ECONSTOR
Make Your Publications Visible.

A Service of

ZBW Leibniz-Informationszentrum Wirtschaft
Leibniz Information Centre for Economics

Ciobanu, Radu et al.

Article

Investigating Determining Factors Affecting the Waste Collection Rate From Electrical and Electronic Equipment

Amfiteatru Economic

Provided in Cooperation with:
The Bucharest University of Economic Studies

Suggested Citation: Ciobanu, Radu et al. (2023) : Investigating Determining Factors Affecting the Waste Collection Rate From Electrical and Electronic Equipment, Amfiteatru Economic, ISSN 2247-9104, The Bucharest University of Economic Studies, Bucharest, Vol. 25, Iss. 62, pp. 134-146, https://doi.org/10.24818/EA/2023/62/134

This Version is available at:
https://hdl.handle.net/10419/281695

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

https://creativecommons.org/licenses/by/4.0/

WWW.ECONSTOR.EU

Mitglied der Leibniz-Gemeinschaft

INVESTIGATING DETERMINING FACTORS AFFECTING THE WASTE COLLECTION RATE FROM ELECTRICAL AND ELECTRONIC EQUIPMENT

Radu Ciobanu[1*], Dragoș Huru[2], George Ștefan[3], Margareta Florescu[4], Dănuț Mihai[5] and Florin Dobre[6]
[1), 2), 3), 4), 5), 6)] *Bucharest University of Economic Studies, Bucharest, Romania*

Please cite this article as:
Ciobanu, R., Huru, D., Ștefan, G., Florescu, M., Mihai, D. and Dobre, F., 2023. Investigating Determining Factors Affecting the Waste Collection Rate From Electrical and Electronic Equipment. *Amfiteatru Economic*, 25(62), pp. 134-146.

DOI: 10.24818/EA/2023/62/134

Article History
Received: 30 September 2022
Revised: 29 November 2022
Accepted: 21 December 2022

Abstract
Using a data sample from all 27 EU Member States from 2009-2020, the present study quantifies the factors that can lead to an increase in the collection rate of waste from electrical and electronic equipment (EEE). The results underline the fact that an increase in the quality of road infrastructure and an aggressive online campaign can lead to an obvious increase in the amount of electrical and electronic equipment used. Quantile regression forecasts show that the impact of some variables such as GDP per capita, private consumption, government effectiveness, or research and development expenses has asymmetric effects on the degree of collection but can lead to an improvement of this activity under certain conditions.

Keywords: Circular economy, electrical and electronic equipment, EU 27, quantile regression.

JEL classification code: C22, C54, F64

* Corresponding autor, **Radu Ciobanu** – email: radu.ciobanu@fin.ase.ro

This is an Open Access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. © 2023 The Author(s).

Introduction

The amount of electrical and electronic waste collected has a fast growth rate, exceeding 2% per year, according to complex estimates from industry companies (Interreg Europe, 2022). This phenomenon has been regarded as conjunctural for a long time, the conjuncture being formed by consumption behaviors at both the firm or private household level. A high level of endowment of labour with technical capital consisting of electrical and electronic equipment, the wide endowment of households with specific equipment, as well as the pace of their change dictated by physical or moral depreciation can no longer be considered as satisfactory factors for explaining the phenomenon of constant increase of collected quantities. The interest in efficient waste collection management and ensuring an enclosed recycling process, but also a decrease in entropy as an economic phenomenon, derives from the diverse composition of this type of waste, which consists of a complex compound of materials, including hazardous content that requires specific management to avoid major environmental and health damage or high-value and critical raw materials for many industries.

The level of economic and social efficiency that can be achieved by increasing the waste collection rate and recycling volume in this segment derives from the high added value materials from electronic waste components that can be recovered (Pearce and Turner, 1993), an edifying example representing the gold consumed in a proportion of 10-15% of the newly mined gold in the electronic manufacturing industry, waste collection rates reaching maximum 40% of the total amount of waste where we thus encounter huge unoccupied market reserves, the relatively low costs of waste collection management because such waste represents identifiable asset with a high degree of localization in industries, but also the high rate of recycling, reaching approximately 80% (European Environment Agency, 2014). The concern of identifying factors that can improve waste collection also derives from the need that markets have to integrate the Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE), according to which Member states must fulfill 65% of collected waste from electrical and electronic waste. These factors can then be used to reduce behavioral costs through public interventions that create structural and psychological social reasons for collecting electronic and electrical waste.

In the field studied, we assume environmental motivation and behavioral costs as determining factors in the formation of the circular economy phenomenon, but the study approach captures a specific field of the entire waste collection activity because simply people are aware that the phenomenon of counterintuitive thinking must be avoided, and also identify direct approaches aimed at structural improvements and indirect approaches aimed at materials and social behaviors that can effectively reduce short-term costs and improve recycling behavior.

Not only do consumers and companies that activate in this field play a pivotal role in navigating the path of success, but also the consistent strategy of collecting waste ensures the success of recycling (Coscieme et al., 2022). This, consequently, has the role of avoiding ad hoc transaction costs that would promote inefficiency for companies activating in this field, can ensure an enclosed recycling process in a flow without waste, and can provide time for industries to mature until reaching the threshold of a minimally efficient production scale. The identification of those factors that can be characterized as determinants and must be stimulated and subsidized in the short term to achieve the objectives mentioned above, we consider it as a relevant support in order to ensure a circular economy in the electrical and electronic industries.

The article is organized in more detail as follows. The first section briefly presents the state of knowledge in the field, the second section presents the methodology used to identify the

determinants, the third section considers the database used, and in the fourth section the main results are analyzed, and finally the conclusions are presented.

1. Review of the literature

During the past decade, more and more research papers focused on circular economy, considered relevant in addressing the problem of waste electrical and electronic equipment (widely known as WEEE or electronic waste). Basically, the circular economy aims to increase the level of waste collection by product optimization and its lifespan at the hand of cleaner and renewable technologies, promoting policies in this regard (Ghisellini, Cialani and Ulgiati, 2016).

Changing the mindset and behavior of the population to facilitate the circular economy in e-waste management is an important aspect in all EU member states and in the world (Aboelmaged, 2021). Recent studies try to identify influencing factors of these aspects in order to increase the degree of intervention of decision-makers regarding increasing resource sustainability due to growing demand, use of critical resources, and challenges in handling the resulting waste stream (Parajuly et al., 2020).

Previous studies have shown that many countries do not manage the generated e-waste sufficiently, and more effort is needed to ensure a more effective and sustainable management of it (Andeobu, Wibowo and Grandhi, 2021). Furthermore, appropriate public policies are essential for the development of the circular economy and the management of electronic waste (Winans, Kendall and Deng, 2017), because studies have shown that implementing policies that are inadequate or not applied to the specific economic situation of one state can represent an important barrier in the successful transition to a circular economy (Kazancoglu and Kazancoglu, 2020).

The circular economy can be an appropriate solution in terms of the management of e-waste, achieving convergence toward the sustainable development of the environment and the economy (Lieder and Rashid, 2016). Effective e-waste management can lead to closing the product life cycle, more efficient and long-term use, and, why not, to reducing pollution (Geissdoerfer et al., 2017).

Previous analyses of e-waste collection rates have shown that public policy interventions must be directed at the local, regional, and international levels to converge toward an increase in this field and an adequate implementation of the circular economy (Milios, 2018). Research activities in terms of sustainable development are a determining factor in the implementation of policies that increase the degree of collection (Walrave and Raven, 2016). Indeed, studies have shown that, in the European Union, the circular economy and efficient management of electronic waste can have an immediate and effective impact on environmental policies (Cainelli, D'Amato and Mazzanti, 2020) and can lead to more sustainable and efficient systems in the long term, with the objective of eliminating the unwanted effects of consumerism and waste of electrical and electronic products (Lauridsen and Jørgensen, 2010). See Dumitrescu et. al. (2022) for a more complex discussion of the determinants of household consumption.

The identification of determinants in the case of waste collection rate is a very important aspect to support the joint decision-making process by decision-makers and organizations throughout the supply chain (Araújo et al., 2012). At the same time, the identification of relevant factors can reduce the economic uncertainties related to recycling electronic products and find the most effective methods to promote the circular economy (Bouzon et

al., 2016; de Oliveira Neto, Correia and Schroeder, 2017). Additionally, empowering the population to improve waste collection rate is a desire that all member states tend toward (Ghisolfi et al., 2017). At the same time, previous studies have shown that education plays an active role in motivating people to recycle and understanding the benefits of the circular economy (Ciobanu et al., 2022).

As previously presented, the purpose of this article was to investigate the economic, infrastructure, and governance factors that influence waste collection rate. The specialised literature addresses determining factors, both on global and regional scales (Ongondo, Williams and Cherrett, 2011; Cucchiella et al., 2015), as well as models that assess the impact of national-level interventions (Araújo et al., 2012; Wang et al., 2013; Guzzo, Rodrigues and Mascarenhas, 2021). However, studies identified in the literature search are mostly static and only a few points out factors that could have a gradual impact on waste collection rate. Moreover, depending on the current level of waste collection from electrical and electronic equipment, Member States must consider different strategies and factors in the public policies proposed in the field for the next period. For this reason, a quantitative econometric analysis is useful, based on the level of e-waste collection, the results being relevant both for political factors and for entities that aim to implement the circular economy and sustainable development.

2. Research methodology

To investigate economic, infrastructure, and governance factors that influence the rate of waste collection of electrical and electronic equipment, quantile regression was used as an econometric technique. Considering that the degree of waste collection presents a rather pronounced heterogeneity at the level of the EU countries, a linear analysis in the classical sense could generate some results that distort reality, and, for this reason, a quantile regression with fixed effects proposed by Koenker (2004).

The use of this technique is required when the dependent variable, the degree of waste collection in the present case, has an asymmetric distribution and the study of the conditional average does not reflect in the best possible way the links between economic, infrastructure, and governance variables, on the one hand, and the dependent variable, on the other.

Generally, at any level (τ) across the distribution of the degree of waste collection, which we will denote by y, conditioned by the economic, infrastructure and governance considered as independent variables, the conditional quantile shows $Q_y(\tau|x) = \inf\{k: F(k|x) \geq \tau\}$ where $F(\bullet\,|x)$ is the conditional distribution function. Therefore, the panel quantile regression is illustrated by the following specification:

$$Q_{y_{i,t}}(\tau|x_{i,t}) = \alpha_i + x_{i,t}^T \beta(\tau). \tag{1}$$

where $i = \overline{1,N}$ and $t = \overline{1,T}$, denote the number of countries and years respectively, $x_{i,t}$ denotes the set of covariates, $\beta(\tau)$ is the common slope coefficient while α_i is individual-specific fixed effect coefficient. Control for the unobserved heterogeneity, Koenker (2004), treats the fixed effects as nuisance parameters:

$$\min_{(\alpha,\beta)} \sum_{k=1}^{K} \sum_{t=1}^{T} \sum_{i=1}^{N} w_k \, \rho_{\tau_k} \left(y_{i,t} - \alpha_i - x_{i,t}^T \beta(\tau_k) \right) + \lambda \sum_{i}^{N} |\alpha_i|. \tag{2}$$

In Eq. (2) $K$is the quantiles' index, ρ_{τ_k} is the quantile loss function while w_k is the relative weight given to the k^{th} quantile. The penalty term λ is diminishing the impact of individual effects on achieving higher efficiency for the global slope coefficients.

3. Data description

This analysis focuses on a panel format from all 27 Member States of the European Union over the period 2009-2020. The dependent variable is given by the waste collection rate and measured in kilograms per inhabitant. In Figure no. 1 is presented the evolution of this indicator for the EU member states:

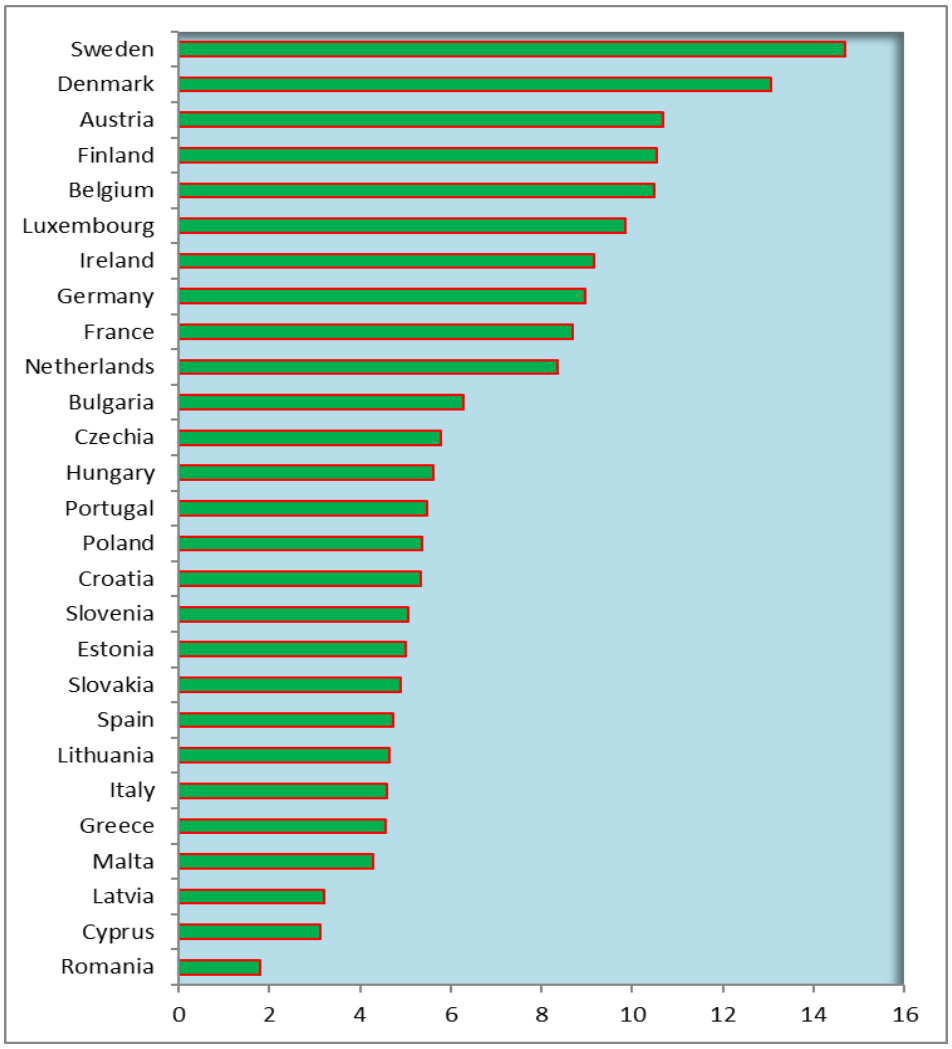

Figure no. 1. Average waste collection rate of electrical and electronic equipment (Kg per resident)

Source: Authors' calculation

As can be seen in the figure above, Romania ranks among the last at the EU level, while the leading positions are held by the Nordic countries. In Table no. 1 is presented the description of all the variables used in the empirical study, along with their source. The choice of these variables took into account the current literature, but at the same time, the possible influence of other factors that could influence the degree of waste collection was analyzed: the degree of Internet use (DIU), the quality of roads (RQ), and the degree of urbanization (DU). The aim was to see if the degree of infrastructure development (IT and road) in a state can explain a greater dynamic of the circular economy.

Table no. 1. Definition of variables

Variable	Definition	Source	Previous literature
Collection rate (CR)	The number of kilograms per capita collected from electrical and electronic waste.	EUROSTAT	(Parajuly et al., 2020)
GDP per capita (GDPc)	GDP per capita is the gross domestic product divided by the mid-year population. GDP is the sum of gross value added by all resident producers in the economy plus any taxes on products and minus any subsidies not included in the value of products. Data in US dollars.	The Global Economy	Cucchiella et al., 2015
Household consumption (HC)	It represents the market value of all goods and services, including durable goods (such as cars, washing machines, and home computers), purchased by households. The variable is calculated as a percentage of GDP.	The Global Economy	(Lauridsen and Jørgensen, 2010)
Government effectiveness index (GE)	The index captures perceptions of the quality of public services, the quality of the public service and its degree of independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	Worldwide Governance Indicators – World Bank	(Winans et al., 2017; Milios, 2018)
Regulatory Quality Index (RQI)	It captures perceptions of the government's ability to formulate and implement sound policies and regulations that enable and promote private sector development.	Worldwide Governance Indicators – World Bank	(Milios, 2018; Parajuly et al., 2020)
Degree of internet usage (DIU)	Internet users are individuals who have used the Internet (from any location). The Internet can be used through a computer, a mobile phone, a personal digital assistant, a game machine, a digital TV, etc. The variable is calculated as a percentage of the total pollution.	The Global Economy	Variable proposed by the authors
The roads quality (RQ)	It represents an assessment of road quality in a given country based on data from the World Economic Forum Opinion Survey, a long-running and extensive survey that taps the views of more than 14,000 business leaders in 144 countries. The road quality indicator score is based on a single question. Respondents are asked to rate the roads in their country of operation on a scale of 1 (underdeveloped) to 7	The Global Economy	Variable proposed by the authors

Variable	Definition	Source	Previous literature
	(extensive and efficient according to international standards).		
Research and development expenses (R&D)	Gross domestic expenditure on research and development (R&D), expressed as a percentage of GDP. This includes both capital expenditures and current expenditures in the four main sectors: business enterprise, government, higher education, and private non-profit. R&D covers basic research, applied research and experimental development.	The Global Economy	(Ghisellini et al., 2016)
Degree of urbanization (DU)	The percentage of people living in the urban environment of the total resident population.	The Global Economy	Variable proposed by the authors
Degree of education (DE)	The number of people attending high school as a percentage of the total number of eligible people.	The Global Economy	(Ciobanu et al., 2022)

Before running the regression, it is necessary to study the stationarity of the data series. Even if the quantile regression is not so restrictive on the existence of this phenomenon, in order to eliminate any risk of a spurious regression, we will run the stationarity test proposed by Levin, Lin and Chu (2002) for both level and first difference. All specifications include a trend and a constant. The results are reproduced in Table 2.

Table no. 2. Stationarity test

Variable	Level		First difference	
	Test value	**Associated probability**	**Test value**	**Associated probability**
CR	-7.08	0.0000	-13.20	0.0000
GDPc	-2.65	0.0000	-4.91	0.0000
HC	-11.37	0.0000	-14.61	0.0000
GE	-6.52	0.0000	-10.63	0.0000
RQI	-5.34	0.0000	-5.17	0.0000
DIU	-6.61	0.0000	-12.59	0.0000
RQ	-7.71	0.0000	-18.62	0.0000
R&D	-5.69	0.0000	-3.29	0.0005
DU	-19.44	0.0000	-32.56	0.0000
DE	-5.42	0.0000	-9.69	0.0000

Source: Authors' calculation

As can be seen in the table above, all variables are stationary at level. For this reason, the basic regression will only include the variables reported in the level. The next step after testing stationarity is to study the phenomenon of multicollinearity. This step is mandatory to investigate potential problems with the consistency of the estimates caused by this phenomenon. Usually, to test the degree of multicollinearity, we use the correlation matrix of explanatory variables. However, this approach is quite limited, and for this reason, we will use the VIF (Variance influence Factor) method. Thus, after running the linear model with fixed effects, we calculated the VIF for each explanatory variable and only values below

5 resulted, as recommended by Kline (1998). Thus, we can overlook the potential problems caused by the phenomenon of multicollinearity. Additional details are found in Table no. 3:

Table no. 3. Multicollinearity testing

Variable	Centered VIF
CR (-1)	1.54
GDPc	1.57
HC	1.86
GE	1.52
RQI	1.26
DIU	2.30
RQ	1.25
R&D	1.26
DU	1.87
DE	1.19

Source: Authors' calculation

4. Analysis results

In Table 4 we summarize the quantile regression estimates with the degree of electrical and electronic equipment waste collection as the dependent variable. The chosen representative quantities are: q10, q25, q50, q75, and q90. The lower quantiles describe the situations in which we have a low or moderate waste collection rate (q10, q25), q50 describes the situation of a medium degree of collection and can be compared with the standard fixed effects approach for robustness, and finally the upper quantiles describe the situations when we have a high or extremely high rate of waste collection (q75, q90). To search for potential autoregressive effects, we also included the first lag of the dependent variable, denoted by GC(-1).

Table no. 4. Quantile regression

	q10	q25	q50	q75	q90
CR (-1)	0.8265***	0.8889***	0.9458***	1.0008***	1.0800***
GDPc	0.4167*	-0.0433	-0.2197	-0.4821**	-0.9719**
HC	-0.0206*	-0.0098	-0.0145*	-0.0240*	-0.0239
GE	0.1013	-0.3425*	-0.4909*	-0.8872*	-1.2129**
RQI	-0.4623	0.0298	0.0239	0.2004	-0.7520**
DIU	0.0135	0.0222***	0.0187**	0.0172	0.2116
RQ	-0.0586	0.1263	0.1469*	0.1833**	0.3309**
R&D	0.2857*	0.0526	0.1213	0.0590	0.0283
DU	-0.0015	0.0007	0.0053	0.0074	0.0071
DE	-0.0023	0.0027	0.0038	0.0033	-0.0008
Obs.	324	324	324	324	324
R^2	0.6849	0.7460	0.7828	0.7715	0.7581

Note:, **, *** suggest statistical significance at the confidence level of 90%, 95%, and 99%.*

On the basis of the estimates presented in the table above, some quite interesting conclusions can be drawn. First, it can be seen that the lag of the dependent variable is statistically significant for absolutely all the selected quantiles. Thus, it can be concluded that the waste collection method has a strong autoregressive character. This indicates that a well-established

collection system in a given year will also contribute to efficient collection in the next year. One can observe the monotonous increasing trend of the coefficients from the lower to the upper quantiles (from 0.8265 to 1.0800).

The degree of economic development of a country, given by the GDP per capita values, exerts an asymmetric impact on the waste collection rate. Thus, in the initial stage, when the collection rate is positioned at lower quantiles, the increase in economic development will also lead to greater attention to the dynamics of the circular economy. This result is normal and intuitively correct, being similar to the study conducted by Boubellouta and Kusch-Brandt (2021). Moreover, as the waste collection rate increases and reaches a very high level, economic development exerts a negative impact, this being an aspect also highlighted by Boubellouta and Kusch-Brandt (2021) based on a Kuznets-type curve at the level of 147 countries.

However, increasing household consumption does not lead to a higher collection rate of waste from electrical and electronic equipment. This raises many public policy questions and may be a starting point for a much broader program of vouchers to collect old electronics and appliances for new ones.

In situations where a moderate or average collection rate is observed, an increase in the number of Internet users leads to an increase in the collection rate of waste from electrical and electronic equipment. This is intuitively correct and can underpin more aggressive online campaigns to raise general public awareness about the benefits of more effectively collected waste and how it can be achieved. Similar conclusions can be drawn for the coefficients associated with the quality of road infrastructure. The more this is developed, the more the collection of waste from electrical and electronic equipment will increase. Although the results are valid for the middle and upper quantiles, it is a sign that some promotional and investment campaigns are needed to make the collection rate and transport of this waste more efficient.

At the same time, if governance factors are taken into account, it can be seen that when the degree of collection is positioned at the upper quantiles, the government's ability to formulate and implement public policies and sound regulations (measured by the regulatory quality index) and perceptions of the quality of services (measured by the government effectiveness index) either does not influence or leads to a decrease in the collection rate of e-waste. This shows that the over-regulation in the field and the public services dedicated in this regard do not lead to the desired effect of increasing the collection rate, but often have the opposite effect.

Finally, increasing research and development spending in the economy contributes to an improvement in the waste collection rate. Contrary to expectations, the degree of urbanization and education did not turn out to have an impact on the circular economy, possibly due to the fact that their effect on the degree of waste collection is not immediate, but appears in several years away.

Altogether, the regressions reported in Table no. 4 present a fairly high degree of performance, the Pseudo R-squared coefficients being in four out of five cases above the 70% threshold.

Conclusions

The aim of this article was to investigate the economic, infrastructure and governance factors that impact e-waste collection, and the impact of their action on moving towards a circular economy. As expected, the results indicate that the EU states more focused on this issue are the most developed, where there is increased awareness among citizens on these issues. The policy of these states supports more sustainable product policies and engagement in circular business models. Practically, this leads to a gradual change in consumer behavior in ways that improve e-waste management by repairing and reusing functionally defective products and the timely and appropriate disposal of products without a reuse potential.

Adding to the existing literature, the results are useful to public decision makers in the implementation of policies specific to recycling and the circular economy, further explaining what factors can lead to better collection, but taking into account the current level of the degree of collection of waste of electrical and electronic equipment recorded in the economy. Practically, depending on this current level of collection, the member states must consider different strategies and elements in the development of public policies in the field for the next period.

According to the results obtained, it can be observed that there is growing consumption among the population, leading to behavioral attitudes that do not lead to an increase in electronic waste collection. However, we believe that, on the basis of the results obtained, a development of online recycling campaigns and infrastructure would improve people's enthusiasm for having an efficient management of waste from electrical and electronic equipment. The ubiquity of the Internet and online popularization of the advantages of circular economy can improve citizens' perception of these issues, increase consumer awareness, cultivate their concept of environmental recycling, and encourage them to adopt online recycling of electronic waste. Our results confirm the aspects mentioned in the EU's Circular Economy Action Plan (European Commission, 2015), address the need for public awareness campaigns to change their behavior regardless of the degree of development of the economies of the European Union.

The study provided robust results to better understand the main determinants of e-waste collection rates in the European Union. Although the level of collection differs greatly between Member States, policy makers should take into account further study and support the reduction of consumerism and the acceleration of R&D, with the aim of increasing the short life cycles of electronic products and promoting recycling and reuse.

In many situations, the decision to recycle is related to the individual's behavior and their perception of the usefulness of the circular economy. Therefore, a limitation of the study is the fact that we explained the level of e-waste collection from a macroeconomic perspective, with indicators specific to each state, considering that they explain the opinion and perception of each person in a state. However, as a future research direction, an analysis at the individual level can also be considered to conclude whether the same factors explain the level of collection of electrical and electronic equipment waste.

Acknowledgement

This paper was funded by the Research Project *Forecast of the Evolution of Economic Environment*, 2021 edition, research project developed by the Bucharest University of Economic Studies (BUES). The results should be used only by the appropriate citation means.

References

Aboelmaged, M., 2021. E-waste recycling behaviour: An integration of recycling habits into the theory of planned behaviour. *Journal of Cleaner Production*, [online] 278, no.124182. https://doi.org/10.1016/j.jclepro.2020.124182.

Andeobu, L., Wibowo, S. and Grandhi, S., 2021. An assessment of e-waste generation and environmental management of selected countries in Africa, Europe and North America: A systematic review. *Science of The Total Environment*, [online] 792, no.148078. https://doi.org/10.1016/j.scitotenv.2021.148078.

Araújo, M.G., Magrini, A., Mahler, C.F. and Bilitewski, B., 2012. A model for estimation of potential generation of waste electrical and electronic equipment in Brazil. *Waste Management*, [online] 32(2), pp.335-342. https://doi.org/10.1016/j.wasman.2011.09.020.

Boubellouta, B. and Kusch-Brandt, S., 2021. Cross-country evidence on Environmental Kuznets Curve in Waste Electrical and Electronic Equipment for 174 Countries. *Sustainable Production and Consumption*, [online] 25, pp.136-151. https://doi.org/10.1016/j.spc.2020.08.006.

Bouzon, M., Govindan, K., Rodriguez, C.M.T. and Campos, L.M.S., 2016. Identification and analysis of reverse logistics barriers using fuzzy Delphi method and AHP. *Resources, Conservation and Recycling*, [online] 108, pp.182-197. https://doi.org/10.1016/j.resconrec.2015.05.021.

Cainelli, G., D'Amato, A. and Mazzanti, M., 2020. Resource efficient eco-innovations for a circular economy: Evidence from EU firms. *Research Policy*, [online] 49(1), p.103827. https://doi.org/10.1016/j.respol.2019.103827.

Ciobanu, R., Țuclea, C.-E., Holostencu, L.-F. and Vrânceanu, D.-M., 2022. Decision-Making Factors in the Purchase of Ecologic Products. *Sustainability*, [online] 14(15), p.9558. https://doi.org/10.3390/su14159558.

Coscieme, L., Manshoven, S., Gillabel, J., Grossi, F. and Mortensen, L.F., 2022. A framework of circular business models for fashion and textiles: the role of business-model, technical, and social innovation. *Sustainability: Science, Practice and Policy*, [online] 18(1), pp.451-462. https://doi.org/10.1080/15487733.2022.2083792.

Cucchiella, F., D'Adamo, I., Lenny Koh, S.C. and Rosa, P., 2015. Recycling of WEEEs: An economic assessment of present and future e-waste streams. *Renewable and Sustainable Energy Reviews*, [online] 51, pp.263-272. https://doi.org/10.1016/j.rser.2015.06.010.

de Oliveira Neto, G.C., de Jesus Cardoso Correia, A. and Schroeder, A.M., 2017. Economic and environmental assessment of recycling and reuse of electronic waste: Multiple case studies in Brazil and Switzerland. *Resources, Conservation and Recycling*, [online] 127, pp.42-55. https://doi.org/10.1016/j.resconrec.2017.08.011.

Dumitrescu, B.A., Enciu, A., Hândoreanu, C.A., Obreja, C. and Blaga, F., 2022. Macroeconomic Determinants of Household Debt in OECD Countries. *Sustainability*, [online] 14(7), p.3977. https://doi.org/10.3390/su14073977.

European Commission, 2015. *Închiderea buclei - un plan de acțiune al UE pentru economia circulară.* [online] Available at: <https://eur-lex.europa.eu/legal-content/RO/TXT/HTML/?uri=CELEX:52015DC0614&from=ES> [Accessed 27 March 2022].

European Environment Agency - European Union, 2014. *Waste: a problem or a resource?* [online] Available at: <https://www.eea.europa.eu/ro/semnale/semnale-de-mediu-2014/articole/deseurile-o-problema-sau-o-resursa> [Accessed 27 March 2022].

Geissdoerfer, M., Savaget, P., Bocken, N.M.P. and Hultink, E.J., 2017. The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production*, [online] 143, pp.757-768. https://doi.org/10.1016/j.jclepro.2016.12.048.

Ghisellini, P., Cialani, C. and Ulgiati, S., 2016. A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, [online] 114, pp.11-32. https://doi.org/10.1016/j.jclepro.2015.09.007.

Ghisolfi, V., Diniz Chaves, G. de L., Ribeiro Siman, R. and Xavier, L.H., 2017. System dynamics applied to closed loop supply chains of desktops and laptops in Brazil: A perspective for social inclusion of waste pickers. *Waste Management*, [online] 60, pp.14-31. https://doi.org/10.1016/j.wasman.2016.12.018.

Guzzo, D., Rodrigues, V.P. and Mascarenhas, J., 2021. A systems representation of the Circular Economy: Transition scenarios in the electrical and electronic equipment (EEE) industry. *Technological Forecasting and Social Change*, [online] 163, no.120414. https://doi.org/10.1016/j.techfore.2020.120414.

Interreg Europe, 2022. *Collection and recycling of WEEE: Key learnings*, [online] Available at: <https://www.interregeurope.eu/> [Accessed 22 August 2022].

Kazancoglu, I., Sagnak, M., Kumar Mangla, S. and Kazancoglu, Y., 2021. Circular economy and the policy: A framework for improving the corporate environmental management in supply chains. *Business Strategy and the Environment*, [online] 30(1), pp.590-608. https://doi.org/10.1002/bse.2641.

Koenker, R., 2004. Quantile regression for longitudinal data. *Journal of Multivariate Analysis*, [online] 91(1), pp.74-89. https://doi.org/10.1016/j.jmva.2004.05.006.

Lauridsen, E.H. and Jørgensen, U., 2010. Sustainable transition of electronic products through waste policy. *Research Policy*, [online] 39(4), pp.486-494. https://doi.org/10.1016/j.respol.2010.01.021.

Levin, A., Lin, C.-F. and James Chu, C.-S., 2002. Unit root tests in panel data: asymptotic and finite-sample properties. *Journal of Econometrics*, [online] 108(1), pp.1-24. https://doi.org/10.1016/S0304-4076(01)00098-7.

Lieder, M. and Rashid, A., 2016. Towards circular economy implementation: a comprehensive review in context of manufacturing industry. *Journal of Cleaner Production*, [online] 115, pp.36-51. https://doi.org/10.1016/j.jclepro.2015.12.042.

Milios, L., 2018. Advancing to a Circular Economy: three essential ingredients for a comprehensive policy mix. *Sustainability Science*, [online] 13(3), pp.861-878. https://doi.org/10.1007/s11625-017-0502-9.

Ongondo, F.O., Williams, I.D. and Cherrett, T.J., 2011. How are WEEE doing? A global review of the management of electrical and electronic wastes. *Waste Management*, [online] 31(4), pp.714-730. https://doi.org/10.1016/j.wasman.2010.10.023.

Parajuly, K., Fitzpatrick, C., Muldoon, O. and Kuehr, R., 2020. Behavioral change for the circular economy: A review with focus on electronic waste management in the EU. *Resources, Conservation & Recycling: X*, [online] 6, no.100035. https://doi.org/10.1016/j.rcrx.2020.100035.

Pearce, D.W. and Turner, R.K., 1993. Market-based approaches to solid waste management. *Resources, Conservation and Recycling*, [online] 8(1-2), pp.63-90. https://doi.org/10.1016/0921-3449(93)90020-G.

Walrave, B. and Raven, R., 2016. Modelling the dynamics of technological innovation systems. *Research Policy*, [online] 45(9), pp.1833-1844. https://doi.org/10.1016/j.respol.2016.05.011.

Wang, F., Huisman, J., Stevels, A. and Baldé, C.P., 2013. Enhancing e-waste estimates: Improving data quality by multivariate Input–Output Analysis. *Waste Management*, [online] 33(11), pp.2397-2407. https://doi.org/10.1016/j.wasman.2013.07.005.

Winans, K., Kendall, A. and Deng, H., 2017. The history and current applications of the circular economy concept. *Renewable and Sustainable Energy Reviews*, [online] 68, pp.825-833. https://doi.org/10.1016/j.rser.2016.09.123.