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WHAT IS THE IMPACT OF CIRCULAR ECONOMY IMPLEMENTATION ON COUNTRY'S WEALTH IN THE EUROPEAN UNION 27 COUNTRIES? : AN EMPIRICAL STUDY WITH EUROSTAT DATA

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ABSTRACT

Circular Economy is considered to be the most appropriate approach to achieve a sustained economy in a sustainable way. Although many scholars have investigated the impact of circular economy implementation on how it will contribute to a country's economy the results are still vague. To examine the relationship of Circular Economy and its impact towards a country's wealth I performed a multiple linear regression on 27 European Union countries and the findings revealed a significant correlation between circular economy adaptation and the contribution to

wealth in the countries. The findings implicate how policy makers could adopt a circular economy and achieve a sustainable economy.

INTRODUCTION

Over the last decade the concept of Circular Economy (CE) has been gaining attention in the economic world. CE emphasis on turning the conventional way of economy into something that is more circular or commonly known as a closed loop cycle. In linear economy principles, the life cycle of a product is based on taking from natural resources, making the goods itself, and then disposing of it when the product has come to its end in their life cycle. This continuous cycle has brought a dilemma within the society, as more people exist on earth the amount of natural resources that is needed will also increase. The increasing needs of resources surely does not go hand in hand with how nature reproduces itself, hence it could lead to resource scarcity which is the current problem in the world. The introduction of CE in society helped to shed a light on the case of how the economy can go in hand with nature. CE focuses on how to reuse and regeneration of materials and products also focusing on continuation of production in a sustainable way. This can be achieved through their closed loop cycle of economy, meaning that every waste that is produced in the economic cycle then turned into new materials which can be used in order to produce another product. In short, CE focuses on how we turn waste into materials and minimizing the need to take raw materials while also producing a minimum amount of waste. This principle could be applied and help society when it comes to mitigating economy and environmental issues. Researchers found that CE can help in addressing matters regarding waste generation, resource scarcity, when also achieving sustained economic benefits (Lieder & Rashid, 2016) . In addition, CE could impact a country's wealth in a way by promoting the growth of the economy through increase of revenue from CE activities as well as a lower cost of production by utilizing more productive inputs (Ellen MacArthur Foundation, 2023).

Circular Economy principles have been recognized as a solution to the current dilemma within resources and production, CE is also known to be a more sustainable way to achieve good economic performances. With this current knowledge regarding the way of CE, a few countries have been trying to implement and develop their economy around the principles of CE itself. The European Union (EU) can be considered as one of the world leaders when it comes to implementing CE. The EU commitment towards achieving a more sustainable world is aligned

with the principles of CE. Their commitment to adopting CE can be shown by the European Commission (EC) in 2015 by introducing the Circular Economy Action Plan (CEAP). This shows their deep commitment to transitioning from a linear economic cycle towards a circular economy. The CEAP consists of 54 action plans which ignites EU economic transformation, those action plans are then completed in the year of 2019. Their commitment was not only bound by the first action plan, in 2020 the EC adopted a new action plan in order to achieve climate neutrality and halting the biodiversity loss by 2050 (Ellen MacArthur Foundation, 2023). Their new action plan primarily focuses on how products that are being designed and produced can be kept and utilized as long as possible in their economic activities.

By knowing how CE can benefit the society not only by reducing waste while also reducing the use of raw materials, CE can also benefit the economy by promoting resource productivity, lowering the cost of production and job creation in the related sectors. CE was then considered as a way to resolve economic and environmental problems, which then attracted academic and also business practices on researching and implementing the idea. CE which was introduced by Peace and Turner (1990) can be considered as a new concept, which led to a rising discussion on whether CE can be truly implemented and still become beneficial for business while also having a positive impact on the environment. Some researchers argues that CE has a relationship with the growing economy in a country (Browne et al., 2009;Aid et al., 2016;Lieder & Rashid, 2016;Cucchiella et al., 2017;Hysa et al., 2020;) whereas others found that the impact of CE on economic, social, and environment are still lack in evidence (Hobson & Lynch, 2016;Velis, 2018;Donati et al., 2020;Lekan & Rogers, 2020;Lindgreen et al., 2020). Others researchers also adds that CE trade-offs that is linked with resource scarcity and climate change are still insufficient (Bleischwitz & Miedzinski, 2017;Lehmann et al., 2018;Giampietro, 2019;Schroeder et al., 2019;Campbell-Johnston et al., 2020).

Despite the controversies that CE has sparked among researchers, CE is still the only best alternative for economic development to go hand in hand with the environment. What CE proposes surely will benefit society in a larger picture, by promoting reusing, reducing, and recycling products will help minimize the negative impact of economic activities towards the environment. Also by extending the age of a product and keeping the product in circular activities, extracting natural resources will not be necessary due to products that have reached their end of life can then be repurpose into new materials that can be used for other production processes.

Nevertheless, the empirical evidence on CE implementation is still insufficient. Which then became the main motivation for this research, is to address the gaps by providing empirical evidence on how CE contributes to a country's economic wealth within the European Union.

The research question for this study is: **"What is the impact of Circular Economy implementation towards a country's wealth in EU-27 Countries?"** The question that has been stated will allow this study to explore the practices of CE and how they contribute to a country's wealth by promoting economic growth. This study will also examine the influence of CE practices on a country's wealth by examining the effect of resource productivity, circular material use rate and recycling rate. The findings from this study then can help the policymakers to decide the implementation of CE itself. As well as contributing for practitioners and researchers regarding how CE can help to achieve a sustained economy. The research itself will be based on EU-27 countries from 2012-2020 and will be conducted in the form of panel data. To analyze the impact of CE activities towards the GDP Per Capita of a country this study will use multiple linear regression. From previous studies it is shown that CE practices will contributes positively towards a country's wealth by contributing to the Gross Domestic Product (GDP) growth (Geng et al., 2012;Franklin-Johnson et al., 2016;Walker et al., 2018) the studies which also motivates this research to be conducted. This research found that several activities of CE could impact a country's wealth whereas other activities do not significantly impact a country's wealth. From the findings of this study, they can be used as references and also help policymakers to determine which CE activities that need to be implemented more due to the fact that they can significantly contribute to a country's wealth level.

THEORETICAL BACKGROUND

Circular Economy

Over an extended period, the economic model followed the "take, make, waste" paradigm (Ness, 2008), with minimal attempts to utilize the byproducts generated during the processes of production and consumption. This established pattern resulted in environmental pollution and a reduction in availability of resources. On the other hand, the Circular Economy (CE) was introduced in order to reduce the environmental impact by reducing, reusing, and recycling materials. CE itself is not a new concept in the economic world. Circular economy was partly influenced by the modern environmental movement of the 1960s and 1970s (Etkins et al.,

2019). In the 1970s the 3R concept of reduce, reuse, and recycle received a growth in awareness along with environmental movements. Another study that influenced CE is Boulding's (1966) work, where he introduces 'closed economy' or 'space economy'. In his work he describes that in the future economy, humans need to find the balance between economy and ecology (Boulding, 1966). Primarily CE is introduced by Pearce and Turner (1990) based on the work of Boulding's. In their book, they explained that the shift from linear economy towards circular is due to the *law of thermodynamics* (Georgescu-Roegen, 1971) they explained that the environment provides the input of economic activities and also serves as a waste sink from the output of the economy.

In the present time, CE itself has gained interest both from researchers as well as business practicals. CE is shown as a way for businesses to gain sustainable growth (Ghisellini et al., 2016;Murray et al., 2017). Other researchers have been trying to define the concept of CE itself (Lewandowski, 2016;Sauvé et al., 2016;Lieder & Rashid, 2016;Blomsma, 2017;Murray et al., 2017; Geissdoerfer et al., 2017). With the raise of interest in CE, critiques also submerge into the conversation. It is stated that the concept of CE is still too obscure and hard to implement (Van den Brande et al., 2011; Peltonen, 2017). Nevertheless, despite the contradictory opinion regarding CE concept, CE can be defined as a system of economy where the 'end-of-life' cycle is being replaced by reducing, reusing, recycling and recovering materials in production, consumption, and distribution processes (Kircherr et al., 2017). Ellen MacArthur Foundation (EMF) also introduced the concept of CE practices as a restorative and regenerative economy (Ellen MacArthur Foundation). The EMF definition was also aligned with the Geissdorfer et al. (2017) which stated that "Circular Economy as a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops" (Geissdoerfer et al., 2017). In accordance with the literature that is already mentioned, CE can be conducted through three main activities, which are called 3 R's Principles: Reduction, Reuse, and Recycle (Sakai et al., 2011;Preston, 2012;Reh, 2013;Su et al., 2013).

Circular Economy in the European Union

The implementation of CE was popularized in China during the 1990s to facilitate economic growth as well because of the resource scarcity that occurs in China (Zhijun & Nailing, 2007;Wang et al., 2013;Naustdalslid, 2014). Circular economy itself is implemented to balance resources and environmental use with economic growth and development, as well as taking

advantage of the recycling of material uses (Zhu et al., 2010). In the European Union (EU) itself, Germany started to introduce environmental policies to tackle concerns relating to the use of natural resources for long-term economic growth (Geng & Doberstein, 2008). Whereas Portugal and Denmark utilize CE for waste management (Costa et al., 2010). Also the Netherlands and Austria already developed a strategy that is in accord with the circular economy principles (Heck, 2006). By using the principles of CE it is shown that it will potentially benefit the society in different aspects. CE principles can generate economic benefits while also having an advantage towards the environment and society (Ellen MacArthur Foundation, 2015). The European Commission then introduced their EU action plan on CE in 2015 to facilitate their 2050 goals to achieve climate neutrality and stop natural resources loss. By introducing the CE action plan, the EU could possibly generate €320 billion in the form of CE investment in mobility (€135 billion), food (€70 billion), and environment (€115 billion) (Ellen MacArthur Foundation, 2017). Circular economy action plan by the EU is sought to establish sustainable products as the norm within the EU, particularly focusing on resource-intensive sectors and waste reduction (European Commission, 2023). The EU implements their action plan through business innovation, shifting from consumer to user, supply-chain integration, as well as policies and regulations (Lazarevic & Valve, 2017;Leipold & Boix, 2018;Mhatre et al., 2021).

Circular Economy Implementation and Country's Wealth

By implementing a circular economy, a business and country could attain the balance between bringing more growth in their GDP as well as reducing the negative impact from their economic processes. Relationship between circular economy and increasing economic wealth has brought attention to many scholars. It is found there is a relationship between circular economy and its positive contribution towards wealth by uplifting the economic growth (Browne et al., 2009) and also there is a positive correlation between circular economy and growth of GDP, in highlights of the role from sustainability, innovation, and investment in-no waste initiatives (Hysa et al., 2020). Where other researchers also found that environmental taxes revenue, recycling rates, environmental innovation, innovation in the recycling sector and trade of recyclable raw materials will bring a positive impact towards economy by providing a positive impact towards the increase on GDP level of a country (Aid et al., 2016;Lieder & Rashid, 2016;Cucchiella et al., 2017;Murray et al., 2017;Busu & Nedelcu, 2018;Kihl & Aid, 2020).

Resource Productivity and Country's Wealth

Resources productivity is an essential indicator of CE (Blomsma, 2017). Resources Productivity can be defined as a ratio of a country's GDP towards their domestic consumption. This indicator also shows how efficient a country is in using their resources to produce goods and services (Haas et al., 2015). Resource productivity itself could affect a country's wealth in several ways. Firstly, a higher resource productivity could lead to a higher output of goods and services that is generated which led to a higher Gross Domestic Product (GDP) Per Capita, Warr (2006) study in Thailand shows that with an introduction of irrigation in agriculture could led to increase 5% increase in the overall GDP of the country. Another study also found that resource productivity in a circular economy could also bring a positive effect towards the GDP Per Capita growth in European countries (Busu & Trica, 2019). Where (Geng et al., 2012) also stated that productivity of resources has a direct impact on economic growth. From the literature above it can be concluded that Resource productivity could positively influence the GDP of a country hence impacting the country's level of wealth.

H1: Resources Productivity contributes positively to country's GDP Per Capita

Circular Material Uses Rate and Country's Wealth

Circular material uses can be described as utilizing resources through a material retention that can be achieved by an effective recycling process also optimizing the materials and products through their life cycle (Franklin-Johnson et al., 2016;Walker et al., 2018). A study that is conducted in order to show the impact of circular material use rate towards growing GDP (Busu & Trica, 2019) shows a positive impact of circular material use rate towards the growth of a country's wealth. Others also found that circular materials used are positively contributing towards the GDP of a country significantly (Hysa et al., 2020). From the literature that is mentioned, it motivates this study to find whether circular material use will have a positive impact on economic wealth of respective countries.

H2: Circular Material Use Rate contributes positively to country's GDP Per Capita

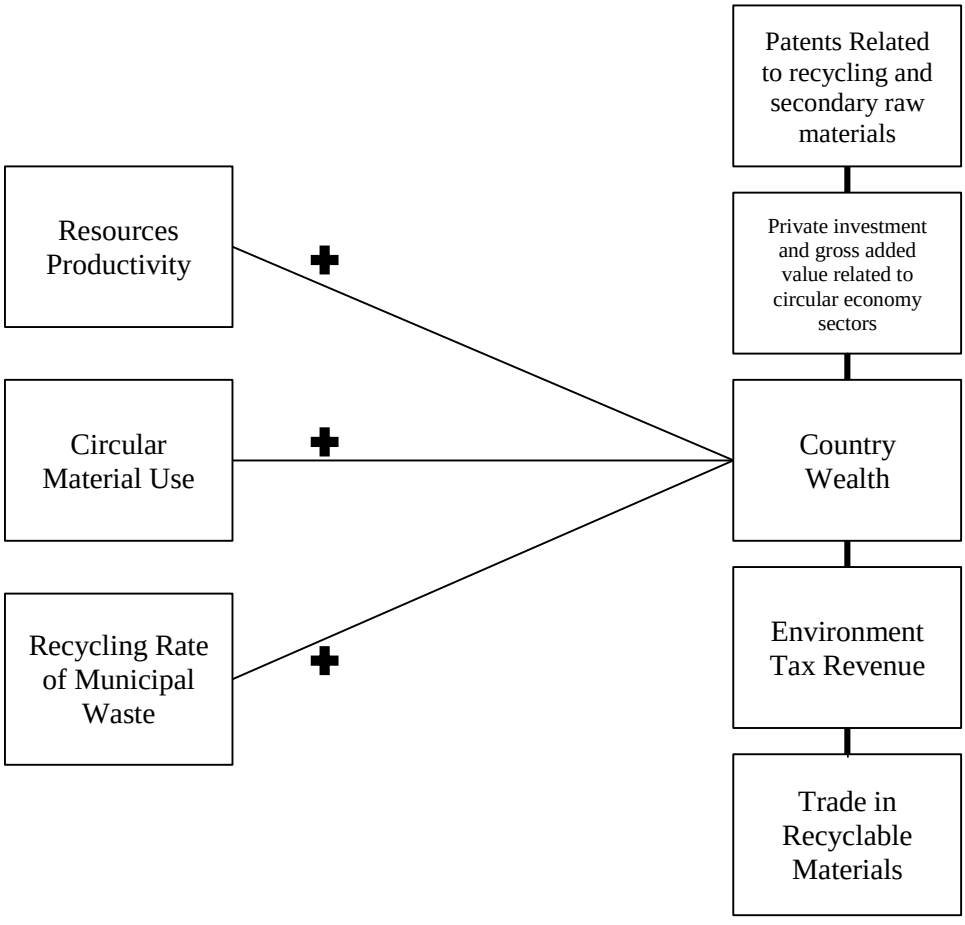
Recycling Rate and Country's Wealth

Recycling is considered to be one of the main actions of the circular economy. Recycling establishments could generate jobs which then also contribute towards the government tax revenue, in the United States recycling sectors generate $5.5 billion in tax revenues (Environmental Protection Agency, 2023). Researchers also found that recycling rate of municipal waste contributes positively towards the growth of a country's GDP Per Capita (Tantau et al., 2018;Kazulytė, 2019). From the literature it can be concluded that recycling can benefit a country's wealth by generating tax revenues and also promoting economic growth.

H3: Recycling Rate of Municipality Waste contributes positively to country's GDP Per Capita

Conceptual Model

From the literature research that has been used as a foundation towards the hypothesis developments, we can conclude it into this conceptual framework.



DATA

This research aims to investigate the effect of CE implementation towards the wealth of a country. This will explain an occurrence by testing the theory instead of generating a new theory. The study will be conducted using quantitative research so the data can be analyzed using statistical methods. This study will use a form of secondary data due to one main reason. This study will be using samples on a country level and all the data is publicly available on the EU statistical agency, which is named as EuroStat. The sample of this study consists of 27 EU countries and is obtained from EuroStat from 2012-2020 which then provided this study with panel data. Eurostat is the EU statistical agency that provides the metadata that covers the environment, economy, and social index of every country that is in the EU which can be easily accessed through their website. By obtaining the data from a formal agency of the EU, it will ensure the validity and reliability of the data. Furthermore, by using the sample that is provided by the EuroStat is aligned with the purpose of this study.

The dependent variable that is used in this study is the Gross Domestic Product (GDP) per capita in my sample. Measuring a country's wealth by using GDP per capita enables the study to do cross-country comparisons. By using GDP per capita to represent the wealth of a country, it will enable the research to determine and examine the contribution of CE activities towards a country's GDP . This variable will allow the study to analyze the contribution of circular economy practices towards the GDP per capita growth.

The implementation of CE is mainly through the 3 R's activities of reduce, reuse and recycle (Sakai et al., 2011;Preston, 2012;Reh, 2013;Su et al., 2013). This study will have three main independent variables (IV) that represent implementation of CE. First, the IV that this study will use is Recycling Rate of Municipal Waste (RMW). The RMW variable quantifies the percentage share of recycled municipal waste in the total municipal waste generation. Secondly, Circular Material Use Rate (CMU) will be used to represent the reuse activities in 3R principles. This variable quantifies the percentage share of material recovered from the economy and then used in overall material use. The last IV that this study will use is resources productivity (RP) which will represent the reduce principle. This variable will quantify the productivity of resources by dividing GDP with domestic material consumption.

In order to exclude alternative explanations and reduce error terms, this study will include control variables. There are multiple variables that can influence GDP per capita level of a country. First control variable is Environmental Tax Revenues which is quantified by shares of environmental tax on GDP. Second is trade in recyclable materials which quantifies trade between the EU member states. Third, Private investment and added value in CE sectors and lastly number of patents in recycling sector. The chosen control variables are found to have a positive effect on GDP (Aid et al., 2016;Lieder & Rashid, 2016;Cucchiella et al., 2017;Murray et al., 2017;Busu & Nedelcu, 2018;Kihl & Aid, 2020).

Table 1: Data Description

Variable	Name	Definition	Unit	Type
GDP	GDP Per Capita	Ratio of real GDP to the average population of a specific year	Euro/Capita	Y
RMW	Recycling rate of municipal waste	Share of recycled municipal waste in the total municipal waste generation	Percentage (%)	X1
CMU	Circular Material Use Rate	Share of material recovered and fed back into the economy in overall material use	Percentage (%)	X2
RP	Resources Productivity	Gross domestic product (GDP) divided by domestic material consumption (DMC)	Euro/Kg	X3
Tax_Rev	Environment Tax Revenues	Share percentage of environment tax on gross domestic product (GDP)	Percentage (%)	Control
TRRM	Trade in Recyclable Materials	Quantities of selected waste categories and by-products that are shipped between the EU Members States	Tonne	Control
lnv_CE	Private investment and gross added value related to circular economy sectors	"Gross investment in tangible goods" and "Value added at factor costs" in the following three sectors: the recycling sector, repair and reuse sector and rental and leasing sector.	Million Euro	Control
Pat_Rec	Patents related to recycling and secondary raw materials	Number of patents related to recycling and secondary raw materials.	Number	Control

Descriptive Statistics & Correlation

The result of descriptive statistics can be seen on Table 2 and the result of correlation matrix can be seen on Table 3. The dependent variable of *GDP* is measured as logarithm and has a mean of 9.96633 and a standard deviation of 0.6236265. The dependent variable is highly correlated with variables *RP* which indicates that an increase in resources productivity will lead to a higher GDP Per Capita. The other independent variables of RMW and CMU have mean of 36.0312 and 1.900637 respectively. RMW has a standard deviation of 14.93534 where CMU has a standard deviation of 0.7700694. Both of the variables are not highly correlated with other variables.

EMPIRICAL METHOD

The objective of this research is to investigate the relationship between CE implementation and how it contributes towards wealth in a country. The methodology of this research will be multiple linear regression analysis as there are three main predictor variables. Regression analysis is the most common tool that is used to examine statistical relationships especially where the dependent variables are continuous and are predicted by one or more independent variables (Yan & Su, 2009). The regression analysis will display the relationship between the dependent variable and independent variables. The data analysis itself will be conducted using a statistical program named StataSE. The statistical model that will be used to analyze the data is represented by the following equation.

$$GDP = \beta_0 + \beta_1 RMW + \beta_2 CMU + \beta_3 RP + \alpha_i + \varepsilon_{it}$$

Testing for assumption of Multiple Linear Regression

Outliers and Sample Size

The sample consists of EU-27 countries which are valid for the dependent variable and independent variable which consists of 243 observations. To check for outliers, I looked at the histogram of each variable. Variables *GDP*, *Inv_CE*, and *Pat_Rec* show that there are outliers in their data where variables *RMW, RP*, and *TRRM* did not show any signs of outlier. To proceed with the study I transformed variables *GDP*, *CMU*, and *Inv_CE* into logarithmic variables. It shows that using transformation of variables can be an effective method to accommodate outliers (Osborne, 2002). The variables *Pat_Rec* does not transform into logarithmic variables due to the

massive missing values that are generated by transforming the variables into logarithms. Whereas for missing value, there is only one missing value in variables *RMW* to accommodate this issue I replace the missing value with the mean of *RMW.*

Linearity and Normality

The linearity of dependent variables and independent variables are essential in multiple linear regression analysis since non-linearity in variables could lead to the relationship between variables being underestimated (Osborne & Waters, 2002). By producing scatter plots of dependent variables and each one of independent variables it is proven that the relationship between dependent and independent is linear which is symbolized by the straight line. Hence, it can be concluded that the relationships are linear (Appendix A) (Appendix B) (Appendix C). Other assumptions of normality also need to be fulfilled, to check whether the distribution of the data is normal I check it using skewness and kurtosis with the threshold of zero for skewness and three for kurtosis. From the statistics that are shown from table 2 it shows that *Pat_Rec* shows kurtosis far above the threshold, but the variables can not be transformed into logarithmic variables due to the massive missing values that will be generated by transforming it into logarithmic variables.

Multicollinearity

Other assumptions that are also important is to ensure that the independent variables are not highly correlated with each other (Mansfield & Helms, 1982). In conclusion it is essential to ensure that there is no multicollinearity within the independent variable. To check whether there is an existence of multicollinearity by using VIF. From Table 4 it can be seen that the VIF are between 1 and 5 which means that there is a moderate multicollinearity. Since the multicollinearity is not severe it does not need special attention towards the variables.

Heteroscedasticity

The last assumption of multiple linear regression is homoscedasticity which means that the variance in the variables are equal. To check this assumption, I use Breusch-Pagan test (Appendix D) . The result shows that under the threshold of 0.05. This means that there is heteroscedasticity in the data, but we can ignore this because the regression will have a robust model.

Fixed Effect

The choice between using a fixed effects model and a random effects model is assessed using the Hausman-test. Fixed effects models are used when there is unobserved variability across the units of observation, such as individual traits or features specific to a country. Random effects models are used when the unobserved heterogeneity is expected to be random and may be averaged out in the regression. The Hausman test results indicate that the p-value is 0.0001 and the chi-squared statistic is 26.92. This indicates that the fixed effects model ought to be applied and the null hypothesis that the random effects model is suitable is rejected. Fixed effects regression is necessary in this situation since the Hausman test has shown that the random effects model is unacceptable to the result of the Hausman-test can be seen on table 5.

Robust Fixed Effect

To address potential heteroskedasticity this study will use robust standard errors, where the variance of error varies among the observations. Compared to the standard error, robust standard errors are less prone to bias with the presence of heteroskedasticity. The result of the robust fixed-effects shows the results are similar which is shown on table 6.

Regression

Table 7: Robust Regression Table

Dependent Variable: GDP

GDP	Model 1	Model 2	Model 3	Model 4	Model 5
RMW	0.026***	0.024***	0.015***	0.015***	0.015***
	0	0	0	0	0
CMU		0.069	-0.061	-0.026	-0.026
		-0.05	0.04	0.05	0.05
RP			0.321***	0.332***	0.332***
			-0.03	-0.03	-0.05
Tax_Rev				-0.055	-0.055
				-0.04	-0.05

TRRM				-2.12E-08	-2.69E-08
				2.33E-08	2.71E-08
Inv_CE				-0.009	-0.009
				-0.03	-0.03
Pat_REC				-0.0000802	-0.0000802
				0.0021229	0.0019821
_cons	9.042***	8.042***	9.028***	9.172***	9.172***
	-0.08	-0.09	-0.08	-0.22	-0.23
R-Squared	0.3772	0.3821	0.5926	0.6012	0.6012
Adj R-Squared	0.3746	0.3769	0.5875	0.5893	0.5893

In this study, multiple linear regression is performed to analyze the influence of independent variables of *RP, CMU,* and *RMW* towards the dependent variable of *GDP*. This study hypothesized that all the independent variables have a positive impact towards the dependent variables. The control variables that are used in this study are *TRRM, Inv_CE*, *Pat_Rec*, and *Tax_Rev*. The results of the regression are shown on table 5.

In the *first model* it only includes the *GDP* and Independent variables of *RMW* it shows that this model is significant at 1%. Since the dependent variables are measured in logs and the independent variables are measured in level this model can be concluded as semi-log. In this model we can see that every increase of one unit in *RMW* will lead to 2.6% increase in *GDP*

In the *second mode*l it includes *GDP* and Independent variables of *RMW* and *CMU*. From this model it shows that *RMW* is significant at the level of 1% whereas *CMU* are not significant. In this model every unit change in *RMW* will lead to 2.4% increase in *GDP* and every one % change in *CMU* will lead to an increase of 0.069% in *GDP*.

In the *third model* it includes the regression of *GDP* and *RMW, CMU,* and *RP*. From this model it shows that *RMW* and *RP* are significant at the level of 1% where *CMU* are not significant. From the model we can conclude that every unit change in *RMW* will lead to a 1.5% increase in *GDP*. Where in this model every one % change in *CMU* will lead to a decrease of 0.061% in *GDP*. Lastly, every increase of one unit in *RP* will lead to 32.1% increase in *GDP*.

In the *fourth model* it includes the regression of *GDP* with all the independent variables and control variables. All the control variables have a negative effect towards *GDP* but all of the

control variables are not statistically significant. Whereas *RMW* and *RP* are both statistically significant at the level of 1%. Every one unit change in *RMW* will lead to a 1.5% increase in *GDP* and every one unit change in *RP* will lead to a 33.2% increase in *GDP*. The last independent variable is *CMU*. This variable is not statistically significant and every one % change will lead to a decrease of 0.026% in *GDP*.

In the fifth model is the robustness check from the model 4 since it is found that there is heteroscedasticity that is detected in this study. From the statistical analysis that has been done, we then can conclude the mathematical model of this regression

$$y = 9.172 + 0.015X_1 - 0.026X_2 + 0.332X_3 + e + fe$$

FINDINGS & DISCUSSION

The objective of this study is to investigate the relationship between CE implementation on a country's wealth to examine whether CE implementation can also benefit the economy. Previous study has tried to find proof of the relationship between CE implementation and how it can affect the economy in a country. It is found that CE implementation could affect the economy of a country (Aid et al., 2016;Lieder & Rashid, 2016;Cucchiella et al., 2017;Murray et al., 2017;Busu & Nedelcu, 2018;Kihl & Aid, 2020). Other findings also strengthen that CE activities including resource productivity, the use of circular material and recycling rate of municipalities could benefit the economy positively (Tantau et al., 2018;Kazulytė, 2019;Busu & Trica, 2019;Hysa et al., 2020). This study will offer the analysis by adding control variables as well as an updated timestamp. By conducting this study it is able to answer the question of the study: **"What is the impact of Circular Economy implementation towards a country's wealth in EU-27 Countries?"**.

This study found mixed evidence, it found the positive relationship between Recycling Rate of Municipality and Resource productivity towards country's wealth. It suggests that a form of CE activities could impact a country's wealth by increasing the GDP Per Capita. Recycling rate could increase a country's wealth by generating tax revenue from recycling sectors as well as from job creation in the recycling sector. Whereas resource productivity indicates that efficiency in the use of resources will generate a higher GDP Per capita since it indicates that a country will spend less on input and generate more output. Moreover, the finding from this study is that there is a lack of evidence where Circular Material Use could impact the wealth in a country. From the literature

it can be concluded that Circular Material Uses will affect the economy through a longer product lifetime use (Franklin-Johnson et al., 2016). This indicates that the direct effects of Circular Material Use are not significant.

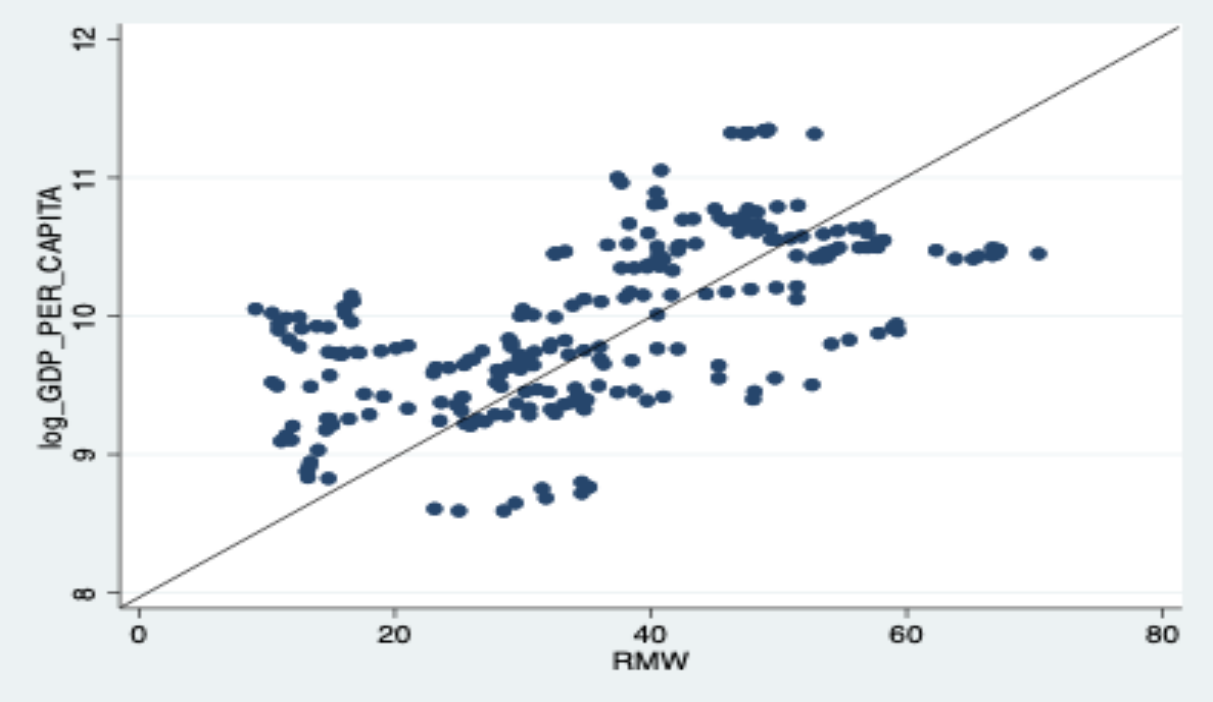
In conclusion, economic activities and the environment need to go hand in hand, especially in the current world where resource scarcity and degradation of the environment are already happening. By shifting the pattern of linear economy towards a more circular closed loop will allow us to keep on doing economic activities and maintaining the sustainability of our environment for future generations. Nevertheless, implementing CE will also benefit on an individual level where CE can offer a longer product lifetime use.

This research is conducted by using the data of EU-27 countries from 2012-2020 that was collected from EuroStat. The research will only focus on the European Union and the findings from this study might be not applicable to other regions that will have different economic, social and political situations. The data will only include a few of the CE implementations and the time stamp for this study are still considered to be brief so the long impact of CE implementation and economics could be considered vague. Whereas GDP Per Capita is used to determine the wealth of a country, this may not capture the full effect of Circular Economy implementation.

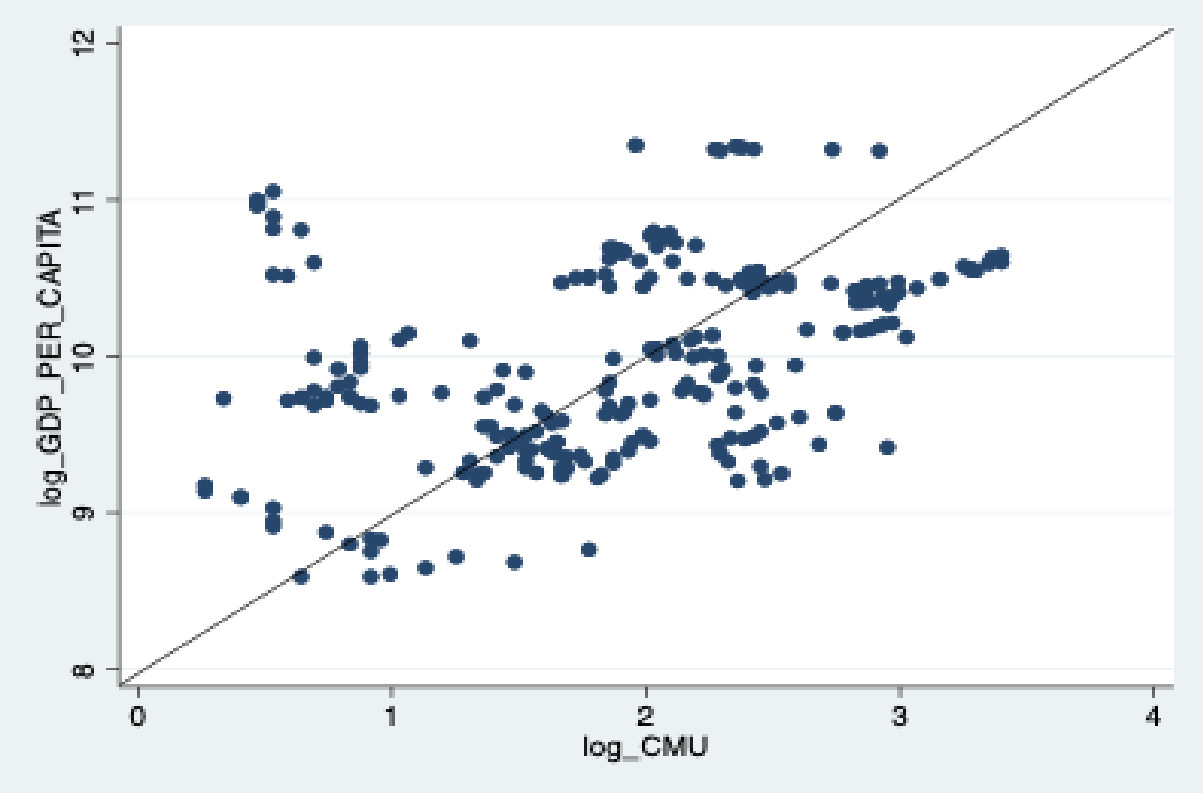
For future research that is looking into the study of Circular Economy and how it will affect country wealth it is important to include more dependent variables to capture a broader impact of Circular Economy towards wealth level. It is necessary to compare the impact of Circular Economy on cross-region analysis, so the findings can be generalized in other regions of the world. Providing more variables of Circular Economy to obtain a comprehensive understanding regarding the effect of this implementation. The indirect impact of Circular Material Use Rate also needs to be studied further by using a mediating of longer product lifetime use. Providing a longer time frame to capture a better understanding on the long-term impact of Circular Economy.

APPENDIX

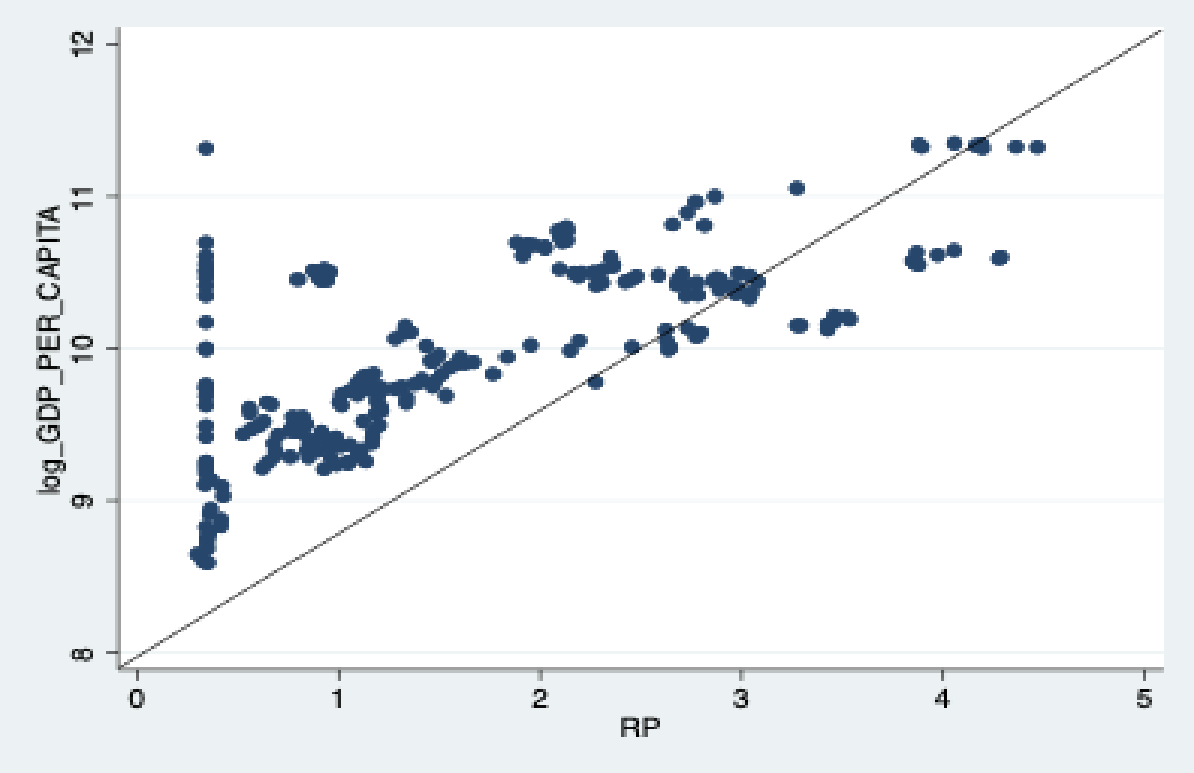
Appendix A: Linearity of GDP and RMW



Appendix B: Linearity of GDP and CMU



Appendix C: Linearity of GDP and RP



Appendix D: Breusch-Pagan Test

Breusch-Pagan test for heteroskedasticity

Assumption: Normal error terms

Variable: Fitted values of **GDP**

H0: Constant Variance

$$chi^2 = 6.77$$

Prob > = 0.0093

Table 2: Descriptive Statistics

Variable	OBS	Mean	Std. dev.	Min	Max	Skewness	Kurtosis	Std. err.
*log*_GDP	243	9.966339	0.6236265	8.5923	11.34852	0.037576	2.431095	0.0400057
RMW	243	36.0312	14.93534	9.1	70.3	0.0582826	2.155833	0.9632265
CMU	243	1.900637	0.7700694	0.2623643	3.401197	-0.230848	2.27265	0.0494
RP	243	1.62641	1.099914	0.2996	4.47	0.7339581	2.568626	0.0705595

Variable	OBS	Mean	Std. dev.	Min	Max	Skewness	Kurtosis	Std. err.
*log*_GDP	243	9.966339	0.6236265	8.5923	11.34852	0.037576	2.431095	0.0400057
RMW	243	36.0312	14.93534	9.1	70.3	0.0582826	2.155833	0.9632265
Tax_Rev	243	2.619218	0.6327395	1.2	4.14	2.568626	2.405997	0.0405903
TRRM	243	1463359	1879035	738.386	8490836	1.582195	4.813563	120540.2
Inv_CE	243	6.891258	1.607818	3.496508	10.4484	0.2575469	2.118289	0.1031416
Pat_Rec	243	11.91992	19.00473	0	103.78	2.606989	10.23401	1.219154

Table 3: Correlation Matrix

	GDP	RMW	CMU	RP	Tax_Rev	TRRM	Inv_CE	Pat_Rec
GDP	1							
RMW	0.6142	1						
CMU	0.4133	0.5371	1					
RP	0.7181	0.5347	0.5005	1				
Tax_Rev	-0.1473	-0.0999	0.0751	-0.1048	1			
TRRM	0.3404	0.4343	0.5152	0.5076	0.0107	1		
Inv_CE	0.4283	0.62	0.5382	0.4975	-0.2142	0.7129	1	
Pat_Rec	0.2649	0.4623	0.4606	0.2935	-0.2001	0.6496	0.7165	1

Table 4: VIF

Variable	VIF	1/VIF
CMU	1.72	0.581945
RMW	1.63	0.612889
RP	1.52	0.657907
Mean VIF	1.62	

Table 5: Hausman Test

	Coefficients			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	fe	re	Difference	Std. err.
RMW	.003572	.0038358	-.0002638	.0001091
CMU	.0091223	.0107664	-.0016441	.0030606
RP	.0125713	.0148358	-.0022644	.0006434
Tax_Rev	-.062612	-.063494	.000882	.0031157
TRRM	3.88e-08	3.59e-08	2.84e-09	6.77e-09
Inv_CE	.1205346	.1155761	.0049585	0. .0037209
Pat_Rec	.0004308	.0003461	.0000847	.0001211

b = Consistent under H0 and Ha; obtained from xtreg.

B = Inconsistent under Ha, efficient under H0;obtained from xtreg.

Test of H0: Difference in coefficients not systematic

$$\square\square\square^2(6) = (\square - \square)'[(\square\_\square - \square\_\square)^{(-1)}](\square - \square) = 26.92$$

$$\square\square\square\square > \square\square\square^2 = 0.0001$$

Table 6: Robust Fixed Effect

GDP	Coefficient	Robust std. err.	t	P>t	[95% conf.	interval
RMW	0.003572	0.0008294	4.32	0	0.0018671	0.0052768
CMU	0.0091223	0.0316176	0.29	0.775	-0.0558685	0.0741132
RP	0.0125713	0.0109545	1.15	0.262	-0.009946	0.0350887
Env_Tax	-0.062612	0.0469423	-1.33	0.194	-0.1591032	0.0338792
TRRM	3.88E-08	2.00E-08	1.94	0.063	-2.28E-09	7.98E-08
Inv_CE	0.1205346	0.0187763	6.42	0	0.0819393	0.1591299
Pat_Rec	0.0004308	0.000746	0.58	0.569	-0.0011026	0.0019641

_cons	9.071354	0.1709529	53.06	0	8.719955	9.422752
sigma_u	0.54117413					
sigma_e	0.05505187					
rho	0.98975767	(fraction of variance due to u_i)				
R-Squared	0.5223					
F-Statistics	0.0000					

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