148	.619(**)	1	-0.146	.563(**)	0.073	0.351	-0.239	-0.349
TRREE	-0.241	-0.013	-0.146	1	-0.188	0.157	-0.082	0.214	0.090
RRB	.535(**)	.810(**)	.563(**)	-0.188	1	0.049	.489(**)	-0.339	-0.336
TRRCD	-0.082	0.177	0.073	0.157	0.049	1	0.098	0.261	-0.073
TUMC	0.065	.556(**)	0.351	-0.082	.489(**)	0.098	1	-0.049	-0.364
IBBM	-.609(**)	-0.185	-0.239	0.214	-0.339	0.261	-0.049	1	.439(*)
PE	-0.288	-0.252	-0.349	0.090	-0.336	-0.073	-0.364	.439(*)	1

*. The Correlation is significant at the 0.05 level (2-tailed).

**.. The Correlation is significant at the 0.01 level (2-tailed).