SOCIOECONOMIC FACTORS AFFECTING E-WASTE COLLECTION RATE IN COUNTRIES FROM EUROPEAN UNION

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ABSTRACT
Waste is driven by a variety of factors and as well electronic waste, as a specific category of waste. Studying the factors that influence the collection of e-waste offers a huge opportunity in improving the ways to collect and recycle e-waste, taking into consideration that all countries have national targets for the amount of e-waste to be collected and recycled. The undertaken analysis gives a macroeconomic perspective on these factors. The authors use a panel data approach for constructing a regression model and for substantiating the influence of certain independent variables on the Collection rate of e-waste. The findings of the estimation suggest that the Age of a person has the highest impact on the collection rate of WEEE, followed by the Unemployment rate, which is a factor describing the social condition of a society. The variable regarding education has no relevant influence on the collection rate of WEEE while the lowest influence is reported for the variable dealing with the minimum level of wages, a proxy for the population's income.

KEYWORDS: *e-waste, recycling, collection rate, WEEE.*

JEL CLASSIFICATION: *C33, Q53.*

1. INTRODUCTION

As a consequence of technological innovations and new applications of Electrical and Electronic Equipment (EEE), e-waste or electronic waste (also called WEEE - Waste Electrical and Electronic Equipment) has experienced a rapid growth in the last decade conducting to important changes in the current pattern of development, production and consumption. Because of their components, e-waste categories of equipment are classified as hazardous waste. Materials like cadmium, selenium, and hexavalent chromium or lead, mercury and arsenic, should have a special treatment in the process of recovery, recycling and reuse of electronic waste. If not properly handled and managed, such materials and elements can cause serious environmental and health problems (European Commission, 2002). And do have why to worry about if we consider the official data regarding the global quantity of e-waste generation in 2014 that was around 41.8 million tons (Baldé, Wang, Kuehr, & Huisman, 2015). In the same year, according to the report called The global e-waste monitor (Baldé, Wang, Kuehr, & Huisman, 2015), Asia generated the greatest quantity of e-waste about 16 million tons, followed by America (North America, Central America and South America) with 11.7 million tons and Europe with 11.6 million tons.

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The collection and the recycling processes are shaped by two Directives of the European Commission's activity. One is the Directive on waste electrical and electronic equipment (WEEE Directive) with two parts of legislation: the Directive 2002/96/EC and the Directive 2012/19/EU, and the second one is the Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive). Through the WEEE Directive, a minimum collection target of 4 kg per year per capita is established for electronic waste from households, for countries in European Union. There are countries which already achieved the target and also exceeded it. For 2014, according to Eurostat statistics (2014), Sweden, Belgium, Austria, Ireland and Finland are among countries which reported a collection rate of WEEE, higher than 8 kg per capita. In the same time there are many countries which could not achieve the target. From 2016, a new set of targets will be introduced, obviously higher than the first one mentioned above. So, how would all countries boost their collection rate in order to avoid penalties? Which are the factors that can influence the entire process and lead to successful collection and recycling programs? In this context, it is important to study the factors that influence the collection process of e-waste, which precedes the recycling process.
In this paper, we are interested in finding socioeconomic factors that affect the collection of WEEE, at a macroeconomic level. Discovering and studying their behavior in relation to the collection rate of e-waste, will facilitate the information transfer to officials or waste managers, who can seek new ways to improve collection and recycling. We aim to demonstrate that besides microeconomic analysis of factors affecting WEEE collection, macroeconomic analysis are also important, as they manage to create an overall image or a country profile regarding the collection process of e-waste. We admit that our study is in its early stages and it can be improved by taking into consideration other indicators available at a national level that hinder or boost the collection and recycling of e-waste.

2. LITERATURE REVIEW

A multitude of factors were studied along time in relation to the collection and recycling behavior. The studies found in the literature reveal two different ways to investigate and discover the drivers of WEEE collection: the first one from a microeconomic perspective and the second one from a macroeconomic perspective.
Studying these factors at microeconomic level means understanding first "the individual's desire to protect the environment with his behavior" (Philippsen, 2015). So, the factors are closely related to the human behavior and research in the field has revealed the following ones (Philippsen, 2015; Tekkaya, Kilic & Sahin, 2011; Sommer, 2011; Ho, Tong, Ahmed, & Lee, 2013):

- Behavioral intention to recycle which refers to the willingness to try to recycle;
- Attitude, a factor referring to the individual's belief that recycle is good and should be advocated as a behavior ;
- Subjective norm represents a factor dealing with norms accepted in the society, norms that may impact an individual to see recycling as valuable;
- Perceived behavioral control refers to the perception of an individual upon how easy or difficult is to recycle;
- Perceived moral obligation relates to a personal norm that dictates what is the right thing to do;
- Knowledge, as a factor refers to being aware of the process of collection and recycling, to knowing how to collect waste or where are the locations that facilitate the waste collection;
- Inconvenience represents a factor related to a perception that tells and individual that it is hard to collect and recycle or that it takes a lot of time to do it.

The studies undertaken at microeconomic level are based on personal interviews or on questionnaires or detailed surveys on a sample of respondents (Singhirunnusorn, Donlakorn & Kaewhanin, 2012; Ittiravivongs, 2011).
For instance, Robinson and Read (2005) conducted two large-scale surveys of households in London and a first result of the surveys is that "there is a need for more education and provision of information to raise public awareness of the need for recycling" (Robinson & Read, 2005). Another conclusion of the study refers to the lack of incentive to recycle, which acts like a barrier.
Studies at macroeconomic level are based on reliable national indicators that are able to highlight some characteristics of a nation as a whole. Among these indicators the following ones are considered (Troschinetz, 2005; Troschinetz & Mihelcic, 2009): Government Policy, Government Finances, Waste Characterization, Waste Collection and Segregation, Household Education, Household Economics, Waste Management Plan, Waste Management Administration, Waste Management Personnel Education, Local Recycled-Material Market, Technological and Human Resources, Land Availability.
In other studies, authors use as factors that influence the collection of e-waste (Starr, 2014; Chen, 2010): the population density, the number of persons per household, the median age of population, per capita income, the percent of population with a Bachelor's degree, the unemployment rate, the political affiliation (a proxy for the attitude related to environmental issues), or the community preservation.
Studies at macroeconomic level are able to provide data and contribute to country profile description regarding collection and recycling process of waste. For instance, for Sweden, a complex study based on bivariate and multivariate data analysis reveals that there are four crucial factors for the future development of waste collection systems (Dahlen, 2008):

- "Convenience of separate collection of recyclables and hazardous waste;
- Information and communication programs;
- The type of waste collection fee;
- The role and function of supervised recycling centers".

All factors included in the mentioned study for Sweden are grouped by the author in three categories (Dahlen, 2008):

1) Factors that can be controlled by local waste management strategies;
2) Factors that can be controlled by national waste management strategies;
3) Factors that are beyond the control of waste management strategies.

3. DATA AND METHODOLOGY

3.1. Data

In order to analyze the factors influencing the collection rate of WEEE from a macroeconomic perspective, we thought to develop an econometric model based on multiple linear regression. We selected at first the macroeconomic indicators that became variables in our model and the available period for them (from 2007 to 2013) for 20 countries from European Union. So, the variables are as follows:
- The dependent variable: the Collection rate of WEEE (Eurostat, 2016a);
- The independent variables: the Population which attained Tertiary studies (Eurostat, 2016b), the Minimum Wage (Eurostat, 2016c), the Median Age (Eurostat, 2016d), the Unemployment rate (Eurostat, 2016e).

The countries chosen for study had data available for the considered period for all indicators included into the model. We separated them into two groups using the Gross domestic product at market prices – euro per capita (Eurostat, 2016f) with values from 2013, as follows:

- Group 1 includes all countries with a level of GDP per capita in 2013 lower than the EU-20 average of 22640 euro per capita;

- Group 2 includes all countries with a level of GDP per capita in 2013 higher than the EU-20 average of 22640 euro per capita;

The next table shows the two groups of countries, along with their GDP per capita and the 2 digit ISO country codes (Countrycode.org, 2016) used to abbreviate the name of the country. The purpose of using the abbreviations is to facilitate the writing of further regression equations.

Table 1. The groups of countries used in the analysis

Group of countries	GDP per capita in 2013 (euro per capita)	Code for country abbreviation
Group 1		
Bulgaria	5800	BG
Czech Republic	15000	CZ
Estonia	14400	EE
Greece	16500	GR
Hungary	10200	HU
Latvia	11300	LV
Lithuania	11800	LT
Malta	18100	MT
Poland	10200	PL
Portugal	16300	PT
Romania	7200	RO
Slovakia	13600	SK
Slovenia	17400	SL
Spain	22100	ES
Group 2		
United Kingdom	32000	GB
France	32100	FR
Belgium	35400	BE
Netherlands	38900	NL
Ireland	39200	IE
Luxembourg	85300	LU

Source: authors after Eurostat (2016f) and Countrycode.org (2016)

3.2. Methodology

For developing the model of multiple regression equations, we used panel data. This means that the variables in the model can vary in time (so a time dimension *"t"* is included in regression) or space (represented by the *"i"* cross-sections of the models, in this case the countries). The general form of the regression equation is:

$$CR_{it} = a_i + b_i \times PTE_{it} + c_i \times MW_{it} + d_i \times MA_{it} + e_i \times UR_{it} + \varepsilon_{it} \quad (1)$$

Where: CR_{it} is the Collection rate of WEEE (Eurostat, 2016a);
PTE_{it} is the Population which attained Tertiary studies (Eurostat, 2016b);
MW_{it} is the Minimum Wage (Eurostat, 2016c);
MA_{it} is the Median Age (Eurostat, 2016d);
UR_{it} is the Unemployment rate (Eurostat, 2016e);
i is the number of cross-sections;
t is the time period;
ε_{it} is the error term;

a_i is the constant term;
b_i ,c_i ,d_i , e_i are the estimated coefficients of the independent variables.

The method used in estimating the coefficients of the model is Pooled Estimated Generalized Least Squares. The estimation is undertaken by using econometric software (EViews 8), so the following options were selected:

- Cross Section Fixed Effects for obtaining different constant terms for each country;
- Cross Section Weights because we are assuming the presence of cross-section heteroskedasticity (the observations do not have the same errors variance and they are correlated).
- White period for standard errors estimation and covariance, as this option assumes that the errors for a cross-section are heteroskedastic and serially correlated.

We expect that the independent variables of the model to have a certain influence on the dependent variable. For instance, we expect that as the number of persons which attained Tertiary studies increases, so will the collection rate of WEEE. The variable referring to the income of population, the Minimum Wage is expected to positively influence the collection rate and so is the Median Age. The Unemployment rate is expected have a negative influence on the collection rate of WEEE.

4. RESULTS AND DISCUSSION

After applying the method above described, we obtained the following equations, for each group of countries:

Results for Group 1:

CR_BG = 83.018 - 38.5 + 0.0733*MW_BG - 0.037*PTE_BG + 0.179*UR_BG - 0.295*MA_BG (2)

CR_CZ = 294.56 - 38.5 - 0.0419*MW_CZ + 0.0245*PTE_CZ - 0.261*UR_CZ - 6.63*MA_CZ (3)

CR_EE = 34.6 - 38.5 - 0.016*MW_EE + 0.0000027*PTE_EE - 0.0079*UR_EE + 0.32*MA_EE (4)

CR_GR = -129.94 - 38.5 - 0.0011*MW_GR - 0.023*PTE_GR - 0.32*UR_GR + 5.21*MA_GR (5)

CR_HU = 83.36 - 38.5 + 0.023*MW_HU + 0.0098*PTE_HU - 0.059*UR_HU - 1.45*MA_HU (6)

CR_LV = 48.93 - 38.5 + 0.0042*MW_LV - 0.0024*PTE_LV - 0.072*UR_LV - 0.176*MA_LV (7)

CR_LT = -9.17 - 38.5 - 0.017*MW_LT + 0.041*PTE_LT - 0.209*UR_LT + 0.86*MA_LT (8)

CR_MT = -125.9 - 38.5 + 0.018*MW_MT - 0.223*PTE_MT + 2.398*UR_MT + 3.73*MA_MT (9)

CR_PL = 22.33 - 38.5 - 0.015*MW_PL + 0.0036*PTE_PL - 0.362*UR_PL + 0.25*MA_PL (10)

CR_PT = -29.78 - 38.5 + 0.0226*MW_PT + 0.0047*PTE_PT - 0.768*UR_PT + 1.577*MA_PT (11)

CR_RO = 14.275 - 38.5 - 0.0218*MW_RO – 0.000083*PTE_RO - 0.55*UR_RO + 0.819*MA_RO (12)

CR_SK = 82.42 - 38.5 + 0.024*MW_SK + 0.0103*PTE_SK - 0.28*UR_SK - 1.33*MA_SK (13)

CR_SL = -93.711 - 38.5 + 0.003*MW_SL - 0.0748*PTE_SL + 0.167*UR_SL + 3.74*MA_SL (14)

CR_ES = -274.97 - 38.5 + 0.096*MW_ES - 0.0117*PTE_ES - 0.91*UR_ES + 9.22*MA_ES (15)

Results for Group 2:

CR_GB = -580.65 - 6.12 - 0.0097*MW_GB - 0.003*PTE_GB - 0.382*UR_GB + 16.424*MA_GB (16)

CR_FR = 354.39 - 6.12 + 0.285*MW_FR - 0.0134*PTE_FR - 0.0525*UR_FR - 14.64*MA_FR (17)

CR_BE = 94.567 - 6.12 + 0.013*MW_BE + 0.0057*PTE_BE - 0.345*UR_BE - 2.61*MA_BE (18)

CR_NL = 8.52 - 6.12 + 0.031*MW_NL - 0.0088*PTE_NL - 0.51*UR_NL - 0.232*MA_NL (19)

CR_IE = 88.872 - 6.12 - 0.02*MW_IE + 0.025*PTE_IE - 0.34*UR_IE - 1.875*MA_IE (20)

CR_LU = 34.28 - 6.12 - 0.0081*MW_LU + 0.073*PTE_LU - 0.252*UR_LU - 0.285*MA_LU (21)

The intercept or the constant term of the equations is composed of two values: the first one represents the deviation from the average value of the intercept, specific to each country and the second one is the average value of the intercept. For instance, for the first group of countries, 38.54 represent the average value of the constant term. So, the constant term for Romania is the sum of the deviation from the mean, 14.275 and the mean for the group, 38.5. This means that, assuming that all variables from the model equal to zero, the constant term is 52.775. The constant term refers to all those factors that are not included into the model, but have an influence of 52.775 percentage points on the collection rate of WEEE for Romania.

After reporting results of estimation, the following conclusions can be drawn:

- Of all variables used in the regression, the age has the highest impact (either positive or negative) on the collection rate of WEEE. So, for the first group of countries, one can observe that the highest negative impact is registered for France. For each additional year on the median age, a reduction of 14.64 percentage points in the collection rate of WEEE appears. The Median Age for France is 41 years (value corresponding to 2013), which means that half of the population is under the age of 41 and the other half is older than this median age. Also for the first group of countries, the highest positive impact appears for Great Britain. For each additional year on the median age, an increase of 16.42 percentage points in the collection rate of WEEE is registered.

- The second factor with a considerable influence on the collection rate of WEEE is the unemployment rate. The estimation of coefficients reports, in most cases, a negative impact of the unemployment rate on the collection rate. There are several countries for which, this impact is positive: Slovenia, Bulgaria and Malta; they are included in the first group of countries, with a level of GDP per capita in 2013 lower than the EU-20 average. Among countries for which this variable is reported with a negative influence, is also Belgium. An increase of 1 percentage point in unemployment rate triggers a decrease of the collection rate of 0.345 percentage points. It is assumed that people who are looking for a job have little interest towards environmental issues, no longer having time to sort waste for recycling. That explains the decrease of collection rate under the influence of rising unemployment.

- Regarding the influence of the third factor, the Population which attained Tertiary studies, the estimation reports sub unitary coefficients. This indicates a reduced influence on the collection rate. We assumed that a part of the population that graduated from tertiary education, so with a high level of education, will positively influence waste collection rate. This hypothesis has not been validated as several cases in which the influence is negative occurred. For instance, 1 percentage point increase in the number of persons who have bachelor's degree is associated with a decrease of 0.223 percentage points of electrical and electronic waste collection rate for Malta (this being the highest negative record). The biggest positive influence is registered for Luxembourg of 0.073 percentage points.

- The variable that has the lowest influence on the collection rate of WEEE is the Minimum Wage. In general, people with higher income will have a greater inclination to participate in the collection of WEEE for recycling. However, the relationship between these two variables is not significant, as suggested by the very low values of estimated coefficients.

5. CONCLUSIONS

By developing an econometric model for studying the influence of socioeconomic factors or variables on the collection rate of WEEE, we aimed to understand this process from a macroeconomic perspective. The majority of analysis developed in this field is focused on behavioral factors that act like drivers or barriers in communities or economic agents. Our model is a starting point for further analysis and it can be improved by using other variables of interest for collection of WEEE.

The independent variables included in the analysis have a different influence on the collection rate of WEEE, the dependent variable of the regression model. This fact is valid for both groups of countries.

So, if we take into consideration the median age, this indicator has a bivalent influence (negative and positive) on the dependent variable (for ten countries the influence was a negative one, while for the other ten, the influence was positive). The highest positive value is recorded by Spain (+9.22) and Great Britain (+16.424). Both of them are countries for which the median age contributes to an increase in the collection rate of WEEE. The highest negative value are recorded for Czech Republic (-6.63) and France (+14.64), cases in which the median age has a negative influence ono the collection rate of WEEE.

Quite far from the first independent variable analyzed as level of influence on the rate of waste collection, the unemployment rate has mainly a negative influence on dependent variable (there are 17 countries for which a negative relationship is reported, while only for 3 countries a positive relationship appears). However, unlike the median age, this independent variable has a relatively low influence (a maximum value of 2.398 is reported for Malta).

The last two independent variables (the population which attained tertiary studies and the minimum wage) have, as in the case of median age, a bivalent influence (for instance for the population which attained tertiary studies, 10 countries show a positive influence while the other 10 countries show a negative influence). This ambivalence is preserved even within each group of countries, for both variables. For example, the minimum wage for 6 countries in the first group negatively influences the collection rate of WEEE, while for 8 countries in the same group reports a positive influence. Going further to the second group, the same indicator negatively influences the collection rate of WEEE in three countries while in the other 3 countries shows a positive influence. This fact accentuates a neutral characteristic of these two independent variables (the population which attained tertiary studies and the minimum wage). Overall, we can say that their influence is significantly reduced (compared, for example, to the median age); the highest coefficient for the minimum wage is +0.285 (for France) and the highest coefficient for the persons with tertiary education is +0.04 (for Lithuania).

To conclude, the results of our analysis show that it is possible to relate socioeconomic indicators to the collection rate of WEEE in order to understand their influence on collection and furthermore on recycling. So, besides the analysis of microeconomic factors or behavioral factors (as we showed in the literature review section) which is extremely important to understand a community willingness to collect and recycle, the analysis of macroeconomic factors is also necessary to understand a country's capacity to meet national targets on collection and recycling of WEEE.

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