The Circular Economy as a Driver for Sustainable Business Development and the Role of ICT

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Abstract

The general objective of this research is to analyze the current impact of the circular economy on sustainability and the role that companies anticipate that ICT can have in this process. The research methodology is based on the critical analysis of specialized literature, the interpretation of statistical data and econometric modeling. The econometric analysis used to estimate the relationship between the circular economy and sustainability was carried out using the Netherlands as a reference, since the latest statistical data indicate that this country has the highest circular material use rate. The main results show, first of all, the fact that currently the circular economy does not have a considerable impact on the stimulation of sustainability, and secondly, the vision of companies from EU Member Countries, who have high expectations regarding the positive impact of ICT in boosting the business sustainability and circular material use rate. At the same time, we propose a Quintuple Helix approach for the fulfillment of sustainability objectives and for the transition to the circular economy. The article also may be a contribution to the state of knowledge in the field, especially by highlighting certain limits of the circular economy in enhancing sustainability. Our study may have possible practical implications, especially for companies that do not adopt an organizational culture based on sustainability.

Keywords

circular economy, ICT, sustainability, business, environment.

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Introduction

Some of the main challenges that global companies are currently facing are the efficient use of resources and the reduction of the impact of their activities on the environment. For this reason, business models must be rethought in accordance with the Sustainable Development Goals (United Nations, 2015) and environment, social and governance requirements (ESG), with an emphasis on efficiency and innovation. Even if in the last decade measures to increase sustainability have generated positive effects, industrial activities continue to produce waste and a considerable footprint on the environment, many companies lagging behind with the concrete strategies regarding this objective (Bocken and Short, 2021).

There are many industries where has been demonstrated the need for sustainable transformation of production and consumption models. For example, Kabirifar et al. (2020) draw attention to the consequences of the construction and demolition waste, while Batista et al. (2019) discuss the need for resource recovery management in the food packaging industry.

In this context, the main objective established for this paper is to analyze the degree to which the circular economy currently represents an important factor in supporting the sustainable development of business models, and also what is the expected impact of ICT in this process.

We believe that through this research we can make a contribution to the state of knowledge by empirically showing, based on a particular case, the current influence of the circular economy on sustainability and the limits.

The work is structured as follows: in Section 1 is presented synthetically the state of knowledge, in Section 2 is described the applied research methodology, and in Section 3 are detailed the main results. The paper ends with the authors' general conclusions.

1. Review of the scientific literature

In the scientific literature, various solutions are analyzed and proposed as a response to the sustainability requirements that organizations must incorporate within their business models, namely digital transformation (Piscitelli et al., 2020; Agrawal et al., 2021) and the transition to the circular economy (Betancourt and Zartha, 2020; Bertassini et al., 2021; Nikolaou and Tsagarakis, 2021).

The connection between the new digital technologies and the circular economy is increasingly analyzed in scientific research, showing in particular how the technological and digital advance can contribute to the development of the circular economy and implicitly to sustainability. Among these are the studies carried out by Biloslavo et al. (2020), Colombi and D'Itria (2023), Rusch et al. (2021) or Bag et al. (2021), Han et al. (2023).

Voulgaridis et al. (2022) and Ghobakhloo et al. (2022) go further and discuss about Industry 5.0 as an enabler of digital circular economy, highlighting, in addition to digital technologies, the importance of the human factor involvement. Serrano—Bedia and Perez-Perez (2022) explains the extremely important role of higher education institutions, but demonstrates that at this moment the collaboration between these institutions, private organizations and the government sector is not developed enough in order to generate the potential benefits.

On the other hand, Cezarino et al. (2019) highlight the important role of the government sector, through the implementation of solid regulatory policies. Among the barriers that hinder the implementation of digital technologies and the development of the circular economy in business, Kumar et al. (2021) specifically identifies the lack of necessary funds, while Ozkan-Ozen et al. (2020) highlights "the lack of knowledge about data management among stakeholders".

The systematic literature review shows that the subject related to sustainability is intensely debated, and researchers are making efforts to analyze how it can be achieved, emphasizing the capabilities of the circular economy and ICT.

2. Research methodology

In order to fulfill the objective of this paper, we used the critical analysis of the specialized literature so as to capture some of the most recent and representative results obtained by researchers regarding the link between the circular economy and the sustainable development of companies, and on the other hand the role that ICT plays in this process.

Secondly, we analyzed a series of factors characteristic of sustainability related to circular economy to see the extent to which companies emphasize them within their circular business models. In this regard, we applied the multiple regression analysis method, using as dependent variable circular material use rate (CMUR), and as independent variables resource productivity (RP), share of renewable energy in gross final energy consumption (SRE), recycling of biowaste (RB) and energy productivity (EP).

The multiple linear regression is described by the following equation:

$$y_i = \alpha + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_z x_{iz} + \varepsilon \quad (1)$$

where:

y_i = dependent variable

x_i = independent variable

β_z = slope coefficient

α = intercept

ε = error term

Before the regression analysis, we tested the data series stationarity by Augmented Dickey-Fuller (ADF) test.

The ADF stationarity test can be described mathematically by the following equation:

$$\Delta_{y_t} = \alpha + \beta t + \delta y_{t-1} + \sum_{j=1}^{p} y_j \Delta_{y_{t-j}} + \varepsilon_t \qquad (2)$$

where:

y_t= the value of time series at a specific time *t*

Δ_{y_t} = 1st difference of the time series

α, β, δ = parameters to be estimated

ε_t = error term

j = number of lagged differences

The null hypothesis of ADF test is $H_0: \beta_i = 0$ (time series has a unit root), meaning it is non-stationary, while the alternative hypothesis is $H_1: \beta_i < 0$. The rejection of null hypothesis highlights the stationarity of the series.

Based on the stationary series, we determined also the correlation matrix to analyze the connection between the selected variables. For the representativeness of the results, the case study was carried out based on data related to the best performing EU Member State in terms of circular material use rate, namely the Netherlands. The data source is the Eurostat database, and the data processing was carried out through EViews 12 software.

In order to analyze the impact of ICT on the development of sustainable business models, we interpreted statistical data from a 2021 survey made by the European Commission regarding the contribution of ICT to the environmental sustainability of actions of EU enterprises.

3. Results and discussion

As we can see, other research has demonstrated that the circular economy has a very high potential to stimulate sustainable business development, being one of the main ways through which companies can achieve both their profit-related objectives and those related to the environment, society and corporate governance.

The most recent Eurostat data show that Romania ranks last in the EU in terms of circular material use rate, while the highest performances are recorded by the Netherlands (Figure no.1).

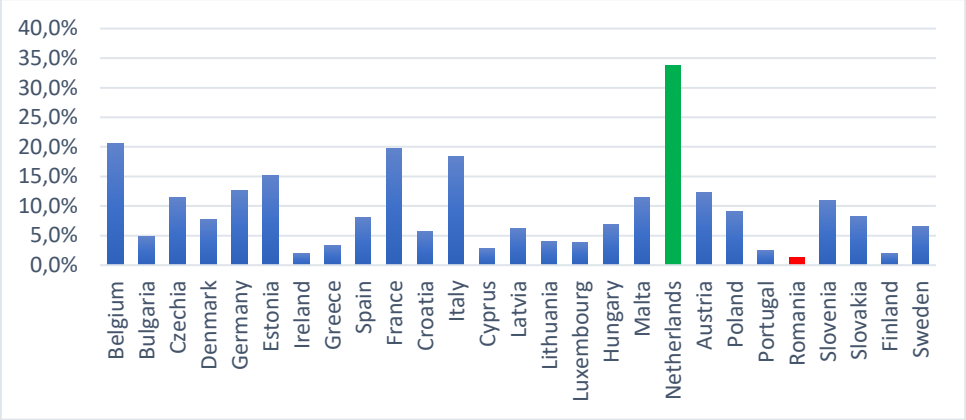

Figure no. 1. Circular material use rate in EU, 2021
Source: designed by authors based on Eurostat data

In order to see how this type of economy is currently developing, and to analyze if we can outline a best practice for countries such as Romania, we tested the impact of some determining factors, according to the methodology described in the previous section.

The results of the Augmented Dickey-Fuller test show that the data series included in the analysis are stationary in level or in 1st difference, as we show in Table no.1.

Table no. 1. Augmented Dickey-Fuller Unit Root Test results

	CMUR	EP	RB	RP	SRE
Augmented Dickey-Fuller stat.	-2.146071	-4.130724	-3.583945	-3.446839	-4.41394
Stationarity	1st diff.	level	1st diff.	1st diff.	1st diff.
Test critical values					
1% level	-2.81674	-5.295384	-2.81674	-5.835186	-5.29538
5% level	-1.1982344	-4.008157	-1.982344	-4.246503	-4.00816
10% level	-1.601144	-3.460791	-1.601144	-3.590496	-3.46079
Prob.	0.0367	0.0431	0.0023	0.1197	0.03

Source: made by authors based on Eurostat data.

Therefore, we implemented our statistical models in the first differences of all variables.

Next, we determined the correlation matrix to test the intensity of the link between the variables (Table no. 2).

Table no. 2. The correlation matrix between the variables

	CMUR	EP	RB	RP	SRE
CMUR	1				
EP	-0.31353	1			
RB	-0.50479	0.247974	1		
RP	0.895292	-0.07698	-0.50872	1	
SRE	-0.46857	-0.1622	0.782969	-0.46204	1

Source: made by authors based on Eurostat data.

Regarding the dependent variable, circular material use rate is positively correlated with resource productivity, while negative correlations appear in relation to recycling of biowaste, share of renewable energy in gross final energy consumption and energy productivity. At the same time, we found a strong positive correlation between recycling of biowaste and share of renewable energy in gross final energy consumption and a quite strong negative correlation between resource productivity and recycling of biowaste. On the other hand, the results of the regression equation (Table no. 3) demonstrate, on the one hand, the validity of our model (R-squared = 0.91), and on the other hand, it shows the impact of the independent variables on the dependent one.

Table no. 3. The regression equation between the dependent variable and the independent variables

Dependent Variable: cmur Method: Least Squares Included observations: 11 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	0.66	0.42	1.57	0.17
EP	-3.84	1.51	-2.54	0.04
RB	0.16	0.12	1.39	0.21
RP	3.75	0.64	5.83	0.00
SRE	-0.38	0.23	-1.59	0.14
R-squared	0.91	Mean dependent var		0.77
Adjusted R-squared	0.84	S.D. dependent var		1.48
S.E. of regression	0.59	Akaike info criterion		2.07
Sum squared resid	2.07	Schwarz criterion		2.26
Log likelihood	-6.41	Hannan-Quinn criter.		1.96

F-statistic	14.51	Durbin-Watson stat	2.84
Prob(F-statistic)	0.00		

Source: made by authors based on Eurostat data.

The Durbin-Watson statistical test results (2.84) indicate the positive autocorrelation, while the Akaike information criterion has the lowest possible value, demonstrating that the model matches for the selected variables. After we run the regression model, we obtain that the significant variables are resource productivity and energy productivity (due to their p-values < 0.05), which boosts largely the correlation results.

These results show us that currently the best performing state in the EU in terms of circular material use rate, the Netherlands, is mainly based on resource productivity for the transition to the circular economy, and energy efficiency is at a level that negatively influences this transition. The share of renewable energy in gross final energy consumption and recycling of biowaste are not important factors in supporting this complex process, which proves that the circular economy is not currently an important source of supporting the sustainability of companies.

In order for the transition from a linear business model to a circular one to stimulate as much as possible the level of sustainability of companies, it is imperative that they also take into account the listed factors. Companies have to improve permanently their production resources efficiency by reducing inputs and waste and increasing renewable material and also to optimize production processes to reduce energy consumption. At the same time, it is extremely important for the production of goods and services to put an important emphasis on reducing the negative impact on the environment.

Further, we will analyze the perception of companies from EU Member States regarding the role of ICT in the transition process to a circular and sustainable business model.

According to the European Commission data, the largest share of the companies included in the analysis consider that the digital technologies presented in Figure no.2 have a positive impact on the environmental footprint.

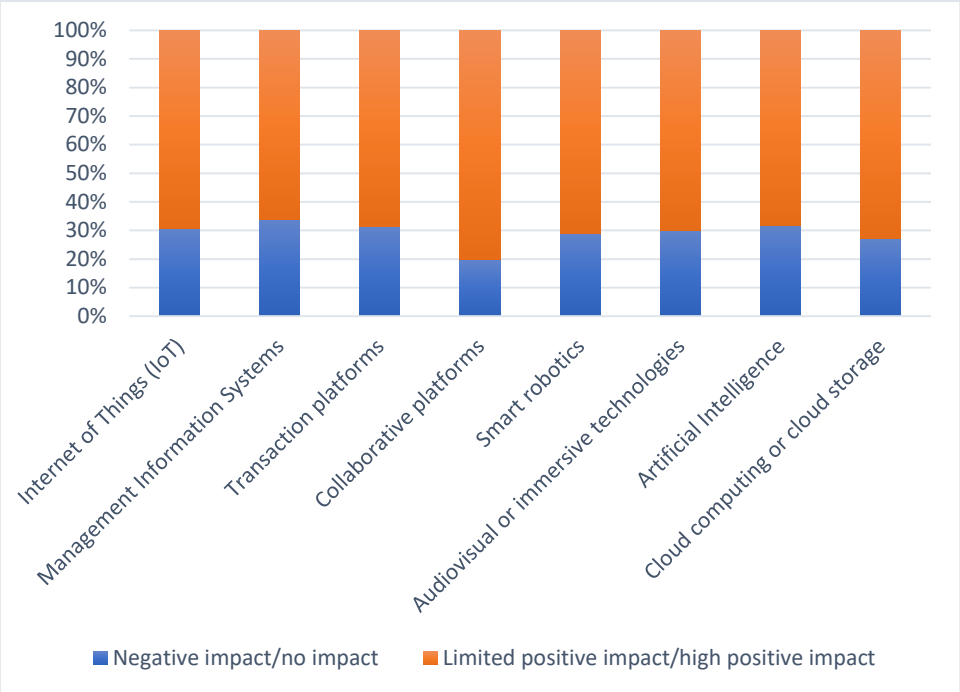

Figure no. 2. Technology's impact on firm's environmental footprint

Source: designed by authors based on European Commission data
Survey on the contribution of ICT to the environmental sustainability of actions of EU enterprises | Shaping Europe's digital future (europa.eu)

It can be observed that in the case of all selected information technologies, the positive impact prevails, even if for all categories the majority is represented by limited positive impact. On the other hand, regarding the concrete role of these technologies in the sustainable development of business models, we especially note the efficient use of resources and the potential to protect the environment (Figure no. 3).

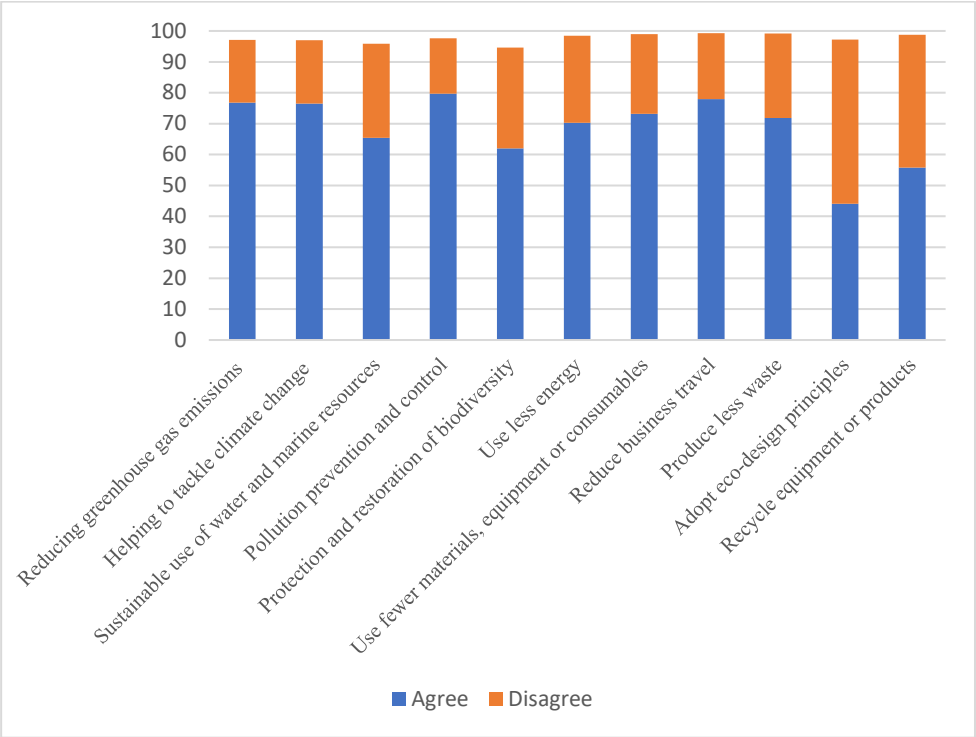

Figure no. 3. Digital technologies impact/potential impact on business sustainability
Source: designed by authors based on European Commission data
Survey on the contribution of ICT to the environmental sustainability of actions of EU enterprises | Shaping Europe's digital future (europa.eu)

Weights of more than 70% are found in the case of most factors, with the exception of the role in sustainable use of water and marine resources, protection and restoration of biodiversity, adopt eco-design principles and recycle equipment or products, all these factors still having weights of more than 50% in the perception of the analyzed companies.

Considering these aspects, we can say that once the expected effects of digitalisation and technology are evident in concrete results, they will stimulate the fundamental transition to the circular economy and significantly contribute to increasing the level of sustainability of companies.

In order for these effects to be realized in an inclusive long-term manner, we consider a Quintuple Helix type approach to be fundamental.

Conclusions

Although the importance of the circular economy in the sustainable development of businesses is demonstrated in the scientific literature, we note that currently it is not sufficiently developed so as to contribute to a considerable extent to the fulfillment of such an objective.

However, at the EU level, the companies from the Member States place an important emphasis on digitalisation and technology and consider these tools essential for the objectives of gradual transition to the circular economy and implicitly for the sustainability of their business models. Correlating this attitude of companies with the scientific results that demonstrate the high potential of ICT, we can say that there are clear indications that in the near future such objectives will be achieved.

We believe that through the methodology applied and through the results obtained, we managed to fulfill the objective set in this work, showing some limits of the circular economy in supporting the businesses sustainability, and at the same time the expected impact of the integration of ICT within the production processes.We also believe that this work may have possible practical implications, because it may help certain companies that do not currently adopt sustainability measures to better understand how to manage their activities in order to become circular and sustainable and what are one of the main tools for that.

There are possible extensions of this research, such as the analysis of the most effective practices for implementing circular economy principles in SMEs and large companies, taking into account the industry in which they operate.

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