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ICT Usage by Companies and Sustainability Approach within the European Union

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Abstract. *ICT represents the industry with a rapid development and is very much linked to sustainability. The indicator ICT and Sustainability presents the following items: Enterprises applying some measures, affecting the amount of paper used for printing and copying; Enterprises applying some measures, affecting the energy consumption of the ICT; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment; When the ICT equipment of the enterprise is no longer used, it is disposed of in electronic waste collection/recycling; When the ICT equipment of the enterprise is no longer used, it is sold, returned to a leasing enterprise, or donated. The research methodology focuses on descriptive statistics, correlation and factor analysis. The results represent an important step forward from a sustainable point of view, connecting the ICT practices and environment.*

Keywords: ICT usage, Environment analysis, Sustainability, European Union, Enterprises.

Introduction

Digital technology should go together with the sustainable approach within most of the companies, as there is a growing interest in harnessing ICT to drive *"sustainability awareness and strengthen sustainable activities and actions among software engineering and digital innovation researchers"* (Adisa et al., 2024). However, the adoption of the digital technology should be accompanied by the *"SMEs technology readiness, which implies the organization's capability to adopt, use and benefit from digital technologies"* (Mujahed et al., 2024).

A complex definition of digital transformation was given by Gartner report (2021), stating that it *"can refer to anything from Information and Communication Technology (ICT) innovation (cloud computing) to digital optimisation and invention"*. On the other hand, sustainable development can be defined as *"the ability to meet the needs of the present without compromising the ability of the future generations to meet their own needs"* (Brundtland Gro, 1987).

Literature review

The adoption of the digital technologies gained a lot in importance during the COVID-19 outbreak. (Parra- Sanchez and Talero-Sarmiento, 2024) Nowadays, the term green growth promotes *"environmental sustainability and economic prosperity by supporting the preservation of natural*

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resources, energy conservation, environmentally conscious farming and waste disposal" (Jiang et al., 2024) On the other hand, as a scale effect, together with the expansion of the industries at their early phases of growth, the pollution and the energy consumption rise, with a negative impact on the environment. (Usman et al., 2024)

Responsible management is seen today as an engine to harness creativity and ingenuity to address environmental issues while producing economic value. (Alfehaid et al., 2024) ICT usage can be used to potentially influence environmental sustainability in two ways. (Higon et al., 2017) The first way is based on underlining the negative effects of ICT usage, production and disposal, such as the increased carbon emission due to electricity consumption. The other way, emphasizes the fact that the environmental footprint of ICT extends beyond energy usage and should include manufacturing process and maintenance of infrastructure, such as data centres. (Ropke and Christensen, 2012) In response, the green ICT response promises to address environmental challenges. (Zheng et al., 2023, Wang et al., 2024)

ICT is essential for advancing environmental sustainability, based on smart energy management, effective waste management and efficient transportation systems. (Khan et al., 2020) We propose to highlight the correspondence between ICT and sustainability throughout the following indicators: Enterprises applying some measures, affecting the amount of paper used for printing and copying; Enterprises applying some measures, affecting the energy consumption of the ICT; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment; When the ICT equipment of the enterprise is no longer used, it is disposed of in electronic waste collection/recycling; When the ICT equipment of the enterprise is no longer used, it is sold, returned to a leasing enterprise, or donated.

The hypotheses were developed as follows:

H1. The small and medium companies, from 10 to 249 persons employed, favor the following environmental practices related to ICT (all activities, except agriculture, forestry and fishing, and mining and quarrying, without financial sector): Enterprises applying some measures, affecting the amount of paper used for printing and copying; Enterprises applying some measures, affecting the energy consumption of the ICT; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment; When the ICT equipment of the enterprise is no longer used, it is disposed of in electronic waste collection/recycling; When the ICT equipment of the enterprise is no longer used, it is sold, returned to a leasing enterprise, or donated.

H2. The big companies, with 250 persons employed or more, favor the following environmental practices related to ICT (all activities, except agriculture, forestry and fishing, and mining and quarrying, without financial sector): Enterprises applying some measures, affecting the amount of paper used for printing and copying; Enterprises applying some measures, affecting the energy consumption of the ICT; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment; When the ICT equipment of the enterprise is no longer used, it is disposed of in electronic waste collection/recycling; When the

ICT equipment of the enterprise is no longer used, it is sold, returned to a leasing enterprise, or donated.

The research methodology focuses on descriptive statistics, correlation and factor analysis.

Methodology

The research method is based on statistical analysis in SPSS 30.0 software, using the data from Eurostat on ICT and environment by size class of enterprise (2022). For each of the EU-27 member states, a number of six items was analyzed. (Table 1).

Table 1. ICT and environment by size class of enterprise (2022)

Variables
Enterprises applying some measures, affecting the amount of paper used for printing and copying
Enterprises applying some measures, affecting the energy consumption of the ICT
The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them
The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment
When the ICT equipment of the enterprise is no longer used, it is disposed of in electronic waste collection/recycling
When the ICT equipment of the enterprise is no longer used, it is sold, returned to a leasing enterprise, or donated

Source: Authors' own research.

Results and discussions

In this section we present the main findings of the research, for small and medium companies and for big companies.

The first construct is the extend to which the small and medium companies, from 10 to 249 persons employed, favor environmental practices related to ICT (all activities, except agriculture, forestry and fishing, and mining and quarrying, without financial sector) and is measured through the following variables: Enterprises applying some measures, affecting the amount of paper used for printing and copying [Q1.1.]; Enterprises applying some measures, affecting the energy consumption of the ICT [Q1.2.]; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them [Q1.3.]; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment [Q1.4.]; When the ICT equipment of the enterprise is no longer used, it is disposed of in electronic waste collection/recycling [Q1.5.]; When the ICT equipment of the enterprise is no longer used, it is sold, returned to a leasing enterprise, or donated [Q1.6].

According to the results from the Table 2, there is a strong correlation between: The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them [Q1.3.] and The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment [Q1.4.] (Pearson coefficient = 0,909, sig. = 0,01); Enterprises applying some measures, affecting the amount of paper used for printing and copying [Q1.1.] and Enterprises applying some measures, affecting the energy consumption of the ICT [Q1.2.] (Pearson coefficient = 0,714, sig. = 0,01).

Table 2. Correlations for the extent to which the small and medium companies favor environmental practices related to ICT

Correlations							
		Q1.1.	Q1.2.	Q1.3. The	Q1.4.	Q1.5.	Q1.6.
Q1.1.	Pearson Correlation	1	**.714****	.142	.513**	.382*	.453*
	Sig. (2-tailed)		<.001	.479	.006	.049	.018
	N	27	27	27	27	27	27
Q1.2.	Pearson Correlation	.714**	1	.255	.517**	.353	.346
	Sig. (2-tailed)	<.001		.200	.006	.071	.077
	N	27	27	27	27	27	27
Q1.3.	Pearson Correlation	.142	.255	1	**.909****	.209	.140
	Sig. (2-tailed)	.479	.200		<.001	.296	.486
	N	27	27	27	27	27	27
Q1.4.	Pearson Correlation	.513**	.517**	.909**	1	.326	.329
	Sig. (2-tailed)	.006	.006	<.001		.097	.094
	N	27	27	27	27	27	27
Q1.5.	Pearson Correlation	.382*	.353	.209	.326	1	.483*
	Sig. (2-tailed)	.049	.071	.296	.097		.011
	N	27	27	27	27	27	27
Q1.6.	Pearson Correlation	.453*	.346	.140	.329	.483*	1
	Sig. (2-tailed)	.018	.077	.486	.094	.011	
	N	27	27	27	27	27	27
**. Correlation is significant at the 0.01 level (2-tailed).							
*. Correlation is significant at the 0.05 level (2-tailed).							

Source: Authors' own research, using SPSS 30.00 for Mac.

Applying factor analysis, we intend to define one or more variables that best describe the extent to which the small and medium companies favor environmental practices related to ICT. The Keiser-Meyer-Olkin (KMO) test has the value of 0,500, while the significance is lower than 0,001. (Table 3)

Table 3. KMO and Bartlet's test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.500
Bartlett's Test of Sphericity	Approx. Chi-Square	42.863
	df	1
	Sig.	<.001

Source: Authors' own research, using SPSS 30.00 for Mac.

The table of the explained variance presents one dimension that resume the information, explaining 95,446% of the variation of the phenomenon. (Table 4)

Table 4. Total variance explained

Total Variance Explained						
	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.909	95.446	95.446	1.909	95.446	95.446
2	.091	4.554	100.000			
Extraction Method: Principal Component Analysis.						

Source: Authors' own research, using SPSS 30.00 for Mac.

The results from the Table 5 define the main variables for the extent to which the small and medium companies favor environmental practices related to ICT. The component matrix underlines one extracted factor, with the following two dimensions: the enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them [Q1.3.] and the enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment [Q1.4.].

Table 5. Component matrix

Component Matrix[a]	
	Component
	1
Q1.3. The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them	.977
Q1.4. The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment	.977
Extraction Method: Principal Component Analysis.	
a. 1 components extracted.	

Source: Authors' own research, using SPSS 30.00 for Mac.

For the reliability statistics, the value of Cronbach's Alpha is 0,948. (Table 6)

Table 6. Reliability statistics

Reliability Statistics	
Cronbach's Alpha	N of Items
.948	2

Source: Authors' own research, using SPSS 30.00 for Mac.

Thus, H1 is partially validated. H1. The small and medium companies, from 10 to 249 persons employed, favor the following environmental practices related to ICT (all activities, except agriculture, forestry and fishing, and mining and quarrying, without financial sector): The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them [Q1.3.]; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment [Q1.4.].

The second construct is represented by the extent the big companies, with 250 persons employed or more, favor the following environmental practices related to ICT (all activities, except agriculture, forestry and fishing, and mining and quarrying, without financial sector) and is measured through: Enterprises applying some measures, affecting the amount of paper used for printing and copying [Q2.1.]; Enterprises applying some measures, affecting the energy consumption of the ICT [Q2.2.]; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them [Q2.3.]; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment [Q2.4.]; When the ICT equipment of the enterprise is no longer used, it is disposed of in electronic waste collection/recycling [Q2.5.]; When the ICT equipment of the enterprise is no longer used, it is sold, returned to a leasing enterprise, or donated [Q2.6].

According to the results from the Table 7, there is a strong correlation between: Enterprises applying some measures, affecting the amount of paper used for printing and copying [Q2.1.] and Enterprises applying some measures, affecting the energy consumption of the ICT [Q2.2.]; (Pearson coefficient = 0,802, sig. = 0,01); Enterprises applying some measures, affecting the amount of paper used for printing and copying [Q2.1.] and The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment [Q2.4.] (Pearson coefficient = 0,735, sig. = 0,01); The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them [Q2.3.] and The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment [Q2.4.] (Pearson coefficient = 0,864, sig. = 0,01); The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment [Q2.4.] and When the ICT equipment of the enterprise is no longer used, it is disposed of in electronic waste collection/recycling [Q2.5.] (Pearson coefficient = 0,903, sig. = 0,01).

Table 7. Correlations for the extent to which the big companies favor environmental practices related to ICT

Correlations							
		Q2.1.	Q2.2.	Q2.3.	Q2.4.	Q2.5.	Q2.6.
Q2.1.	Pearson Correlation	1	**.802****	.334	**.735****	.221	.407*
	Sig. (2-tailed)		<.001	.089	<.001	.268	.035
	N	27	27	27	27	27	27
Q2.2.	Pearson Correlation	.802**	1	.404*	**.681****	.079	.317
	Sig. (2-tailed)	<.001		.037	<.001	.694	.107
	N	27	27	27	27	27	27
Q2.3.	Pearson Correlation	.334	.404*	1	**.864****	-.137	.096
	Sig. (2-tailed)	.089	.037		<.001	.496	.634
	N	27	27	27	27	27	27
Q2.4.	Pearson Correlation	.735**	.681**	.864**	1	.025	.350
	Sig. (2-tailed)	<.001	<.001	<.001		**.903**	.073
	N	27	27	27	27	27	27
Q2.5.	Pearson Correlation	.221	.079	-.137	.025	1	.338
	Sig. (2-tailed)	.268	.694	.496	.903		.085
	N	27	27	27	27	27	27
Q2.6.	Pearson Correlation	.407*	.317	.096	.350	.338	1
	Sig. (2-tailed)	.035	.107	.634	.073	.085	
	N	27	27	27	27	27	27
**. Correlation is significant at the 0.01 level (2-tailed).							
*. Correlation is significant at the 0.05 level (2-tailed).							

Source: Authors' own research, using SPSS 30.00 for Mac.

With the factor analysis, we define one or more variables that best describe extent to which the big companies favor environmental practices related to ICT. The Keiser-Meyer-Olkin (KMO) test has the value of 0,509, with the significance lower than 0,001. (Table 8)

Table 8. KMO and Bartlet's test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.509
Bartlett's Test of Sphericity	Approx. Chi-Square	112.797
	df	6
	Sig.	<.001

Source: Authors' own research, using SPSS 30.00 for Mac.

The table of the explained variance presents one dimension that resume the information, explaining 73,247% of the variation of the phenomenon. (Table 9)

Table 9. Total variance explained

Total Variance Explained						
	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.930	73.247	73.247	2.930	73.247	73.247
2	.838	20.958	94.205			
3	.215	5.378	99.584			
4	.017	.416	100.000			
Extraction Method: Principal Component Analysis.						

Source: Authors' own research, using SPSS 30.00 for Mac.

The results from the Table 10 define the main variables for the extent to which the big companies favor environmental practices related to ICT. The component matrix underlines one extracted factor, with the following four dimensions: Enterprises applying some measures, affecting the amount of paper used for printing and copying [Q2.1.]; Enterprises applying some measures, affecting the energy consumption of the ICT [Q2.2.]; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them [Q2.3.]; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment [Q2.4.].

Table 10. Component matrix

Component Matrix[a]	
	Component 1
Q2.1. Enterprises applying some measures, affecting the amount of paper used for printing and copying	.848
Q2.2. Enterprises applying some measures, affecting the energy consumption of the ICT equipment	.849
Q2.3. The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them	.754
Q2.4. The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment	.960
Extraction Method: Principal Component Analysis.	
a. 1 components extracted.	

Source: Authors' own research, using SPSS 30.00 for Mac.

For the reliability statistics, the value of Cronbach's Alpha is 0,876. (Table 11)

Table 11. Reliability statistics

Reliability Statistics	
Cronbach's Alpha	N of Items
.876	4

Source: Authors' own research, using SPSS 30.00 for Mac.

Thus, H2 is partially validated. H2. The big companies, with 250 persons employed or more, favor the following environmental practices related to ICT (all activities, except agriculture, forestry and fishing, and mining and quarrying, without financial sector): Enterprises applying some measures, affecting the amount of paper used for printing and copying [Q2.1.]; Enterprises applying some measures, affecting the energy consumption of the ICT [Q2.2.]; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them [Q2.3.]; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment [Q2.4.].

Conclusion

The results represent an important step forward from a sustainable point of view, connecting the ICT practices and environment. The research has an important impact in economy, enhancing environmental practices through ICT in small and medium companies and big companies. The small and medium companies favor the following environmental practices related to ICT: The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment. The big companies favor the following environmental practices related to ICT: Enterprises applying some measures, affecting the amount of paper used for printing and copying; Enterprises applying some measures, affecting the energy consumption of the ICT; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them; The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment. The future research may explore the connection between other ICT practices to enhance sustainability.

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References

Adisa, M. O., Oyedeji, S., Porras, J. (2024). The nexus between ICT, top-down and bottom-up approaches for sustainability activities: A systematic mapping study, Journal of Cleaner Production, 449, 141768, https://doi.org/10.1016/j.jclepro.2024.141768 .

Alfehaid, F., Omri, A., Altwaijri, A. (2024). Impact of ICT diffusion and opportunity entrepreneurship on environmental sustainability in Saudi Arabia, Heliyon 10, e39009, https://doi.org/10.1016/j.heliyon.2024.e39009 .

Brundtland Gro, H. (1987). Our Common Future.

Gartner (2021). Gartner Top 10 Data and Analytics Trends for 2021. https://www. gartner.com/ smarterwithgartner/gartner-top-10-data-and-analytics-trends-for- 2021 .

Jiang, H., Yang, Y., Wang, Y., Chandni, K. (2024). Shades of sustainability: Decoding the influence of fintech, natural resources and green ICT on CO2 emissions and green growth in China, Resources Policy, 97, 105275, https://doi.org/10.1016/j.resourpol.2024.105275 .
Khan, F.N., Sana, A., Arif, U. (2020). Information and communication technology (ICT) and environmental sustainability: a panel data analysis. Environ. Sci. Pollut. Control Ser. 27, 36718-36731.
Mujahed, H. M. H., Ahmed E. M., Samikon S. A. (2024). Palestinian small and medium enterprises digital technology. Journal of Open Innovation: Technology, Market and Complexity, 10, 100426, https://doi.org/10.1016/j.joitmc.2024.100426 .
Parra- Sanchez, D.T., Talero-Sarmiento, L.H. (2024). Digital transformation in small and medium enterprises: a scientometric analysis. Digit. Transform. Soc. 3(3), 257-276.
Ropke, T.H., Christensen (2012). Energy impacts of ICT- insights from everyday life perspective, Telematics Inf. 29(4), 348-361.
Usman, M., khan, N., Omri, A. (2024). Environmental policy stringency, ICT, and technological innovation for achieving sustainable development: Assessing the importance of governance and infrastructure
Wang, J., Yang, S., Dong, K., Nepal, R. (2014). Is ICT innovation a recipe for carbon efficiency gains? Evidence from patent retrieval, Environ. Impact. Rev., 104, 107331.
Zheng, R., Wu, G., Cheng, Y., Liu, H., Wang, Y., Wang X. (2023). How does digitalization drive carbon emissions? The inverted U-shaped effect in China, Environ. Impact Assess. Rev. 102, 107203.