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Article

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Amfiteatru Economic Journal

Provided in Cooperation with:

The Bucharest University of Economic Studies

Suggested Citation: Mosora, Mihaela Hrisanta; Aceleanu, Mirela Ionela; Alexa, Lucian; Gherman, Anca Maria; Mosora, Cosmin Liviu (2023) : Collection of Waste Electrical and Electronic Equipment at the European Level, Amfiteatru Economic Journal, ISSN 2247-9104, The Bucharest University of Economic Studies, Bucharest, Vol. 25, Iss. 62, pp. 101-114, <https://doi.org/10.24818/EA/2023/62/101>

This Version is available at:

<https://hdl.handle.net/10419/281693>

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COLLECTION OF WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT AT THE EUROPEAN LEVEL

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Please cite this article as:

Mosora, M.H., Aceleanu, M.I., Alexa, L., Gherman, A.M. and Mosora, C.L., 2023. Collection of Waste Electrical and Electronic Equipment at the European Level. *Amfiteatru Economic*, 25(62), pp. 101-114.

DOI: [10.24818/EA/2023/62/101](https://doi.org/10.24818/EA/2023/62/101)

Article History

Received: 30 September 2022

Revised: 28 November 2022

Accepted: 16 December 2022

Abstract

Currently, to ensure the sustainable development of any economy, a very important role is represented by the transition to the circular economy, which manifests itself differently by sectors and types of products. Considering the need to expand the circular economy, a special role is played by the production and consumption of electrical and electronic equipment. The objective of this article is to identify the factors that can influence the collection of electronic and electrical equipment at the European Union level. The methods used are statistical and econometric ones. Based on a panel regression, the study shows the specifics of the collection of electrical and household appliances, depending on several factors, such as the type and size of the appliances, the amount of electrical and electronic equipment (EEE) placed on the market, and the legislative measures taken at the European level. The main results highlight the degree of collection of electrical and electronic equipment according to its type and size; the highest degree of collection being recorded for household appliances. The originality of the paper consists in the identification of the characteristics of the collection of waste electrical and electronic equipment (WEEE), using the econometric method, the research being useful not only for the parties involved in the collection of waste electrical and electronic equipment (WEEE), but also for the decision makers, in order to improve the collection policies for this equipment.

Keywords: Electronic and electrical waste equipment, collection, recycling, circular economy.

JEL Classification: Q53, Q57

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Introduction

The economic reality indicates that things are in a much more pronounced dynamic than any successful economist could predict. However, there are two defining premises that can constitute different plans in the design of the future economic model created ex-ante, which will converge to a large extent with the reality unfolded ex-post (Eisenriegler, 2020). The first concerns variables and phenomena dominated by uncertainty and the unforeseen (for example, the pandemic generated by the Sars-Cov-2 virus, the military conflict between Ukraine and Russia with economic implications for the whole of Europe and beyond, and the energy and combustion crisis). The second premise starts from the possible evolutions of some key variables for the economy such as: resources, sustainable growth, reconversion, and adaptation.

The circular economy appeared as a response to the decrease in non-renewable resources, the increase in resource consumption, the increasing pollution of the environment and the planet. Since 2015, concerns at the European level and beyond have focused on legislative changes and the creation of new measures to transform the economic model in structure and functions, from a linear one - based on raw materials, production, distribution, consumption, waste - into a circular model aimed at reducing the consumption of resources-reuse-collection-recycling. This transformation cannot be achieved without a deep and complex research that leads to as many measures and implementable economic policies as possible (Eisenriegler, 2020).

Ciocoiu and Târțiu (2012) emphasize the importance of creating an adequate legislative framework to support recycling, on the one hand, because some components of electronic waste are valuable and, on the other hand, because they can be dangerous to the environment. Ortan et al. (2016) show the necessity of recycling to protect the environment. An important aspect of ensuring a green environment is represented by smart cities, which involve numerous conditions related to infrastructure, artificial intelligence, renewable energy and recycling of all categories of waste (Șerban and Lytras, 2020).

The current context shows us that there is a need more than ever for a circular economy, in which the consumption of electrical and electronic equipment plays a special role, since a large part of the EEE becomes waste at the end of its useful life, and a part of it can be recycled. In this idea, several authors, such as Bîrgovan et al. (2022), Kumar et al. (2022), Pan, Wong and Li (2022) discuss the circular economy as a premise for the collection and recycling of waste electrical and electronic equipment.

The need for collection, recycling, reuse, reconversion, and adaptation of electrical and electronic equipment is a real need, starting from the fact that, annually, humanity generates impressive amounts of WEEE. In 2021, according to data compiled by the Global Waste Monitor, 57.4 million tons of WEEE were estimated worldwide (United Nations Institute for Training and Research, 2021).

The paper begins with the study of specialized literature in the field of waste collection of electrical and household appliances, approaching two directions - one of previous research and the other of the legislative framework at the level of the European Union. Based on the literature review, a conceptual model is developed for recycling performance according to the level of WEEE collection at the European level, which is then empirically tested using the panel regression method. The methodology and results are presented, and finally the conclusions are written.

1. Review of the literature

1.1. Circular economy in the process of collecting waste from electrical and electronic equipment

Worldwide, 90% of the resources used are not recycled, so this phenomenon is leading to excessive exploitation of planet resources (Bîrgovan et al., 2022). As a result, steps are being taken at the European Union level to reintroduce the circular economy (for example, the reuse of materials used especially in the field of household appliances, which contain rare metals or materials that affect the environment).

The circular economy is based on the following life cycle of a product: 1. use of raw materials; 2. product design; 3. production/reprocessing; 4. distribution; 5. consumption; 6. collection; 7. recycling and 8. transformation of recycled products into raw materials (Orțan et al., 2016).

Ciocoiu and Târțiu (2012) believe, following their research, that electronic waste is characterized by two features: it is dangerous (because it eliminates toxic substances), but at the same time it is valuable due to the precious metals of which it is composed. As a result, to maintain a healthy environment, measures must be taken to recycle these metals, but a legislative framework is also needed to accelerate this process. In the quantitative research that is the basis of this study, the classification of waste into non-hazardous versus hazardous categories (medical, biological, etc.) was taken into account, as well as the existing legislative framework.

Furthermore, Orțan et al. (2016) consider that electronic product waste can be extremely harmful to the environment for two reasons: 1. their incineration produces a very large amount of toxic chemical elements and 2. throwing it in a landfill has an effect similar to incineration. As a result, WEEE recycling becomes a necessity to prevent an ecological catastrophe. At the same time, the presence of precious and rare materials in their composition is another reason why recycling of electronic products becomes necessary. In addition, the authors Orțan et al. (2016) consider that the recycling of such products has both economic benefits (reduction of energy costs, procurement of raw materials) and environmental benefits (reduction of stored waste, increase in the quality of life of people and animals, increase in ground quality).

Bîrgovan et al. (2022) identified several indicators that could be used in evaluating the degree of implementation of the circular economy at the level of cities such as environmental indicators, social indicators, economic indicators and SMART indicators. Environmental indicators include carbon dioxide (CO₂) emissions, the amount of recycled materials, resource reuse, while economic indicators refer to the budget allocation for pilot projects that stimulate the circular economy, environmental costs (the cost of CO₂ emissions, the cost of polluted water), the value of reused products. Social indicators include quality of life, the number of new jobs created, the quality of drinking water, the number of initiatives regarding the growth of the circular economy, etc. The SMART indicators involve the combination of the three types of indicators in order to obtain an overall picture of the degree of presence of the circular economy.

In addition to these indicators, Kumar et al. (2022) identify different factors that facilitate the implementation of a circular economy, such as economic factors, social factors, environmental factors, technological and infrastructure factors, and governmental and

institutional factors. Also, the same authors (2022) note several theories regarding the management of electronic waste (WEEE) among which: "Natural resource-based view" (NRBV - products based on natural resources) - the design of products must include raw materials of organic origin; "Stakeholder Theory" – businesses should include all interested/affected parties, including those dealing with environmental protection, in the decision-making process regarding the creation of products; "Institutional Theory" - due to external regulations regarding environmental protection, organizations in general are obliged to integrate into the production and/or supply process of "green" goods and services (such as, for example, environmental protection practices).

Pan, Wong and Li (2022) identified five areas of research regarding the implementation of the circular economy, especially in the technological sphere, which are: waste management systems and practices, recycling of electronic products, e-waste legislation, the responsibilities of producers, the recycling of essential materials from the composition of electronic products, and the strategies of the circular economy. The authors Pan, Wong and Li (2022) come to the conclusion that the effects of electronic waste management practices are not known with certainty, but the involvement of companies and the presence of a legislative framework are essential for protecting the environment.

Other authors (Herat and Agamuthu, 2012; Staicu, Bărbulescu and Moraru, 2013) call attention to transboundary e-waste (waste originating from another country but stored in a third state) that affects the quality of life of people in the countries that store such waste, especially in the context in which the respective countries themselves face a large amount of e-waste. This problem particularly affects Asian countries, such as China and India, despite government-imposed bans on e-waste imports.

Ylä-Mella and Román (2019) show that at the European Union level, regulations (especially those that followed Directive 2002/96/EC) had an essential role in increasing the amount of recycled electronic materials, a fact that determined imposing more and more ambitious objectives in this field. However, not all EU states show the same results, because most of the recycled quantities were found in Sweden and Denmark, as well as in Switzerland and Norway, which, even if they are not members of the European Union, apply increased recycling policies of electronic materials.

Regarding Romania's performance about the circular economy implementation in the field of electronic products, Gavrilesu et al. (2021) show that, in 2014, the level of collection and reuse of these products was low, and this trend is still maintained today, even if Romania shows an average performance of recycling and environmental protection (other indicators such as air, water, and energy quality show a very high level, while the collection and reuse of resources in general show a very low level).

In the book *The Circular Economy in the European Union* (Eisenriegler, 2020), accomplished on the data collection from relevant surveys, it is stated that:

- there is a cognitive dissonance among consumers who, even if they want a longer lifetime of appliances (telephones, washing machines, other household appliances), they expect from the start that the lifetime will be limited;
- devices are usually repaired within the warranty limit, because after that, the repairing is much too expensive (here could be tracked the average of repairs before and after the end of the warranty);

- the main obstacle for the implementation of a circular economy concerns the lifestyle of the society, which should be adapted/modified to a large extent.

Starting from all these aspects identified in the specialized literature and in order to conduct a relevant analysis and to be able to formulate relevant conclusions and recommendations, it must take into account the regional and interstate disparities in terms of the selective collection, reuse, and recycling of electronic and household appliances, infrastructure and institutional capacity of each member state of the European Union.

1.2. Legislative context for waste electrical and electronic equipment (WEEE)

The main directives and regulations regarding WEEE adopted at the European Union level and implicitly by the member countries in the period 2007-2019 are presented in Table no. 1.

Table no. 1. Dates related to the WEEE Directive

17 December 2019	⇒ Decision 2019/2193
19 February 2019	⇒ Regulation for decision 2019/290
18 April 2017	⇒ The Application Regulation 2017/699
14 February 2014	⇒ New WEEE Directive become effective
13 August 2012	⇒ New WEEE Directive enters into force

Source: European Commission, 2022

Directive 2012/19/EU of the European Parliament and of the Council on electrical and electronic waste (WEEE) entered into force on August 13, 2012, with a deadline for transposition into national legislation on February 14, 2014. It repeals Directive 2002/96/EC starting February 15, 2014. This directive states that, starting from August 15, 2018, it will regulate all EEE that will be divided into six categories instead of 10, namely: (1) temperature exchange equipment, (2) screens and monitors, (3) lamps, (4) large equipment, (5) small equipment, (6) small IT and telecommunications equipment (European Commission, 2022).

Furthermore, this directive proposed to increase the waste collection rate to 65% annually for products placed on the market in the last three years in a member state or to 85% of WEEE for products made on the territory of that state (Directive 2012/19/EU).

There is also an exception for Bulgaria, Latvia, the Czech Republic, Lithuania, Hungary, Malta, Poland, Romania, Slovenia, and Slovakia, which states that they can record a collection rate of less than 45%, but greater than 40% of the average weight of EEE introduced on the market in the previous three years, starting with August 14, 2016. Furthermore, the obligation to the 65% collection rate for 2019 was postponed until August 14, 2021.

The Directive 2012/19/EU was implemented in 2015 in Romania by emergency ordinance no. 5/2015, which also regulated the waste collection rate, as follows: for 2016 at a 40% level; 45% for the period 2017-2020; and 65%, starting with 2021.

This ordinance also established the minimum objectives for the recovery of EEE (what % is recovered and what % is recycled). In 2019, ordinance no. 5/2015 was amended and supplemented by ordinance no. 44, but the waste collection, recovery, and recycling rates did not change (Romanian Government, 2019).

In order to successfully implement Directive 2012/19/EU, three regulations were adopted in the European Union countries that come in "support" of this directive and can be found in Table no. 2.

Table no. 2. Support measures for the adoption of Directive 2012/19/EU

Regulation 2017/699	through which a common methodology was established for the EU states to calculate both the weight of electrical and electronic equipment and waste electrical and electronic equipment (WEEE)
Regulation 2019/290	which aims to harmonize the reports made by EEE producers or authorized representatives of collected, recycled or recovered WEEE
Implementation decision 2019/2193	this decision establishes the main rules for the calculation, verification and reporting of WEEE, in particular the determination of the weight of WEEE that are prepared for re-use, enter a recycling facility, is recovered and treated in the state where WEEE has been collected, in another member state or a third country.

Source: The authors' processing of the EU Regulations

The countries of the European Union adopted numerous measures on the management of EEE waste in the period 2000-2019. The Czech Republic adopted the largest number of measures, namely 37, Lithuania 27, and at the opposite pole we find Germany and Bulgaria, with 1 measure each (Figure no. 1).

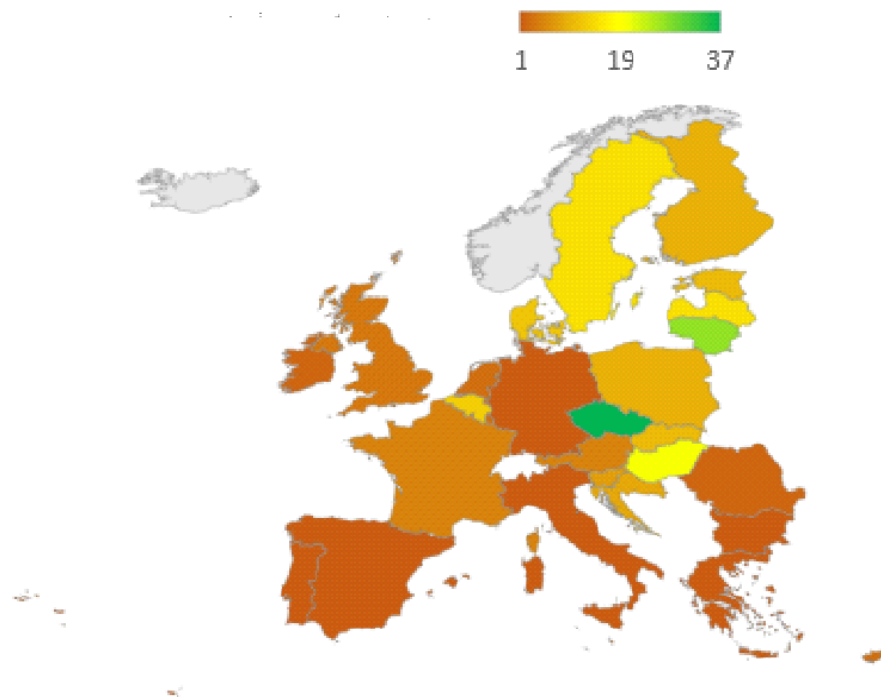


Figure no. 1. Number of legislative measures

Source: Eurostat, 2000-2019

2. Research Methodology

The paper has as its general objective the identification of the main factors that can influence the waste collection process (WEEE), and based on them the foundation of economic policies that can improve collection rates.

Starting from the aspects captured by the specialized literature, the following research hypotheses are formulated:

H1: for large electrical appliances, there is a greater impact on the collection rate in relation to the products introduced on the market;

H2: small lighting equipment has the lowest impact on the collection rate in relation to the products on the market.

In order to empirically validate these hypotheses, quantitative research was carried out and the data was taken from the Eurostat database.

It was used by the Eurostat database for information on the collection rate and the number of employees in the waste collection sector. For waste collection, the Eurostat dataset (env_waselee) provided yearly data on collection expressed in kilograms of waste per capita. The latest available data are 2018, while the oldest is 2007. Data were extracted for all 27 EU countries (the current members of the EU, after Brexit). This dataset contains information about all the products put on the market, as well as various metrics of collection and treatment (e.g., Waste collected, Waste treatment, Recovery, Recycling and preparing for reuse).

A panel regression was used in which five types of WEEE were considered: (1) total waste, (2) large household appliances, (3) small household appliances, (4) IT and telecommunications equipment, (5) lighting equipment and two variations for the number of employees. Two equations were created to estimate the degree of collection of electrical and electronic equipment according to its size and type.

To test the intensive components of the collection process, the number of employees in the waste collection sector was considered. The number of employees was chosen over the number of firms since the collection process is significantly limited by the available labor force, and the number of firms does not account for differences in their size. For this purpose, the Eurostat data set on structural business statistics (sbs_na_ind_r2) was used to extract information about the number of employees at two levels:

- a higher level that covers waste collection and treatment in general (NACE rev. 2 class 38 - Waste collection, treatment and disposal activities; materials recovery).
- narrower level that covers only nonhazardous waste collection (NACE rev. 2 code 3811 - Collection of nonhazardous waste), as the broader category includes also hazardous (such as medical/biological) waste collection and, separately, treatment activities, that were, at this point, beyond the scope of the analysis.

To match the data on waste collection, we extracted yearly data from 2007 to 2018.

To account for other factors that may have a significant impact on collection performance, a *dummy variable was constructed* that accounts for the implementation of the EU Directive 2012/19/UE. It entered into force in 2012 and was transposed into the national legislation of the EU states in 2014/2015.

The indicators used in this work are: the total amount of EEE placed on the market (own production + import-export), the number of workers in the activity sector with CAEN code 38 (collection, treatment and disposal of waste; recovery activities of recyclable materials) and 3811 (non-hazardous waste collection).

3. Results and Discussion

An efficient circular economy is dependent on its capacity to collect and recover already used materials from products at the end of their life cycle. In this analysis, the factors that may influence the collection of waste from electrical and electronic equipment (WEEE) are investigated to identify which are the most important drivers of collection. Identifying the relevant behavioral and/or structural factors in the collection of WEEE can lead to policy proposals that can improve collection rates.

The first step to ensure a good recycling performance is to have a performant WEEE collection. Thus, in the current analysis, the focus is on the quantities put on the market and the quantities collected. From the Figure no. 2, it can be seen that Lichtenstein collects 100% of what is sold on the market, Croatia 68%, Bulgaria 64%. Romania, on the other hand, occupies the last place, with 24%, in 2018. Another reason why, at this point, the analysis limits itself only to this step is that treatment and recovery may occur in different geographical regions than the ones in which the WEEE were collected, significantly affecting any estimation.

The differences recorded in the collection of waste electrical and electronic equipment at the level of the European Union are explained by the regulations, policies, and measures adopted by each country, as well as by the differences in education and information of consumers regarding the recycling of electrical and electronic equipment (Figure no. 2).

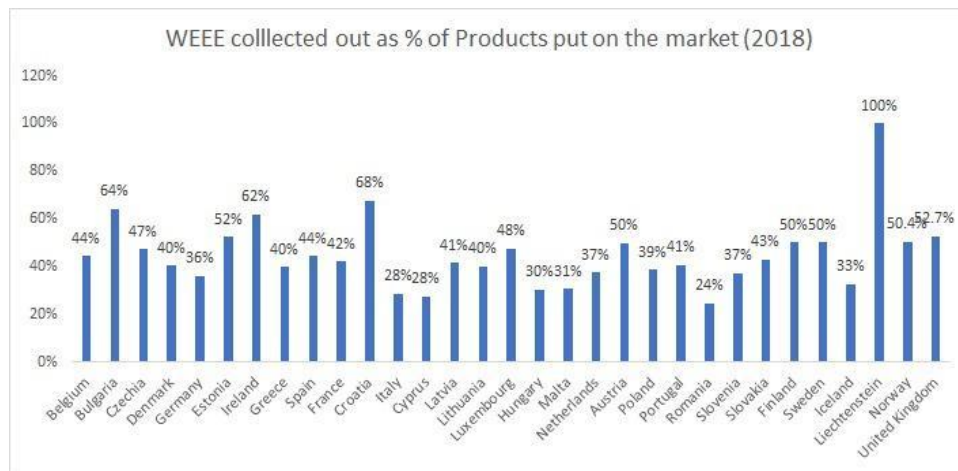


Figure no. 2. WEEE collected from the total number of products placed on the market (2018)

Source: Own calculations based on Eurostat data 2018

Thus, looking at the quantities of Electrical and Electronic Equipment (EEE) put on the market and the WEEE collected, the extensive component of collection was highlighted. Given the fact that the data set also provided a breakdown on different types of WEEE, four types of WEEE were selected to analyze separately: Large appliances for the home, Small appliances for the home, IT and telecommunication equipment, Lighting equipment.

Given our data structure, we estimated a panel regression considering five types of WEEE: Total waste, Large appliances for households, Small appliances for households, IT and telecommunications equipment, Lighting equipment, and two variations for the number of employees (NACE 38, respectively NACE 3811). To isolate any national peculiarities in the collection process, we enforced fixed cross-section effects on all estimations.

The first estimate was performed at a broader level (i.e., considering all NACE 38 employees) and has the following form:

$$WEEE\ collected = \beta_0 + \beta_1 \times Products\ put\ on\ the\ market + \beta_2 \times Number\ of\ employees\ E38 + \beta_3 \times EU\ directive\ implementation + \varepsilon \quad (1)$$

The dependent variable and is expressed in kg per capita of WEEE, the products put on the market are also expressed in kg per capita, the number of employees is expressed in absolute value, and the dummy variable has a value of 1 starting with the year of the implementation of EU directive and 0 before that. The results are presented in Table no. 3.

Table no. 3. Equation 1 estimation outputs

Variabiles	Total WEEE (1)	Large appliances (2)	Small appliances (3)	IT and telecommunications equipment (4)	Lighting equipment (5)
Products put on the market (for each category)	0.085909***	0.234	0.000318***	0.050732*	0.091051*
	(0.02811)	(0.03243)	(0.03035)	(0.02312)	(0.01609)
NACE E38 employees	0.0000157**	0.00001	0.0000054***	0.0000014***	0.0000001***
	(0.0000070)	(0.0000050)	(0.0000009)	(0.0000020)	(0.0000004)
Implementation of EU directives	1.233092***	0.673	0.207	0.058898*	0.071767*
	(0.24739)	(0.12380)	(0.02952)	(0.03319)	(0.01688)
Constant	4.479641***	0.900	0.258	0.923	-0.002534***
	(0.60551)	(0.35112)	(0.05675)	(0.08014)	(0.02057)
R ²	0.8888	0.8679	0.8565	0.8765	0.6832
R ² adjusted	0.8760	0.8525	0.8398	0.8621	0.6460
Standard errors are presented in parentheses. significance: *** 1%, ** 5%, * 10%					

As can be observed, at the aggregate level, for all WEEE, all the coefficients are significant at 5% or better. An interesting aspect is that the highest impact on the intensity of collection

was the implementation of the EU directive (an increase of 1,23 kg per capita in the collection of WEEE). Stricter rules and significantly higher collection quotas drove an increase of collection efforts at the EU level. The total products put on the market have a significant impact on collection per capita, but this impact is very small, respectively, an increase just by 80 grams per capita in WEEE collected for every 1 kg per capita of products put on the market. Furthermore, the impact of the number of employees in the waste collection sector is very small, in part being affected by the difference in order of magnitude between variables.

To see if different categories of EEE behave differently when it comes to waste management, we estimated equation 1 for four individual categories of EEE. The hypotheses tested by these estimations, formulated starting from the study carried out by Magalini et al. (2015), are the following:

- 1) For large household appliances, there is a greater impact on the collection rate generated by the products put on the market, since they are, in general, significantly heavier than any other EEE categories.
- 2) For lighting equipment, it is expected to register the smallest impact in collection rate because they are, in general, lightweight and relatively easily disposable compared to other WEEE.

The first hypothesis was infirmed, mainly due to the lack of statistical significance of the coefficients for variation (2) of the first equation. This result can be due to the fact that some of the new products put on the market are not replacing old ones (extensive consumption). Another possible explanation is that a newer product may be heavier, on average, than older products, thus compensating the effects on collection, even though newer products are replacing old products. Another important aspect is that this effect is not significant when only large household appliances are analyzed. However, at the aggregate level, the collection of waste from large appliances has the greatest potential to increase the collection per capita, but this effect is masked by the relative structure of the EEE put on the market and the WEEE collected in all combined categories.

The second hypothesis was also confirmed, lightning equipment EEE collection being influenced by the products put on the market stronger than small household appliances and IT and telecommunication equipment. One possible explanation for this effect is that the small size of lighting equipment (especially light bulbs), makes it also easier to collect compared to other WEEE such as small household appliances and IT and telecommunication equipment. People can be prompted more easily to collect such WEEE, for example, by placing a collection bin in highly frequented places (e.g., convenience stores) compared to the other types of WEEE.

The second estimate was performed at a narrower level (considering only NACE 3811 employees) and has the following form:

$$WEEE\ collected = \beta_0 + \beta_1 \times Products\ put\ on\ the\ market + \beta_2 \times Number\ of\ employees\ E3811 + \beta_3 \times EU\ directive\ implementation + \varepsilon \tag{2}$$

The results are presented in Table 4. The same hypotheses were considered with respect to the collection of large household appliances and the collection of lightning equipment. The same conclusions apply to equation 2 as to equation 1 with respect to the above-mentioned hypotheses. However, there are some notable changes when considering only the employees

involved in nonhazardous waste collection rather than all the employees in the sector. First, at the aggregate level, the impact of EU directive implementation is reduced to only 0.96 kg increase in per capita collection. Second, the impact of the number of employees more than doubles, but it remains very modest (3.5 grams increase in collection per capita for every 1000 additional employees). Third, the impact of products put on the market increases slightly, from 80 grams to 130 grams per capita for every additional 1 kg per capita of products put on the market.

Table no. 4. Equation 2 estimation output

Variabiles	Total WEEE (1)	Large appliances (2)	Small appliances (3)	IT and telecommu nications equipment (4)	Lighting equipment (5)
Products put on the market (for each category)	0.129967***	0.180098	-0.000415***	0.086805*	0.164253***
	(0.02737)	(0.03222)	(0.02659)	(0.02507)	(0.03510)
NACE E3811 employees	0.0000359**	0.0000112***	0.0000055***	0.0000043***	0.00000118*
	(0.00002)	(0.00001)	(0.00000)	(0.00000)	(0.00000)
Implementation of EU directives	0.961624***	0.726394	0.174354	0.094935*	0.067501***
	(0.19058)	(0.12351)	(0.02548)	(0.01971)	(0.01480)
Constant	3.783841***	1.459721	0.313446	0.791387	-0.071346**
	(0.55277)	(0.34936)	(0.04406)	(0.06367)	(0.03344)
R ²	0.91099	0.88068	0.86555	0.89686	0.723834
R ² adjusted	0.89889	0.86422	0.847	0.88263	0.685742
Standard errors are presented in parentheses.					
significance: *** 1%, ** 5%, * 10%					

The estimation for large appliances for household still generates no statistically significant coefficients besides the one corresponding to the number of employees, suggesting that this WEEE category behaves differently, in terms of collection, from other categories of WEEE.

In equation 2, the estimation for small household appliances (3) generates a statistically significant negative coefficient corresponding to the products put on the market. This negative coefficient suggests that of all the EEE considered, small appliances may be the least prone to collection of all the EEE categories; this can be determined by the fact that compared to the other categories of EEE are considerably larger in size, making them less easy/convenient to dispose them easily, and compared to large appliances, they are less attractive for the collection efforts of all the parties involved, since the collection quota are expressed in absolute kg.

Conclusions

The transition to the circular economy is an ongoing process that works differently across sectors and product types, and is very useful under current conditions.

Electrical and electronic equipment plays an important role in the circular economy because a large part of it can be recovered and recycled. EEE are replaced at different intervals of time, some longer, some shorter, and this requires a better collection and recycling policy for this used equipment.

The waste of electrical and household appliances has experienced a significant increase over time, which requires the adoption of recycling measures and policies, both on a microeconomic and macroeconomic level.

From our estimations, we identify that the most important categories, from a policy perspective, are household appliances, both large and small. Large appliances seem to have an impact on overall WEEE collection, being the easiest way to ensure collection quotas expressed in absolute kg. Buy-back programs provided by stores and other measures by local or general government support the simultaneous collection of old EEE at the purchase of a new one, assuring collection close to par. On the other hand, small appliances are at the other end of the spectrum, implying significantly effort both on part of the user to transport them to specialized collection points, compared to other WEEE (such as light bulbs, small electronics, etc.) and to parties involved in collection (stores or firms would have to put efforts similar to the collection of a large appliance in order to reach significantly less of the collection quota). The collection rate in Romania at the general level remains low, 24% in 2018, compared to other European countries, this fact being confirmed by the study conducted by Gavrilăscu et al. (2021).

Thus, the main results of the research show that from the point of view of collection, it is easier to collect household appliances, especially large ones. Magalini et al. (2015) showed that the largest share of total recycled EEE is occupied by large equipment. At the European Union level, concerns for WEEE recycling have increased, although regional disparities are still high.

The limitations of the present research are related to the relatively small number of explanatory variables used in the panel, due to the lack of indicators to measure the level of collection. However, as stated in the paper, the model is statistically significant. Another limitation is related to not taking into account the environmental component in the econometric analysis.

Future research directions aim to analyze the behavior of the consumer about recycling and highlight the factors that can stimulate responsible behavior. For this research, a laboratory analysis will be performed, applying the difference-in-difference method. At the same time, economic policy measures will be proposed to improve WEEE recycling in Romania.

A possible policy direction could cover the improvement in *the collection of small household appliances by creating a logistical framework* for parties involved in collecting WEEE, as well as incentives for users to recycle WEEE when purchasing a new EEE.

The implications of research on how to collect electrical and electronic equipment waste are both theoretical, by contributing to the knowledge of the field and characteristics of these products, and practical, by analyzing and identifying the best methods to stimulate collection

for the future in Romania. All of this will contribute to the development of a sustainable economy.

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