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Digitalisation's Vital Role in Sustainable Circular Economy

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Abstract

The circular economy has emerged as a concept in the pursuit of achieving sustainable development goals, representing a pivotal paradigm shift toward resource efficiency and environmental sustainability. Current research examines the transformative potential of digitalisation, as a core factor of shifting to an economic environment, shaped by the characteristics of circular economy, therefore fostering the increase in sustainability. By leveraging emerging digital technologies, businesses can optimise resource utilization, minimize waste generation, and enhance their transition to practices with positive outcome over the environment. The current article aims to review and explore the relationship between digitalisation and circular economy, both of the concepts understood by connected variables, such as the DESI score, the investment in adopting and implementing multiple digital technologies, the recycling packaging rate, and WEEE collection. Through data analysis, centred on correlations and two statistical regressions, the present study provides insight of digitalization's role in recycling and reusing the main resources integrated in adopting and implementing the latest digital technologies in business activities and operations. It concludes by providing a structured answer to the research question. Is digitalisation impacting the circular economy?

Keywords: digitalisation, circular economy, business environment, sustainable development.

JEL Classification: O33.

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1. Introduction

During recent years, the sustainable circular economy has emerged as a concept based on a crucial framework to address the powerful environmental challenges our planet faces. With the ongoing increased recognition of the limited natural resources and the urgent need to minimise waste and maximize recycling and reusing resources, a concrete global effort has been presented to transition toward more sustainable economic business models (Trevisan et al., 2021).

Meanwhile, since the paradigm of the economic and business environment has shifted as well, currently at the heart of this transition lies the transformative power of digitalisation. Therefore, the integration of emerging digital technologies into various sectors and business activities has widely reshaped the perspective in which individuals and organisations produce, consume, and manage resources (Gil-Lamata et al., 2024).

Furthermore, from the Internet of Things (IoT) devices and advanced data analytics, to blockchain and Artificial Intelligence (AI) applications, the phenomenon of digitalisation offered unprecedented opportunities to optimise the usage of resources, to improve supply chain efficiency, and to promote the foundations of circular economy (Sterev, 2023).

This paper explores the vital role that digitalisation plays in driving the transition towards a sustainable circular economy, a global trend that is developing simultaneously with the current digital economy paradigm.

2. Problem Statement

Digital technologies and therefore, digitalization, play an important role in enabling the transition from the classical linear economy to the circular economy, and there is no evidence against it. However, operationalising this transition remains a challenge for the business environment, as the understanding process of how digital technologies directly support the circular economy is still ongoing for many businesses and organisations (Cagno et al., 2021).

Meanwhile, digitalisation through digital technologies, has the power to enable real-time monitoring and tracking of resources throughout their entire lifecycle. Using that power, businesses can facilitate more efficient resource management and reduce waste reduction, especially the waste from electrical and electronic equipment (WEEE). Harnessing the power of digital tools, such as Big Data analytics, businesses through digitalisation, can gain valuable insights into consumption pattern. At the same time, opportunities for resource recovery and recycling can be identified, and businesses can also optimise production processes to minimize their environmental impact (Kurniawan, 2022).

Furthermore, digital platforms and sharing economy models enable the exchange and reuse of products and materials, fostering a culture of resource conservation and circularity. At the same time, the digitalised infrastructure of circular economy has the potential to facilitate and achieve the structural conditions for business models and production operations that are based on sustainability.

The high level of digitalisation that is present in the current circular economy is based on tangible technological innovations blended with softer intangible innovations that once combined, it can create the environment for improved business performance, efficient resource usage, and smart business models development (Allen and Sarkis, 2021).

At the same time, scholars have been strongly debating whether the framework provided by the characteristics of the circular economy will be adopted as the new economic paradigm. For example, the study conducted by Bressanelli et al. (2022) aimed that the economic environment should be transitioning to the *smart circular economy paradigm* that emphasises the role in achieving the goals of the circular economy. In their perspective, digitalisation involves a combination of various techniques, not just specific technologies. Their results show that the latest digital technologies represent smart tools in establishing product redisign, business models, and smart supply chains. Meanwhile, their study argues that digitalisation alone does not ensure higher sustainability, although the waste resulting from the linear consumation, combined with the data provided by adopting and implementing the emergent technologies, represents the adaptation of the classical circular economy principle for the digital age.

Digitalisation's vital role in sustainable economy has not yet been decided or accepted as a general statement by the scientific community. This leads to a gap in the literature that can only be fulfilled or abandoned when all the research possibilities and research perspectives have been explored.

Hence, current research repersent one more approach in the process of determining the role in enhacing the circular economy.

3. Research Questions / Aims of the Research

There is no reason in denying that the transition towards a circular economy has been constantly supported by the adoption and implementation of the latest digital technologies into business models and business activities. Therefore, digitalisation and its tools are permanently involved in achieving the sustainability goals that the member states of the European Union have aimed to achieve.

At the same time, it is mandatory to understand the correlation between the DESI score, the basic level of digital infrastructure, the investments in multiple digital technologies, the collection of WEEE and the Recycling rate of packaging. In other words, the relationship between digitalisation and circular economy, as businesses operating in the current digital economic environment should be aware of the importance of recycling and reusing the available resources.

Hence, the main goal of the current study is to identify and provide an explanation for the correlations that could be acquired between digitalization and circular economy, in the current context of the digital economy as a main economic paradigm.

Therefore, as a research question for the current paper, the following can be formulated: *Is digitalisation impacting the circular economy?* At first glance, the research question is broad, although it will be narrowed, explained, and exposed in the study conceptualised by the authors.

4. Research Methods

As the authors aimed to provide a brief but comprehensive overview, the data were collected from various sources. The authors have decided to divide the data into two groups, one regarding **digitalisation** and the second group regarding the main aspects of the **circular economy**.

Regarding digitalisation, the following data has been collected: DESI score (European Commission, 2022); Basic level of digital infrastructure – basic level of digital infrastructure (European Investment Bank, 2023); and Multi-technology investments – the percentage of firms that have invested in multiple digital technologies (European Investment Bank, 2023).

Regarding the circular economy, the following data has been collected: Recycling rate of packaging waste – in percentage (Eurostat, 2023a); and WEEE collected – in kilogrammes per inhabitant (Eurostat, 2023b).

All data collected is representative of the member states of the European Union and has been summarized in Table 1.

Table 1. Data summary

EU State	DESI score	Basic level of digital infrastructure	Multiple technology investment	Recycling rate of packaging waste	WEEE collected
AT	54.70	67.3	54.77	65.8	15.46
BE	50.30	77.1	56.21	80.4	14.63
BG	37.70	47.2	22.91	61.2	13.56
CY	48.40	70	33.01	63.5	3.96
CZ	49.10	68	60.16	69.1	12.7
DE	52.90	77.3	40.81	67.9	12.1
DK	69.30	88.8	50.68	64.0	13.1
EE	56.50	66.9	40.24	70.4	9.0
EL	38.90	41.2	36.04	60.1	5.98
ES	60.80	67.5	53.75	70.1	8.72
EU27	**52.30**	**69.1**	**41.29**	**64.0**	**10.97**
FI	69.60	89.5	52.55	72.5	14.68
FR	53.30	63.5	22.26	61.8	14.67
HR	47.50	57.8	31.88	50.8	8.98
HU	43.80	51.7	28.50	52.4	8.71
IE	62.70	84.5	44.77	58.1	14.27
IT	49.30	69.9	39.54	72.9	8.5
LT	52.70	63.7	34.20	61.8	7.05
LU	58.90	66.2	33.53	73.7	10.4
LV	49.70	52.3	36.64	61.0	8.53
MT	60.90	77.9	45.13	38.4	6.85
NL	67.40	80.1	55.10	76.8	11.75
PL	40.50	61.0	31.75	55.5	11.24
PT	50.80	70.3	32.37	63.1	5.18
RO	30.60	52.5	34.62	39.9	4.75
SE	65.20	86.9	54.06	59.6	12.98
SI	53.40	67.1	54.99	55.1	7.37
SK	43.40	60.2	34.47	70.8	9.57

Source: data collected by the authors.

At the same time, in order to answer the research question, a simple correlation between the variables and two regressions have been conducted using the Data Analysis Tools provided by Microsoft Excel. The analyses are explored and extended in the next chapter of the paper.

5. Findings

The first step in formulating a statement for the research question is to run a correlation between the variables selected for the current study. Therefore, using the correlation tool, the results presented in Table 2 have been provided.

Table 2. Correlations between the analysed data

Correlation results	DESI Score	Basic level of digital infrastructure	Multiple technology investment	Recycling rate of packaging waste	WEEE collected
DESI Score	1				
Basic level of digital infrastructure	0.84	1			
Multiple technology investments	0.58	0.62	1		
Recycling rate of packaging waste	0.34	0.30	0.32	1	
WEEE collected	0.41	0.42	0.33	0.42	1

Source: authors' contribution.

The results provided by the correlation show that there are only direct correlations between the selected variables; therefore, the models constructed for the two regressions are empirically valid. As expected, the strongest correlation (0.84) is between the DESI score and the basic level of digital infrastructure, but this is not a new result, as the level of digitalization could be assimilated as a major element in determining the DESI score of a country.

The most notable result of the correlation summary is that both the Recycling rate and WEEE collected possess a moderate correlation with the remaining variables, which represents the reason why both regressions are required for more details of the impact over the environmental aspects of the circular economy. Therefore, it is observable that the Basic level of digital infrastructure is stronger correlated with the WEEE collected than with the Recycling rate of packaging waste, since the electrical and electronic equipment can be assimilate as the standard physical resources used in adopting and implementing the latest digital technologies into business models or economic activities.

In Table 3, the summary of Regression 1 is presented. The model has been proposed to determine the influence of digitalisation over the WEEE collected. For this instance, the dependent variable (Y) has been considered to be the

WEEE collected, while the independent variable (X) has been the digitalisation, represented by: DESI score, basic level of digital infrastructure, and multiple technology investment.

Regarding statistical hypotheses, the null hypothesis (H0) has been defined as *Digitalisation is not impacting the WEEE collected*, while the alternative hypothesis (H1) states that *Digitalization does impact the WEEE collected*, if at least one of the variables associated with the independent variable is impacting the WEEE collected.

Table 3. Regression 1: Digitalisation – WEEE Collected

Regression Statistics	**df**	**SS**	**MS**	**F**	**Significance F**
Regression	3	59.39417	19.79806	1.978677	0.144072
Residual	24	240.1369	10.0057		
Total	27	299.5311			
Multiple R	**R Square**	**Adjusted R**	**Standard Error**	**Observations**	**Intercept P-value**
0.445298	0.198291	0.098077	3.163179	28	0.605596

Source: contributions of authors.

Regarding the summary of the regression, the model returned a value of R Square of 0.19, which indicates that the model is not the strongest in explaining the relationship between digitalisation and WEEE collected.

Hence, only 19% of the variability of the model is attributed to the considered variables used in constructing the regression, highlighting the fact that 81% of the influence over the WEEE collected is determined by other variables, not integrated in the presented model. However, the output suggests that 19% of the total WEEE collected is influenced by digitalisation as understood through the three independent variables.

The output generated by the regression also highlights the Significance F valued at 0.144072. It should be noted that this generated value is substantially greater than the reference value of 0.05 used as a threshold.

This result suggests that the model as an overall output cannot be significant from a statistical point of view. Therefore, it should be agreed that the independent variables chosen for the model do not have a significant impact on the dependent variable.

Regarding the intercept p-value, the outcome of 0.605596 follows the Significance F and indicates that it is not statistically significant. Hence, there is no sufficient evidence to conclude that the intercept is different from zero, which is why, at the same time, it can be confirmed that there is no sufficient evidence to reject the null hypothesis.

Therefore, the regression analysis is in favour of the null hypothesis (H0), which confirms that the level of WEEE collected is not strongly and directly impacted by digitalization, as understood by the DESI score, the basic level of digital infrastructure, and the percentage of firms that invest in multiple digital technologies.

Table 4. Regression 2: Digitalisation – Recycling rate of packaging waste

Regression Statistics	df	SS	MS	F	Significance F
Regression	3	381.4944	127.1648	1.372204	0.275155
Residual	24	2224.127	92.67195		
Total	27	2605.621			
Multiple R	**R Square**	**Adjusted R**	**Standard Error**	**Observations**	**Intercept P-value**
0.382638	0.146412	0.039714	9.626627	28	0.000448

Source: authors' contribution.

The summary of Regression 2 is presented in Table 4. The model proposed in the second regression aims to determine and to discover the influence of digitalisation over the Recycling rate of packaging waste. Therefore, digitalisation, as understood like in Regression 1, represents the independent variable (X), while the recycling rate of packaging waste represents the dependent variable (Y). At the same time, the statistical hypotheses are the null hypothesis (H0), which states that the recycling rate of packaging waste is not impacted by digitalisation, and the alternative hypothesis (H1) which states that the Recycling rate of packaging waste is impacted by the current trend of digitalization towards the digital economy and circular economy.

Regarding the output of the regression, the value of R Square returned by the model is 0.14, suggesting that the model has a weak explanatory power. Therefore, only 14% of the total recycling rate of packaging waste is impacted by digitalisation, the remaining 86% being influenced by other variables that have not been included in the model proposed.

At the same time, Significance F valued at 0.275155 highlights a higher critical value compared with the 0.05 accepted value. This aspect leads to understanding the fact that the overall model can not be significant for statistical purpose, taking into consideration that there is not enough evidence to reject the null hypothesis. At least, the intercept P-value of 0.00048 suggests the statistical relevance of the intercept variable.

Considering the outcome of the regression regarding significance F, the independent variables selected for the model are not significant for the dependent variable chosen to be analysed. Therefore, the results suggest that the null hypothesis (H0) has been validated. Taking this into account, we can conclude that the recycling rate of packaging waste is not directly impacted by digitalisation, as understood through the three composing variables: DESI score, Basic level of digital infrastructure, and investment in multiple digital technologies.

Regardless of the analyses of different variables, the models examined provide valuable insight into how digitalization through digital infrastructure and firms' investments in multiple digital technologies interact with the factors attributed to the circular economy. The two regression analyses help address the research question: *Is digitalisation impacting the circular economy?*

Understanding the relationships between the selected variables represents a critical point in determining whether the digital advancements drive the effectiveness of circular economy and, therefore, plays a vital role in promoting the sustainability goal aimed by the circular economy. Therefore, beside the correlation, the two regressions proposed in the current scientific study have the major role in defending the research hypothesis that digitalization is impacting the circular economy.

Hence, examining both regressions, it can be determined if digitalisation plays a vital role regarding its direct and indirect effects on environmental outcomes, providing a comprehensive answer to the stated research question, taking into account the selected variables.

6. Conclusions

Despite analysing variables that do not have a strong impact in the implementation and development of circular economy, as highlighted by the correlation and the two regression analyses proposed by the study, the models present valuable insights into how digitalisation, as represented by the three independent variables, interacts with two of the main aspects of circular economy: recycling and collecting waste in ways that sustain the environmental policies.

The correlation has shown the strong relationship between the DESI score and the Basic level of digital infrastructure, both major elements of digitalisation, highlighting at the same time the moderate relationship between digitalization and the circular economy, the results providing a direct medium correlation between the variables considered for digitalization, and the variables taken into account for circular economy.

Meanwhile, in the first regression, the data collected for digitalisation is not strongly impacting the aspect of circular economy, as the significance F has been valued at 0.14, which compared to 0.05 is a higher value. At the same time, the explanatory power of the square model, determined by the R valued at 0.19 confirms that the DESI score, the basic level of digital infrastructure, and multiple technology investments do influence just a small fraction of the total of WEEE collected.

Simultaneously, the second regression reveals that digitalisation, as understood by the same three independent variables, explains only a limited fraction of the variability of recycling rate of packaging waste, as suggested by the low R Square valued at 0.14. At the same time, the significance F value (0.27), compared with the threshold value, is significantly greater, aspect that suggests that the impact of digitalization over the Recycling rate of packaging waste is not directly throughout the three variables used in the model.

In general, these findings illustrate a nuanced relationship between digitalisation, understood by the DESI score, the basic level of digital infrastructure, and the multiple investments in technology of firms, and circular economy, understood by the WEEE collected and Recycling rate of packaging waste. While digital readiness significantly drives firms' investments in digital technologies, these investments do not necessarily lead to improved environmental results, such as increased WEEE collection or a higher Recycling rate of packaging waste, even if electrical and electronic equipment is the main resource consumed in adopting and implementing the latest digital technologies and that the equipment is provided most of the time in a package that can be either recycled or reused. Therefore, those aspects are not sufficient to demonstrate the positive impact of digitalisation over the effective advancement of circular economy toward its sustainability goals.

The correlation between the two regressions with respect to the main components of digitalisation and circular economy, underscores the complexity of leveraging digitalization for sustainable circular economy goals. Digital advancements encourage investments, and investments encourage the usage of resource, but at the same time also encourage the increasement of WEEE. Therefore, the main gap of the vital role in sustainable circular economy is to find the requirements needed to encourage the reuse of electric and electronic equipment, the collection of WEEE and the recycling if possible, and the increase in the Recycling rate of packaging waste.

In conclusion, the present study highlighted that digitalisation do play a major role in circular economy, especially in achieving the sustainability goals aimed, but it is not the only variable that can impact the main aspects of the circular economy, such as the WEEE collection rate or the recycling rate of packaging waste, even if those two represent the main operations promoted by the circular economy: reusing and recycling resources.

Hence, taking into account the awareness regarding research limitations, a deeper holistic approach is required to align digitalization and firms' investments in digital technologies with environmental objectives, while fostering a more effective and proactive circular economy, at the same time.

Bibliography

[1] Allen, S.D., Sarkis, J. (2021). How can the circular economy-digitalization infrastructure support transformation to strong sustainability?. Environmental Research: Infrastructure and Sustainability, 1(3), 033001.

[2] Bressanelli, G., Adrodegari, F., Pigosso, D.C., Parida, V. (2022). Towards the smart circular economy paradigm: a definition, conceptualization, and research agenda. Sustainability, 14(9), 4960.

[3] Cagno, E., Neri, A., Negri, M., Bassani, C.A., Lampertico, T. (2021). The role of digital technologies in operationalizing the circular economy transition: A systematic literature review. Applied Sciences, 11(8), 3328.

[4] European Commission (2022). Digital Economy and Society Index (DESI) 2022. Thematic chapters. https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2022 (accessed April 2024).

[5] European Investment Bank (2023). European Investment Bank Investment Survey 2023: European Union overview. https://www.eib.org/en/publications/online/all/eib-investment-survey-2023.htm (accessed April 2024).

[6] Eurostat (2023a). Packaging waste statistics. https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fec.europa.eu%2Feurostat%2Fstatistics-explained%2Fimages%2F6%2F6d%2FPackaging_waste_2023-10_.xlsx&wdOrigin=BROWSELINK (accessed May 2024).

[7] Eurostat (2023b). Waste statistics – electrical and electronic equipment.

[8] Gil-Lamata, M., Fuentelsaz, L., Latorre-Martínez, M.P. (2024). Does digitalization foster the path to a circular economy? An exploratory analysis of European Union countries. Corporate Social Responsibility and Environmental Management, 31(2), 1239-1253.

[9] Kurniawan, T.A., Othman, M.H.D., Hwang, G.H., Gikas, P. (2022). Unlocking digital technologies for waste recycling in Industry 4.0 era: A transformation towards a digitalization-based circular economy in Indonesia. Journal of Cleaner Production, 357, 131911.

[10] Sterev, N. (2023). Industry 5.0, Digitalization of business and Circular economy. SHS Web of Conferences, 176, p. 02002.

[11] Trevisan, A.H., Zacharias, I.S., Liu, Q., Yang, M., Mascarenhas, J. (2021). Circular economy and digital technologies: A review of the current research streams. Proceedings of the design society, 1, 621-630.