DIGITALIZATION FOR CIRCULAR ECONOMY IN EU27

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Both digitalization and the circular economy represent current challenges for mankind, both of which involve significant funding for their full-fledged implementation in society. If digital technologies are viewed from a new perspective, they can be an opportunity for the efficient implementation of the circular economy. Therefore, this article aims to treat econometrically the importance of digitization from the perspective of the circular economy. So, it have been selected some indicators of the circular economy and others of digitization at the firm level, performing, in addition to the correlation matrix, a series of regression equations, in order to better understand how to interconnect these domains. The results of the study indicate the need that, before answering at the problems of circularity, the field of digital economy must itself become as green as possible.

Keywords: *digitalization, sustainable development, circularity, European Union, efficacy, development*

JEL classification: L22, O14, O33, P48, Q56

Introduction

If the circular economy (CE) aims to reduce waste, optimize the functionality of products and services over long cycles, repeatable use and reuse, the digital economy (DE) involves economic resettlement on a computerized structure that allows complex processing of data and information and their delivery to society, safely, for optimizing personal and business human activity. Therefore, circular businesses and supply chains can benefit from the feasibility, increased performance and increased satisfaction offered by digitization to their customers.

Not only companies and physical persons can benefit from digitalization but also public administrations, digitalization allowing faster and more efficient connection of citizens with administrations, with less effort and bureaucracy, but also a better transmission of the vision of public administrations to citizens, and the easier involvement for the latter in the process of society's transition to a clean - green economy.

Creating a circular economy requires fundamental changes in thinking for the whole of human society: - a different thinking, education and behaviour of citizens and consumers, - a resettlement of businesses, businesses requiring a different value chain, a different type of product, a different way of selling, other models of conservation of biological and natural resources, other business models, other capabilities of monitoring and control of products and services but also - another reporting of institutions to citizens, in which they become partners in the transformation of society.

Literature review

The literature abounds in references to digitization in organizations and customer relationship (Zammuto et al., 2007; Kozinets et al. 2010 etc.) but also to the circular economy (Ellen MacArthur Foundation, 2015; Murray et al., 2013; Ghisellini et al., 2015; Kirchherr et al., 2017, etc.), but few achieve a relatively proper marriage between the two extremely important topics today (Yoo, 2010; EIT Climate-KIC, 2018, Antikainen et al., 2018, Okorie et al. 2018 etc.). Also, few point out that the digital technology sector, not long ago, knowingly, ignored development sustainability issues, consuming a lot of resources, energy and even catalyzing the polluting and harmful effects of other industries. Remanufacturing, repairing and reusing have not been integrated into digital technologies from the very beginning and today this still leads to serious problems regarding heavy metal pollution.

Digitization allows to improve the communication between the parties (company - client), but also the production process and the product through elements such as: digital twins, robotisation, websites, apps, big data, machine learning, IoT, blockchain, sensor technologies, digital design, data analytics etc. All these technological means must be placed in a new paradigm so that the digitization itself subscribes to a green efficiency.

Regarding the implementation of the circular economy in the field of business, the visions are generally different. In general, small companies integrate completely new business approaches while large

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companies tend to focus on optimizing internal processes and waste streams (WBCSD, 2018). Digitization offers European industry opportunities to build better business models based on the principles of the circular economy (Futuring, 2018).

The purpose of research

Many papers analyze the impact of circular economy indicators on economic growth, considering that CE indicators are strongly correlated with economic growth, and the connection of digitalization with economic growth, less studies are linking the two areas directly. European Commission showed direct interest in transposing digitalization as a facilitator of circular economy, therefore we can consider that circularity can become a function of digitization. Also, the connection between the two domains can offer the chance to design better indicators, more relevant for the better interconnection between the two domains.

Given the importance of the fastest possible circumscription of the economy to the natural environment and especially to the paradigm of circularity, but also the fastest and most efficient solution of the systematization of the economy by increasing digitalization, taking into account the link between circularity and digitalization for the analysis in this article, a series of indicators presented in methodology were chosen. Thus, the article aims to more clearly identify the link between the topics, to make a series of observations and proposals on the indicators pursued for a better analysis of these areas: CE-DE for the future.

Research methodology

The article uses annual data provided by Eurostat for all 27 EU countries, and the analysis period is 2009-2018, and their systematization is panel type. The indicators selected are: Recycling rate of packaging waste by type of packaging (noted Rrpw), Trade in recyclable raw materials (noted Trrm), Generation of municipal waste per capita (Gmwpcapita), Private investments, jobs and gross value added related to circular economy sectors (noted Privinvce), Business demography by size class (from 2004 onwards, NACE Rev. 2) (noted Bdscls), Percentage of the ICT sector in GDP (noted PICTsGDP), Share of enterprises' turnover on e-commerce - % (noted Setecom) and Enterprises having received orders online (at least 1%) - % of enterprises (noted Ehroo).

Although it had been performed other analyzes, the article presents only a correlation matrix between several indicators of circularity in relation to some indicators of digitization, as well as a series of regression equations results, to better identify the link between the above mention indicators. Given the very different domains and the fact that the indicators do not reflect from their conception the potential of the connection between the domains, the results must be viewed with caution.

Main results

Looking at the situation of the Recycling rate of packaging waste by type of packaging (Rrpw) correlated with the Business demography by size class (from 2004 onwards, NACE Rev. 2) (noted Bdscls), Share of enterprises' turnover on e-commerce - % (noted Setecom) and Enterprises having received orders online (at least 1%) - % of enterprises (noted Ehroo) it can be observed (Table no. 1) that the correlation matrix shows that the intensity of the correlations is much higher then with the selected indicators for circularity.

Table no.1 - Correlation matrix between Rrpw, Trrm, Gmwpcapita, Privinvce, Bdscls, PICTsGDP, Setecom and Ehroo

	Rrpw	*Trrm*	*Gmwpcapita*	*Privinvce*	*Bdscls*	*PICTsGDP*	*Setecom*	*Ehroo*
Rrpw	1							
Trrm	0.348	1						
Gmwpcapita	0.203	0.154	1					
Privinvce	0.271	0.523	0.385	1				
Bdscls	0.234	0.643	-0.021	0.604	1			
PICTsGDP	-0.215	-0.211	0.187	-0.126	-0.191	1		
Setecom	0.416	0.009	0.132	0.108	0.058	0.274	1	
Ehroo	0.477	0.155	0.255	-0.013	0.002	0.204	0.745	1

Source: Authors' own research, using Eurostat annual data and and Excel data analysis soft.

The negative of Percentage of the ICT sector in GDP (noted PICTsGDP) suggest that recycling rate of packaging waste evolves in the opposite direction in respect with the evolution of ICT sector in GDP. Also, Private investments, jobs and gross value added related to circular economy sectors (noted Privinvce), Trade in recyclable raw materials (noted Trrm) and Business demography by size class (noted Bdscls) present negative correlation in respect with PICTsGDP. This suggests that investments in circularity and trade in circular raw materials do not positively affect the evolution of the ICT field, i.e. practically, although it is called to support the fields of sustainable development and the circular economy, in reality the ICT sector has not yet evolved in support of this economic paradigm.

In order to show causality, of Rrpw with selected digital economy indicators in Table no.2 there are shown the results of the regression equation formulated as Rrpw=f(Bdscls, PICTsGDP, Setecom, Ehroo) or

$$Rrpw= \alpha0+\alpha1*Bdscls+\alpha2*PICTsGDP+\alpha3*Setecom+\alpha4*Ehroo+\varepsilon \quad (1)$$

Table no. 2 - Results for regression equation for Rrpw depending on Bdscls, PICTsGDP, Setecom and Ehroo

Dependent Variable: RRPW
Method: Least Squares
Date: 08/18/21 Time: 12:47
Sample: 1 270
Included observations: 270

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	60.53351	2.164669	27.96433	0.0000
BDSCLS	4.29E-05	1.34E-05	3.209895	0.0015
PICTSGDP	-2.913347	0.471304	-6.181458	0.0000
SETECOM	0.288376	0.105622	2.730254	0.0068
EHROO	0.558512	0.104569	5.341110	0.0000

R-squared	0.376385	Mean dependent var	62.24399
Adjusted R-squared	0.366972	S.D. dependent var	9.905154
S.E. of regression	7.880842	Akaike info criterion	6.985091
Sum squared resid	16458.53	Schwarz criterion	7.051729
Log likelihood	-937.9873	Hannan-Quinn criter.	7.011850
F-statistic	39.98547	Durbin-Watson stat	0.561093
Prob(F-statistic)	0.000000		

Source: Authors’ own research, using Eurostat annual data and Eviews11 soft.

Analyzing the value of the determination coefficient or R2, which is used to measure the intensity of the correlation between the endogenous variable and its determinants, it is observed that the value of 0.376385 is not so satisfactory, as expected, as shows also the adjusted R2, which suggest that there is a relatively weak correlation between the variables in the model. But things must be interpreted with caution, the domains are completely different and the indicators are not indicators of correlation between domains (e.g. there is no indicator that reflects the degree of recycling of ICT companies on raw materials, etc.). The coefficients of independent variables are not significantly different from zero, except for PICTsGDP. All the independent variables have a p-value well under 0.05, which confirms that for those indicators, the null hypothesis H0 can be rejected, which proposes the indicators for the model. Looking at the Durbin-Watson statistics, we notice that DW is over R2 which indicates that the regression performed is not spurious.

When concerning the Trade in recyclable raw materials (noted Trrm) in relation to Bdscls, PICTsGDP, Setecom and Ehroo, we can see that the value of the R2 of 0.489446 is relatively ok for the data series, and the adjusted R2, equal to 0.481739 at the sample level shows that there is relatively satisfactory correlation intensity between the variables in the model. The equation is formulated as:

$$Trrm= \alpha0+\alpha1*Bdscls+\alpha2*PICTsGDP+\alpha3*Setecom+\alpha4*Ehroo+\varepsilon \quad (2)$$

The coefficients of independent variables are significantly different from zero, and the sign is negative for PICTsGDP and Setecom. The p-values for the independent variables are below 0.05 probability benchmark for all explanatory variables, except for PICTsGDP. So the circularity equation, formulated as above, can be reduced ultimately at a function of Bdscls, Setecom and Ehroo (Trrm=f (Bdscls, Setecom, Ehroo)).

To understand more, we formulate the following regression equation for the Generation of municipal waste per capita (Gmwpcapita) identically as above, in the form:

$$Gmwpcapita = \alpha0+\alpha1*Bdscls+\alpha2*PICTsGDP+\alpha3*Setecom+\alpha4*Ehroo+\varepsilon \quad (3)$$

Analyzing the value of the R2 for the Gmwpcapita and the chosen independent variables it is observed that the value of 0.097980 and of adjusted R2 is 0.084364 incredibly low, which is why the equation should be reformulated by adjusting it with other explanatory variables. The coefficients of independent variables are significantly different from zero, except Bdscls and Setecom has a negative sign.

The p-values for the independent variables are below 0.05 only for PICTsGDP, Setecom and Ehroo, so only these variables should be included in the model.

Table no.3 - Results for regression equation for TRRM depending on Bdscls, PICTsGDP, Setecom and Ehroo

Dependent Variable: TRRM
Method: Least Squares
Date: 08/18/21 Time: 12:55
Sample: 1 270
Included observations: 270

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	90198.71	99159.33	0.909634	0.3638
BDSCLS	8.720141	0.612294	14.24176	0.0000
PICTSGDP	-40278.58	21589.54	-1.865653	0.0632
SETECOM	-21265.08	4838.353	-4.395106	0.0000
EHROO	28488.71	4790.086	5.947431	0.0000

R-squared	0.489446	Mean dependent var	336732.7
Adjusted R-squared	0.481739	S.D. dependent var	501464.8
S.E. of regression	361006.2	Akaike info criterion	28.44952
Sum squared resid	3.45E+13	Schwarz criterion	28.51616
Log likelihood	-3835.686	Hannan-Quinn criter.	28.47628
F-statistic	63.51090	Durbin-Watson stat	0.284456
Prob(F-statistic)	0.000000		

Source: Authors' own research, using Eurostat annual data and Eviews11 soft.

Table no.4 - Results for regression equation for Gmwpcapita depending on Bdscls, PICTsGDP, Setecom and Ehroo

Dependent Variable: GMWPCAPITA
Method: Least Squares
Date: 08/18/21 Time: 13:05
Sample: 1 270
Included observations: 270

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	346.1875	33.89928	10.21224	0.0000
BDSCLS	7.30E-05	0.000209	0.348954	0.7274
PICTSGDP	19.91181	7.380746	2.697804	0.0074
SETECOM	-3.326562	1.654072	-2.011135	0.0453
EHROO	6.642846	1.637571	4.056523	0.0001

R-squared	0.097980	Mean dependent var	485.0741
Adjusted R-squared	0.084364	S.D. dependent var	128.9764
S.E. of regression	123.4160	Akaike info criterion	12.48734
Sum squared resid	4036352.	Schwarz criterion	12.55398
Log likelihood	-1680.791	Hannan-Quinn criter.	12.51410
F-statistic	7.196226	Durbin-Watson stat	0.291467
Prob(F-statistic)	0.000016		

Source: Authors' own research, using Eurostat annual data and Eviews11 soft.

Also, if we look at the Private investments, jobs and gross value added related to circular economy sectors (noted Privinvce), analyzing the regression equation results, the value of the R2 it is observed that the value of 0.381899 is relatively close with the results of fist equation, and the adjusted R2, equal to 0.372569 at the sample level. The equation for Privinvce is formulated initially as:

Privinvce= $\alpha0+\alpha1$*Bdscls+$\alpha2$*PICTsGDP+$\alpha3$*Setecom+$\alpha4$*Ehroo+ε (4)

Given that the interconnected variables are from different spheres, the intensity of the correlations can be considered extremely admissible as being ok. The coefficients of independent variables are significantly different from zero, except for Bdscls, and the sign is negative forPICTsGDP and Ehroo. The p-values for the independent variables are below 0.05 probability benchmark for all the variables from the model, except PICTsGDP. So the equation can be reduced ultimately at a function of Bdscls, Setecom and Ehroo.

Table no.5 - Results for regression equation for Privinvce depending on Bdscls, PICTsGDP, Setecom and Ehroo

Dependent Variable: PRIVINVCE
Method: Least Squares
Date: 08/18/21 Time: 13:10
Sample: 1 270
Included observations: 270

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1618.119	1880.450	0.860496	0.3903
BDSCLS	0.136908	0.011611	11.79076	0.0000
PICTSGDP	-293.0914	409.4225	-0.715865	0.4747
SETECOM	249.1518	91.75418	2.715427	0.0071
EHROO	-196.8771	90.83885	-2.167323	0.0311

R-squared	0.381899	Mean dependent var	5328.140
Adjusted R-squared	0.372569	S.D. dependent var	8642.913
S.E. of regression	6846.096	Akaike info criterion	20.51909
Sum squared resid	1.24E+10	Schwarz criterion	20.58573
Log likelihood	-2765.077	Hannan-Quinn criter.	20.54585
F-statistic	40.93318	Durbin-Watson stat	0.313554
Prob(F-statistic)	0.000000		

Source: Authors’ own research, using Eurostat annual data and Eviews11 soft.

Conclusions

Together with the G20, the World Bank, the OECD, etc., the European Union through its institutions is constantly working for a smarter EU, more anchored in technology and artificial intelligence, proposing constant updates of legislation and digitalization strategies. In this sense, the goals of the circular economy are seen by the EU as being more achievable in terms of digitalization.

In this context, the article aims to assess the link between a number of indicators of the circular economy and the digital economy. Even if the results obtained do not indicate an extremely favourable situation at present (digitization indicators explaining no more than 50% of changes in circularity indicators), digitization seems to be a future solution for optimizing the circular economy, thus confirming the existing theory in the field. The elaboration of some indicators that would better reproduce the way of penetrating the technology in the circular economy but especially of the circularity in the field of digitalization must be a constant preoccupation of the policy makers and strategists of the two fields.

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