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## Article

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## CIRCULAR ECONOMY AND INNOVATIVE ENTREPRENEURSHIP, PREREQUISITES FOR SOCIAL PROGRESS

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**Abstract.** Quality of life and social welfare are objectives of the social policy of any state. The study aims to identify the influence of factors such as the circular economy, digital innovation, sustainable entrepreneurship on social progress and completes the current approach identified in the literature by assessing the dependencies between the phenomena represented by them. The quantification of the influences of the enumerated factors on social progress was achieved by identifying some synthetic indicators, such as composite indices, which would surprise the complexity of the analyzed phenomena. To measure the progress of the transition to the circular economy – using multivariate analysis methods – a composite indicator has been proposed and determined that allows the ranking of EU states according to its orientation, as a premise of social progress, and can substantiate the adjustment national policies. The integration of the proposed indicator in the regression models used, with similar indices, is done to highlight the impact of the circular economy, innovation and sustainable entrepreneurship on social progress. Thus, the adaptation of digital technologies in current business models, the development of sustainable innovative entrepreneurship support the transition from the linear economy to a circular economy and offer new study opportunities.

**Keywords:** circular economy, entrepreneurship, digital innovation, social progress, multivariate analysis.

**JEL Classification:** C38, O35, O44, Q55.

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## Introduction

Sustainability, the foundation of the current global framework for sustainable development under the 2030 Agenda for Sustainable Development (United Nations & General Assembly, 2015), integrates elements of economic and social development, as well as environmental protection based on innovation, especially digital innovation. Achieving the goals of sustainable development is based on the transition from a linear to a circular economy, which is also reflected in the importance given to sustainability policies and programmes by the European Commission (2020). Also, one of the conclusions of the study “Impacts of circular economy policies on the labor market” shows that the application of the principles of the circular economy throughout the EU economy can generate about 700,000 new jobs and an increase in GDP by 0.5% by 2030 (European Commission, 2018b).

For citizens, the circular economy can be considered a form of social progress highlighted by sustainable products and services aimed at a better quality of life. In addition to the efficient use of all existing resources, the circular economy brings to market the idea that the reuse of finished products is the most effective tactic to protect the environment. Certainly, any business, investment or project makes its mark on the environment in which it occurs, which makes investors and companies around the world act with greater social responsibility. In this sense, it is necessary to identify and analyze the stage of implementation of the fundamental principles and values of corporate social responsibility to make possible the elimination of growth policies and their diversification (Androniceanu, 2019).

A main component of the evolution towards the circular economy of business models in recent decades is digital innovation, which involves both the incorporation of modern technology in the production, promotion, distribution of goods and services, but also in how to use it, through the proposed creative approaches, thus generating disruptive or accelerated solutions. By integrating new technologies, the consumption of raw materials is reduced, new sources, alternative renewable energy are used, enhancing the efficiency of production processes in which resources are maximized and waste is reduced. Another factor that can lead to sustainability in the economic, environmental and social sectors is blockchain technology, whose applicability has been recognized in stimulating ecological behavior, and the identification of alternative solutions that consume less energy makes it considered an essential component in the evolution from a linear to a circular economy (Rana et al., 2019).

The idea of the necessity and influence of digital instruments is described by Tohănean et al. (2020) as a necessary and competitive factor in the development of sustainable businesses, innovation, sustainability and technology being the key pillars for business model innovation.

The correlation of modern technologies with the circular economy in digital entrepreneurship supports the achievement of the Sustainable Development Objective “Responsible consumption and production” (SDG 12), by reducing the need to use new resources (Figure 1).

The authors aim in this article to highlight the influence of factors such as digital innovation, sustainable entrepreneurship and the circular economy on social progress as the core of a sustainable and inclusive society. In order to quantify the influences of the listed factors on social progress, we identified synthetic indicators, such as composite indices, in order to capture the complexity of the analyzed phenomena.



Figure 1. Prerequisites of social progress (source: created by the authors)

Thus, in the literature composite indices that measure social progress were identified – the Social Progress Index (SPI); the “health” of the entrepreneurial ecosystem – The Global Entrepreneurship Index (GEI), as well as the latest trends in global innovation – The Global Innovation Index (GII) (Ács et al., 2017; Social Progress Index, 2019; World Intellectual Property Organization, 2019). For the circular economy there is a set of common indicators at the level of EU Member States, as mentioned, in the literature, we may find proposals for the construction of a composite indicator. The development of the research had as a starting point the identification of the influences of the circular economy and of the innovative entrepreneurship on the social progress, these being the working hypotheses.

The research is structured in 6 sections: Literature review, Research methodology, Creating the Circular Economy Index, Circular economy, digital innovation and innovative entrepreneurship as determinants of social progress, Results and comments and Conclusions. The first two sections were dedicated to the review of the literature in the field and the statistical and econometric methods used in the analysis. In the next section, Creating the Circular Economy Index, based on statistical data for indicators calculated by Eurostat, the authors create a composite indicator that quantifies the circular economy, providing a monitoring and ranking of EU economies. The fourth section, Circular economy, digital innovation and innovative entrepreneurship as determinants of social progress, includes an analysis, based on the composite indices identified for each of the areas under study, to verify the dependencies between the circular economy, social progress and innovative entrepreneurship. The Results and comments section contains discussions on the influence of the circular economy, digital innovation and sustainable entrepreneurship on social progress. The last section includes the authors’ conclusions, as well as the main limits and future research possibilities.

## 1. Literature review

### 1.1. Circular economy

The circular economy (CE) is a regenerative concept that requires a systemic economic change, which brings the business reasoning, from production to consumption (Moraga et al., 2019). Defining and quantifying the circular economy is a complex process, which involves challenges in creating a system of indicators that aligns the development of the cir-

cular economy with the social progress. Thus, according to Mitrović and Veselinov (2018), assessing progress and stimulating the creation and adoption of innovative and corrective policies and strategies for the development of the circular economy requires the use of a coherent and synthetic method, the authors of this paper considered it necessary to create a *composite index*, based on the set of indicators provided by Eurostat, aimed at strengthening the research, development and implementation of the circular economy.

The paper “A systematic review for measuring circular economy: The 61 indicators” summarizes the concerns of researchers and specialists on the definition and quantification of the circular economy, the authors identifying a framework for possible measurements, which can be applied to spatial levels of sustainability – micro, meso and macro (De Pascale et al., 2021). The approach on the three spatial levels was structured by Kirchherr et al. (2017), as follows: at micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and not only), and the concept of Circular Economy is associated with recycling and reuse in the processes of production, distribution and consumption.

The authors of the article agree with the idea supported by Arbolino et al. (2018) as well as the perspective of substantiating public policies in the CE field that a composite indicator must have the ability to better synthesize the available data and to transmit information on the performance of an entity: company, economic sector, region, country. At the same time, the constructed composite indicator can provide an overview of the opportunities created by the use of the circular economy, but also of the currently existing limitations, generated mainly by the absence of a standardized measure of it (Yigitcanlar, 2010). The complexity of this indicator derives from the quantification of the factors that lead to the development of the circular economy, based on a unique and valid measurement model that can be applied to the economies under analysis.

During the past years, the responsible and cyclical use of resources and the development, the policies to minimize the negative effects on the environment and to boost the economy make the circular economy be defined as an umbrella concept, found in the literature as “a broad concept or idea used loosely to encompass and account for a set of diverse phenomena” (Hirsch & Levin, 1999). This is the result of the identification of common characteristics on the basis of which a relationship can be created between certain phenomena, that were not related to previous approaches and that evolves when a field does not have guiding theories or a development paradigm (Hirsch & Levin, 1999). All this undergoes the definition of the circular economy as an umbrella concept that applies various mechanisms aimed at minimizing waste generation, and thus decoupling economic growth from natural resources (Hirsch & Levin, 1999; Blomsma & Brennan, 2017).

European legislation includes issues related to the circular economy since the 1970s (European Economic Community, 1975). However, even though European policies in the 2000s also refer to resource efficiency (European Commission, 2011), the first country to enact a specific law was China in 2008 (Naustdalsslid, 2014; International Reference Centre for the Life Cycle of Products, Processes and Services, 2015). At European level, at the end of 2015, the European Union approved the law “Closing the loop – An EU action plan for the Circular Economy” (European Commission, 2015). The legislative package includes actions that aim

to cover the whole life cycle: from production and consumption to waste management and optimizing the use of secondary raw materials. In 2018, based on the action plan for the circular economy, a set of indicators was proposed, which would constitute a monitoring framework for the circular economy with the aim of measuring its progress. The indicators, grouped by areas of the circular economy, allow monitoring of future developments of its main elements and can provide information for the policy-making process. At the same time, the monitoring framework will allow the evaluation of the applied measures and the identification of good practices in the field (European Commission, 2018).

Private consultants, who work regionally, nationally or internationally in various fields other than the circular economy, including the Ellen MacArthur Foundation – EMF (UK), LandSI (Italy), Sustainable Innovations Europe (Spain), InteriorPark (Germany), Antea Group (USA), Business and Sustainability (Argentina), Circular Economy Alliance Australia have a major contribution to the development of policies in the field.

The development of the circular economy, by increasing recycling and decreasing the amount of waste generated per capita, is a result of the National Green Procurement Plans. The positive impact of their adoption is also underlined by the implementation of public policies by both central and municipal authorities (Siminică et al., 2020).

## **1.2. Digital innovation**

New digital solutions are essential elements of the circular economy by tracking the flow of production and sales, the resulting data and information providing the possibility of optimal management of resources and decision making at different stages of the life cycle of products and services (Antikainen et al., 2018; Bressanelli et al., 2018; European Commission, 2020). At the same time, digital technologies have an important role in the use of information that allows resource flows to become more circular. This can be easily observed when talking about the Internet of Things (IoT), which can allow automatic location tracking thus facilitating resource monitoring (Ellen MacArthur Foundation [EMF], 2016, 2019). The use of Big Data facilitates the generation of the necessary information regarding the production and consumption processes of the entire production cycle. Thus, understanding the requirements and operations of each stage of this cycle leads to the development of circular strategies to determine sustainable business models (Dubey et al., 2019; Low et al., 2018; Gupta et al., 2019). At the same time, Gupta et al. (2019) propose new perspectives of economic actors interested in the circular economy using Big Data as a tool in decision making that can lead to the implementation of sustainable business practices in accordance with the principles of the CE concept. From determining the quality and state of wear of products and optimizing the use of resources, to the design of sustainable businesses, the implementation of new IT technologies and the use of data analysis determine new ways to use the circular economy in production processes (Conboy et al., 2020; Mikalef & Krogstie, 2020; Micu et al., 2021).

The digital economy is considered to be the fourth industrial revolution, characterized by the ability to transform economies, jobs and even society as a whole, by introducing new technologies and processes. The digital economy is expected to contribute to social and economic equality. At the same time, technology will help increase access to education, jobs and finance, even if, in the short term, it could lead to a reduction in repetitive and value-added

jobs in almost all economic sectors, whether we are talking about industry, agriculture or services. In Romania, it is estimated that approximately 60% of existing jobs could be affected by the digital economy (Deloitte, 2018). The main causes are the development of the concept of e-government, robotization and automation in industrial sectors and the transfer of services from the traditional area to the digital area. If previous industrial revolutions have produced changes over several generations, the digital economy is producing significant effects in a much shorter period of time.

### **1.3. Innovative entrepreneurship**

One of the objectives of the Digital Agenda Europe 2020 (European Commission, 2010) is to achieve a new economic framework, which ensures the compatibility of activities between information systems and the circular economy. Thus, we can consider the digital circular economy as a premise of a sustainable society, and the intelligent use of resources in the CE can be supported by innovation.

Innovation and entrepreneurship, two distinct but closely linked concepts, are essential ingredients in building a successful business enterprise. Developing companies and improving business based on innovation is not only part of a durable and sustainable economy, but can be an essential aspect of entrepreneurship. At the same time, the actions on climate change taken for the transition to a circular economy lead to innovation and make companies more competitive (Davidescu et al., 2020).

It is agreed in the literature that the technological progress is the main premise of economic growth. Tsvetkova (2015) highlighted the link between innovation and regional economic performance through the businesses developed by local entrepreneurs. The entrepreneurial ecosystem approach emphasizes that entrepreneurship takes place in a community of interdependent actors (Stam, 2015). Each entrepreneurial ecosystem is unique, there are practically a variety of configurations that ecosystems can take (Spigel, 2017; Szerb et al., 2019).

If the version proposed by Spigel argues that ecosystems are composed of 10 cultural, social and material attributes that provide benefits and resources to entrepreneurs and that the relationships between these attributes reproduce the ecosystem, the quantification of entrepreneurial ecosystem performance supported by The Global Entrepreneurship and Development Institute (The GEDI Institute) has a different approach. Thus, the performance of the entrepreneurial ecosystem formed by the mix of attitudes, resources and infrastructure is analyzed through the Global Entrepreneurship Index. According to the methodology, the Global Entrepreneurship Index (GEI) consists of three sub-indices covering 14 areas of the entrepreneurial ecosystem (Ács et al., 2017), including data on entrepreneurial attitudes, entrepreneurial skills and aspirations of the local population (Figure 2). Each country under analysis may have one or more critical areas which may affect the ecosystem.

The importance of using GEI also stems from the fact that it is considered a tool that can be used in assessing the entrepreneurial ecosystem in order to create more jobs. In addition to the image of the performance of each country, from the point of view of the entrepreneurial ecosystem, actions that could be taken to generate improvements in each of these



14 areas measured by GEI can be identified both in the domestic and in the international context (GEI, 2018). Obviously, these are actions that cannot cover all the contexts or all the economies analyzed, but can lead to solutions at regional, national or European level to improve the problems of blockage in the entrepreneurial ecosystem.

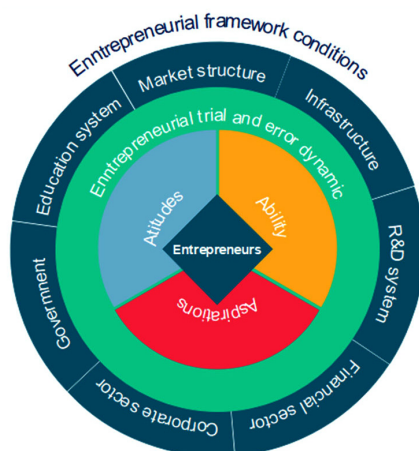


Figure 2. The Entrepreneurial ecosystem configuration (source: Global Entrepreneurship Development Institute, 2019, created by the authors)

The entrepreneurial ecosystem is strongly influenced by the digital transformation, and the innovation in the technology sector will lead to lower data processing costs, while digital integration will expand through artificial intelligence. All these transformations require new approaches to public policies to support the new generations of entrepreneurs. Tax regulations make the business environment relatively homogeneous at European level, but when it comes to digital entrepreneurship, the difference is given by the level of development of the digital infrastructure. This also emerges from the analysis of the Digital Economy and Society Index (DESI), a composite index that includes relevant indicators on the digital performance of European states and tracks the evolution of EU Member States in terms of digital competitiveness.

#### 1.4. Social progress

A sustainable society based on inclusive economic growth requires, in addition to economic progress requires social progress. Economic growth leads to improved quality of life, but a sustainable development strategy based on this alone is incomplete. If in the past century the analysis of the evolution of the gross domestic product was sufficient because it offered a perspective of economic development and social progress, in recent years, in the literature, has been emphasized that this approach can only quantify material well-being. Kuznets (1934), the economist who developed the modern concept of GDP, warned against equating his growth with well-being. While some countries continue to use GDP as the main tool for measuring a country's economy, others see its use as an insufficient and misleading indicator. In order to provide a panoramic picture of a nation's economic and social well-being,



non-economic factors should also be included in the analyzes: pollution and crime or factors that measure other important aspects of quality of life: health and education. Therefore, according to Costanza et al. (2014), other indicators can be used as an alternative to GDP, such as the *The Genuine Progress Indicator – GPI* (Talberth et al., 2007), *Gross National Happiness – GNH*, implemented by the Kingdom of Bhuthan since 1972 and the Social Progress Index (SPI) (Costanza et al., 2014; Kubiszewski & Costanza, 2015).

Launched in 2014, the Social Progress Index (SPI) is a composite indicator developed based on extensive discussions with stakeholders around the world on what can be lost when policymakers focus on GDP and exclude social performance. SPI includes indicators that measure elements of social and environmental performance aggregated in a complex general framework (Mihai, 2017). On the other hand, the analysis of indicators in the composition of the SPI helps us to identify performance at country or regional level, so some countries have included the SPI in their development of policies and strategies. At the same time, SPI was accepted and adopted by private companies to establish investment strategies, and the European Commission determined the EU-SPI indicator at regional level as a measure of the contribution to the “Beyond GDP” agenda (Annoni & Bolsi, 2020). Similar to the Global Social Progress Index, the regional social progress index facilitates benchmarking between European regions by helping policy makers assess the evolution of regions in terms of social and environmental issues in order to support EU cohesion policy.

For the calculation of EU-SPI 2020, being an aggregate index, 55 indicators (Annoni & Bolsi, 2020, p. 5) were selected from an initial set of 73 social and environmental indicators initially proposed. Compared to the first version of the index, calculated in 2016, this edition contains regional estimates with remarkably improved reliability, especially for those indicators in the EU Eurostat survey on income and living conditions and in the Gallup World Poll (Annoni & Bolsi, 2020). It should be noted that approximately 56% of the indicators are provided by Eurostat, and the new composition of the index includes 14 new indicators covering mainly concepts such as personal security, gender equality, fairer labor markets and cohesive societies (Annoni & Bolsi, 2020, p. 5).

## 2. Research methodology

In order to analyze the impact of the circular economy, respectively of the innovative entrepreneurship on the social progress, the aggregation of the indicators, available in the Eurostat database and the construction of a composite index of the circular economy (CEI) was realized. The proposed index is also useful for monitoring the progress of each EU member state towards a circular economy.

For the research of the two hypotheses in the title of the article, namely: Hypothesis 1 – The influence of the circular economy on social progress and Hypothesis 2 – The influence of innovative entrepreneurship on social progress, we included in the analysis indicators characterizing the three areas mentioned above, based on Eurostat data (CEI & EU-SPI); The Global Entrepreneurship and Development Institute (EGDI); Social Progress Imperative (SPI) and Cornell University, INSEAD, and the World Intellectual Property Organization (GII), and data processing is done with SPSS (ver. 26).

In order to test the research hypotheses according to which social progress is influenced by the circular economy and the digital innovation in the business environment, correlation and regression analysis was used.

The quantification of existing information on the circular economy at EU level is done through the set of individual indicators provided by Eurostat. Their integration, in a way that mirrors the economic reality, through the composite indicator requires a complex theoretical framework. To compare the performance of countries, a composite indicator must reflect the complexity of the results and policies analyzed by the individual indicators. Essential in creating a composite indicator is, in addition to selecting an initial set of appropriate indicators, and combining and weighting them so as to ensure a clear analysis of a country's performance (Nardo et al., 2008).

Given the above, we considered that, in building a reliable composite indicator, we must pay special attention to addressing the imputation of missing values. In the present analysis, the compensation of missing data for some states was performed using cluster analysis and mean substitution. The evaluation of individual indicators to determine the share with which they are aggregated in a composite indicator is not done by a standard methodology, the literature offering a variety of methods. For the data set used in the case of the circular economy analysis we chose to use the Principal Components Analysis, because in this case the weighting corrects the overlapping information and does not necessarily represent a measure of the importance of the associated indicator.

### 3. Creating the Circular Economy Index

Eurostat defines circular economy as an opportunity to reinvent the linear economy into a more sustainable and competitive one. Monitoring also, provides access to relevant data on various aspects of the circular economy so that the progress of policies in the field and the possibility of correcting them may be assessed as well. Last but not least, it is essential in achieving sustainable development goals (European Commission, 2016).

The set of indicators and sub-indicators, proposed by the European Commission, for the creation of a monitoring framework for the circular economy, is divided into four specific areas: Production and consumption, Waste management, Secondary raw materials and Competitiveness and innovation. In order to create a composite index that would capture all aspects of the circular economy, we considered it necessary to include 14 indicators out of the 15 proposed by Eurostat. These indicators come mostly from Eurostat but are also provided by the Joint Research Center (JRC), the Directorate-General for the Internal Market, Industry, Entrepreneurship and SMEs (DG GROW) and the European Patent Office. The *EU self-sufficiency for raw materials index*, used to monitor progress towards a circular economy in the thematic area of "production and consumption", was not included in the creation of the composite index. It is calculated at EU level and measures the EU's global independence in terms of raw materials.

In order to be able to use the set of indicators in the construction of the composite index, it was necessary to impute the data for certain countries using cluster analysis. At the same time, with the help of this method of multidimensional data analysis, a grouping of EU states was identified based on the similarities of the indicators included in the analysis.

Following the analysis, four clusters emerged. The first cluster contains most of the states, Romania being in the second cluster – along with Belgium, Czech Republic, Croatia, Latvia, Hungary, Poland, Slovakia and Sweden. If before the imputation of the data Belgium and Sweden were in the first cluster, later they migrated to the second cluster. It should be noted that cluster 3 includes only Denmark, and the fourth cluster includes Estonia and Bulgaria. This position is explained by the fact that in Denmark there are many companies and startups that adopt circular economy solutions, being known for their approaches to the development and adoption of innovative policies that stimulate the circular economy. It is known that Denmark has a tradition in the field of environmental protection, the orientation towards the ecological economy and the efficient use of resources which has been continuous since the 70s. In 1971, it was one of the first countries in the world to have a ministry dedicated to the environment – the Ministry of Pollution Control. Denmark is a leader in the application of green technologies in the business environment, highlighting itself at European and international level through innovative initiatives in the circular economy, while demonstrating that sustainable development and economic growth are interdependent (EMF, 2015a, 2015b; State of Green, 2016).

Consumption patterns, the way waste is collected and managed, and the level of economic development generate significant differences among EU countries. The results of studies carried out for the period 2005–2016, although showing a decrease in municipal waste per capita at EU level, show different trends within the Member States.

For the construction of the composite index, the Principal Components Analysis (PCA) was used as the method combines the indicators in order to reduce the redundancy between them, while capturing the maximum amount of variance of the data. The values 0.573 for the KMO statistics and 159.341 for the Bartlett sphericity test ( $Sig. = 0.000$ ) indicate the existence of a strong relationship between the indicators selected for constructing the composite index, we can reject the hypothesis that the variables are uncorrelated. Simultaneously, these values certify the presence of one or more common factors, which motivates the application of a factor extraction procedure using the PCA method. The 5 main components identified represent approximately 78% of the data variability. The coefficients used in the construction of the composite index were determined by calculating the weights of the individual variance of the components retained in the analysis, from the total variance explained by them, and applying them to each variable based on the results in Component Score Coefficient Matrix (Appendix, Table 1). The values of the composite index are determined using the formula (Equation (1)):

$$CEI = 0.046 \cdot In_1 + 0.046 \cdot In_1 + 0.075 \cdot In_2 + 0.025 \cdot In_3 + 0.020 \cdot In_4 - \\ 0.027 \cdot In_5 + 0.028 \cdot In_6 + 0.134 \cdot In_7 + 0.148 \cdot In_8 + 0.163 \cdot In_9 + \\ 0.022 \cdot In_{10} - 0.049 \cdot In_{11} + 0.049 \cdot In_{12} + 0.189 \cdot In_{13} + 0.052 \cdot In_{14}. \quad (1)$$

The determined values of the CEI (Circular Economy Index) make a hierarchy of EU countries from the perspective of the aspects of the circular economy, in the first place being Denmark, with the best results, which confirms its position in the previous cluster analysis. Among the countries with low values of the indicator, we find: Romania, Poland, Hungary, Lithuania, Bulgaria, Greece (Figure 3).

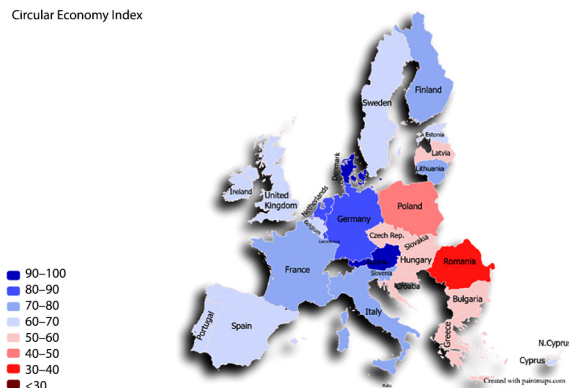


Figure 3. Circular Economy Index for UE country (source: created by the authors using Color maps with statistical data, Paintmaps, 2014)

4. Circular economy, digital innovation and innovative entrepreneurship as determinants of social progress

The statistical data for composite indices used in the analysis, recorded at EU level for 2019 (Appendix, Table 2), were subjected to descriptive analysis specific to the construction of regression models. The data are homogeneous, the distribution of indices is approximately normal, in the case of CEI, the Box-Plot diagram made shows Denmark as outlier. The analysis of the data related to the considered indices presents their approximately normal distribution.

The correlation analysis highlights the existence of direct and statistically significant links between the composite indices considered, correlation coefficients with values between 0.599 and 0.913.

The constructed multifactorial regression model (Model I) has as factorial variables CEI, GII and GEI, the effect variable being SPI. The results obtained highlight a valid model, which identifies a direct and significant dependence between SPI and CEI (*Sig.* = 0.000).

$$SPI = 0.112 \cdot CEI + 0.030 \cdot GEI + 0.226 \cdot GII. \tag{2}$$

As the results of the analysis signal the presence, to a certain extent, of the multicollinearity phenomenon (*VIF*<sub>GEI</sub> = 6.782, a value lower than 10), we resorted to estimating another regression model (Model II). This model is estimated for 26 EU countries, Denmark being removed from the analysis (records an outlier value for the CEI variable), the factorial variables being the CEI and GII (the GEI variable was removed).

$$SPI = 0.129 \cdot CEI + 0.266 \cdot GII. \tag{3}$$

The results obtained (*Sig.* = 0.000) show that Regression Model II is valid, the coefficients of the predictive variables CEI and GII are statistically significant. The hypotheses of the regression model regarding the residual variable are also verified.

## 5. Results and comments

The research hypotheses, formulated from the very title of the paper, which involve identifying the impact of the circular economy and innovation on social progress are summarized in Model II of analysis presented above. The two factorial variables considered, CEI and GII, explain approximately 75% of the SPI variation, the model is valid and the regression coefficients are statistically significant. Therefore, the model obtained confirms that social progress is dependent on innovation, on the orientation towards a circular economy, both at macroeconomic level, through public policies, and at microeconomic level through the support of sustainable innovative entrepreneurship.

The values of the Circular Economy Index determined by applying the methodology presented in this paper place Denmark in first place and Romania at the end of the ranking (Figure 4), the link between SPI and CEI being strong for most EU countries. The intensity of the link between the two variables decreased by the values recorded for SPI and CEI in the case of countries such as Bulgaria, Hungary, Croatia Sweden, Finland.

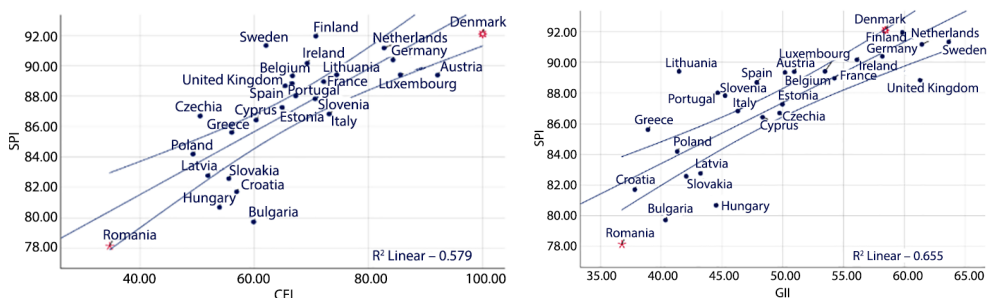


Figure 4. The correlation between SPI and CEI (source: created by the authors) and The correlation between SPI and GII (source: created by the authors)

Measuring social progress is necessary because it can underpin the development strategies of EU states. Statistical data show high levels of social progress in the Nordic countries, the Netherlands, Austria, Germany, Luxembourg and the United Kingdom. Estonia and the Czech Republic have good scores on the social progress index, although they are not correlated with their relatively low level of development.

The analysis of the correlation between the Social Progress Index and the Global Innovation Index (Figure 4) also highlights the existence of a direct and strong link, with countries such as Romania, Bulgaria and Hungary registering low values for both SPI and GII.

The correlation analysis performed is an additional argument for validating the research hypotheses, which confirms the influence of the factors studied on social progress to create a sustainable economy.

## Conclusions

The aim of the paper is to contribute to a better understanding of how the orientation towards a circular economy, the stimulation of innovative entrepreneurship through the in-

tegration of new technologies determine an increase in the quality of life and constitute a form of social progress.

The methods used to achieve this objective were: the construction of a composite index of the circular economy (The Circular Economy Index – CEI) starting from the indicators determined by Eurostat, the analysis of the links between the obtained index and other composite indices, identified in the literature: entrepreneurial ecosystem performance (The Global Entrepreneurship Index – GEI), social progress (The Social Progress Index – SPI), the latest trends in innovation (The Global Innovation Index – GII). The proposed regression models highlight the direct and significant influence of the circular economy and innovation on social progress. The integration of modern technologies in current business models, the development of sustainable innovative entrepreneurship support the transition from a linear economy to a circular economy and are prerequisites for social progress.

The results emphasise the importance of developing new policies and implementing new technologies and innovative sustainable models that make the transition to a circular economy, especially in countries such as Romania, Bulgaria, Hungary.

There are a number of limitations to the study that stem from the complexity of monitoring the progress of the transition to the circular economy, as it refers to a systemic change in the entire economy, all products and services. In an ideal situation, the indicator should capture on the one hand the preservation of the economic value of resources, raw materials and products, and on the other hand aspects related to the waste generated, their management, the impact on the environment.

Future research opportunities aim to increase the predictability of the proposed models, both by including new variables and by updating the values of the composite index of the circular economy (The Circular Economy Index – CEI), in the context of the orientation of EU states towards a circular economy. Well-being and social progress are influenced by stimulating innovative entrepreneurship by integrating digital technologies into business models, a significant element for a sustainable economy. Based on the new information collaborated with the policies implemented in the field, a grouping of EU member states will be made to highlight the similarities and gaps between them.

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## **Author contributions**

The authors conceived the study and were responsible for the design of the methodology, for data collection and interpretation.

## **Disclosure statement**

The authors declare no conflict of interest.

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## APPENDIX

Table 1. Component Score Coefficient Matrix and Coefficients index (source: created by the authors)

	Component					Coefficients
	1	2	3	4	5	
Circular material use rate [CEI_SRM030]	.136	-.027	-.102	-.103	.274	0.046
Generation of municipal waste per capita [CEI_PC031]	-.023	.050	.066	.496	.023	0.075
Generation of waste excluding major mineral wastes per domestic material consumption [CEI_PC033]	-.008	.144	-.206	-.091	.364	0.025
Generation of waste excluding major mineral wastes per GDP unit [CEI_PC032]	-.137	.277	-.074	-.023	.205	0.020
Patents related to recycling and secondary raw materials [CEI_CIE020]	-.113	-.162	.034	.283	.131	-0.027
Recovery rate of construction and demolition waste [CEI_WM040]	.024	-.210	.179	-.369	.053	0.028
Recycling of biowaste [CEI_WM030]	.032	-.058	.408	-.098	-.038	0.134
Recycling rate of e-waste [CEI_WM050]	.125	.251	.435	.121	-.018	0.148
Recycling rate of municipal waste [CEI_WM011]	-.086	-.169	.146	.114	.571	0.163
Recycling rate of packaging waste by type of packaging [CEI_WM020]	.230	.043	.103	.165	.007	0.022
Private investments, jobs and gross value added related to circular economy sectors [CEI_CIE010]	.248	-.204	.098	-.109	.031	-0.049
Private investments, jobs and gross value added related to circular economy sectors [CEI_CIE010]	.070	.495	.087	.095	-.179	0.049
Private investments, jobs and gross value added related to circular economy sectors [CEI_CIE010]	.300	.143	.105	.047	-.059	0.189
Recycling rate of all waste excluding major mineral waste [CEI_WM010]	.271	.043	-.207	-.247	-.248	0.052

Note: Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Component Scores.

Table 2. The values of the indicators for the countries included in the analysis

GEO (Labels)	CEI	GEI	GII	SPI
Denmark	100.00	79.30	58.44	92.08
Austria	92.11	64.90	50.94	89.38
Luxembourg	85.57	58.10	53.47	89.40
Germany	84.30	66.70	58.19	90.38
Netherlands	82.74	72.30	61.44	91.16
Lithuania	74.43	44.10	41.46	89.40
Italy	73.11	45.10	46.30	86.82
France	72.15	67.10	54.25	88.95
Finland	70.78	70.20	59.83	91.94
Slovenia	70.65	56.50	45.25	87.82
Ireland	69.27	71.30	56.10	90.16
Portugal	67.26	46.30	44.65	88.01
Belgium	66.69	62.20	50.18	89.33
United Kingdom	66.63	77.50	61.30	88.83
Spain	65.41	46.90	47.85	88.68
Estonia	64.88	57.80	49.97	87.26
Sweden	62.06	70.20	63.65	91.32
Cyprus	60.32	45.60	48.34	86.42
Bulgaria	59.88	30.10	40.35	79.73
Croatia	56.91	36.10	37.82	81.71
Greece	56.05	35.40	38.90	85.61
Slovakia	55.54	42.60	42.05	82.58
Hungary	53.90	46.20	44.51	80.69
Latvia	51.88	39.30	43.23	82.77
Czech Republic	50.51	43.50	49.73	86.69
Poland	49.26	49.50	41.31	84.19
Romania	34.68	38.60	36.76	78.14