CIRKULAR ECONOMY AND ITS CHALLENGES

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Abstract: The primary objective of this article is to assess the impact of increased investments in the circular economy on municipal waste generation and recycling rates in the EU27 countries. The article is structured into two main sections. The first section explores the historical development and theoretical foundations of the circular economy with a particular focus on the role of private investments in this advancement. The second section presents the findings of an empirical analysis. In the introduction, this study examines the trends in key statistical indicators of the circular economy, specifically highlighting private investments in the circular economy, the municipal waste recycling rate and the generation of municipal waste. The second section investigates the relationship between private investments in the circular economy and the recycling rate of municipal waste as well as the relationship between these investments and municipal waste generation in the EU27 countries. The analysis covers the period from 2012 to 2020, chosen to ensure a balanced dataset. The study employs fixed effects model and a random effects model for panel data analysis. The findings reveal a statistically significant positive impact of private investments in the circular economy on the recycling rate of municipal waste. Differences were observed between groups of countries based on their annual investment growth rates. However, the anticipated effect of increased investments in the circular economy on reducing municipal waste generation was not confirmed. The data for empirical analysis was sourced from Eurostat, and calculations performed using the Gretl software.

Keywords: circular economy, investments, municipal waste, panel data, recycling rate.

1 Introduction

In 2023, the EU´s circularity rate was 11.8%, slightly up compared with the previous year and 3.6 percentage points up from to 2004, the first year for which data are available (Eurostat, 2024). Despite the increase, the value of 11.8% is still low, indicating that the majority of materials used in the EU come from primary sources (European Commission, 2023). The material circularity rate, an important indicator of the circular economy, reflects the extent to which the economy uses recycled materials and reduces the consumption of primary raw materials. The upward trend in its development is encouraging, though the slow pace of growth remains a concern. From 2014 to 2023, the average annual growth rate was just 0.68%. Global consumption of materials such as biomass, fossil fuels, metals and minerals projected to double over the next four decades OECD, 2019), while annual waste production is projected to rise by 70% by 2050 (Kaza et al., 2018). To achieve its climate and environmental targets by 2030, such as doubling the circularity rate to approximately 23%, the EU must implement additional fundamental measures.

The European Commission adopted the first Circular Economy Action Plan (CEAP) in December 2015. Four years later, the European Green Deal was adopted. The European Green Deal established a common strategy for a climate-neutral and competitive economy (European Commission, 2019**)**. It states that the EU must accelerate the transition to a regenerative growth model, which is an essential part of the EU's new industrial strategy. The new CEAP was adopted in March 2020. According to the European Green Deal, the EU's transition to a circular economy will slleviate pressure on natural resources, foster sustainable growth and generate new jobs. It is essential for achieving the EU's goal of climate neutrality by 2050 and stopping biodiversity loss (European Commission, 2020)**.**

The concept of a circular economy (CE) is built on the following principles: optimizing the use of limited resources for maximum efficiency, prioritizing the utilization of renewable resources, recovering materials at the end of their life cycle, and restoring natural ecosystems. (Lewandowski, 2016). This concept aligns with the EU's new Circular Economy Action Plan and the European Green Deal. A more comprehensive explanation of this concept is outlined in the Bellagio Declaration in 2020, endorsed by several European countries, including Germany, France, Slovakia, Switzerland, the Netherlands, Austria and Italy, Bellagio outlines seven fundamental principles for an effective transition to a circular economy (EEA, 2020).

The European Commission is implementing legislative and non-legislative measures focused on areas where EU-level action can deliver significant added value. The new Action Plan aim to establish sustainable products as the standard in the EU, empower consumers and public buyers, reduce waste, promote circularity across people, regions and cities, and drive the global transition to a circular economy.

2 Theoretical background

The circular economy is based on three principles: a) design production to minimize waste and pollution, b) extend the lifespan of products and materials through repair, recycling, and reuse, and c) regenerate natural systems and reduce their environmental impact (Ellen MacArthur Foundation, 2013). The goal of the circular economy is to preserve the value of products, materials, and resources for as long as possible by reintegrating them to the production cycle after their use, while minimizing waste. (Le Hesran et al., 2020).

The cornerstone of progress in the field of circular economy lies in the efforts of Pearce and Turner (1989), who laid groundwork for the circular economy within the framework of natural resources and environmental economics. Their work combines a theoretical framework with practical insights, offering a robust foundation for understanding the economic aspects of environmental policy. This work established the foundations upon which other authors have built. For example, Jackson (1996) in his book "Prosperity without Growth: Foundations for the Economy of Tomorrow" emphasizes that environmental problems such as biodiversity loss, water, air and soil pollution, resource depletion and overuse of land are increasingly threatening the systems that support life on Earth. This approach further develops the idea of the circular economy and its connection to sustainable development. Kinnaman and Fullerton (1999) provide an overview of the latest trends in solid waste and recycling, as well as related public policy issues. Their work plays a significant role in the broader discussion on the circular economy and its practical implementation.

In 2015, the Ellen MacArthur Foundation introduced the Circular Economy Principle (CEP) to transition the traditional linear economy towards a circular economy model (Ellen MacArthur Foundation, 2013). This approach was elaborated in the foundation's work "Towards the circular economy Vol. 1: An economic and business rationale for an accelerated transition." (Ellen MacArthur Foundation, 2013).

Lewandowski (2016) proposed a new business model for the circular economy, which includes nine building blocks. The transition from the current linear economic model to a circular one has recently attracted increased attention from large global companies such as Google, Unilever, Renault, and policymakers attending the World Economic Forum. The motivation lies in the substantial financial, social and environmental benefits (Lewandowski, 2016). The integration of circular economy principles into the value chains across various economic sectors is gaining significance, as highlighted by numerous studies and research, including the work of Ávila-Gutiérrez et al.(2019). Yamamoto & Eva (2022) define a circular economy as an economy based on the 3R principle: 1. reduce, 2. reuse and 3. reccle. These definitions and approaches enhance the understanding and promote the implementation of the circular economy.

Tracking the circular economy indicators, including waste generation, utilization and proper management is crucial for sustainable development. The core concept of the circular economy revolves around waste minimization (López Ruiz et al., 2020; Popovic et al., 2022). Various studies, such as those by Cagno (2012), Cooper (2017), and Geissdoerfer *et al. (2017) have explored* the issues related to waste elimination and processing, as well as the adoption of new technologies to enhance waste processing. *Alongside waste minimization, improving the efficiency of waste collection and processing is another critical solution* (Gutierrez et al., 2015; Goutam Mukherjee et al., 2021). Podľa Lohri et al. (2013) ensuring the financial sustainability of solid waste management remains a significant challenge for cities in developing countries. Ferronato et al. (2019) addresses the issue of solid waste management in these urban areas.

In 2023, the European Commission updated the Circular Economy Monitoring Framework originally adopted in 2018. It monitors circular economy indicators in five areas: production and consumption, waste management, secondary raw materials, competitiveness and innovation, and global sustainability and resilience **(**European Commission, 2023**).** The monitored areas and circular economy indicators in the Eurostat database are listed in the table 1.

Tab.1: Areas and indicators of the circular economy reported in Eurostat

Area	**Indicators**
Production and consumption	Material footprint
	Resource productivity
	Waste generation per capita
	Generation of waste excluding major mineral wastes per GDP unit
	Generation of municipal waste per capita
	Food waste
	Generation of packaging waste per capita
	Generation of plastic packaging waste per capita
Waste management	Recycling rate of municipal waste
	Recycling rate of all waste excluding major mineral waste
	Recycling rate of packaging waste by type of packaging
	Recycling rate of waste of electrical and electronic equipment (WEEE) separately collected
Secondary raw materials	Circular material use rate
	Contribution of recycled materials to raw materials demand – end-of-life recycling input rates (EOL-RIR)
	Trade in recyclable raw materials
Competitiveness and innovation	Private investment and gross added value related to circular economy sectors
	Persons employed in circular economy sectors
	Patents related to recycling and secondary raw materials
Global sustainability and resilience	Consumption footprint
	Greenhouse gases emissions from production activities
	Material import dependency
	EU self-sufficiency for raw materials

Source: *European Commission, 2023*

This study explores the indicators generation of municipal waste per capita (area production and consumption), the recycling rate of municipal waste (area waste management) a private investment and gross added value related to circular economy sectors (area competitiveness and innovation).

Municipal waste generation is influenced by several factors. Demographic factors encompass elements such as population size, population density and the age distribution of individuals within a community or region. Economic factors also play a role, such as higher living standards leading to increased waste generation, household incomes affecting the consumption of semi-finished food products, and the more frequent replacement of durable consumer products. (Fullerton & Kinnaman, 1995). Technological factors are crucial, particularly regarding e-waste management and advancements in production methods (Ghisellini et al., 2018). *Social and cultural factors, such as of the population´s education level, significantly impact waste management. Higher education levels are associated with increased rates of waste sorting and recycling. Conversely, in marginalized communities, social exclusion and limited access to infrastructure contribute to inefficient waste management practices and the development of illegal landfills* (Dokoupilová et al., 2022). The generation and recycling of municipal waste can be governed by laws and legislative regulations. Equally important is fostering environmental awareness among the population to encourage waste reduction and promote recycling. By combining effective planning, robust legislation and public education, society can significantly decrease the overall volume of municipal waste and mitigate its environmental impact.

3 Sources of private investment for the introduction of the circular economy

The implementation of circular activities requires the mobilization of various financial resources to support the transition to a circular economy. Collaboration among the public, private and non-profit sectors is essential for optimizing the use of available resources and ensuring the successful implementation of circular initiatives. The availability of funds, the quality of companies' financial resources and access to public subsidies positively influence the adoption and implementation of circular economy initiatives within enterprises. (Aranda-Usón et al., 2019). Investments can support this philosophy by funding innovations in areas such as recycling, renewable energy and resource efficiency. (EEA, 2024).

Targeted financing for circular activities is rapidly gaining traction around the world. Capital-rich organizations are testing creative ways to finance circular strategies in debt capital markets. For example, fashion retailer H&M Group issued a €500 million sustainability bond in February that ties pricing to everal of the company's 2025 goals, including increasing the share of recycled materials used in its products to 30%. With less than 1% of the materials used to make clothing globally currently recycled into new clothes, this commitment could be an unprecedented step towards a circular economy in fashion if achieved.

Total assets under management through public equity funds dedicated solely or partially to the circular economy have grown more than 25-fold in just a year and a half, from $300 million at the beginning of 2020 to $8 billion by the end of June 2021. BlackRock's BlackRock Circular Economy Fund 2 reached $2 billion in assets under management in June 2024, reflecting the explosive growth in the sector (BlackRock, 2024). The fund invests at least 80% of its total assets in equity securities of companies worldwide that benefit from the development of the "circular economy" or contribute to environmental or social objectives. (De Smet, 2024).

European Investment Bank (EIB). From 2019 to 2023, the EIB provided EUR 3.83 billion to co-finance 132 circular economy projects in various sectors (EIB, 2024). In addition to capital, the EIB provides financial and technical advisory support to improve the bankability and investment readiness of circular economy projects. Together with the European Investment Advisory Hub, they launched the Circular City Financing Guide website and the Circular City Centre – C3 (EIB & EC, n. d.), a competence and resource centre within the EIB aimed at supporting EU cities in their transition to a circular economy. The EIB is also an active member of the Multilateral Development Bank (MDB) Circular Economy Working Group, together with the African Development Bank, the Asian Development Bank, the European Bank for Reconstruction and Development, the Inter-American Development Bank, the International Finance Corporation, and the World Bank. The World Bank is actively involved in investing in projects and initiatives that lead to sustainable development, including

the circular economy (Al-Hagla, 2024). Its aim is to ensure that investments provided to governments contribute to protecting people and the environment from possible negative impacts.

Specialized banking products designed to promote the development of the circular economy are increasingly emerging in the financial market. Intesa Sanpaolo has established a €6 billion loan facility to support circular activities, while ABN Amro facilitated nearly €850 million in circular economy transactions between early 2019 to the end of 2020 (Lawlor & Spratt, 2020). Additionally, several companies are now linking debt financing to circular economy key performance indicators (KPIs). For example, AB InBev's $10 billion revolving credit facility incorporates terms tied to the use of recycled materials in its primary packaging (Abbott et al., 2021).

Analysing the level of private investment in the circular economy and its influence on waste reduction is crucial for assessing the private sector´s role in driving the ecological transition. Private investment plays a crucial role in funding technological advancements, innovations and processes that support the circular economy, such as advanced recycling systems, eco-design and digital platforms. It often serves as a valuable complement to public funding. Investments in recycling infrastructure and waste collection systems increase the share of recycled materials and reduce the amount of waste that ends up in landfills or incinerators. Private investments can support educational campaigns aimed at encouraging sustainable consumer behaviour. A low level of private investment hinders the implementation of circular measures, leading to slower progress and sustained high levels of waste. Investments must be effective to achieve waste reduction targets. A supportive regulatory environment and legislative framework are also crucial. Given the assumption that private investment influences the amount of waste generated, four research on European Union countries to analyse the impact of private investment on waste generation. Analysing private investment enables us to assess the significance of the private sector´ contribution to achieving circular economy goals. Furthermore, we investigated how the level of private investment in the circular economy impacts municipal waste recycling rates.

Tab. 2: Estimated investment in the circular economy in mill. $

Organization	Value (MUSD)	Unit/sector
McKinsey	$2,140,000	Whole economy
World Economic Forum	$5,350,000	Whole economy
World Economic Forum	$340,000 - 380,000	
Closed Loop Partners and Closed Loop Foundation	$2,000,000	Manufacturing
Closed Loop Partners and Closed Loop Foundation	$7,000	Recycling
Danish Ministry of Environment and Food	$713 – 1,740	Savings on raw materials and manufactured goods
McKinsey	$2,140,000	Whole economy
Accenture	$25,000,000	Whole economy
Veolia	$1,960	Whole economy
Circular Fashion Report	$5,000,000	Fashion
PS consulting	$12,000,000	Plastics
Ellen MacArthur Foundation	$1,180,000	Whole economy
ESA, 2013	$14,000	Whole economy
TNO, 2013	$8,680	Whole economy
TNO, 2013	$1,000 per year	Waste
European Commission	$1,100	Waste
European Commission	$32,000	Paper and cardboard
McKinsey (2011)	$145,000	Iron and steel efficiency
McKinsey (2011)	$132,000	Steel efficiency
European Commission	$1,720	Mobile phone
European Commission	$1,730	Light commercial vehicles
WRAP	$385,000 by 2023	Resource efficiency initiatives
WRAP	$99,000 by 2030	Resource efficiency initiatives
C&A Consulting	$51,000 by 2023	Fashion resale market
C&A Consulting	$2,000	Fashion resale market
Ellen MacArthur Foundation	$605,000	FMLG
Ellen MacArthur Foundation	$10,000,000	Whole economy

Source: (Lawlor & Spratt, 2021)

Table 2 provides an estimate of the investment levels in Central Europe, offering an annual assessment of the circular economy´s scale, which was estimated to account for 8.6% of the total economy in 2021 (down from 9% in 2020).

Many of these estimates lack coherence, with one sector´s contribution in certain estimates exceeding the economy-wide contribution in others. This inconsistency likely stems from varying methodologies and assumptions, as well as a lack of uniform definitions. These estimates primarily focus on investments and potential material cost savings, while often overlooking the costs associated with implementing circular solutions.

4 Data and methods

The main objectives of this study were:

1. to explore the theoretical foundations and historical evolution of the circular economy with specific focus on private investments in the circular economy,
2. to examine the relationship between the level of private investment in the circular economy and the recycling rate of municipal waste in the EU27 countries,
3. to examine the relationship between the level of private investment in the circular economy and municipal waste generation in the EU27 countries.

The analyses were based on data from the Eurostat database on circular economy indicators: private investment and gross added value related to circular economy sectors (cei_cie012) (hereinafter referred to as private investment in the circular economy), waste generation per capita (cei_pc034) a recycling rate of municipal waste (cei_wm011) in the period 2000–2021 in EU countries 27 (UK was not included).

The following research hypotheses were established to evaluate the research:

H_1: There is a statistically significant positive relationship between the amount of private investment in the circular economy and the recycling rate of municipal waste.
H_2: The growth rate of private investment in the circular economy determines the strength of its impact on the rate of municipal recycling rate.
H_3: There is a statistically significant negative relationship between the amount of private investment in the circular economy and municipal waste generation.

We used descriptive time series analysis and panel data models in our analyses. The choice of time period was determined by data availability and the purpose of the analysis. The panel data analysis was performed for all EU27 countries from 2012 to 2020. We used two panel data models: a fixed effects model and a random effects model.

Models built on panel data can generally have different shapes. They differ in the coefficients of the cross-sectional or time component. These can be constant for all countries or time periods, or they can differ from each other in both the time and spatial components.

The basic panel data model has the form:

$$y_{it} = \beta_0 + \beta_1 x_{it1} + \beta_2 x_{it2} + \cdots + \beta_k x_{itk} + \alpha_1 z_{i1} + \alpha_2 z_{i2} + \cdots \alpha_q z_{iq} + \varepsilon_{it} \quad (1)$$

Where: i = 1, 2, ..., n denotes cross-sectional unit, t = 1, 2, ..., T denotes time, X_1, ...X_k are explanatory variables, Z_1, ... Z_k are individual effects that characterize individual countries and are invariant over time, εit represents a random component with zero mean and constant variance.

If we allow different countries' response to changes in explanatory variables, then individual cross-sectional units would also differ in the values of coefficients β, and equation (1) would have the form:

$$y_{it} = \beta_0 + \beta_{1i}x_{it1} + \beta_{2i}x_{it2} + \cdots + \beta_{ki}x_{itk} + \alpha_1 z_{i1} + \alpha_2 z_{i2} + \cdots \alpha_q z_{iq} + \varepsilon_{it} \quad (2)$$

The Fixed Effects Model (FEM) assumes that the individual effects Z_1 to Z_k are unobservable and at the same time correlated with the explanatory variables. The model has the form:

$$y_{it} = \beta_0 + \beta_1 x_{it1} + \beta_2 x_{it2} + \cdots + \beta_k x_{itk} + \varepsilon_{it} \quad (3)$$

The Random Effects Model (REM) contains a composite random component γ_{it}, in which the random component of a particular observation in the *i*-th cross-sectional unit uit and the random component specific to the *i*-th cross-sectional unit are combined:

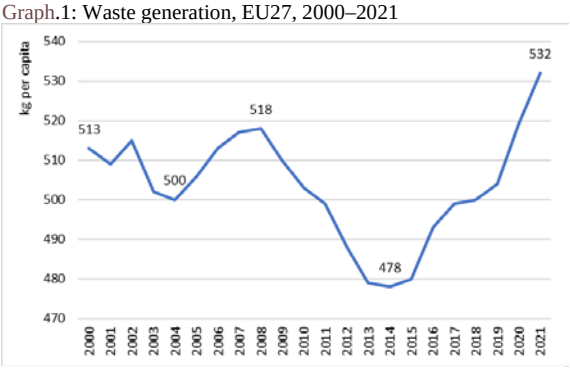
$$y_{it} = \beta_0 + \beta_1 x_{it1} + \beta_2 x_{it2} + \cdots + \beta_k x_{itk} + \gamma_{it} \quad (4)$$

We used Hausman's test to determine if a fixed-effects (FEM) or random-effects (REM) model better fits our panel data. Under the null hypothesis, REM model are preferred due to higher efficiency, while under the alternative hypothesis FEM model are at least as consistent and thus preferred (Baltagi, 2014).

4 Results

The amount of municipal waste generated in the EU 27 has increased by 19 kg per person/year over the past 22 years (2000–2021). Its development can be positively assessed by the downward trend in the years 2008 to 2014, when its total volume decreased by 40 kg per person. The average annual rate of decrease in this period was 98.67%, which in absolute terms is a decrease of 6.67 kg per person per year. This positive trend changed to the opposite in 2014 and continued until 2021 (an increase of 54 kg per capita). The acceleration of the growth of municipal waste was faster than its decrease in the previous period. The average growth rate in this period was at the level of 1.54% (7.71 kg per capita per year) (Graph 1).

Graph.1: Waste generation, EU27, 2000–2021



Source: Eurostat [cei_pc034], own processing

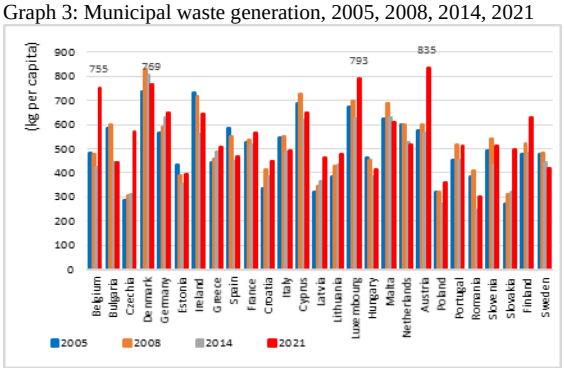
Private investment in the circular economy also grew during the period of increasing municipal waste generation (2016–2020) (Graph 2). In 2014, when the largest decrease in municipal waste generation was recorded, there was the largest year-on-year increase in private investment in the circular economy (by 0.3% of GDP), followed by an equally sharp decline in the following year (Graph 2).

Graph 2: Private investment and gross added value related to circular economy sectors, EU27, 2005–2021

Source: Eurostat [cei_cie012], own processing

The situation in individual EU27 countries reflects spatial variability, manifested both in the volume of municipal waste generated (Graph 3) and in the amount of private investment in waste management (Graph 4).

Graph 3: Municipal waste generation, 2005, 2008, 2014, 2021

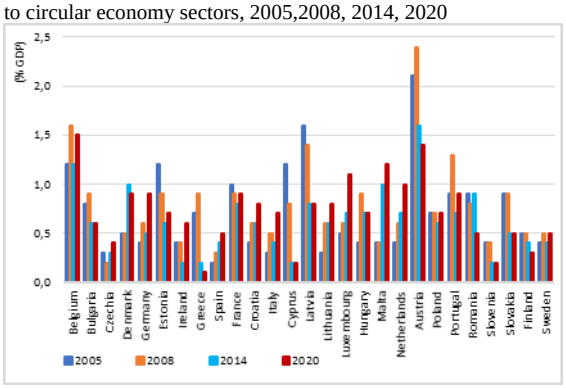


Source: Eurostat [cei_pc034], own processing

In 2021, Austria (835 kg per capita), Luxembourg (793 kg per capita), Denmark (769 kg per capita) and Belgium (755 kg per capita) generated the most municipal waste. In 2005, these were Denmark (736 kg per capita), Ireland (731 kg per capita), Cyprus (688 kg per capita) and Luxembourg (672 kg per capita). Romania (302 kg per capita), Poland (362 kg per capita) and Estonia (395 kg per capita) were the countries that generated the least municipal waste in 2021. Changes in municipal waste generation in individual countries are reflected in the average growth rate of this indicator. During the period of increasing acceleration of municipal waste generation (2014–2021), its volume, expressed as an average annual growth rate, grew fastest in the countries of Czechia (9.09%), Belgium (8.56%), Slovakia (6.49%), Austria (5.74%), Poland (4.17%) and Finland (3.90%). On the other hand, there are countries where this process slowed down significantly. The average growth rate was negative in Sweden (-0.83%), Denmark (-0.70%), Malta (-0.39%) and the Netherlands (-0.33%). In the years 2008–2014, when the trend of municipal waste generation at the EU27 level was decreasing, its volume decreased fastest in Romania (-8.01%), Bulgaria (-4.94%) and Ireland (-4.00%). The opposite trend, although not significant, was recorded in Germany, Greece, Lithuania, Czechia, Slovakia and Latvia.

The positive impact of investments in the circular economy, which increased from 0.7% of GDP in 2015 to 0.9% of GDP in 2020, on the amount of municipal waste generated has not been evident. We expected that increasing investments in the circular economy would affect reducing the volume on reducing the volume of municipal waste generated. As examples of countries for which this relationship does not apply, we cite Austria, Belgium and Poland. Austria and Belgium are among the countries with the highest municipal waste generation, while investing the most in the circular economy. Poland is a country with low investment to the circular economy, but also to the low volume of municipal waste (Graph 4).

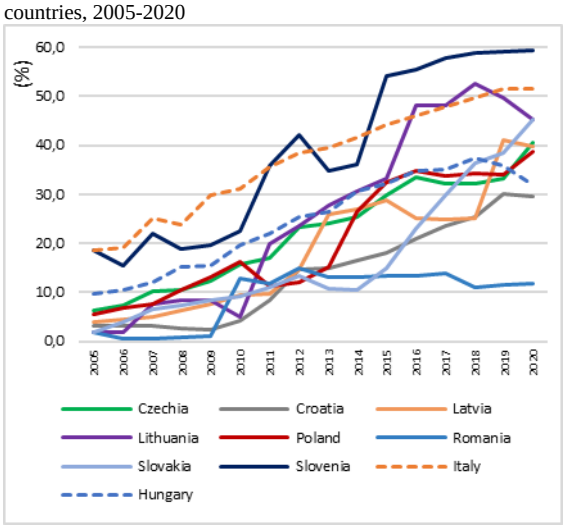
Graph 4: Private investment and gross added value related to circular economy sectors, 2005,2008, 2014, 2020



Source: Eurostat, [cei_cie012], own processing

The trend in the development of municipal waste recycling rates is increasing, which is a positive phenomenon. Between 2005 and 2020, the recycling rate, which expresses the share of recycled municipal waste in the total municipal waste generation (in %), in the EU27 countries increased by almost 1.5 times from 32.5% to 48.7%. It increased annually during this period by an average of 1.03 times. It grew the fastest in the countries that joined the EU in 2004: Italy, Slovenia, Hungary, Cyprus, Czechia, Romania, Poland, Croatia, Latvia, Slovakia and Lithuania. The average annual growth rate in these countries ranged from 1.08 (Italy) to 1.24 (Lithuania) (Graph 5).

Graph 5 Recycling rate of municipal waste, selected EU27 countries, 2005-2020



Source: Eurostat [cei_wm011], own processing

Sweden, Belgium, Austria, Denmark, and Germany are the countries in which the average growth rate of this indicator was negative, or did not exceed 1%. In the rest of the countries, it ranged between 1.21% (Malta) and 4.46% (Bulgaria).

In the next part, we verified the validity of the formulated hypotheses. We used a fixed and random effects model for panel data. The cross-sectional component consisted of 27 EU countries; the time component was from 2012 to 2020. We used Hausman's test to determine if a FEM model or REM model better fits our panel data.

H1: There is a statistically significant positive relationship between the amount of private investment in the circular economy and the recycling rate of municipal waste.

RE model confirmed a statistically significant impact of the amount of investment in the circular economy (INVEST) on the recycling rate (Tab.3).

Tab. 3: Random Effects Model (Dependent variable: Recycling rate of municipal waste), EU27 countries

coefficient		std. error	t-ratio	p-value
const	27.0644	3.56282	7.596	3.05e-014***
INVEST	13.2877	3.86444	3.438	0,0006***

Source: own processing in Gretl

H2: The growth rate of private investments in the circular economy determines the strength of its impact on the rate of municipal waste recycling.

Based on the results of the descriptive analysis (investment growth rates), we divided the countries into three groups: Model 1 (growth rate 1.08 – 1.24), Model 2 (growth rate 1.01 – 1.04), Model 3 (growth rate 0.99 – 1.01).

The results of all three random effects models are in tab. 4.

Tab. 4: Random Effects Model (Dependent variable: Recycling rate of municipal waste), groups of countries

Model 1	**Italy, Slovenia, Hungary, Cyprus, Czechia, Romania, Poland, Croatia, Latvia, Slovakia and Lithuania**			
coefficient		std. error	t-ratio	p-value
const	15.2190	3.77978	4.026	5.66e-05 ***
INVEST	26.8998	5.52270	4.871	1.11e-06 ***
Model 2	**Malta, Luxembourg, Netherlands, Spain, Finland, Estonia, Ireland, France, Greece, Portugal, and Bulgaria**			
coefficient		std. error	t-ratio	p-value
const	32.5542	3.50239	9.295	3.05e-014 ***
INVEST	1.46191	4.35053	0,3360	0.7368
Model 3	**Sweden, Belgium, Austria, Denmark, and Germany**			
coefficient		std. error	t-ratio	p-value
const	52.9847	2.61276	20.28	1.96e-091 ***
INVEST	1.30452	2.15982	0.6040	0.5458

Source: own processing in Gretl

Compared to the results for the entire panel, the impact of the amount of investment in the circular economy on the recycling rate is significantly higher in the group of countries with a high annual growth rate of investment. In the remaining two groups of countries (Model 2, Model 3), the recycling rate did not change statistically significantly with the growth of investment.

H3: There is a statistically significant negative relationship between the amount of private investment in the circular economy and municipal waste generation.

An analysis of the development of municipal waste and investments in the circular economy in the EU27 countries shows significant spatial and temporal differences in both indicators. The average growth rate of municipal waste in the period 2016-2020 was 1.54%, with countries such as Austria, Luxembourg, Denmark and Belgium generating the most waste per capita (Graph 1, Graph 3). Paradoxically, these countries are also characterized by the highest investments in the circular economy, which suggests that the amount of investment may not have directly affected the reduction of municipal waste generation, at least not in the short term. Private investments in the circular economy grew in the monitored period, especially between 2016 and 2020, when they increased by 0.3% of GDP year-on-year (Graph 2). Despite this growth, the expected impact of investments on waste reduction at the EU27 level has not yet been achieved, which may indicate the long-term nature of the return on these investments.

Even the results of panel data models (RE model) did not confirm the validity of hypothesis **H3.** On the contrary, with the increasing volume of private investments in the circular

economy, the volume of generated municipal waste also increases. (Tab. 5).

Tab. 5: Random Effects Model (Dependent variable: Municipal waste), EU27 countries

coefficient		std. error	t-ratio	p-value
const	459.315	27.8223	16.51	3.17e-061***
INVEST	49.4798	21.1737	2.337	0.0194***

Source: own processing in Gretl

5 Conclusion

To meet the challenges of today and ensure sustainable development, it is essential to transform the linear economic model into a circular, cyclical model. This model is characterized by the efficient use of resources, the recovery of materials, products and their components, as well as the practices of sharing, renting, reusing, repairing, renovating and recycling. Its aim is to extend the life cycle of products and minimize the amount of waste.

Recycling, and in particular municipal waste recycling, has become a key issue in implementing the principles of the circular economy. The availability of finance, the quality of companies owns financial resources, as well as public subsidies play a crucial role in stimulating circular economy initiatives in enterprises (Aranda-Usón et al., 2019). Investments can contribute to the development of the circular economy by inancing innovations in areas such as recycling, renewable energy sources and resource efficiency (EEA, 2024).

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In this paper, we present the results of an analysis of three key indicators of the circular economy: the amount of private investment in the circular economy, the rate of municipal waste recycling, and the generation of municipal waste. We conducted the analysis on data for 27 EU countries from 2012 to 2020. We found that increasing private investment in the circular economy statistically significantly increases the rate of municipal waste recycling, which is a positive phenomenon. However, their increase did not produce the desired effect of gradually reducing the volume of municipal waste.

The application of the principles of the circular economy is essential for achieving the goals of sustainable development in the EU countries. In accordance with these goals, it is necessary to increase the efficiency of resource use, introduce innovations and improve the quality of the entire process of waste management. All changes need to be implemented taking into account the differences between individual countries.

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Primary Paper Section: A

Secondary Paper Section: AH