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PANEL DATA ANALYSIS ON THE CIRCULAR ECONOMY AND ITS DETERMINANTS

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Abstract

An environmentally sustainable world is created as a result of the circular economy and steps taken toward recycling. In this way, the contribution of the creation of an environmentally friendly (environmentally conscious) society to the economic growth and social development of countries reaches remarkable dimensions. This study aims to determine the factors affecting the cyclical economy and recycling in the period 2010-2019 for 15 EU member states using a panel data analysis method. While the dependent variable used in this study was the circular economy index, the independent variables were the gross domestic product (GDP) per capita, trade openness, human capital, and renewable energy consumption in the study. In the study, it was concluded that there is a statistically significant and positive relationship between the increase in GDP per capita and the circular economy index. In addition, it was found that there is a statistically significant and positive relationship between human capital, renewable energy consumption, trade openness, and the circular economy index.

Keywords: Circular Economy, Economic Growth, Human Capital, Renewable Energy, Panel Data Analysis

JEL Codes: C23, F43, J24, Q42, Q53

DÖNGÜSEL EKONOMİ VE BELİRLEYİCİLERİ ÜZERİNE PANEL VERİ ANALİZİ

Öz

Çevresel açıdan sürdürülebilir bir dünya, döngüsel ekonomi ve geri dönüşüme yönelik atılan adımlar neticesinde yaratılmaktadır. Bu şekilde çevre dostu (çevre konusunda bilinçli) bir toplumun oluşturulmasının, ülkelerin ekonomik büyümesine ve sosyal gelişimine sunduğu/sunacağı katkılar dikkat çekici boyutlara ulaşmaktadır. Bu çalışmanın amacı; 15 AB üyesi ülke için 2010-2019 döneminde döngüsel ekonomi ve geri dönüşüme etki eden faktörlerin panel veri analiz yöntemi kullanılarak belirlenmesidir. Çalışmada bağımlı değişken döngüsel ekonomi endeksi iken, kişi başına gayri safi yurt içi hâsıla (GSYH), ticari açıklık oranı, beşeri sermaye endeksi, yenilenebilir enerji tüketimi ise bağımsız değişkenler olarak belirlenmiştir. Çalışmada elde edilen bulgulara göre, kişi başına GSYH ile döngüsel ekonomi endeksi arasında istatistiksel olarak anlamlı ve pozitif yönlü bir ilişki olduğu sonucuna varılmıştır. Ayrıca beşeri sermaye endeksi, yenilenebilir enerji tüketimi ve ticari açıklık oranı ile döngüsel ekonomi endeksi arasında istatistiksel olarak anlamlı ve pozitif yönlü bir ilişki olduğu bulunmuştur.

Anahtar Kelimeler: Döngüsel Ekonomi, Ekonomik Büyüme, Beşeri Sermaye, Yenilenebilir Enerji, Panel Veri Analizi

JEL Kodları: C23, F43, J24, Q42, Q53

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INTRODUCTION

Nowadays, in parallel with the increasing population of the world and technological developments, the fact that people act more consumption-oriented also increases waste production. In this way, various wastes such as glass, electronics, paper, and plastic are left in nature, and these wastes threaten biodiversity, harm the ecosystem, increase the carbon footprint, and cause global climate change. To solve these problems, environmental sustainability, a circular economy that respects nature, does not endanger biodiversity and protects the environment, has been developed in the path of sustainable development. This economic model is planned to ensure zero waste output by making products recyclable after they have completed their useful lives. Thus, with the use of recycled material, organic waste was brought to the industry as a new raw material, and a sustainable material was created. The circular economy reduces environmental pollution and reduces the use of resources in economic growth, and creates new employment opportunities. Therefore, with the circular economy model, it becomes possible to leave a livable world for future generations.

The circular economy can be difined a market economy that preserves the added and intrinsic value of physical resources while keeping resources in the economy for as long as possible and valued at end-of-life to minimize raw material consumption, waste and value chain risks (Türkiye Döngüsel Ekonomi Platformu, 2023). The circular economy is characterized by Maintenance (and repair), Reuse/re-transportation, Renewal/Re-manufacturing, Recycling and Gradual Reuse. In the context of the circular economy, generally the fewer stages a material has to go through before it can be reused, the higher the quality of the material it contains. According to Lahti Circular Economy Annual Review (2018), the circular economy is based on the idea of redesigning the economy by transcending the classical build-use-transfer model, with the responsibility of business enterprises to maintain the environmental and sustainable values of society, both shareholders and investors, and society as a whole. According to Korhononn et al. (2018), the circular economy is a sustainable development movement that aims to minimize the linear material and energy flows of social production/consumption systems by applying material cycles, renewable energy and staggered energy flows to the linear economic system.

This study aims to determine the impact of circular economy and recycling on 15 EU member countries (Austria, Denmark, France, Netherlands, Latvia, Lithuania, Spain, Sweden, Italy, Hungary, Norway, Poland, Portugal, Romania, and Slovakia) in the period of 2010-2019 by using panel data analysis method. In the study, while the dependent variable was the circular economy index (private investments in circular economy sectors, occupations, net added value, and patents for recycling), the independent variables were the per capita GDP, trade openness rate, human capital index, and renewable energy consumption. In

this context, the research hypothesis is, “Circular economy index improves economic (GDP per capita, trade openness), social (human capital), and environmental (renewable energy consumption) quality.” structured in the form.

Country data used in the study were taken from World Bank (WB) and Penn World Table, version 10.0 (PWT) and European Statistical Office (EUROSTAT) database. Stata 16 package program was used in the econometric analysis of the study.

In the study, firstly, the theoretical background on the circular economy and recycling within the context of environmental sustainability was created, and the circular economy and recycling approaches in the world and selected EU member countries were discussed. Then, applied literature on the circular economy and recycling is presented. Afterwards, the research method was explained, and the research findings were evaluated. In the conclusion part, a general framework on the subject was established/created/formed, and the findings were interpreted, and political suggestions were made in this direction.

THEORETICAL BACKGROUND

Circular economy and recycling within environmental sustainability

Before the Industrial Revolution, while production was carried out to meet the needs of human beings and for commercial purposes, with the industrial revolution, the environment and natural balance could be deteriorated with the rapidly increasing technology, urbanization, population, and consumer demandas well as urban wastes increased significantly. By the end of the 20th century, problems such as infectious diseases, disasters, migrations and poverty, overcrowding of urban populations, and depletion of agricultural areas, fisheries, and forests had become global in size. Especially the COVID-19 pandemic process, which started in China in 2019 and spread all over the world in 2020 and continues to spread globally, has revealed how climate and environmental risks can affect human life and the global dimension of these risks.

While human beings meet their own needs and even more than their needs today, they are destroying the needs of future generations (Hart, 2008, p.164). As a result of these negative effects, the world is facing with many environmental problems, especially the depletion of natural resources and climate change (Standart, 2018). Therefore, the increasing importance of creating environmental awareness requires human beings to take responsibility towards nature, which offers them all kinds of gifts. The environment is a vital function of living things; it is the area where they continue their biological, economic, cultural, and social lives. Sustainability is the principle of consuming the natural environment and natural resources by

protecting the right to use of future generations. In other words, sustainability is defined as the fair distribution of resources over time, both among the present generation and between present and future generations. Environmental sustainability, which is an integral part of sustainable development, is expressed as the existence of human beings and nature in productive harmony, and the creation and maintenance of conditions that enable the environmental, economic, and social needs of future generations to be met (U.S Department of Energy, 2020). In other words, environmental sustainability means meeting the needs of human beings without compromising the health of ecosystems (Morelli, 2011, p.2). Therefore, an environmentally sustainable system can avoid the overexploitation of renewable resources while allowing the consumption of non-renewable resources only to the extent that they are suitable for investment, thereby maintaining a stable resource base.

The concept of the linear economy, which emerged with the industrial revolution, is a process in which the supply of raw material, the production and consumption of the final good, and the waste form after consumption. In short, these processes can be summarized as "buy-build-dispose." However, at the end of this process, as a result of the rapid depletion of world resources and environmental problems, the phenomenon of a circular economy has emerged. Therefore, as a complement and component of sustainable development, the circular economy is a system that is built on an environmentally friendly economic growth target by eliminating the environmental problems caused by the linear economy. The concept of circular economy was used for the first time in Kenneth Boulding's "The Emerging Spaceship Economy" (Allwood, 2014, p.445). In the main sense, in the study of Pearce and Turner (1990), this concept was encountered (Winans, Kendall and Deng, 2017, p.826). The concept of circular economy is a production structure in which raw materials are used efficiently, nature is damaged at the minimum level during the production process, and the waste generated after production is re-evaluated.

The circular economy is an economic system that aims to facilitate sustainable development with micro and macro applications to prevent the depletion of the resource, energy, and material cycle (Prieto-Sandoval, Jaca and Ormazabal, 2018, p.610). For this reason, the circular economy prevents excessive consumption of limited world resources by reducing waste generation and damage to the environment and aims for sustainable development. This system, which constantly renews itself, was developed by being inspired by the fact that every object in nature forms the source of another phenomenon. As a matter of fact, since every type of waste is seen as a raw material, waste does not exist in circular economy systems. Therefore, the wastes created as a result of the product life process become reusable for the same or similar purposes, are recycled through repair, maintenance, and renewal processes, and new products are obtained by using them for other than their purpose. Thus, zero waste generation is ensured.

The circular economy was introduced with the concept of 3R. 3R is a combination of the initials of the terms Reduce, Reuse and Recycle. When these concepts are considered one by one;

i) Reduce: It means reducing the waste generated after production and consumption activities. Reducing the amount of waste can be characterized as the most important goal in the circular economy.

ii) Reuse: It is the repair and reuse of usable wastes (especially electronic wastes), and the evaluation of those that cannot be used as parts in the manufacture of another product.

iii) Recycle (Recycling): It is the recycling of wastes that have completed their economic life and using them as raw materials in the production of another product (Koçan, Güner and Baştuğ, 2019, p.537).

In some studies, the concept of 3R has been expanded to 6R. In addition to 3R, 6R includes the concepts of redesign, remanufacture, and recover concepts. As a matter of fact, in today's world, it has become possible to recycle the wastes that cause environmental pollution. What is meant by "recycling" is the re-inclusion of the wastes that can be re-evaluated as a result of production and consumption activities into the production process by undergoing certain processes (TÜDAM, 2016, p.5). In other words, the recycling of materials that turn into waste with their use, after the application of certain physical and chemical processes, to the remanufacturing processes in the form of raw materials is called "recycling." Waste materials (accumulators, aluminum, concrete, glass, electronic wastes, paper, motor oil, organic wastes, plastic, and batteries) are evaluated by the material by grouping the parts that make up the composition of the products. In these products, which are grouped as included in the recovery, a new product is obtained by changing the materials to be recycled with some techniques (chemical or physical). In this way, recycled waste materials are made useful (usable) and economically valuable (Guide, Jayaraman and Srivastava, 1999).

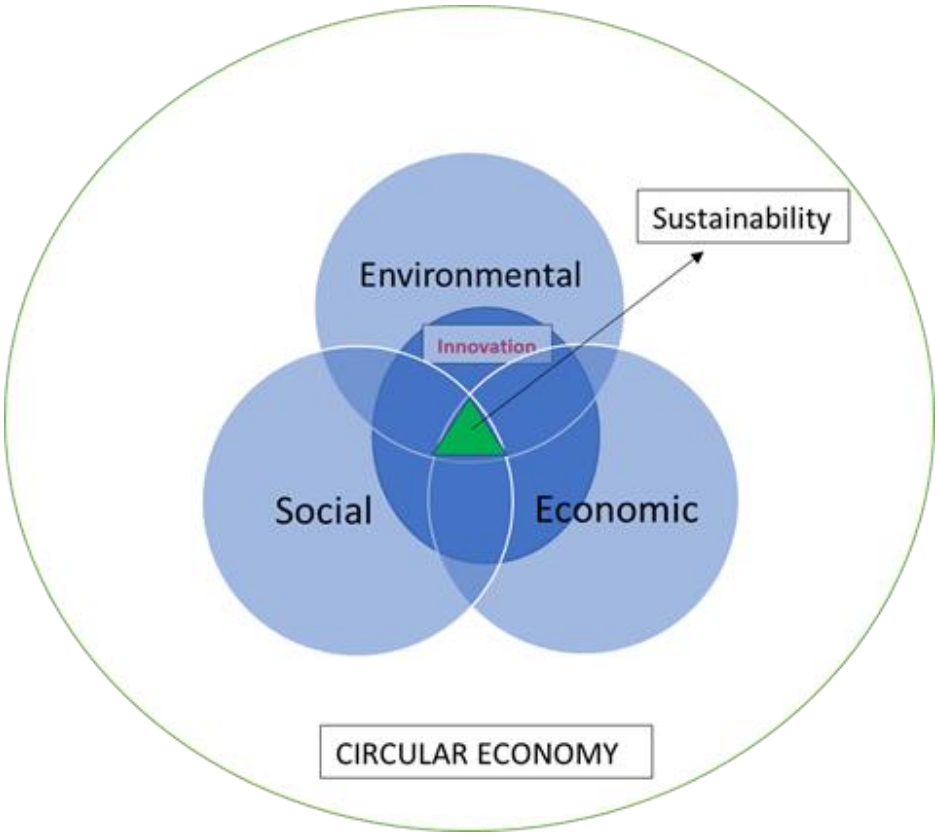
Circular economy, recycling approaches in selected European Union (EU) member countries

When the practices adopted within the framework of the circular economy are examined, practices that shape the sustainable production and consumption approach are encountered. Sustainable production and consumption is the production and using of products and services in an economically viable and environmentally friendly manner that will create social benefits throughout their entire life cycle. Considering the EU specific, it is seen that important steps have been taken regarding the circular economy.

On 17 May 2012, the European Commission took its first official step on the circular economy with the report known as the "Manifesto of Energy Efficiency in Europe" (Bonciu, 2014, p.83). On December 2,

2015, the European Commission adopted the "Circular Economy Package," which includes many regulations for waste management. This package aims to harmonize and improve the waste management policies of EU member countries and to transition to a circular economy system for EU economies. In March 2019, the EU adopted the "Circular Economy Action Plan" (Skrinjaric, 2020, p.2). According to this plan, a target has been set to recycle 65% of household waste and 70% of packaging waste in EU member countries in 2035 (Malinauskaite, 2017). On March 11, 2020, a new "Circular Economy Action Plan" was published by the European Commission, and according to this report, it has been calculated that with the transition of EU economies to a circular economy, GDP will increase by 0.5% in 2030 and seven hundred thousand new job opportunities will emerge (Pantzar and Suljada, 2020, p.8). Circular economy and sustainability are discussed in Figure 1.

Figure 1: Circular economy and sustainability



Source: Hysa, Kruja, Rehman and Laurenti, 2020

The circular economy in Figure 1 is evaluated together with its environmental, economic, and social impacts. "Environmental impact" is environmental tax revenues and recycling rate of municipal waste, "social impact" is environmental tax revenues, circular economy-related private investments, occupations,

net added value, and patents for recycling, “economic impact” is environmental tax revenues, circular economy. Private investments related to the economy include trade in recyclable raw materials as well as occupations, net added value, and patents for recycling (Hysa et al., 2020).

There are serious differences between EU countries in terms of recycling, which is an important component of the circular economy. While the highest levels in terms of recycling rates are seen in Germany, recycling is considered an extremely new concept in countries such as “Romania, Malta, and Slovakia” (Ateş, 2021, p.130).

Efficient use of resources such as energy, water, and raw materials is aimed at efficiency in consumption and production processes. In this respect, recycling aims to reuse the wastes generated as a result of the production process in the most efficient way, to use them as inputs, and to prevent them from causing environmental problems. Recycling also saves energy. For this reason, recycling is accepted as a method that contributes to the economy and environmental protection. In summary, recycling creates new job opportunities, contributes to the country’s economy, and uses less energy and water. As a result, waste is prevented, awareness of savings is created, the environment and natural resources are protected, and climate change is prevented.

Recycling has become a necessity due to the rapid depletion of natural resources. According to the subject from a historical perspective, it is noteworthy that scrap metals are reused in the production of metal money and similar items by melting the helmets, swords, and various metal parts used by many civilizations in furnaces and pouring them into molds. The foundations of recycling are based on these activities.

In 1813, the production of pure cotton from idle textile products by Benjamin Law is one of the examples that can be given in this regard. Later, during the Second World War, it was understood how important recyclable materials were with the serious increase in the raw material problem. During this period, various advertisements and campaigns were made in Europe, and the public was asked to support their country by raising awareness about recycling. At the point we have reached today, waste materials collected for recycling are passed through a separation center and classified as plastic, glass, paper, etc. (Kozanlı, 2022, p.1).

As a result, recycling provides green economic growth for all countries of the world and creates employment (green-collar jobs) in this direction. In addition, recycling can revitalize the tourism industries of the countries and contribute to the foreign exchange reserves of the countries as a result of the attractiveness of a clean environment. However, considering the world in general, it is possible to indicate

that recycling is not widespread enough. Because only 30% of the waste generated in the world is recycled (Chamlin and Gaillochet, 2010, p.32).

LITERATURE REVIEW

Some philosophers call the 21st century the "recovery century" and this century's society the "recovery society." Therefore, in today's age and society, it is extremely important for countries that face economic difficulties and are in a development cycle to prevent waste of waste material to benefit from resources in the long term and with maximum effect. At this point, it is necessary for the countries concerned to research and analyze the issue in economic terms and to find the areas of use. The phenomenon of recovering and reusing (recycling) materials with economic value is a subject that needs to be investigated in the field of economics, as in many disciplines. Table 1 presents the applied literature on the circular economy and the factors affecting recycling.

Table 1: Applied literature on circular economy and factors affecting recycling

Author(s)	Method	Period, Country/Country Group	Finding(s)
Önder (2018)	Panel Data Analysis, Driscoll Kraay Estimator	2007-2012, OECD Countries	This study revealed that industrialization has an increasing effect on waste generation while urbanization has a decreasing effect.
Vuță, Vuță, Enciu & Cioacă (2018)	Panel Econometric Analysis	2005-2016, EU Member (28) Countries	In this study, it was concluded that there is a relationship between economic growth and resource efficiency, recycling rate of household waste, and expenditures on waste recycling and reuse.
Busu (2019)	Panel Data Analysis	2008-2017, EU Member (27) Countries	In the study, it was determined that the recycling rate has a positive effect on economic growth.
Apaydın (2020)	Panel Quantile Regression Analysis	2000-2017, OECD Countries	In the study, it was concluded that all forms of waste management affect economic growth positively.

Table 1: Applied literature on circular economy and factors affecting recycling

Author(s)	Method	Period, Country/Country Group	Finding(s)
Boubellouta and Kusch-Brandt (2020)	Panel Quantile Regression Analysis	2008-2018, 30 European Countries	In this study, it was found that population, energy intensity and credit to the private sector had an impact on the e-waste recycling rate and showed a negative trend.
Grdic, Krstinic & Rudan (2020)	Correlation and Regression Analysis	2008-2016, EU Member Countries	In the study, the circular economy reduces the use of natural resources, provides greater protection of the environment and increases economic growth (GDP).
Torasa and Mekhum (2020)	Panel Data Analysis	2000-2015, Association of Southeast Asian Nations (ASEAN) Countries	It has been determined that transportation and communication have a significant effect on the recycling rate of the selected economies in the models used in the study.
Amor and Hammami (2022)	Dynamic Panel Analysis with the OLS (Ordinary Least Squares)	2001–2020, 24 Tunisian Governorates	The empirical findings show that all exogenous variables except population density have a significant impact on the recycling rate.
Yorulmaz and Önder (2022)	Panel Data Analysis	2004-2017, 26 European Countries	Based on the findings of the study, it is concluded that the GDP variable has a positive effect on waste generation.

It is seen that applied studies are generally examined on per capita income level and various variables for recycling. As a result, the recycling issue, which becomes more important as time progresses, needs to be examined with an econometric approach. In this study, the panel data analysis method was used within the scope of econometric analysis. In the study, while the dependent variable was the circular economy index (private investments in circular economy sectors, occupations, net added value, and patents for recycling), the independent variables were the per capita GDP, trade openness rate, human capital index, and renewable energy consumption. In this context, the research hypothesis is, “Circular economy improves economic (GDP per capita, trade openness), social (human capital), and environmental (renewable energy consumption) quality.” formatted. This fiction reflects the original side and importance of the study by distinguishing it from other studies in the literature.

ECONOMETRIC ANALYSIS

Data set and model

In this study, for 15 EU member countries (Austria, Denmark, France, Netherlands, Latvia, Lithuania, Spain, Sweden, Italy, Hungary, Norway, Poland, Portugal, Romania, and Slovakia), the cyclical economy and the factors affecting recycling aimed to be examined from 2010 to 2019. In the study, while the circular economy index (private investments in circular economy sectors, occupations, net added value, and patents for recycling) is the dependent variable, per capita GDP (US$), trade openness rate, human capital index, and renewable energy consumption are determined as independent variables. Circular economy indicators are production and consumption (cei-pc), waste management (cei-wm), secondary raw materials (cei-srm), competitiveness and innovation (cei-cie). Country data used in the study were taken from World Bank (WB) and Penn World Table version 10.0 (PWT), and European Statistical Office (EUROSTAT) database. Table 2 gives information about the data set:

Table 2: Information on the data set of the research

Period: 2010-2019		
Dependent Variable		
Variable	**Symbol**	**Data Source**
Circular Economy Index	CEI	European Statistical Office (EUROSTAT)
Independent Variable		
GDP Per Capita	GSYH	World Bank (WB)
Renewable Energy Consumption	RNEW	World Bank (WB)
Human Capital Index	HCI	Penn World Table, version 10.0 (PWT)
Trade Openness Rate	TRD	World Bank (WB)

The regression relationship between the variables is established in the following equation:

$$CEI_{it} = \alpha_0 + \beta_1 LN(GDP)_{it} + \beta_2 LN(RNEW)_{it} + \beta_3 LN(HCI)_{it} + \beta_4 LN(TRD)_{it} + \mu_{it} \quad (1)$$

All variables in the study are included in the analysis by taking their logarithms. Here, “CEI” refers to the circular economy index (private investments in circular economy sectors, occupations, net added value, and patents for recycling). “GDP” represented the gross domestic product per capita, “RNEW” represented renewable energy consumption, “HCI” represented the human capital index, “TRD” represented the trade openness rate, and “μ_{it}” represented the error term.

Research methodology

Panel data analysis method was used in the study. This method makes it possible to analyze the unit and time dimensions together. For this reason, both larger data sets can be used, and more complex tests can

be applied compared to time series and cross-section analysis. Panel data analysis models can be defined as follows:

$$Y_{it}=\beta_0+ \beta_1 X_{it} +\mu_{it} \quad (2)$$

Here, the dependent variable is "Y," the parameters related to the variables are "β," the constant variable in the model is "β_0", and the independent variable that is thought to have an effect on the dependent variable is $\beta_1 X_{it}$. In addition, while the error term "μ_{it}" is represented, i=1…N and t=1…T constitute the unit and time dimension that includes the sample, respectively. Fixed Effects Driscoll-Kraay standard errors estimator was applied based on the relevant period for the country group determined in the analysis part of the study.

Driscoll and Kraay (1998) proposed a non-parametric covariance matrix estimator that produces consistent standard errors against heteroscedasticity and autocorrelation while being robust to both general spatial and temporal dependency patterns (Hoechle, 2007, p.282).

Research findings

The motivation of this study is to determine the factors affecting the circular economy and recycling for the period of 2010-2019 for 15 EU member countries. Stata 16 package program was used in the econometric analysis of this study, and the results of the analysis are given below.

Table 3: Descriptive statistics

Variable	Observation	Mean	Standard Deviation	Minimum	Maximum
LNCEI	150	7.854035	1.296833	5.291293	10.02632
LNGDPC	150	10.13454	.6451532	8.939358	11.23856
LNRNEW	150	3.053457	.6234028	1.348073	4.133084
LNHCI	150	1.172031	.0997308	.8591917	1.347823
LNTRD	150	4.575983	.3670611	3.951363	5.250694

Table 3 includes descriptive statistics for the variables used in the model. This table reported that observations (obs), mean (m), and standard deviation (sd), minimum (min), and maximum (max) values about the statistics.

Table 4: Correlation matrix

Correlation Matrix					
Variable	LNCEI	LNGDPC	LNRNEW	LNHCI	LNTRD
LNCEI	1.0000				
LNGDPC	0.5670	1.0000			
LNRNEW	0.2975	0.2443	1.0000		
LNHCI	0.0599	0.2589	0.0156	1.0000	
LNTRD	0.6866	0.3335	0.2250	0.4164	1.0000

Table 4 includes the correlation matrix for the variables used in the analysis. In Table 5, test results of varying variance, autocorrelation and inter-unit correlation were checked. While the Wald test and Wooldridge test are used to check whether the model contains autocorrelation and varying variance problems, the Pesaran CD Test is used to test whether there is a correlation between the units. The Breusch-Pagan Lagrange Multiplier (LM) test is used to test the existence of unit effects. The Hausman test allows to choose between fixed effect and random effect models by testing whether there is a relationship (correlation) between error terms and independent variables. Finally, the F test is used to decide the presence of unit and time effects in panel data models.

Table 5: Autocorrelation, varying variance, and ınter-unit correlation test results for the model

	Hypotheses	**Model**
Modified Wald Test	H_0: There is constant variance H_1: There is a variable variance problem	375.45 (0.000)*
Wooldridge Test	H_0: There is no autocorrelation H_1: There is autocorrelation	20.362 (0.002)*
Pesaran CD Test	H_0: There is no correlation between units H_1: There is correlation between units	22.825 (0.000)*
Breusch and Pagan Modified LM Test	H_0: There is no correlation between explanatory variables and unit effect H_1: There is a correlation between the explanatory variables and the unit effect	232.75 (0.000)*
Hausman Test	H_0: There is no correlation between explanatory variables and unit effect. H_1: There is a correlation between the explanatory variables and the unit effect.	56.59 (0.000)*
F Test	H_0: There are no individual and time effects. H_1: There are individual and time effects.	7.713 (0.000)*
Note: denotes 1% significance level.*		

It can be observed from Table 5 that the stability conditions of the model. According to the corrected Wald Test result, the H_0 hypothesis, which is based on the fact that there is no heteroskedasticity problem (constant variance), was rejected, and it was determined that there was a varying heteroskedasticity problem in this model. According to the Wooldridge Test results, the H_0 hypothesis, which was designed as no autocorrelation, was rejected, and it was determined that there was an autocorrelation problem in the model. According to the results of the Pesaran CD Test, the H_0 hypothesis that there is no correlation between units

was rejected. Thus, it was determined that there was a correlation between units. In addition, since the Breusch and Pagan LM Test probability values (0.000) were smaller than 5%, the H_0 hypothesis was rejected, revealing the existence of a correlation between the explanatory variables and the unit effect. For model selection, the F test and Hausman test were used, and according to both test results, the H_0 hypothesis was rejected ($p=0.000<0.05$), and it was determined that the fixed effects model was more appropriate.

As noted by Baltagi (2013), econometric procedures are applied differently for micro and macro panels. For macro panels where the T dimension is large, unit root, structural break, cointegration and etc. tests should be conducted against the stationarity problem. However, in micro panels where the size of T is fixed or short, there is no need to be concerned with the stationarity problem. In this study, the time dimension of the panel "T" (2010-2019) is not sufficiently large, so no stationarity test was performed as in Önder (2018)'s study "based on the 2007-2012 period interval".

Table 6: Circular economy and ıts determinants: Driscoll-Kraay fixed effects model forecast results

Dependent Variable: LNCEI				
Method: Driscoll-Kraay Fixed Effects Model				
Periyod: 2010-2019				
Number of Observations: 150				
Number of Delays: 2				
Independent Variables	**Coefficient**	**Driscoll-Kraay Standard Error**	**t-statistics Value**	**Probability Value**
LNGDPC	1.3270	0.1063	1.0865	0.000*
LNRNEW	0.1246	0.0871	0.3217	0.008*
LNHCI	3.1331	0.6614	0.3149	0.001*
LNTRD	0.5938	0.1721	0.9833	0.002*
Sabit	6.1692	0.9048	8.2161	0.000*
R^2: 0.8647			**Probability (f-statistics):** 0.000	
Note: denotes 1% significance level.*				

In Table 6, the fixed effects model estimation results of Driscoll-Kraay (1998), which can make effective and consistent estimations despite the varying variance, autocorrelation and inter-unit correlation problems in model estimations investigating the relationships between variables, are investigated. According to the results of the Driscoll-Kraay estimator, the ratio of the independent variables used in the model to explain the changes in the dependent variable was calculated as approximately 86%. According to the estimation results, it has been determined that there is a statistically significant and positive relationship between GDP per capita and the circular economy index. This finding is supported by the study conducted by Grdic et al. (2020). In addition, a statistically significant and positive relationship was found between the human capital index, renewable energy consumption, trade openness, and the circular economy index.

As a result, the independent variable that statistically significant and positive relationship between circular economy index are GDP per capita, human capital, renewable energy consumption, trade openness for 15 EU member countries (Austria, Denmark, France, Netherlands, Latvia, Lithuania, Spain, Sweden, Italy, Hungary, Norway, Poland, Portugal, Romania, and Slovakia) in the period of 2010-2019.

CONCLUSION

In the current era, the traditional economic model has become inadequate in the face of global resource limitations, climate change, and rapid population growth. Therefore, it was necessary to develop a new economy (circular economy), especially in terms of environmental sustainability.

The circular economy is aimed at preventing waste and making them recyclable, thus enabling more efficient and less resource use. Therefore, this economic model is primarily focused on raw material cycles and the energy of renewable resources. The recycling process, which is a part of the circular economy, is carried out by converting the wastes from the materials consumed by people into new raw materials with some physical and chemical processes and reusing them for production. The circular economy, recycling phenomenon is extremely important for the world of today and future generations. In this context, circular economy, recycling has become a subject that needs to be examined in the economic field, as in many disciplines.

This study aims to determine the factors affecting the circular economy, recycling in the period 2010-2019 for 15 EU member states (Austria, Denmark, France, Netherlands, Latvia, Lithuania, Spain, Sweden, Italy, Hungary, Norway, Poland, Portugal, Romania, Slovakia) with using the panel data analysis method. In the study, while the dependent variable was the circular economy index (private investments in circular economy sectors, occupations, net added value, and patents for recycling), the independent variables were GDP per capita, trade openness rate, human capital index, and renewable energy consumption. In this context, the research hypothesis is, “Circular economy improves economic (GDP per capita, trade openness), social (human capital), and environmental (renewable energy consumption) quality.” formatted.

In the analysis of the study, first of all, autocorrelation, varying variance, and inter-unit correlation test results were checked. As a result of the tests, the fixed effects model was determined as the most suitable model for the determined country group, and it was determined that there was a problem of varying variance, autocorrelation, and correlation between units in the established model. According to the estimation results of the fixed effects model of Driscoll-Kraay (1998), which can make effective and consistent estimations despite the problems of varying variance, autocorrelation, and inter-unit correlation in model estimations

investigating the relationships between variables, there is a statistically significant and positive correlation between GDP per capita and the circular economy index. In addition, a statistically significant and positive relationship was found between the human capital index, renewable energy consumption, trade openness, and the circular economy index. In addition, the ratio of the independent variables used in the model to explain the changes in the dependent variable was calculated as approximately 86%.

As a result, the problem of excessive resource consumption and pollution does not belong only to a period or a country but also affects a long-term process and a global area. Today, this excessive resource consumption and pollution problem have reached a level that can cause serious damage to human health. Therefore, countries have tried to determine policies to prevent this problem. Policy recommendations for the findings of the study are presented below:

The traditional economy in the form of “take-use-dispose” should be replaced by circular economy practices that focus on service delivery rather than products in the form of “repair-reuse-recycle.” All countries must act in cooperation to protect the world. For this reason, the concept of circular economy and recycling should be spread to all countries of the world and should be given importance. In addition, international organizations should be established for the transition to a circular economy, and economic incentives and aid should be increased in this direction.

To ensure economic growth in the countries, post-consumption wastes should be added to the product production as raw materials. At this point, the promotion of recycling as a part of the circular economy is of great importance. In this direction, the public should be made aware and educated. In addition, investments, expenditures, and incentives should be increased to increase recycling rates. In this context, it is necessary to get support from international organizations. As a matter of fact, in the context of environmental sustainability, it is extremely important to make investments in environmentally friendly technologies for a green life under the blue sky, to decarbonize the energy sector, and to achieve targets such as increasing energy efficiency in buildings.

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