Circular Economy in the EU- Correlation between the Tertiary Education Attainment and Recycling Rate of Municipal Waste

GEORGE-CORNEL DUMITRESCU
The Institute for World Economy, The Romanian Academy
Calea 13 Septembrie nr. 13, Sector 5, Bucureşti
ROMANIA
george.dumitrescu@iem.ro http://www.iem.ro

Abstract: The new coronavirus crisis revealed the weaknesses of our linear economic model, particularly the overdependence on long supply chains and specific countries. In this new context, the circular economy and the principles of reducing, reusing, and recycling are getting new meanings, forcing the decision-makers into adopting new ways of achieving economic sustainability. In our paper, we investigate if, in the EU, there is any correlation between the tertiary education attainment and the recycling rate of municipal waste. We aim to emphasize that higher education is essential in the transition towards the circular economy. To this end, we used the database of Eurostat and several statistical tools.

Key-Words: - circular economy, waste, education, correlation, sustainability
JEL Classification: C12, O13, Q57

1 Introduction

On the official website of the European Commission, under Internal Market, Industry, Entrepreneurship and SMEs, there is a page dedicated to critical raw materials that are crucial for Europe's economy and are produced and supplied by non-EU countries. For example, China accounts for 62% of the supply of critical raw materials to the EU (e.g. rare earth elements, magnesium, antimony, natural graphite) Other major providers of such materials are the Russian Federation for palladium, the Democratic Republic of Congo for cobalt, the USA for beryllium, Brazil for Niobium, South Africa for iridium and other materials (European Commission, 2020). The EU decision-makers emphasise, thus, the risks associated with the concentration of production in specific countries and became increasingly aware of the necessity of reducing, reusing and recycling as a new normal, especially in the crisis generated by the new coronavirus.

The circular economy is:" a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended" (European Parliament, 2018). In this light, recycling is the last, but not the least component of the circular economy model, to which we are somehow familiar from the communist "golden age".

The recycling rate of municipal waste, one of the two indicators analysed in this paper, measures how waste from final consumers is used as a resource in the circular economy, providing a good indication of the quality of the overall waste management system (Eurostat, 2020a).

According to the statistical office of the European Union, tertiary education[1], the other considered indicator, covers short-cycle tertiary education, bachelor's or equivalent level, master's or equivalent level, doctoral or equivalent level (Eurostat, 2020).

OECD experts have found that 60%, or more, of growth in the gross domestic product, is generated by those who have attained tertiary education. They also emphasise that investing in tertiary education is associated with net returns of more than 60% larger than those linked to upper secondary education (OECD, 2012). Ergo, the quality of highly skilled human capital is critical for any economy.

In our paper, we want to find out if there is a correlation between higher education and the circular economy from the perspective of tertiary education attainment and recycling rate of municipal waste because intuitively it seems like there is.

[1] The level of tertiary education is the percentage of the population of the European Union within the age class from 15 to 64 years old that has tertiary education.

2 Problem Formulation

As a methodology, based on the Eurostat database, we use Pearson`s r correlation coefficient to investigate if, at the EU level, there is a linear relationship between the tertiary education attainment and the recycling rate of municipal waste. In case there is such a relation, we want to find out how strong it is and also to test its statistical significance at a level of confidence of 95%.

3 Problem Solution

To calculate the Pearson correlation coefficient (Pearson`s r) between the tertiary education attainment and the recycling rate of municipal waste, we collected the data from the statistical office of the European Union (Table 1).

Table 1. EU- tertiary education attainment and recycling rate of municipal waste in the EU, between 2007 and 2018

Year	Tertiary education attainment, %	Recycling rate of municipal waste, Thousand tonnes
2007	20.5	35.2
2008	21.1	36.5
2009	22.0	37.3
2010	22.8	37.8
2011	23.7	38.8
2012	24.6	40.8
2013	25.4	41.5
2014	26.0	43.4
2015	26.7	44.8
2016	27.3	46.3
2017	27.9	46.6
2018	28.7	47.4

Source: Author`s based on data provided by Eurostat (2020).

The sample Pearson`s r is calculated with the following formula (1):

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{n\sum x^2 - (\sum x)^2}\sqrt{n\sum y^2 - (\sum y)^2}}$$

Using Microsoft Excel, we calculated the value of Pearson`s r for the analysed data. The value of r is 0.989685. It means that there is a robust linear relationship between the analysed indicators, with a positive slope. Therefore, if one indicator increases, the other one increases too.

We test at a 95% level of confidence to see if the linear relationship between the analysed indicators is statistically significant.

The null hypothesis (H_0), implies there is no statistically significant linear relationship in the EU between the level of tertiary education and the recycling rate of municipal waste.

Our alternate hypothesis (Ha) is that we believe there is a statistically significant linear relationship in the EU between the tertiary education attainment and the recycling rate of municipal waste.

$$\begin{cases} H_0: \rho = 0. \\ H_a: \rho \neq 0. \end{cases}$$

While Pearson`s r is the sample correlation coefficient, ρ is the population correlation coefficient.

To test the hypotheses we use the ***t-distribution***.

Given data:

Level of confidence: LOC=95%;
Level of significance: α = 0,05
Number of observations: n=12;
Degree of freedom: Dof=10.

Calculations:

Since we have a two-tailed test, we calculate the value of $\frac{\alpha}{2}$, given α = 0.05.

$$\frac{\alpha}{2} = \frac{0.05}{2} = 0.025$$

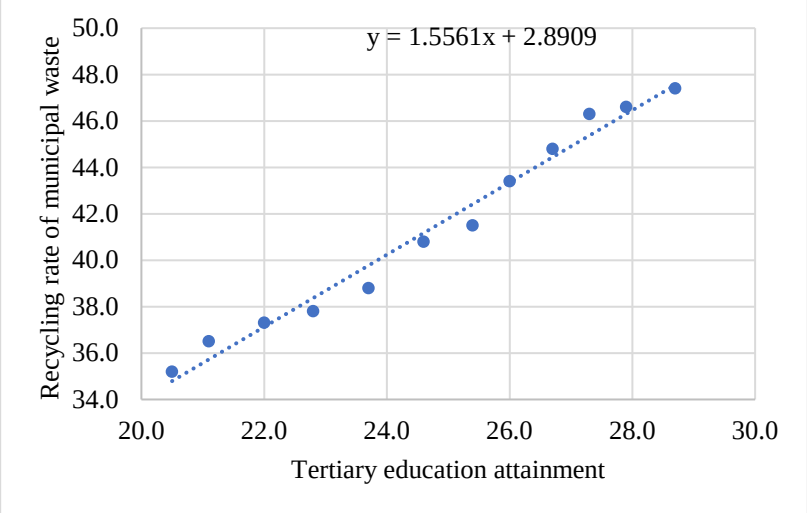
We need to find the value of t that gives the area of 0.025 to the right tail of the t-distribution, namely, $t_{\frac{\alpha}{2}}$ or $t_{0.025}$. For that we use the t-distribution table to find the value of $t_{0.025}$. Taking into consideration the degree of freedom and the level of significance α, we found that the value of $t_{0.025}$ = 2.228 and consequently, since t-distribution is symmetrical, $-t_{0.025}$ = - 2.228 (the value of t that gives the area of 0.025 to the left of t-distribution).

We calculate the test statistic t using the formula:

$$t = \frac{r}{\sqrt{\frac{1-r^2}{n-2}}} \Rightarrow t = \frac{0.989685}{\sqrt{\frac{1-(0.989685)^2}{10-2}}} = 21.84560821 \qquad (2)$$

Placing the value of t in the rejection region, since the value of t > $t_{\frac{\alpha}{2}}$. Therefore, we reject the null hypothesis (H_0). We are 95% confident that there is a statistically significant linear relationship in the EU between the tertiary education attainment and the recycling rate of municipal waste, as chart 1 displays.

Chart 1: EU- The relationship between the tertiary education attainments and the recycling rate of municipal waste



The coefficient of determination (r^2) is 0.97948. That implies that the relationship between the analysed variables explains 97.94% of the variation in the recycling rate of municipal waste. It does not mean that one variable causes the other.

Since the relationship of the variables is statistically significant, we proceed at finding the equation of the linear regression line, or "the least-squares regression line", which minimises the squares of the distances between the data points and the line (See Chart 1).

To this end, we calculate the regression statistics with Excel (Table 1).

The formula for the least-squares regression line is:

$$y = b_0 + b_1 x \qquad (3)$$

where:

$b_1 = \frac{n\sum xy - \sum x \sum y}{\sqrt{n\sum x^2 - (\sum x)^2}}$ (slope) (4)

$b_0 = \frac{\sum y}{n} - b_1 \frac{\sum x}{n}$ (y - intercept) (5)

Table 1: Regression Statistics

	Coefficients	**Lower 95%**	**Upper 95%**
b_0	2.890925229	-1.0551885	6.83703896
b_1	1.556147278	1.397428318	1.71486624

Therefore, the equation of the regression line for our sample is $y = 2.8909 + 1.5561x$, as displayed by Excel in Chart 1.

The equation of the population regression line is:

$Y = \beta_0 + \beta_1 x$ (6)

We can construct a confidence interval for the slope (β_1) and y-intercept (β_0), of the population regression line, based on the data provided by Table 1.

Thus, If we could know all the population data, and draw a regression line through it, we are 95% confident that the line will have $\beta_0 \in$ [-1.0551885, 6.83703896] and $\beta_1 \in$ [1.397428318, 1.71486624].

4 Conclusion

The analysis proved that there is a strong linear correlation (Pearson`s r coefficient is close to one) between tertiary education attainment and the recycling rate of municipal waste, with a positive slope and a high determination coefficient. We also found that the relationship between the analysed indicators is statistically significant at a high level of confidence.

Ergo, the high skilled human capital can be an important driver of the circular economy, from the recycling standpoint.

Since the model of the circular economy is likely to get more traction in the post coronavirus crisis world, the decision-makers should not neglect tertiary education, as a driver of the transition to this renewed model.

References:

[1] European Commission (2020), Critical raw materials. Accessible at: https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en

[2] European Parliament (2018), Circular economy: definition, importance and benefits. Accessible at: https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits

[3] Eurostat (2020), Population by educational attainment level, sex and age (%) - main indicators. Accessible at: https://ec.europa.eu/eurostat/cache/metadata/en/edat1_esms.htm#stat_pres1588607165175

[4] Eurostat (2020), Recycling rate of municipal waste. Accessible at: https://ec.europa.eu/eurostat/databrowser/view/cei_wm011/default/table?lang=en

[5] OECD (2012), Education at a Glance 2012: Highlights, OECD Publishing. http://dx.doi.org/10.1787/eag_highlights-2012-en