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ASSESSMENT OF THE CIRCULAR ECONOMY'S IMPACT IN THE EU ECONOMIC GROWTH

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Abstract

Starting from the significant differences between the European Union's member states regarding framing and implementing the sustainable development strategies and the transition from linear economy towards circular economy (European Commission, 2017a), the article analyses the impact that circular economy indicators, such as the recycling rate of municipal waste, packaging waste and bio-waste, the expenditure on research and development to find solutions to extend the life cycle of materials and reusing waste, as well as the environmental taxes have on the resource productivity and real economic growth. Using these correlations, we consider that the transition from the linear economic model to the circular economic model has positive effects, as proven by this study.

The proposed model uses data for the 28 member states of the European Union, in the 2005-2016 time frame. The novelty of this study lies in using a data panel model for estimating the impact that the measures associated with the circular economy have on the resource productivity and economic growth. The obtained results show that the resource productivity improves by 0.01307 considering one percent increase in the recycling rate of the municipal waste, by 0.159988 if the research and innovation as percentage in the GDP increases by one percent and by 0.068711 when the number of patents in the EU (as for 1 million inhabitants) increases by one unit. All these values stress out the positive effects the circular economy model may have on the society's sustainable development.

Keywords: circular economy, economic growth, sustainable development, research and innovation.

JEL Classification: O44, O47, Q56, Q53, C23

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Introduction

Before the second part of the twentieth century, the development of the economy and the society were deeply influenced by the intensive use of the available natural resources, with a direct impact on the environment. These effects, out of which some are irreversible, led those involved to believe of the need to rethink the way the economy works, by considering the effects induced to the future generations. At this point, the debates on sustainable development were created and refined, the concept of sustainable development being defined by the United Nations as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (UN, 1987).

The three components of the sustainable development (economic growth, social inclusion and environmental protection) aim to provide the pre-conditions for states' welfare and for their citizens, by eradicating the poverty, raising the living standards, reducing the social inequalities or by implementing global management tools and methods for the natural resources. The global nature of the sustainable development concept was envisaged by the September 2015 United Nations summit, when the 2030 Agenda was adopted (UN, 2015). This key document was meant to attain very ambitious goals, such as eradicating poverty and famine, assure the access to education and medical services and protection of the environment by 2030, considered fundamentals for the sustainable development.

These initiatives, supported by the European Union since the beginning of the XXI century, were and still are central for the European Commission, which works for devising and implementing the needed measures to attain the 2030 Agenda. In this respect, at the end of 2016, the European Commission communicated the initiatives for implementing the 2030 Agenda, that include the sustainable development goals among its current priorities, and launching the debate over a much longer term, emphasizing the sectorial development starting 2020 (Bourguignon, 2016).

The transition from the present economy, characterized by linearity (based on extensive use of the natural resources, that impacts the environment and produces waste), towards the circular economy is envisaged by the European Commission. This process may lead to waste reduction and keeping a larger part and for longer time the value of the products, raw materials or resources within the production cycle (European Commission, 2017a). The legislative package that relates to the circular economy, as presented by the European Commission, contains the action plan and the list of all proposals amending the actual legal frame (Bourguignon, 2016). The European Commission initiative has been adopted by the member states, such as the Netherlands and Finland, which have already published their strategies for transition towards the circular economy, by 2050 (Prime Minister's Office, 2015; Ministry of Infrastructure and the Environment, 2016). Moreover, in December 2017, Bulgaria announced that some of its EU Presidency priorities are the circular economy and eco-innovation initiatives (European Commission, 2017b).

Using the most comprehensive data set for the EU's member states, the article provides an independent view on the implementation of the circular economy and an input for this new research field. The obtained results are important for the EU and member states' decision makers, that are involved in framing the rules and regulations needed for the transition towards circular economy, in order to identify the necessary measures to maximize the outcomes. Also, the results reveal the effects these measures may have on the economic

growth among the member states, that are of importance for the business, that may draw accordingly its own development strategies.

The article contains 5 parts, the first listing the reasons for the selected subject, the second presenting the main results from the relevant scientific literature; the third and fourth discussing the methodology and the obtained results; the conclusions, the limits and possible future developments are summarized in the fifth part.

1. Review of the scientific literature

The circular economy concept gains relevance not only for the economists, but also for other researchers and practitioners, interested in finding and implementing the mechanisms that lead to worldwide sustainability (Ghisellini, Cialani and Ulgiati, 2016). Starting from conclusions of the 2012's Rio+20 Conference, which focused on the ecological economic growth, Bartelmus (2013) considers that the sustainable development is a concept that has to be defined globally and not individually, as it relates to the ecological, economic and social sustainable development.

We consider that the circular economy concept is related to the sustainable development, as the latter is the result of the activities that simultaneously and in equilibrium involve all economic, social, environmental and technological aspects within an economy (Ghisellini, Cialani and Ulgiati, 2016). The circular economy concept was defined by Pearce and Turner (1990), who criticized the traditional model for economic development, proposing the transition towards circular economy, using a model that emphasizes the environment's economic functions. Preston (2012) asserts that the circular economy is a process by which waste from the production activities becomes input for other production cycles. The French Environmental Agency defines the circular economy as an exchange and production system that occurs within the lifetime of a product, in order to increase the efficiency of resources' use, as well as reducing the impact on environment (Agence de l'Environnement et de la Maîtrise de l'Énergie, 2014).

The evolutions in the circular economy conceptualization were considered also by Sauvé, Bernard și Sloan (2016), which emphasize the obstacles in implementing the circular economy mechanisms, such as finding the technological solutions for minimizing the total ecological cost, but – especially – the changes in the consumer's behavior. The change in the consumer's behavior, as a prerequisite for implementing the circular economy, has been analyzed by Bratianu (2017) and is facilitated by the transition from the linear to nonlinear thinking and, furthermore, towards the dynamic thinking.

A comparative analysis of the circular economy concepts was provided by Ghisellini, Cialani and Ulgiati (2016), who identified the notable differences in their implementation throughout the world. As in China the circular economy is part of the political strategy of the Chinese government, in the European Union, United States of America and Japan it is a concept that is limited to waste management and environment protection. Therefore, new concepts related to the circular economy appeared, such as the eco-efficiency, eco-design, natural capitalism, ecological industry etc., that intend to realize the transformation and use of the natural resources in such a manner as to maintain and preserve the ecologic equilibrium and the economic growth (Ellen MacArthur Foundation, 2012).

The relevance of the transition process towards the circular economy is revealed by the EU's dependence on imports of raw-materials from all over the world. In order to assess the EU's independence relative to imports of raw materials from outside the EU, Eurostat defined the EU self-sufficiency for raw materials (EUROSTAT, 2017b), whose evolution in 2016 is presented in Figure no.1. This indicator considers the ratio of the net import of raw materials and the apparent consumption (that is defined as the internal production, corrected by the net import). Using this indicator, the largest dependence is for natural graphite, where the indicator has the lowest value from the considered raw materials. The largest independence is on limestone, where the indicator is close to one.

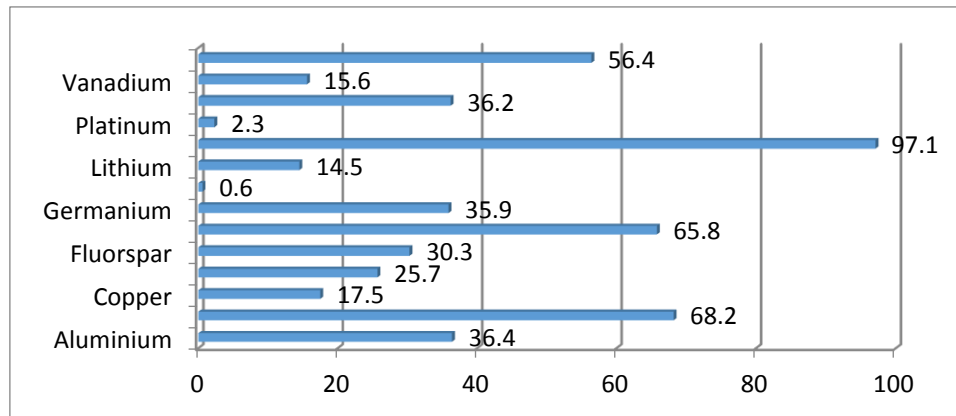


Figure no. 1 EU self-sufficiency for raw materials (%), 2016

Source: own computation, EUROSTAT

Sana (2014) shows that the circular economy is leading to economic growth, estimating that as much as 630 billion euros per year could be saved in Europe from a more efficient use of resources. Moreover, more work places could be delivered if the resource productivity increased by 30% until 2030. In this context, the circular economy can reduce the pressures on the environment, especially by increasing the spending in the research and innovation fields (Ellen MacArthur Foundation, 2013). But looking at the circular economy only by considering the positive effects is not a solution, as the circular economy has both technological and economic limits. For example, a study conducted on the Chinese city of Guiyang revealed that the short term positive results of the circular economy are not guaranteed and this process can also have negative effects on economic growth (Sana, 2014).

The Chinese economy transition from the present state to the circular economy is also central for a large number of researchers (Su and al., 2013, Pauliuk, Wang and Müller, 2012; Yuan, Bi and Moriguichi, 2006). In China, government's strategy of implementing the circular economy based on three pillars: a production that is environmentally friendly, industrial ecology and ecological modernization. As such, using a legislative package adopted in 2003, the polluting companies are required to audit their production activities, in order to assess the impact on the environment (Yuan, Bi and Moriguichi, 2006).

In France, the legislative framework for the circular economy was created starting from 2013, (Le Moigne, 2014), and from 2015 it was integrated into the fiscal laws, the aim being to reduce the economic activities' impact on the climate. Also in Germany, a focal point is on the efficient use of the resources. The results of some studies, (such as Rouquet

and Nicklaus, 2014) show that, for 2012, the governmental measures adopted by the authorities had as a main target maintaining the correlation between the economic growth and the resource utilization. Bonciu (2014) provides an analysis of the way the circular economy concept was applied across the European Union, outlining two examples of European companies that follow mechanisms specific to the circular economy (Renault and Philips), where measures meant to optimize the entire production process, and not only some components, were adopted.

Starting from the fact that the natural resources are at large exhaustible, Sørensen (2017) proposed a model to find the optimal recycling rate for the polluting raw materials and municipal waste. The author proved that the extensive exploitation of the natural resources can be contained by imposing a Pigouvian tax on non-recycling materials, whose value is equal to the present value of the environmental marginal cost of used materials.

Considering the environmental taxes in Europe, it was shown that 20 countries use taxes on waste that led to an increase in the fiscal revenues during 2009-2010 by 2.1 billion EUR that reveals also the openness of the governments towards this new economic model (European Environment Agency, 2012). Stahel (2013) considers that, in order to obtain the requirements of a sustainable and circular economy, it is necessary to impose taxes on non-renewables and suspend any subsidies on them. Nazet-Allouche (2016) shows that, in 2012, the ecologic fiscal measures are not well represented, considering the case of France, where the proportion in GDP of the environmental taxes is below the European average of 2.6%. Another study realized by an expert group (The Ex' Tax project and al, 2016) shows that the European tax system influences the new economic model, as the level of the environmental taxes in the total taxes does not exceed 6%, when more than 50% are from taxes on labor and social contributions.

In our opinion, all the studies on circular economy focused mainly in one country or on a specific economic field, showing the evolutions in the implementation of this concept. Moreover, intense debates on the circular economy concepts still persist among researchers, in terms of the coverage area or the relationship with some other concepts, such as the sustainable development concept.

2. Research methodology

In this study, we evaluate the impact of some circular economy concepts on the classical macroeconomic variables. First of all, the resource productivity is a fundamental concept for the circular economy, that relates to the finding of necessary measures to maintain the natural resources and inputs within the economic cycle as long as possible (Hu et al., 2011). Out of the variables that define the circular economy concept, we use the resource productivity that is the ratio of GDP and domestic material consumption. As a measure to reinsert used materials in the productive activity, we use the recycle rate of the packaging waste. Also, we consider the biowaste that is raw material for compost in agriculture.

The positive impact of the biowaste recycling is outlined by Bastein et al. (2013), that evaluate the value of these inputs reinserted in the agriculture (by 2013) to a total amount of 3.5 billion euros, estimated to increase with one more billion euros (by producing biogas or enhancing the recycling process). As such, the biowaste was approximated by the ratio of municipal waste/compost (measured in units) and total population within a country

(expressed as kilograms per capita). We also consider an indicator used by EUROSTAT for expressing the conversion progress of waste into resources, namely the recycling rate of municipal waste (EUROSTAT, 2017c). As the circular economy is mainly based on research and innovation, we use 2 indicators in this field, namely the gross domestic expenditure on research and development (R&D) as a percentage in the GDP and the number of patents related to recycling and secondary raw, expressed per 1 million inhabitants (EUROSTAT, 2017a). These indicators have been used to assess the impact on some standard macroeconomic variables, associated with sustainable development, such as the real GDP growth rate.

In testing these models, we started from the fact that the variables that evaluate the circular economy impact the resource productivity and the real GDP growth rate. As such, the following research hypotheses were considered:

H₁: The resource productivity is positively influenced by the circular economy measures;

H₂: The research and innovation positively influence the resource productivity;

H₃: The environmental taxes have a positive influence on the resource productivity;

H₄: The recycling activity has a positive impact on real GDP growth rate;

H₅: The innovation related to recycling and secondary raw has a negative relation with the real GDP growth rate.

As such, we used time series data panel regressions, starting from the general regression equation and the model proposed by Schmidheiny (2016), given by:

$$y_{it} = \alpha + X'_{it}\beta + \mu_i + \vartheta_{it} \quad i=1, \dots, N; t = 1, \dots, T \quad (1)$$

where:

I = cross-section dimension (transversal section);

t = time (time series dimension);

α, β = the equation's coefficients;

X'_{it} = the *it* observation of the explaining variables;

u_{it} = individual effect;

ϑ_{it} = residual.

Using time series data panel regressions, we estimate the fixed effect model and the random effect model, the choice for one of them being done using the Hausman test. As the circular economy concept is central for the European Commission and the European Parliament (European Commission, 2017a), we used a sample consisting of the 28 member states of the European Union, in order to assess the measures related to the circular economy in each member state.

We used data for the 2005-2016 timeframe, the longest for which statistical data have been identified in the EUROSTAT database (EUROSTAT, 2017a). This time interval also includes the global financial crisis that had significant effects on some variables that are considered in the analysis on the circular economy (especially, the real GDP growth rate that decreased in almost every member state of the European Union). As the insufficient number of

observations does not validate the use of time series regressions, we use the time series data panel regressions, in order to capture the possible relationships between the circular economy indicators and macroeconomic variables, such as the real GDP growth rate.

The annual data for the 2005-2016 time period for resource productivity (RES_PROD variable), recycling rate of packaging waste (RECYCL_RATE variable), recycling rate of biowaste (RECYCL_BIOWASTE variable), recycling rate of municipal waste (RECYCL_MUNWASTE variable), environmental tax revenues as a percentage in GDP (ENV_TAX_GDP variable), as well as the research activity (given by the number of patents related to recycling and secondary raw per 1 million inhabitants, the PATENTS variable, and the gross domestic expenditure on R&D as a percentage in GDP, the RD_GDP variable), the real GDP growth rate (REALGDP_GROWTH variable) were considered. We used the data available on the official websites of the Eurostat (<http://ec.europa.eu/eurostat>) and World Bank (www.worldbank.org).

3. Results and discussions

Before proceeding to this analysis, in Figure no. 2 we present the evolution of the number of patents related to recycling and secondary raw, in the European Union, for the 2002-2013 time frame (EUROSTAT, 2017a). The aim is to emphasize, once more, the governmental and private sector interest in research and innovation process that tries to lengthen the life cycle of the raw materials and, as a consequence, to implement the circular economy concept.

We can see from Figure no. 2 that in the European Union the importance of the research and innovation in the transition process from the linear economy towards the circular economy has strengthened (as the sustainable development principles are applied), respectively by an increase of more than 40% of the number of patents related to the recycling of raw and secondary raw material in 2013, compared with 2002.

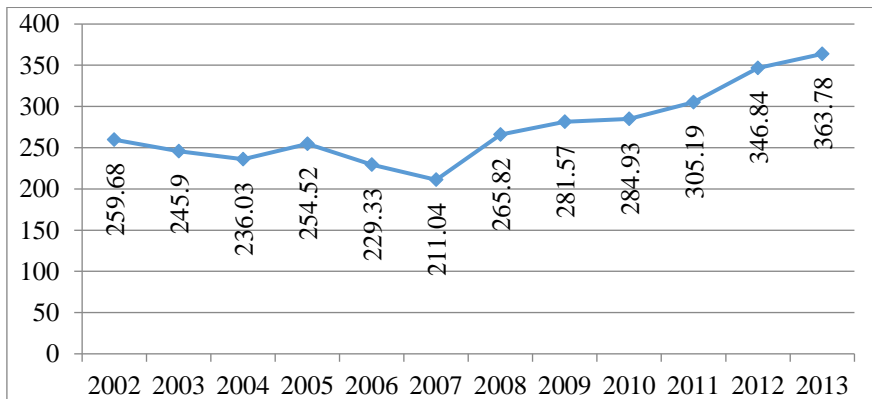


Figure no. 2: The number of patents related to recycling and secondary raw in the EU, per 1 million inhabitants (2002-2013)

Source: own computation, EUROSTAT

In order to estimate the impact on the resource productivity (a main concept in the transition from the linear economy to the circular economy), as expressed by the RES_PROD variable, given by some variables associated to the circular economy, we used time series data panel regressions. We propose a model where the dependent variable is RES_PROD, and the independent variables are RECYCL_RATE, RECYCL_MUNWASTE, ENV_TAX_GDP, PATENTS and RD_GDP, the results being presented in Table no.1. By using the Hausman test, we find that the relationship between the dependent variable and the exogenous variable is given by the random effect model.

Considering this model, that explains 22.72% of the dependent variable RES_PROD evolution using the other 5 independent variables, we observe the existence of a positive relationship between the resource productivity and the considered measures associated to the circular economy, such as the recycling rate of packaging waste, recycling rate of municipal waste, environmental taxes imposed by the European Union member states and the research and innovation (such as the number of patents related to the recycling and secondary raw or the gross domestic expenditure on R&D as percentage in GDP). This result confirms the empirical findings related to the positive impact the environmental protection and recycling measures have on resource productivity in the economy (and, therefore, the Hypothesis H₁ is validated).

Table no. 1: The proposed model for RES_PROD variable, using 5 independent variables, for the 2005-2016 time frame

Correlated Random Effects – Hausman Test				
Test Summary		Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random		9.988421	5	0.0756
Dependent variable	Independent variable	Coefficient	Prob.	R-squared
RES_PROD	RECYCL_RATE	0.006467	0.0023	0.227299
	RECYCL_MUNWAST	0.010307	0.0000	
	ENV_TAX_GDP	0.035855	0.4964	
	PATENTS	0.068711	0.0035	
	RD_GDP	0.159987	0.0246	

Source: own computation, Eviews estimation

The positive relationship between the resource productivity and the recycling (as given by the recycling rate of packaging waste and recycling rate of municipal waste) can be explained by the positive effect on the total costs in the economy, as a result of implementing the adequate measures for environmental protection. These solutions are envisaged by the European Union’s member states that already have elaborated strategies for systemic changes within the economy (the Finland case that adopted a strategy towards the circular economy by 2025). Moreover, increasing the recycling and reusing of the municipal waste, compared to the actual method, of incineration, is aimed to reduce the emissions of greenhouse gases, to decrease the prices of secondary raw materials or to create the compost and energy. Using this model, increasing by one unit the recycling rate of the municipal waste will lead to an increase in resource productivity by 0.01307, a statistically significant relation, but not determinant for improving the productivity. A lower impact (although statistically significant) is given by the recycling rate of packaging waste, a process directly connected with the production activity at the level of the economy.

Analyzing this model, we can identify the existence of a positive relationship between the research and innovation activities from the European Union and the resource productivity, measured by the RES_PROD variable (therefore, the Hypothesis H₂ is validated). This relation confirms the data and empirical observations, being explained by the EU's companies and institutions prone to identification and implementation of the technological solutions needed for production cost reduction. As such, the increase by one unit of the number of patents related to recycling and secondary raw materials in the EU (expressed per 1 million inhabitants) will lead to an increase in the resource productivity by 0.068711, and an 1% increase in the expenditure on R&D as a percentage in GDP will lead to an increase in resource productivity by 0.159988. Similarly, the positive relation between the environmental taxes as a percentage in GDP and the resource productivity is confirmed by the proposed model, even though the coefficient of the variable ENV_TAX_GDP is not statistically significant (therefore, the Hypothesis H₃ is validated). This result confirms the conclusions obtained by Sørensen (2017), who stated that a legislative package related to environment and subsidies, is an important precondition for an efficient recycling activity.

Using this equation's results, the positive relationship between the resource productivity and the direct and indirect measures related to the circular economy, such as the recycling rate of municipal waste, the recycling rate of packaging waste, the R&D related to recycling and secondary raw materials (measured as the number of patents and the gross expenditure on R&D as percentage in GDP), the environmental taxes as a percentage in GDP, was confirmed. By eliminating the only independent variable that is not statistically significant (the one that shows the environmental taxes as a percentage in GDP), we find a new model, presented in Table no. 2. This model shows that the positive relationships from the previous model are also proved, between the resource productivity and the research and innovation related to recycling. As such, the first three research hypotheses are confirmed.

These results stress out the positive impact the new technologies, based on the sustainable development and the efficient use of resources, even those from recycling, have on resource productivity. Moreover, these results provide one more reason for implementing the measures envisaged by the European Commission and the United Nations Organization for worldwide sustainable development, expressed by the documents aiming to fulfill this goal by 2030.

Table no. 2: The proposed model for RES_PROD variable, considering 4 independent variables, in the 2005-2016 time frame

Correlated Random Effects – Hausman Test				
Test Summary		Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random		9.075406	4	0.0592
Dependent variable	Independent variable	Coefficient	Prob.	R-squared
RES_PROD	RECYCL_RATE	0.006394	0.0025	0.226208
	RECYCL_MUNWAST	0.010452	0.0000	
	PATENTS	0.067930	0.0038	
	RD_GDP	0.162467	0.0222	

Source: own computation, Eviews estimation

In order to test the other 2 hypotheses (H₄ and H₅), we use a model that has a dependent variable – the real GDP growth rate, while the independent variables are those associated with the circular economy concept. As such, Table no. 3 presents the results of a time series

data panel model, where the dependent variable is the real GDP growth rate (REALGDP_GROWTH variable), and the independent variables are RES_PROD, RECYCL_RATE, RECYCL_BIOWASTE, ENV_TAX_GDP, PATENTS and RD_GDP. Using the Hausman test, the fixed effect model is the one that we consider, as its probability is below 5%.

Analyzing the data from Table no. 3, we observe a positive relationship between the real GDP growth rate and the resource productivity (although the independent variable's coefficient is not statistically significant), a result that confirms the empirical observations. Using the results from Table no. 3, we observe that the fourth hypothesis H₄ is not confirmed, considering the coefficient of the variable recycling rate of packaging waste (that is negative and statistically significant). This situation is determined by the early stage of implementation of the measures aimed to realize transition towards the circular economy, a fact that maintains the disparities between the present and circular economy (in order for the production to be more efficient, as measured by the real GDP growth rate, are still used – on a large scale – raw materials whose exploitation impacts the environment).

Table no. 3: The proposed model for REALGDP_GROWTH variable, considering 4 independent variables, in the 2005-2016 time frame

Correlated Random Effects – Hausman Test				
Test Summary		Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random		12.961132	6	0.0437
Dependent variable	Independent variable	Coefficient	Prob.	R-squared
REALGDP_GROWTH	RES_PROD	0.751604	0.3713	0.180987
	RECYCL_RATE	-0.117857	0.0000	
	ENV_TAX_GDP	-0.362800	0.6564	
	PATENTS	-0.812382	0.0240	

Source: own computation, Eviews estimation

The results from Table no. 3 also show the confirmation of the fifth hypothesis H₅, related to the negative relationship between the real GDP growth rate and the number of patents related to recycling and secondary raw materials. This relation can be explained by the research and innovation's characteristics, especially by the long time interval between the idea and production (starting the research, making a prototype or finding a new technology, patent registration, practical validation of the patent and, moreover, its use in production, in order to reduce the economic activity's impact on the environment). The results confirm also the negative impact the environmental taxes (measured as percentage in GDP) have on the economic growth (as measured by the real GDP growth rate).

Considering a relevance threshold of 5%, we can conclude that the measures associated with the circular economy (as expressed by the indicators used in the proposed regressions) have a direct impact on the resource productivity and on economic growth, measured by the real GDP growth rate. These results are confirmed by previous studies (Sørensen, 2017, who revealed the effects the environmental taxes have on the transition towards the circular economy, Bastein et al., 2013, that emphasized the positive impact the recycling has on the resource productivity). On the other hand, the observed negative relation between the real economic growth and the research and innovation related to recycling provides a new insight, using data from the European Union, on the effects the transition towards the

circular economy may have on the real economic growth (namely, the decoupling of these two indicators, as others outlined, such as Ghisellini, Cialani and Ulgiati, 2016).

Conclusions

Using data for the 2005-2016 timeframe, for the 28 member states of the European Union, we confirmed the existence of a positive relationship between circular economy measures and resource productivity, with a positive impact on economic growth. The obtained result shows the effect induced on the resource productivity by the measures aimed to achieve sustainable development, by the transition from the linear economy towards the circular economy. From the obtained results, an increase by one unit of the number of patents registered in the EU related to recycling and secondary raw materials will lead to an increase in resource productivity by 0.068711, whereas an increase by one unit of the recycling rate of municipal waste will enhance the resource productivity by 0.01307.

One reason for this evolution is given by the systemic change induced by the transition towards the circular economy, with short term costs, that is revealed by the validation of the H₅ hypothesis, namely the negative relationship between the real GDP growth rate and the number of patents. The benefits induced by the measures associated with the circular economy are not seen at the environment protection level, but also at improving the resource efficiency. As such, Germany, Japan and China defined quantitative objectives related to the resource productivity enhancements, by in China's case – as much as 15% during 2010-2015 (Rouquet and Nicklaus, 2014).

The obtained results confirm the hypothesis, mainly related to the positive effect the measures associated with the circular economy have on resource productivity and economic growth, confirming the European point of view that an increase of the resource productivity with 30% by 2030 may lead to a GDP growth of almost 1% (European Commission, 2014). This study may be of importance for local, regional and national public authorities involved in framing the legislative ground, as well as for companies that can elaborate the business plans according to the expected effects the circular economy implementation may have on every member state. This model provides useful information for companies, as it shows that the economic growth can be achieved not only by using raw materials, but also by reinserting waste into the production cycle, reducing the associated costs. This fact may lead to an increased demand for ecological products, to develop new products and to strengthen the efforts in the research and innovation field.

Considering the limited data on this topic, as well as the effects of the transition towards the circular economy that may lead to major structural changes in the EU member states' economies, we may find new directions of research. As such, starting from studying the impact of other circular economy indicators (such as the dynamics of trade with recycling and secondary raw materials) may have on some macroeconomic variables, we can extend the research also on the impact on the quality of life for the European citizens. Moreover, a large field of research may be the impact of the social economy on reducing the social inequalities and fostering social inclusion in the analyzed countries. Starting from the study's limitations, related to a relatively short time frame available to accurately reflect the path towards circular economy, the early stage in some countries or the lack of necessary data for evaluating the circular economy, a further research area can be in lengthening the

sample and time frame, until 2017, in order to capture new effects derived from the measures adopted in Europe.

References

- Agence de l'Environnement et de la Maîtrise de l'Énergie, 2014. *Guide méthodologique du développement des stratégies régionales d'économie circulaire en France*, [pdf] Available at: <<http://www.ademe.fr/guide-methodologique-developpement-strategies-regionales-deconomie-circulaire-france>> [Accessed 12 March 2018].
- Bartelmuš, P., 2013. The future we want: Green growth or sustainable development? *Environmental Development*, 7, pp.165-170.
- Bastein, T., Roelofs, E., Rietveld, E. and Hoogendorn, A., 2013. Opportunities for a circular economy in the Netherlands, [online] Available at: <<https://www.tno.nl/media/8551/tno-circular-economy-for-ienm.pdf>> [Accessed 18 December 2017].
- Bonciu, F., 2014. The European Economy: From a Linear to a Circular Economy. *Romanian Journal of European Affairs*, 14(4), pp.78-91.
- Bourguignon, D., 2016. *Circular economy package. Four legislative proposals on waste*. [pdf] Brussels: European Parliamentary Research Service. Available at: <<http://www.europarl.europa.eu/EPRS/EPRS-Briefing-573936-Circular-economy-package-FINAL.pdf>> [Accessed 18 December 2017].
- Bratianu, C., 2007. Thinking patterns and knowledge dynamics. In Martins, B. & Remenyi, D. (eds.). *Proceedings of the 8th European Conference on Knowledge Management*, 6-7 September 2007. Consorci Escola Industrial de Barcelona, Barcelona, Spain, pp. 152-157. Reading: Academic Conferences.
- Ellen MacArthur Foundation, 2012. *Efficiency vs. Effectiveness*. [online] Available at: <<https://www.ellenmacarthurfoundation.org/circular-economy/interactive-diagram/efficiency-vs-effectiveness>> [Accessed 18 December 2017].
- Ellen MacArthur Foundation, 2013. *Towards the circular economy, Opportunities for the consumer goods sector*. [online] Available at: <https://www.ellenmacarthurfoundation.org/assets/downloads/publications/TCE_Report-2013.pdf> [Accessed 27 December 2017].
- European Commission, 2014. The road to a circular economy. *Environment for Europeans*. [online] Available at: <https://ec.europa.eu/environment/efe/themes/economics-strategy-and-information/road-circular-economy_en> [Accessed 11 March 2018].
- European Commission, 2017a. *Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the implementation of the Circular Economy Action Plan*. [pdf] Brussels. Available at: <http://ec.europa.eu/environment/circular-economy/implementation_report.pdf> [Accessed 18 December 2017].
- European Commission, 2017b. *Bulgarian EU Presidency includes circular economy among its priorities*. [online] Available at: <<http://circulareconomy.europa.eu/platform/en/news-and-events/bulgarian-eu-presidency-includes-circular-economy-among-its-priorities>> [Accessed 18 December 2017].

- European Environment Agency, 2012. Overview of the use of landfill taxes in Europe. *Working Paper*. [online] Available at: <http://scp.eionet.europa.eu/publications/WP2012_1/wp/WP2012_1> [Accessed 27 December 2017].
- EUROSTAT, 2017a. Database. Available at:<<http://ec.europa.eu/eurostat/data/database>> [Accessed 12 December 2017].
- EUROSTAT, 2017b. *EU self-sufficiency for raw materials*. [online] Available at:<http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=cei_pc010&plugin=1> [Accessed 18 December 2017].
- EUROSTAT, 2017c. *Recycling rate of municipal waste*. [online] Available at: <http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=cei_wm011&plugin=1> [Accessed 18 December 2017].
- Ghisellini, P., Cialani, C. and Ulgiati, S., 2016. A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, 114, pp.11-32.
- Hu, J., Xaio, Z., Zhou, R., Deng, W., Wang, M., and Ma, S., 2011. Ecological utilization of leather tannery waste with circular economy model, *Journal of Cleaner Production*, 19(2-3), pp.221-228.
- Le Moigne, R., 2014. *L'economie circulaire. Comment la mettre en oeuvre dans l'entreprise grâce à reverse supply chain?*. Paris: Dunod.
- Ministry of Infrastructure and the Environment, 2016. *A Circular Economy in the Netherlands by 2050*. [online] Available at: <<https://www.oecd.org/environment/ministerial/whatsnew/2016-ENV-Ministerial-Netherlands-Circular-economy-in-the-Netherlands-by-2050.pdf>> [Accessed 18 December 2017].
- Nazet-Allouche, D., 2016. Economie circulaire et droit., *les Notes du Pôle*, Open Edition, [online] Available at: <<https://halshs.archives-ouvertes.fr/halshs-01316183/>> [Accessed 19 December 2017].
- Pauliuk, S., Wang, T. and Müller, D., 2012. Moving toward the circular economy: the role of stocks in the Chinese steel cycle. *Environmental Science & Technology*, 46(1), pp.148-154.
- Pearce, D.W. and Turner, R.K., 1990. *Economics of Natural Resources and the Environment*, Baltimore: The Johns Hopkins University Press.
- Preston, F., 2012. A Global Redesign? Shaping the Circular Economy, *Briefing Paper*, [online] Available at: <https://www.biblioteca.fundacionicbc.edu.ar/images/d/d7/Bp_0312_preston.pdf> [Accessed 11 March 2018].
- Prime Minister's Office, 2015. *Action plan for the implementation of the key project and reforms defined in the Strategic Government Publication*, [online] Available at: <<http://valtioneuvosto.fi/documents/10616/1986338/Action+plan+for+the+implementation+Strategic+Government+Programme+EN.pdf/12f723ba-6f6b-4e6c-a636-4ad4175d7c4e>> [Accessed 12 March 2017].
- Rouquet, R. and Nicklaus, D., 2014. Comparaison internationales des politiques publiques en matière d'économie circulaire, *Commissariat general au développement durable, Etudes et documents*, 101, pp.3-44.

- Sana, F., 2014. L'économie circulaire: changement complet de paradigme économique?, *Note D'Analyse*, [online] Available at: <<http://www.pourlasolidarite.eu/sites/default/files/publications/files/na-2014-economie-circulaire.pdf>> [Accessed 15 December 2017].
- Sauvé, S., Bernard, S. and Sloan, P., 2016. Environmental sciences, sustainable development and circular economy: alternative concepts for trans-disciplinary research. *Environmental Development*, 17, pp.48-56.
- Schmidheiny, K. 2016. *Panel data: Fixed and Random Effects*. [pdf] Basel Universität. Available at: <<http://www.schmidheiny.name/teaching/panel2up.pdf>> [Accessed 18 December 2017].
- Sørensen, P.B., 2017. *The basic environmental economics of the circular economy*, [online] Available at: <http://www.econ.ku.dk/Kalender/seminarerepru/17112017/paper/Circular_Economy_general_model.pdf> [Accessed 18 December 2017].
- Stahel, W., 2013. *Economie circulaire et Économie de Fonctionnalité – une perspective venir pour un modèle à réinventer*. [pdf] Institut de la Durée. Available at: <<http://www.product-life.org/fr>> [Accessed 17 December 2017].
- Su, B., Heshmati, A., Geng, Y. and Yu, X., 2013. A review of the circular economy in China: moving from rethoric to implementation, *Journal of Cleaner Production*, 42, pp.215-227.
- Yuan, Z., Bi, J. and Moriguchi Y., 2006. The Circular Economy. A New Development Strategy in China. *Journal of Industrial Ecology*, 10(1-2), pp.4-8.
- The ExTax Project, 2016. *New era. New Plan. Europe. A fiscal strategy for an inclusive, circular economy*, [online] Available at: <<http://www.neweranewplan.com/wp-content/uploads/2016/12/New-Era-New-Plan-Europe-Extax-Report-DEF.compressed.pdf>> [Accessed 18 December 2017].
- United Nations, 1987. *Report of the World Commission on Environment and Development: Our Common Future*, [online] Available at: <<http://www.un-documents.net/our-common-future.pdf>> [Accessed 18 December 2017].
- United Nations, 2015. *The 2030 Agenda for Sustainable Development, Economic and Social Commission for Asia and the Pacific*, [online] Available at: <http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E> [Accessed 18 December 2017].
- World Bank, Database. www.worldbank.org [Accessed 12 December 2017].