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Barriers to Green ICT Adoption in Romania

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Abstract *The efficient use and disposal of digital technologies are key factors in economic and social development. The concerns regarding the development and use of information and communication technologies (ICT), without negative influences on the environment, known as green ICT, have increased in recent decades. One explanation for this is the exponential increase in the number of users and connected devices, resulting in the consumption of more energy, as well as the generation of more CO2 emissions and more e-waste. In order to prevent an ecological disaster, governmental organizations, companies and individuals have to adhere to green ICT practices, to select hardware and software based on green criteria and to be involved in green ICT innovation. These concerns vary from one country to another and from one region to another, depending on the respective e-waste regulations and their application, research and development (R&D) expenditure, ICT skills, the level of education of citizens, popular culture and habits, living standards, etc. The paper presents three important barriers to green ICT adoption and development in Romania: e-waste recycling and reuse, R&D expenditure, and digital skills.*

Key words Green ICT, e-waste, ICT skills, R&D expenditure, digital technologies

JEL Codes: O33, Q55, Q56

1. Introduction

The influence of information and communication technologies (ICT) on society, economics and quality of life is extremely high. It is applied to different fields with wide-ranging socio-economic and environmental impacts across sectors (Cecere *et al*., 2014). The economic potential of ICT and its benefits on citizens' life are repeatedly presented in various contexts by scholars, business practitioners and policymakers. Its ubiquity generates direct and indirect effects on the areas of production and consumption influencing the natural environment. These influences can be positive or negative, direct or indirect. Consumers dispose of a large number of old devices (monitors, computers, mobile phones etc.) in landfills instead of recycling them. These devices are used only for three or four years before being replaced with new ones. The good news about these replacements is that newer devices are generally more energy-efficient and capable of reducing the environmental footprint.

The problems that persist are the increase in the volume of e-waste and consumption of non-renewable resources, as well as the rise in pollution from production and distribution processes. The huge potential of ICT in terms of sustainable development clearly outweighs these disadvantages and has received great attention in the literature and among business practitioners. In order to decrease the negative effects and increase the positive effects, ICT research studies have to focus on developing greener and smarter digital technologies. These will consume less energy, generate fewer CO_2 emissions, contain only renewable raw materials and can be fully recycled or reused at the end of their life. More than that, ICT will export more energy to other users.

Nowadays, digital technologies already have some of these features; but, taking into account the rapid growth in the demand for ICT products and services, their implementation speed needs to grow very quickly. These concerns refer to green ICT, ecological informatics, green computing, sustainable ICT etc., that is, ICT offer "better environmental performance than in previous generations (direct impacts) as well as technology utilized to improve environmental performance throughout the economy and society (enabling and systemic impacts)" (Mickoleit, 2010). Green ICT ought to contribute to cost savings and bring competitive advantage to a society increasingly concerned with environmental protection. The main factors that influence green ICT adoption are the "rapid growth of the Internet, increasing cooling requirements, increasing energy costs and restrictions on energy supply access, lower server utilization rates and ICT impacts on the environment" (Chitra, 2011).

The aim of this paper is to analyse some of the main barriers to green ICT adoption and development in Romania. The rest of this paper is organized as follows. Section 2 reviews the main concepts in the field of green ICT. In Section 3, the methodology of the current research is presented. The results and discussions regarding green ICT barriers are presented in Section 4. Finally, Section 5 concludes the paper.

2. Literature review

There is no consensus on the definition of green ICT. Some authors consider only energy efficiency and hardware use, while others include sets of good practices for ICT use and software development. This is explicable, given that green ICT relate to a relatively new and constantly expanding area of research (Zhang and Liang, 2012). In this section, we present some representative opinions.

First, there is a clear distinction between the possibilities of ICT organizations and the possibilities of non-ICT organizations. For the former, green ICT involve the design, manufacture and distribution of hardware and software with minimal or no negative environmental impact. This includes power consumption, manufacturing practices, data centre design and operations, recycling and reuse of computer equipment, system performance and efficient system use (Brooks et al., 2010). For non-ICT organizations, green ICT concern the "acquisition, usage and disposal of ICT equipment in an environmentally friendly manner" (Deshpande and Unhelkar, 2011) or "the study and practice of using computing resources efficiently" (Lamb, 2009). The second distinction is between green ICT and green information systems (IS). 'Green ICT' refers to "equipment and software that either reduces their own environmental impacts or those of other sectors of the economy and society" (Cecere *et al*., 2014). 'Green IS' refers to "information systems that can be developed with or without green IT to support environmental sustainability initiatives" (Tushi *et al*., 2014). The third distinction is between direct, enabling and systemic effects of ICT on the environment, as presented in the following table (Table 1).

Table 1. Classification of ICT and green ICT effects on the environment

	Positive impacts	**Negative impacts**
First-order effects (direct)	Hardware and software created and used directly for environmental protection.	Energy consumption, CO_2 emissions, use of non-renewable and toxic materials, and e-waste.
Second-order effects (enabling)	ICT help other economic and social activities achieve greater efficiency and value in using resources.	The increase in the demand for other products, whose manufacture and distribution lead to more energy consumption, CO_2 emissions, use of non-renewable and toxic materials, and, finally more e-waste.
Third-order effects (systemic)	ICT contribute to changes in economic and social structures and human behaviours towards a dematerialized economy and new lifestyles.	Rebound effects stimulate new demand, which could lead to an increase in the negative aspects of production and distribution processes.

Source: adapted from Berkhout and Hertin (2001), Zhang and Liang (2012).

Some authors consider just two categories of effects of ICT on the environment: direct and indirect. Direct effects correspond to first-order effects and are also known as green in ICT and indirect effects correspond to second- and third-order effects and are known as green by ICT. According to Calero and Piattini (2015), green in ICT is defined as "the IT sector's own activity and its impact on environmental efficiency" and green by ICT is "the impact of IT on the environmental productivity of other sectors".

Given the variety of definitions and classifications, green ICT embody an important and challenging concept, with influences in numerous fields. According to a study by Cecere *et al.* (2014), there are "65 technological domains, corresponding to different combinations of green and ICT classes" with various level of maturity. ICT development and adoption are conditioned by factors such as the level of education, R&D expenditure, ICT skills, interest in environmental protection, and legislation in the field of environmental protection.

3. Methodology of research

The paper is the result of an investigation and critical interpretation of the studies on the research theme. In order to identify the barriers to green ICT adoption in Romania, we analysed the data provided by Eurostat, the Organisation for Economic Co-operation and Development (OECD) and the World Bank. The study period is 2010-2016 for e-waste problems and R&D expenditure and 2015-2017 for ICT skills. We have chosen to analyse different periods because of the availability of information, as well as the dynamics of their influence on the analysed issue. Romania's accession to the European Union (EU) has been followed by European regulations and strategies adoption including e-waste, ICT, R&D the environment, among others. Some are mandatory, while others are recommendations with a view to supporting the economic and social sustainable development of Romania and the EU. Based on previous studies, we have identified the following barriers

regarding green ICT development and adoption: e-waste regulations and their application, R&D expenditure, ICT skills, the level of citizens' education, popular culture and habits, and living standards. This paper analyses only the first three indicators. To highlight the situation in Romania, the data presented are compared to the average from all EU countries.

4. Results and discussions

In Romania, the ICT sector is extremely dynamic, but poverty, lack of information, lack of investment in R&D, political instability etc. are important barriers to green ICT development and adoption. As an EU member, the country must adopt and apply EU regulations and directives, including those related to green ICT, in line with the ICT4Society pillars (European Commission, 2014). For example (Radu, 2016; Hoeltl *et al.,* 2014):

- Directive 2012/19/EU promotes the reuse, recycling and other forms of recovery of e-waste to reduce the amount of waste based on a take-back system.
- Good Practice Collection in Green Public Procurement promotes the adoption of green ICT in public institutions.
- The Substances in Electrical and Electronic Equipment (RoHS) Directive and the RoHS Recast Directive (RoHS 2) limit the use of hazardous substances in electrical and electronic equipment.
- Directive 2006/32/EC regulates energy end-use efficiency and energy services.
- Directive 2009/125/EC establishes a framework for establishing eco-design requirements for energy-related products.
- Directive 2002/96/EC regulates waste electrical and electronic equipment (WEEE) in terms of prevention, recovery and assurance of safe disposal of waste.

While legislation exists in the above areas, it is not applicable to all countries. Recycling and reusing hardware are important aspects of green ICT adoption. Computers contain hazardous materials, such as lead, mercury and cadmium. They will have a long-lasting effect on human health and the environment in the case of improper disposal. Developed countries have and apply strict regulations regarding ICT disposal. Even in these conditions, according to a study by Baldé *et al.* (2017), in 2016, only 20% of e-waste was documented as collected and properly recycled. Since 2007, when Romania became a member of the EU, it has assumed "a gradual achievement of objectives in terms of selective collection, recycling, recovery and disposal of municipal waste" (Târțiu, 2011); but, between 2007 and 2016, the amount of waste disposed of in landfills exceeded 70%. In 2016 the total volume of e-waste was equal to 11.6 kg/capita in Romania. In recent years, some trends have driven the increase in e-waste (e.g., multiple-device ownership, the tendency to electrify non-electrical equipment, the growth in cloud computing services, a growing number of data centres and shorter replacement cycles) (Balde *et al.,* 2017). The development and ubiquity of smart devices make it difficult to distinguish between e-waste from ICT equipment and that derived from other sources. In this context, the recycling process should be evaluated for all WEEE. According to Eurostat, the recycling rate of WEEE in Romania was much lower than in the whole of the EU in the period 2010-2014, but it had been growing, except in 2011 (Figure 2). We only have data for these years.

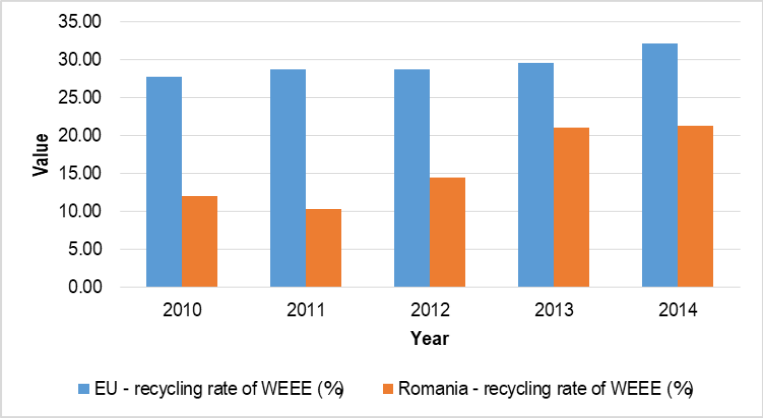

Figure 2. Dynamics of recycling rate of WEEE in Romania and EU countries, over 2010–2014

Source: Own representation based on data collected from Eurostat database (Eurostat, 2018a)

According to Păceșilă *et al.* (2016), the following factors contribute to this low rate of recycling in Romania: inadequate infrastructure for WEEE collection, the lack of public awareness regarding WEEE collection, the lack of public interest in improving WEEE management and using electronic products older than three years. Green ICT implementation is possible

only with a change in the mindset and habits of the public. Since the number of devices per capita and Internet users is growing very fast, these changes must occur very quickly.

The second barrier is the lack of investment in R&D. Green ICT represents a generational change. Old hardware and software are replaced with newer versions, which are more energy-efficient and reliable. In order to facilitate these changes, technological innovation is necessary. An important indicator is the percentage of GDP used for R&D. According to a study published by the OECD, the value of this indicator for Romania is much lower than that recorded for other member states and the EU-28 average (Figure 3).

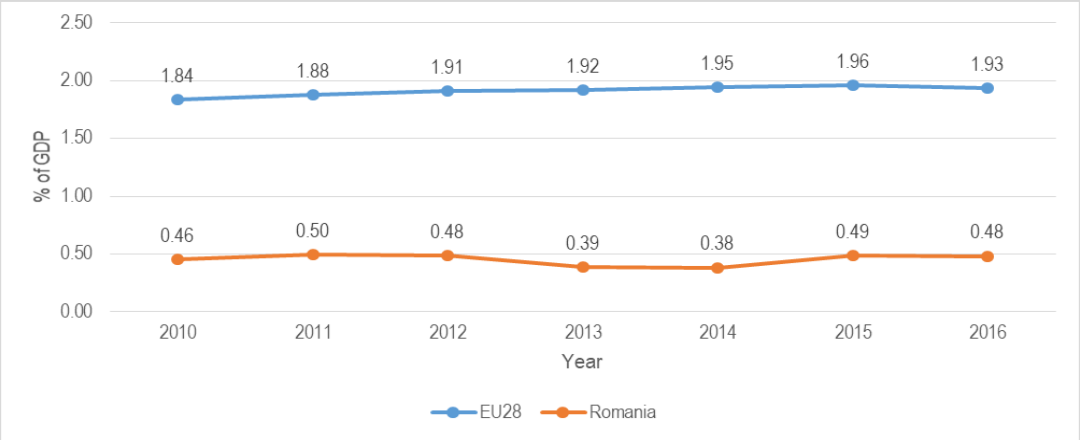

Figure 3. Dynamics of GDP on R&D in Romania and EU countries, over 2010–2016

Source: Own representation based on data collected from OECD database (2018)

Expenditure by the business enterprise sector on R&D is also much lower than the EU average: in 2016, this was 0.27% of GDP in Romania and 1.23% of GDP in the EU (Eurostat, 2018c). This low level of funding in R&D has significant consequences for the interest in innovation among Romanian citizens. It negatively influences the number of patents, the number of articles published in indexed journals, the value of high-tech exports, etc. For example, the number of patent applications to the European Patent Office per million inhabitants was 164.79 in the period 2015-2017 and 329.1 for EU countries in the same period (Eurostat, 2018b). But not all the results and information regarding the ICT field are negative. The number of employers in high- and medium-high-tech manufacturing sectors and knowledge-intensive service sectors has seen a favourable evolution. It has exceeded the EU-28 average in Romania in the last two years. Furthermore, the value of high-tech exports is higher than other EU members in South-east Europe (Figure 4). In short, the difference between Romania and these other countries is significant. Regarding its position compared to the rest of the developing countries in the EU, the value of high-tech exports is growing, but it is less than in the case of Hungary and Poland.

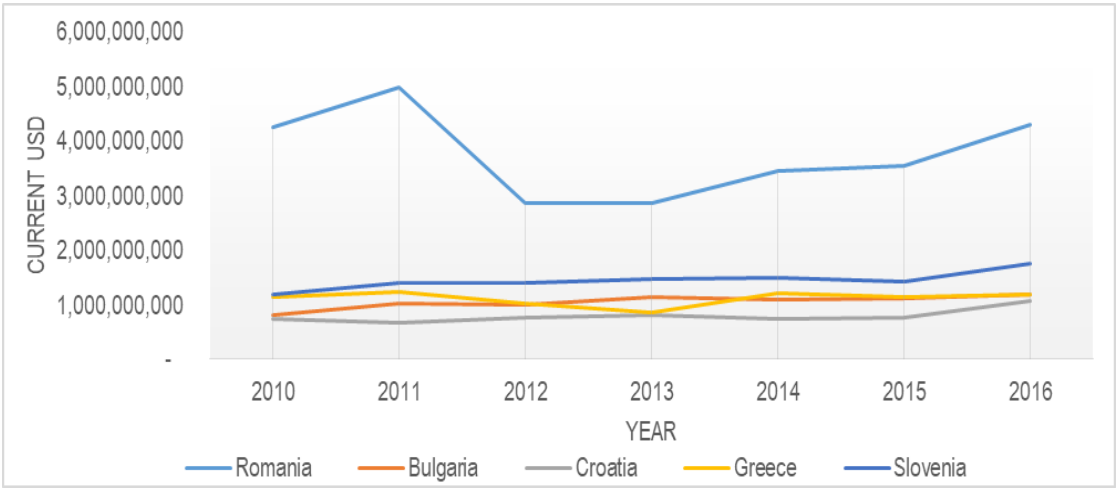

Figure 4. High-tech exports over 2010–2016

Source: Own representation based on data collected from The World Bank databases (The World Bank, 2018)

According to a World Bank report, in 2016, high-tech exports from Romania exceeded those from some developed countries including Finland. Between 2010 and 2015, they exceeded those of Portugal, Lithuania and Latvia, among others. This trend will favourably influence the development of the ICT field in the future and maybe of green ICT.

The lack of digital skills is another barrier to green ICT adoption. In Romania, according to Eurostat (2018), the percentage of individuals who have basic or above basic overall digital skills is almost half that of the European average (Figure 5).

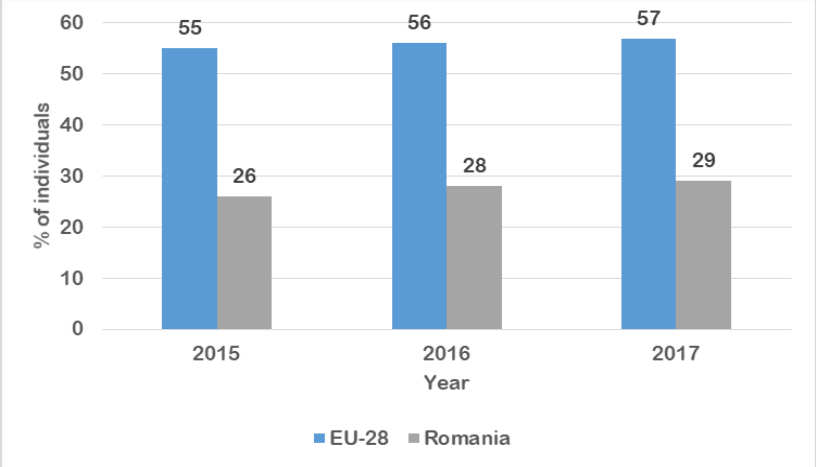

Figure 5. The individuals who have digital skills in Romania and EU countries, over 2015–2017

Source: Own representation based on data collected from Eurostat database (2018d)

The development of technologies, such as the Internet of Things, artificial intelligence and robotics, is extremely fast-paced. But ICT knowledge and competences are critical to various areas of activities. According to a survey by Foerster-Metz and Golowko (2018), the percentage of ICT skills demanded per job category is as follows: 77% for customer service, 43% for finance, 60% for human resources and 80% for sales. The lack of digital skills negatively influences the ability to buy new hardware and software, as well as the capacity to learn how new technologies work, including their influences on the environment. These limitations are the result of a lack of appropriate training or limited training opportunities (Wabwoba *et al.*, 2012). In Romania, the ICT sector is one of the most developed, but there is a real crisis in terms of available specialists. An important cause is the gap between the educational system and labour market needs. This is an important barrier to green ICT development and implementation: companies do not have enough personnel to develop green hardware and software, apply green practices nor raise awareness among employees about the relationship between ICT and the environment, let alone allow them to use green ICT applications.

5. Conclusions

Digital technologies have changed the world. They continue to transform industries, improve citizens' lives and increase competitiveness. The Digital Single Market Strategy for Europe tries to direct all countries in the EU to a high level of development. Environmental protection and the ICT sector are important strategic areas in this context. Given their symbiotic relationship, it is critical to analyse how they can evolve with minimal negative influences.

The paper has analysed three important barriers in this field: recycling and reuse of e-waste, R&D expenditure, and ICT skills. According to our findings, the situation in Romania is below the EU average for all analysed indicators, but the country's ICT sector has confidently evolved. Its contribution to GDP in 2016 was 7%, exceeding the 5% target set for 2023. This significantly increases the chances of green ICT development. That said, WEEE is the area with the weakest results and poses immediate and persistently negative consequences for the environment. Thus, complex initiatives at the level of both public institutions and companies are necessary.

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