

Önder, Hüseyin

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THE SOCIO-ECONOMIC DETERMINERS OF RECYCLING: AN ANALYSIS ON EUROPEAN COUNTRIES THROUGH A MACRO PERSPECTIVE

Hüseyin Önder*

Dumlupınar University, Kütahya, Turkey.

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Abstract

The growing economies and the increase in urbanization have increased the process of waste production. Recycling of the wastes resulting from economic processes through certain operations would both decrease the amount of wastes and the need for area to store them and minimize the demand for virgin resources in production. This study aims to examine the socio-economic factors that are effective on recycling from macro perspective. Therefore, a Panel Data Analysis was conducted with data of 31 European Economic Area (EEA) countries concerning the period from 2004 to 2014. In the model used in the analysis, the recycling rate is represented by the packaging waste recycling rate. As an independent variable, Education, Income, R & D expenditures, Resources and Agricultural sector added values were used. As a result of the analyses conducted in this research it was determined that education and amount of resources are in a positive relationship with recycling rate while income levels and the agriculture sector are in a negative relationship with the recycling rate.

Keywords: Recycling, Socio-Economic Factors, European Economic Area (EEA) countries, Panel Data

JEL Classification: Q53, C33

Introduction

Rapid and uncontrolled population growth coupled with increased human needs forced businesses to consume more resources. The increase in resource consumption disrupts the natural balance and harms the environment. At this point, the importance of recycling comes to light. Moreover, the fact that natural resources are not distributed homogeneously around the world has led some countries to become “poor” in terms of natural resources and “rich” in others. Countries that are poor in terms of natural resources attach more importance to recycling in order to protect themselves from the external dependency and the fluctuations in natural resource prices. In the traditional economic system, the existing

* Author’s contact, e-mail: huseyin.onder@dpu.edu.tr

production and consumption styles are often based on the linear principle. Sources are extracted, processed, used and eventually discarded as waste. Thus, wastes are typically disposed of by burning or storage. In both cases the materials are withdrawn from the circulation or destroyed. Such a linear economic model can only function if there are unlimited resources to satisfy endless demands. However, a linear economy will inevitably encounter limits. At the center of the circular economy concept, the value of materials and products is kept as high as possible. This high price helps minimize the need for new materials and energy input, thus reducing the environmental stress associated with the product life cycle (European Parliament, 2017).

The concept of cyclical economy is associated with the concept of 3R. The concept of 3R stands for Reduce, Reuse and Recycle. Recycling has been a fundamental part of sustainability for many years. Recycling is also an important factor in the cyclical economy (Murray et al., 2017). Although recycling is perceived more as behavior of individuals in the literature, recycling basically develops as the collective behavior of society as a whole. The education and income levels of the individuals in the society, institutional structures developed for recycling, incentives and penalties affect recycling behavior. For instance, in terms of recycling of textile products, motives such as conscience and helpfulness play an important role and used clothes are recycled via municipalities. However, in terms of recycling of glass, metal and plastic materials social, economic or political motives are more effective (Hawley, 2006). In this perspective the European Parliament with its directives has been encouraging countries to determine their recycling goals in macro terms and it designs legal and institutional proposals needed for realizing these goals. As a result, the need for approaching recycling through a macro perspective becomes evident. In this study, socio-economic factors influencing recycling were examined from a macro perspective. For this purpose, education, income level, and some other variables will be tested with a model covering the European Economic Area (EEA) countries by establishing a simple panel data model with macro factors.

1. Recycling in European countries

A side effect of high Gross Domestic Product (GDP) is the large amount of wastes per capita. The European economy is still producing in a mostly linear economic system and with make-take-disposal principle. Recently this approach has started to be replaced by circular economy. Zero waste, resource productivity, reusing and recycling are the basic determinants of this process (European Parliament, 2017).

Europe has been conducting studies on the necessity and application of the cyclical economy. The standards and rules that European Union member states are supposed to obey have been determined. Different regulations regarding waste management and recycling in particular are still being made. It is one of the main objectives to improve the environmental structures of the Member States of the European Union with these regulations. Countries that are members of the European Union are in the process of creating a rapid waste. Figure no.1 shows the waste generation, recovered and recycled waste rates of the European Union member countries.

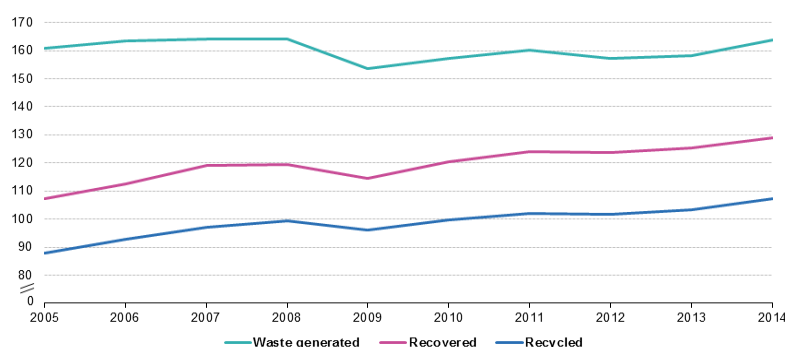


Figure no. 1: Development of overall packaging waste generated, recovered and recycled, EU-27, 2005–2014 (kg per inhabitant)

Source: Eurostat, 2017

According to figure no. 1, between the years 2005 and 2014, a constant increase trend was observed in waste generation, recovered and recycled waste rates. Despite a decline between 2008 and 2009, the increase continues in all three rates, especially after 2009. The economic crisis that was experienced during this period had a great effect on this decrease between 2008-2009. A serious gap was observed between the amount of waste generated and the recovered and recycled waste rates.

The most important waste comes from packaging and package waste. The distribution of these packaging wastes by type is shown in figure no. 2. As much as 41% of the resulting packaging waste is made up of paper and cardboard waste. This is followed by glass and plastic waste with 19%.

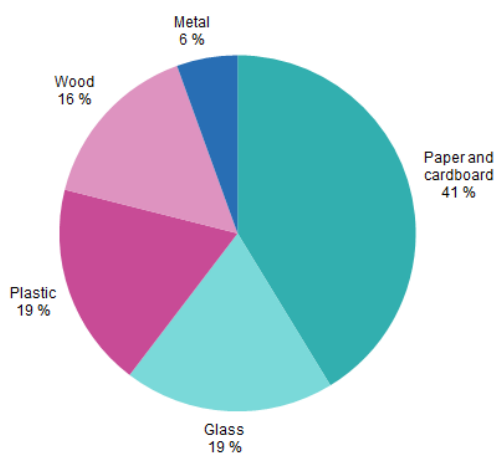


Figure no. 2: Shares of packaging waste generated by weight, EU-28, 2014 (%)

Source: Eurostat, 2017

The European Union has published the European Parliament and Directive of the Council numbered 94/62 / EC on 20 December 1994 in order to ensure a high level of

environmental protection. This Directive contains measures aimed at improving packaging waste production and recycling. With this directive, it is aimed to reach the recycling ratio of 60% for glass, paper and wood, 50% for metals, 22.5% for plastics and 15% for wood in packaging waste until December 31, 2008. Waste burning with energy recovery is considered to contribute to the realization of these objectives (EC, 94/62 Directive). In all wastes, a target of 55% was set for EEA countries except Latvia. Figure no. 3 shows the countries reaching this target.

A large proportion of the EEA countries have captured the 55% waste recycling rate as shown in figure no. 3. Croatia, Greece, Hungary and Malta could not catch the specified rate. Those countries that could not catch the 55% limit except Malta are very close to this 55% limit.



Figure no. 3: Recycling rate for all packaging, 2014

Source: Eurostat, 2017

By releasing Waste Framework Directive-2008/98/EC, the European Union stipulated that the member countries must prepare a waste management plan that will include the kind, quantity, source and collection system of waste. The European Union has made a number of other regulations related to waste management and recycling. It is possible to list the significance of these regulations as follows (Ministry of Science Industry and Technology, 2014):

- Directive on the Disposal of PCB / PCT (96/59 / EC),
- Regular Storage Directive (99/31 / EC),
- The Lifetime Completed Vehicles Directive (2000/53 / EC),
- Waste incineration Directive (2000/76 / EC).
- Directive on the Management of Mine Waste (2006/21 / EC),
- Directive on batteries and accumulators (2006/66 / EC),
- Waste Electrical and Electronic Equipment Directive (WEEE) (2012/19 / EU)

These activities of EU have been very beneficial in terms of creating a legislation concerning recycling and setting goals thereof. However, what really matters is the individual and social behavior patterns. These patterns are formed as a result of the experience of long periods of time and influenced by the socio-economic factors of the society they are formed in.

2. Literature review

It is seen that the studies on the recycling rates in literature are mostly done through a micro perspective. The data obtained via survey method are generally used in these studies. The studies include research on the recycling behaviors of households, explaining the recycling behavior of the country and even several different countries. There are also studies that examine the recycling rate of different materials. It is possible to point out that the perspective of the micro perspective is related to household recycling studies. Saphores and Nixon (2014), with a national survey conducted in 2006, in U.S.A., examined the determinants of house recycling for 4 items, aluminum, other metals, glass, and plastics. In the study, either generalized ordered logit or multinomial logit models were used. As a result of the analysis, it was determined that the most important determinants of household recycling are the attitudes of people towards recycling. Jenkins et al. (2003) measured the impact of socio-economic and institutional regulations on the recycling rates of five different materials. In survey results conducted by e-mail at central 20 settlements in the United States, it was concluded that the level of education and income significantly influenced the recycling rate.

In Bezzina and Dimech (2011) study, the impact of attitudes and behaviors and socio-economic factors on recycling in Malta was investigated by the survey method. The findings show that the "personal recycling attitudes, norms and skills" and "satisfaction with service provided" variables affect the recycling attitude in Malta. The study was based on the Theory of Planned Behavior (TPB) approach. There are many studies to measure the effect of people's behavior on recycling using this approach. Some of them are Tonglet et al. (2004), Siti and Kamisah (2010), Zhang et al. (2015), Scalco et al. (2017). Colesca et al. (2014) developed the WEEE behavior model with the data obtained by the survey method in their research in which they examined factors that are effective on recycling (WEEE) in electronic products in Romania. In the created model, socio-economic factors such as age, education and income are influential, and institutional supports are found to be effective in addition to the factors such as environmental norms and recycling information.

Afroz, Hanaki and Tudin (2011) examined the factors that affect the waste generation of the dwellings conducting interviews with 402 participants in Dhaka city of Bangladesh. As a result of the study in which the Ordinary Least Square Regression Model was used, it was determined that Dhaka city was significantly affected by household size, income, environment, and willingness to separate the waste. Guerin et al. (2001) have tried to determine the socio-economic factors of recycling with hierarchical regression analysis using the survey results obtained in 15 different European countries. It was learned from the result of the analysis that environmental activation alone is an important variable affecting recycling in Europe.

Pinka et al. (2012) examined socioeconomic factors affecting household solid waste generation and composition in Freetown Sierra Leon. In order to do this, solid waste

generation and composition as well as family size, education, income level among others variables were used. As a result of this study, it was determined that the production and composition of solid waste in Freetown was significantly influenced by the average family size, employment status, monthly income, and the number of rooms / rooms used by the families. These studies which were conducted through a micro perspective tried to explain the behavior patterns of the households. This approach basically focuses on individualism. However the concept of recycling is quite sensitive to some certain variables such as the organizations of the government concerning recycling, incentives and the attitude of the society in general. Therefore, it is necessary to examine recycling from a macro perspective as well. Despite this need for a macro perspective in recycling studies, the number of such studies is rather limited in literature.

When studies on the macroeconomic level are examined, it is visible that some national indicators are used. It is possible to rank the indicators that reflect a nation as a whole, as follows: 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, Landing Availability (Marinescu et al., 2016). These twelve factors are mostly used in countries' studies on municipal solid waste management (MSWM) (Troschinetz, 2005). One of the studies on recycling from the macroeconomic point of view belongs to Marinescu et al. (2016). In this study, the influence of socioeconomic factors or variables on the collection rate of e-waste or electronic waste (also called WEEE-Waste Electrical and Electronic Equipment) was investigated. The data of the 20 EU member countries between 2007 and 2013 were used. In the study, the effect of the Population, the Minimum Wage, the Median Age, and the Unemployment Rate on e-waste collection rate was investigated by creating a Multiple Linear Regression Model. As a result of analysis, it was determined that the Age of a person has the highest impact on the collection rate of WEEE. The Minimum Wage had the lowest effect on the collection rate of WEEE and it was followed by the Unemployment Rate.

The above mentioned macroscale studies ignored the effects of the amount of a country's resources, the technological means and the agricultural sector. For instance, the countries with a developed agricultural sector would not prefer to store wastes on the land which is appropriate to be used for production. Besides, those countries which do not have the necessary technology of waste processing would not be able to set up the organizations needed for recycling. Also, the countries lacking resources would prefer to compensate for this need through recycling.

3. Research methodology and data

The model in Equation 1 will be used to analyze the socio-economic factors that are effective in the process of recycling the wastes produced as a result of economic processes from the macro perspective. The model in equation no. 1 was created out of the micro-perspective studies made in this area. The model is the following.

$$ReR_{it} = \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 RD_{2it} + \beta_3 RES_{it} + \beta_4 EDU_{it} + \beta_5 AGR_{it} + u_{it} \quad (1)$$

Variables and explanations in the model are as follows:

ReR: It reflects the recycling rate of the country's waste. For this, the recycling rate of packaging waste is used as a Proxy. This data set is taken from EuroStat.

LnGDP: It shows the income level of the country. It was created by doing logarithmically transforming the data received with fixed prices in 2010 from The World Bank, World Development Indicators (WDI) Database.

RD: It shows the technological level of the country. It was used in the model as the ratio of GDP expenditures made by countries for research and development. The data obtained from WDI was used.

RES: It represents the amount of the source to be used as input for the country. For this, Mineral Rant values from WDI are used as proxy. Minerals included in the calculation were tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate.

EDU: The variable used to represent the educational level of the country. The values calculated by WDI as the ratio of education expenditures to GDP of countries were used.

AGR: It shows the importance of agriculture in the country. In the total added value, the data provided by WDI as share of agriculture was used.

This model is set up to test the idea that as the educational level of the country, its income level, its technological capacity, the importance of agriculture increase and the amount of resources decreases, recycling will increase. In studies conducted at the micro level, incomes of households and education level are the generally used variables. The recycling rate and technical capacities of the countries are also likely to be effective on recycling. On the other hand, countries that suffer from scarcity of natural sources (especially metals and minerals) are likely to want to overcome this strain by recycling. Moreover, countries with higher agricultural activities than other countries are expected to use precious agricultural land for production purposes instead of storing wastes.

This model includes the European Economic Area (EEA) countries. The EEA consists of 31 countries, including 28 European Union member countries and Liechtenstein, Iceland and Norway. The data of these countries concerning to the period between the years 2004 and 2014 were analyzed by sampling. The availability of data relating to the recycling rate at the time of selection of this sample and the date range has been used as a basic criterion. Analysis will be performed using the model Simple Panel Data Method in equation no. 1. Simple Panel Data Method can be realized with three different techniques. These are Pooled OLS, Fixed Effects and Random Effects. Among these three different techniques the one to be used was chosen by F-Test, Lagrange Multiplier Test (Breusch Pagan) and Hausman Tests.

4. Result and discussion

Descriptive statistics related to the variables used in the analysis; mean, median, maximum, minimum, and standard error are given in table no. 1. The mean and median values of the descriptive statistics for the variables in the model in table no. 1 are indicative of how close the data is to normal dispersion. In cases where the data have a standard normal distribution, the mean and median values approximate each other (Pett, 1997). Table no. 1

also shows that the mean and median values of all variables are very close to each other. For this reason, it is assumed that all variables in the model are close to the standard normal distribution.

Table no. 1: Descriptive Statistics

	ReR	Ln_GDP	RD	RES	EDU	AGR
Mean	56.024	26.052	1.521	0.121	5.406	2.29
Median	58.050	26.196	1.383	0.001	4.900	2.240
Maximum	84.00	28.p24	3.749	2.074	18.190	13.984
Minimum	5.900	22.754	0.377	0.00	2.810	0.274
Std. Err.	13.552	1.579	0.877	0.319	2.437	1.734

Correlation table was used to investigate the existence of Multiple Linear Link Problem among the variables used in the model. Since the correlation coefficients in table no. 2 are smaller than ± 0.70 , it is assumed that there are no Multiple Linear Connection Problems among the variables (Weinberg and Carmeli, 2008).

Table no. 2: Correlation Chart

	ReR	Ln_GDP	EDU	RES	RD	AGR
ReR	1	0.336	-0.010	-0.003	0.387	-0.353
LnGDP	0.336	1	-0.206	-0.084	0.436	-0.398
EDU	-0.010	-0.206	1	-0.116	0.111	-0.056
RES	-0.003	-0.084	-0.116	1	-0.090	0.275
RD	0.387	0.436	0.111	-0.090	1	-0.485
AGR	-0.353	-0.398	-0.056	0.275	-0.485	1

F-Test, Breusch Pagan Test, and Hausman Tests were performed to determine whether the method used in the analysis of the research model in equation no. 1 was random effects, random effects or pooled data after reporting descriptive statistics for the variables used in the model.

The aim of using the F test is to test the validity of the Pooled Model from the intended Static Panel Data Models against the Fixed Effect model (Urban, 2015). Restricted and unrestricted models are required to perform this test.

Restricted Model: $Y_i = X\beta + ui = 1, 2, \dots, N$ (2)

Unrestricted Model: $Y_i = X_i\beta_i + u$

$$H_0: \beta_i = \beta; H_1: \beta_i \neq \beta$$

If the Hypothesis H_0 is not rejected; it will be $\beta_i = \beta$ in such a case, a classical model is accepted and a solution is made by using the pooled EKK technique. Otherwise, the Fixed Effect Mode will be valid.

Table no. 3 shows the F test statistical results. The hypothesis H_0 is rejected since the probability value is lower than the error according to these results. It was determined that the pooled model would not be suitable for analysis.

Table no. 3: Fixed Effect Test

F Statistics	11.506
F Stat. Prob.	0.0001

The Breusch-Pagan Lagrange Multiplier Test is used to make a choice between the Pooled Method and the Random Models (Block, 2009). The hypothesis that the variance of random effects is zero is as follows;

$$H_0: \sigma_u^2 = 0 ; H_1: \sigma_u^2 \neq 0$$

In case the variance of the unit effects is zero, it indicates that the model will be analyzed with the Pooled Model. The results of the Breusch-Pagan Test are shown in table no. 4.

Table no. 4: Lagrange Multiplier Test (Breusch Pagan) For Random Effect

	Cross Section	Time	Both
Coefficient	325.78	75.995	401.77
Probability	0.0001	0.0001	0.0001

When we examine the test results in table no 4, the H_0 hypothesis is rejected when the probability value is smaller than 0.05. In this case, it was concluded that the Pooled OLS model was rejected. It is understood from the analyses above, the pooling of the model in equation no. 1 was not appropriate. After the validity of the pooled model is rejected in the Simple Panel Data Analysis, it is now necessary to test which of the Fixed and Random Effect pairs should be preferred.

The hypothesis as to the Hausman test is established as follows (Wang et al., 2015):

H_0 : There is no correlation between explanatory variables and unit effects.

H_1 : There is a correlation between explanatory variables and unit effects.

The Hausman Test tests the testing with statistics that fit the χ^2 (chi-square) distribution. The Hausman Test, tested with this statistic, is shown in table no. 5.

Table no. 5: Hausman Test

Chi-Square Statistic	1.5811
Chi-Square Statistic Prob.	0.9539

When table no. 5 is examined, the hypothesis of " H_0 : No correlation between explanatory variables and unit effects" is rejected because the table value is greater than 0.05. According to this analysis, the Fixed Effects estimator is effective and consistent. The estimated results of the model Fixed Effects estimator in Equation 1 are shown in table no. 6. The F statistic, which shows the general significance of the model, shows that 1% of the likelihood model is statistically significant. It is seen that the corrected R^2 value in table no. 6 is 0.60. In other words, 0.60 of the 1 unit change from the dependent variable can be explained by the independent variables in the model. According to the results in table no. 6, LnGDP and AGR variables were statistically significant at 5% significance level and EDU and RES variables at 10% significance level in terms of statistical significance. The RD variable was statistically insignificant at the 10% significance level.

Table no. 6: Analysis Results

Variables	Coefficient	Std. Error	Prob.
C	90.793	16.235	0.0001*
<i>LnGDP</i>	-1.494	0.625	0.0176**
<i>EDU</i>	0.591	0.313	0.0606***
<i>RES</i>	7.501	3.906	0.0559***
<i>RD</i>	1.848	1.147	0.1084
<i>AGR</i>	-0.0816	0.487	0.0318**
R ² = 0.65	Adj R ² = 0.60		
F-statistic = 14,473	Prob. 0.0001		

When the coefficients of significant variables are interpreted individually; an increase of 1 unit in the LnGDP variable reduces the recycling rate by 1.49 units. 1 unit increase in the AGR variable also reduces the recycling rate by 0.081 units. 1 unit increase in the EDU variable increases the recycling ratio by 0.59 units. Furthermore, an increase of 1 unit in the RES variable increases the recycling rate by 7.50 units. The RD variable is insignificant. However, this variable has a value close to the significance level of 10%. For this reason, it will be useful to emphasize the positive relation of RD variable on recycling rate. The greatest impact on the recycling rate is generated by the RES variable. This variable is followed by the variables RD, LnGDP, EDU and AGR respectively according to the effect size.

Conclusions

Recycling can be roughly described as the regeneration participation of inputs used in production. For this process, besides the attitudes and behaviors of the individuals, the socio-economic structure of the country is very important. This study examines the socio-economic factors which are effective on recycling. For this purpose, the Simple Panel Data Model covering the years from 2004 to 2014 was established on 31 European countries. As a result of the analysis, it has been concluded that the income level, education, resource level, technological level and the agricultural sector are influential on the recycling.

Although the world population has increased 6-fold during the last 200 years, the urban population increased almost 100-fold during the same period. Some of the wastes resulting from the phenomenon of urbanization are recycled while the rest is stored. The land and parcels used for storage are located on resources like agricultural fields and available groundwater resources which are very important for present and future generations. The increase in recycling rates would in turn decrease the size of the land used for these aims (Leao et al., 2001). As a result of the study, it was determined that the decrease in the share of the agricultural sector in the total added value in the countries caused the recycling rate to decrease. This result may be interpreted as an inverse situation with the expectation, but it can be interpreted as the fact that an increase in the value added by agriculture causes a decrease in the value added by services and industrial sector. Thus, the increase in the value added by agriculture means a decrease in the value added by the other two sectors, and consequently the amount of waste to be recycled is reduced.

The relationship between income and recycling was not clearly explained by the previous studies conducted through a micro perspective. While some studies, such as Jenkins et al. (2003), proved the existence of this relationship; some other studies, such as Colesca et al. (2014), were not able to detect any relationship at all. This result reveals that if the study is conducted in different regions or countries, the outcomes will also differ. According to the results of this study, an increase in income reduces the recycling rate. However, the level of public consciousness is expected to be in high-income societies and the public is expected to have placed institutional structures in recycling; as a result the recycling rate should be high. However, the case was just the opposite of this expectation in this study. This result can be interpreted as the fact that countries with high income levels do not care about the recycling sector, they obtain the resources they need from the raw materials or these countries do not need the savings that the recycling sector will bring.

Another result contradicting the expectation is related to the resource level. The increase in income from resources (especially minerals) increases the recycling rate. This can be interpreted as the fact that due to an increase in the amount of resources, the amount of the waste that can be recycled increases, which in turn feeds the recycling industry. There are two variables with coefficients that are consistent with expectations. These are education and R & D - Research and Development expenditures that show the technical capacity of the country. Although R & D expenditure gave results which are statistically insignificant (close to 10% significance level), the mark is in line with expectations. It can be concluded that due to the development of the technical capacity of the country, recycling rates increase. Similarly, an increase in the level of education results in an increase in the recycling rate. It is also possible to conclude that a society of educated individuals act responsibly towards recycling. A similar result was underlined by Jenkins et al. (2003) and Pinka et al. (2012) in their studies through micro perspective. Jenkins et al. (2003) and Pinka et al. (2012) concluded that there is a statistically significant positive relationship between the level of education and the recycling rate.

Recycling is one of the most fundamental components of the cyclical economy. The determination of the working principle of this basic component from the macro perspective may be a guide for the policies that the decision makers will develop. The studies in the literature on recycling often look at the subject from a micro perspective and the exclusion of the macro perspective is a major drawback of recycling issue. With this study, it is expected that the existing deficiency may be eliminated and it may be a resource for the studies to be conducted in this area.

The possibility of examining recycling through a macro perspective was proven by both Marinescu et al. (2016) and this study hereby. The variables that were used in the model set forth in this study can be used, diversified and developed in new studies. The analyses may be repeated with data gathered from different country groups (such as OECD, G20, geographical groups etc.) and differences between these groups can be compared. Moreover, examining the effects of religious concepts which are important actors of behavior patterns on recycling would probably bring different viewpoints to the macro perspective.

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