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The development of circular economy in Western Balkan countries

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Abstract

The circular economy implies that the primary source of economic growth is the maximum reuse of many materials obtained from products at the end of their life cycle and the minimum extraction of new resources. In contrast to it, the traditional linear economy follows a simple path "take - produce - dispose", i.e., it is based on the constant extraction of new resources and the disposal of used products as waste without the possibility of their reuse as inputs in the production of the same or another product. In Western Balkans countries, this paper reviews the degree of progress made in developing Circular Economy. The efficiency of Western Balkan countries when it comes to developing and implementing a circular economy will be demonstrated in the DEA analysis. The key trends in the evolution of circular economies in the Western Balkan countries, as well as the most important elements hindering its faster development and mutual convergence with the countries of European union will be highlighted in this paper.
***Keywords*:** *Circular Economy, Economic Growth, DEA*

1. Introduction

Environmental protection today is one of the most critical problems public policymakers faces. A significant impact on the environment is how the creation of goods and services and their disposal at the end of life is organised (the country's economic system). Traditional production processes do not consider problems such as pollution, degradation of environmental quality and depletion of natural resources. In countries where economic (fiscal policy) does not internalise indirect external costs, producers ignore the effects of their business activities on the environment. The life cycle of a physical good begins with simply taking the necessary resources from nature, producing products, using them and disposing of them for waste. Increasing environmental pollution, rising prices of resources, materials and energy, and population growth have led businesses and policymakers in developed countries to adopt a series of strategies and action plans aimed at reducing the extraction of new resources from nature and the amount of waste generated at the end of the life cycle of products. At the beginning of the 21st century, the development of an entirely new economic concept called circular economy gradually prevailed in financial, technical and other sciences. The circular economy implies that the primary source of economic growth is the more significant reuse of many materials obtained from products that have completed their life cycle and the less extraction of new resources. In contrast, a traditional linear economy follows a simple "take – produce – dispose" path; that is, it is based on the constant extraction of new resources and the disposal of used products on waste without the possibility of their reuse as inputs in the production of the same or any other product.

The paper, using Data envelopment analysis (DEA), analyses the efficiency of development of the circular economy in the Western Balkan countries. The DEA methodology is used to determine the changing efficiency of European Union countries in building a circular economy over time. The DEA numerically expresses the achieved efficiency of the circular economy development process and, therefore, represents an adeqaute tool for determining the efficient or inefficient position of the country that is the subject of the analysis. The paper will show whether the countries of the European Union converge with each other in terms of the degree of development of the circular economy or whether their mutual divergence occurs. The circular economy's development level will be measured by creating a composite indicator through DEA analysis.

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2. Circular Economy

Industrial production in the European Union during the 20th century was based on a linear model of resource use, i.e. linear economy. This production model follows a simple "take - produce – dispose" path. This production model directly takes resources from nature ("take"). Resources are further processed, creating final products by applying energy and labour ("produce"). The end-user discards the product when it breaks down or can no longer serve its original purpose ("disposal"). It means that the final product and all the resources invested in its production end up in landfills or waste incinerators. Therefore, in the linear economy model, there are no (or are very limited) incentives for reducing waste in the production and consumption phase, i.e., for its valorisation and reuse.

At the beginning of the 21st century, policymakers in the European Union are beginning to realise that an economic system cannot be sustainable in the long term if it operates based on a linear economy. As early as the 1960s, many scientists from different disciplines in developed countries began to point out the negative impact of the linear economy on the state of natural resources and the environment. The need for a gradual transformation of the Linear Economic Development model to a newer one with more attention paid to nature's resource needs, which should be maintained in future generations, has been driven by emerging ecological problems that have developed over time.

Kenneth Boulding, an American economist, is one of the founders of a new concept on how to use resources. In his 1966 article, "The Economics of the Coming Spaceship Earth", he used the term "the circular economy" for the first time, comparing Earth to a spaceship with a scarcity of resources and a need for constant recycling and reproduction. To put it another way, Earth is a closed economy system where economies and the environment don't just connect with one another but are interconnected by circularity.

The limitations of linear economics began to be pronounced as early as the 1970s. The two energy crises have shown a high degree of mismatch between economic growth and limited resources. It is why the Club of Rome's "Growth Constraints" report proposed an economic model as a closed system based on limited resources and an alternative to the linear growth model of the time. The circular economy as a closed model does not represent a new economic model that is excluded from international trade but a model that can achieve economic growth with as little share of new resources as possible and as much as possible the use of resources derived from products that have completed their life cycle.

Swedish economist Karl Goran-Mahler focused his research on the economic effects of nonlinear dynamic ecosystems as one of the fields of research in environmental economics. His book "Environmental Economics: a Theoretical Inquiry" (1974) examined the relationship between economic growth, environment quality, consumption and social well being.

Arguments in favour of reducing the extraction of new resources and more frequent use of materials derived from products whose lifespan has passed began to appear in the literature as early as the last decade of the 20th century. Pearce and Turner (1990), in their book Economics of Natural Resources and the Environment, detailed the interplay between the economy and the environment. They paid special attention to pollution and depletion of natural resources. In this paper, they also use the concept of circular economy. In his 1992 paper "Allocation, distribution and scale: toward an economics that is efficient, just, and sustainable", he expressed concern for the future of what he considers inefficient, unjust and unsustainable economic development.

Göttsching (1996) studied Germany's development path from importer to exporter of paper waste in the period from the 1970s to the 1990s. Schwarz et Steininger (1997) studied the functioning of a network of enterprises that each enterprise uses as input waste created by the previous enterprise. Strebel (2004) argued that economic models should follow the model of nature, i.e., the circulation of materials and energy in the economy should follow what is characteristic of nature. Wedekind et Haasis (2004) argued that manufacturers must monitor and be responsible for the entire life cycle of their product. Illge et Schwarze (2009) introduced the economic concepts of market failures, externalities, and state policy into the circular economy concept. In their opinion, the one-way stream of matter "resource consumption – production – emission" should be replaced by a cyclical flow of matter "resource use – production – resource recovery".

At the beginning of the 21st century, the greatest contribution to the promotion, theoretical and applied research related to the circular economy was made by the Ellen Macarthur Foundation (http://www.ellenmacarthurfoundation.org/) founded in 2010. Ellen Macarthur was a British sailor. Although it is not considered a modern founder of the circular economy, the merits of its foundation in raising awareness, education and accelerating the transition to a circular economy are very important.

The necessity to develop a new concept for economic growth is due to the tendency of companies to respond to rising resource and energy prices, i.e. their costs and decreases in revenues resulting from stagnant demand. A more frequent use of a large number of materials generated from products that have run their lifetimes and less production of new resources is the primary source of economic growth in this circular economy. Therefore, the products are designed to be easily reused, disassembled, repaired, or recycled. A resource such as labour plays a central role in the economic system, while limited natural resources are given the role of support.

However, today's circular economy is still much more theoretical than a practical concept of an economic system. Since the circular economy is a multidisciplinary concept, it isn't easy to set a single definition that fully covers everything it encompasses. The circular economy is yet to come and is a developing concept. As seen from the above, no precise definition would cover the economic, social and environmental pillars of sustainability on which the circular economy is based.

3. Methodology

Malmquist's productivity index is the first example in the literature of introducing a dynamic component in the analysis of enveloped data. This index evaluates the changes in productivity of the observed unit (country) between two periods and is an example of comparative statistical analysis (Fare et al., 1998). The Malmquist productivity index is defined as the productivity of a catch-up effect and a frontier shift effect (Fare et al., 1994). The first effect (catching up effect) shows whether a country has improved its relative input efficiency, i.e., whether it is achieving growth or regressing. The second effect measures the shifting of the boundary of production capabilities (technological constraint) in time, i.e. the change of technology and, in this paper, shows whether the country applies the new concept of circular economy (eco-innovation) or stays with the existing one. According to the methodological explanation presented by Sanchez (2018), here is a calculation of the Malmquist Index, changes in comparison efficiency with use of inputs and pushed boundaries for production capabilities.

Calculating the Malmquist index involves determining the value θ DEA model and applying linear programming using the following equation (s represents the number of limits of production possibilities and takes the value of 1 and 2, and t the number of periods observed and takes the value of 1 and 2, respectively, the designations of two periods that are compared to each other) (Zhu (2011):

$$\delta^s(x_0, y_0)^t = \min_{\theta,\lambda} \theta \qquad (1)$$

where is

$\delta^s x_0^t \geq X^s \lambda_i$
$y_0^t \leq Y^s \lambda_i$
$\lambda_i > 0$
$i = 0, 1, 2, \ldots, N$

An input-oriented DEA model, such as the one described above, requires a combination of the smallest possible inputs to produce an output. In contrast to this model, the output-oriented model of calculating the Malmquist index assumes that it is necessary to determine the potential output that the observed country can achieve with given inputs if it were to use these inputs as well as countries that are at the very limit of production capabilities (the most efficient countries) (Fare et al., 1994).

In the case of an output-oriented model, the calculation of the Malmquist index and θ values would take place via linear programming via the following equation and the set constraints:

$$(x_0, y_0)^t = \min_{\theta,\lambda} \theta \qquad (2)$$

where is

$x_0^t \geq X^s \lambda_i$
$\left(\frac{1}{\theta}\right) y_0^t \leq Y^s \lambda_i$
$\lambda_i > 0$
$i = 0, 1, 2, \ldots, N$

This model as linear programming problem would consist of four equations. The vector λ=(λ1, λ2,..., λN) represents an array of N variable λi, which constructs the efficiency limit, i.e. the limit of production capabilities, while e represents the vector e=(1, 1, ..., 1) of magnitude 1×N. X represents the matrix in which the inputs are entered, and Y represents the matrix containing data on output values for each observed country, i.e. DMU (the number of rows in the matrices X and Y corresponds to the number of inputs and outputs respectively, and the number of columns of the number of units observed, i.e. countries). The model is calculated N times for each pair of values (s, t), where N represents the number of units observed (DMU).

The Malmquist index shall be calculated as MI=EC*TC. The first component (EC) shows the magnitude of technological efficiency changes for two time periods. For instance, compared to its comparative effectiveness with inputs. It indicates whether there has been an improvement, a decrease or no change. The second expression (TC) shows the shift of the boundary of production capabilities, that is, the change in applied technology between two time periods.

In order to evaluate the efficiency of the Western Balkan countries in applying the circular economy principles, it is necessary to select certain indicators representing inputs and outputs. Table 1 provides an overview of the selected indicators. Three indicators related to applying circular economy principles in the observed country represent inputs, while the fourth indicator represents output (GDP per capita).

Table 1. Indicators used in DEA analysis

Dimension	Indicator
Input	GMWpc – Generation of municipal waste per capita (kg per capita)
	RMW – Recycling rate of municipal waste (%)
	MID – Material import dependency (%)
Output	GDPpc – BDP per capita (EUR)

Source: Eurostat (https://ec.europa.eu/eurostat)

According to Eurostat's methodology, waste generated by or on behalf of local authorities and disposed of through the waste management system is measured by the indicator of municipal waste per capita (GMWpc). Household waste is mainly involved, though other types of waste can also be considered, including those originating from sources like commercial activity, offices or state institutions. The recycling rate of municipal waste (RMW) measures the share of recycled municipal waste in overall production. Recycling involves recycling materials, composting and anaerobic digestion. The material import dependency is a ratio expressed in per cent (%) as both terms are measured in the same unit, namely tons. This indicator provides the ratio of imports over direct material inputs in percentage. As described above, the amount of an economy's reliance on imports to meet its material needs is characterised by material import dependency. It must not be more than 100% that the material import dependency is negative. The 100% or above values indicate that domestic extractions were not made during the reference year.

For determining the limits of technological efficiency, i.e. the limitation of production capabilities of the DEA analysis, this paper covers five countries of the Western Balkans and the EU-27 average: Bosnia and Herzegovina, Montenegro, North Macedonia, Albania and Serbia. The data are from the period 2010-2021.

5. Results and discussion

In order to understand the dynamics of change in the application of the principles of circular economy and the factors that influence this change, it is necessary to improve the DEA analysis by including a dynamic component. This was achieved precisely by introducing the Malmquist productivity index, obtained using the DEA method (input-output-oriented model with variable returns) and efficiency coefficients for all observed countries from 2010-2021 (Table 2).

Table 2. Malmquist Index (MI) scores

	2011/2010	2012/2011	2013/2012	2014/2013	2015/2014	2016/2015	2017/2016	2018/2017	2019/2020	2020/2019	2021/2020
Albania	1,029	1,016	1,045	0,951	1,108	1,086	0,835	1,037	1,016	0,409	1,056
Bosnia and Herzegovina	1,004	1,039	1,338	0,933	1,065	1,030	1,020	1,069	1,065	0,971	1,073
Montenegro	1,030	1,030	1,049	0,980	0,997	1,029	1,068	0,674	0,932	0,955	1,078
North Macedonia	1,003	0,932	1,038	1,057	1,008	1,028	1,010	0,948	0,970	0,956	0,961
Serbia	1,020	1,046	0,746	1,009	1,025	1,210	0,925	1,037	1,307	0,436	1,005
EU-27	1,025	0,980	1,001	1,000	0,999	0,998	1,022	1,014	1,021	0,957	1,048

Source: Author's calculation based on MaxDEA 9.0

Based on the DEA analysis and the results obtained by calculating the Malmquist productivity index, this coefficient from 2010 to 2021 for the five observed countries ranged from 0.409 to 1.338. For the interpretation of the value of the Malmquist index to be considered complete, it is necessary to look at the trends of its components simultaneously: the utilisation of existing resources (EC) and the introduction of new technology (TC). Both components affect the level of use of inputs on economic growth, but now it is a question of the very structure of these changes. For example, the value of the MI index is constantly high for Serbia, with the exception of the last two years when the overall productivity decreases. It is precisely in those years of lower values that this country recorded a decrease in the TC index, which indicates that this is a period when the country slowed down with the introduction of new circular economy technology. At the same time, the application of existing inputs was constant (EC).

Table 3. Relative efficiency (EC) scores

	2011/2010	2012/2011	2013/2012	2014/2013	2015/2014	2016/2015	2017/2016	2018/2017	2019/2020	2020/2019	2021/2020
Albania	1,034	0,988	1,227	1,000	1,000	1,000	1,000	0,996	0,639	0,483	0,987
Bosnia and Herzegovina	1,009	1,011	1,257	1,000	1,000	1,000	1,000	1,000	0,941	1,063	1,000
Montenegro	1,035	1,002	1,140	1,033	0,946	0,972	1,094	0,644	0,921	1,046	0,974
North Macedonia	1,008	0,906	0,963	1,157	0,936	1,025	0,955	0,905	0,862	1,046	0,854
Serbia	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0,550	0,955
EU-27	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000

Source: Author's calculation based on MaxDEA 9.0

Notably, a few countries have values of the Malmquist Index below 1, which decreases from 2010-2021. The most noticeable in this sense are Montenegro and Macedonia. In the analysed period, Montenegro relied on existing resources, and introducing new technology did not significantly impact increasing productivity, i.e., the application of the CE concept. Conversely, Macedonia has had fluctuating trends in the use of existing resources and has practically used certain positive effects to compensate for the lack of introducing new technology. It is interesting to follow the situation regarding Serbia, as an economy in which the CE concept has been present for many years than in other Western Balkans countries. Serbia has a stable, constant use of existing resources with the continual introduction of new technology, increasing productivity (MI).

Table 4. Technical efficiency (TC) scores

	2011/2010	2012/2011	2013/2012	2014/2013	2015/2014	2016/2015	2017/2016	2018/2017	2019/2020	2020/2019	2021/2020
Albania	0,995	1,028	0,852	0,951	1,108	1,086	0,835	1,041	1,589	0,847	1,069
Bosnia and Herzegovina	0,995	1,028	1,065	0,933	1,065	1,030	1,020	1,069	1,132	0,914	1,073
Montenegro	0,995	1,028	0,920	0,949	1,054	1,059	0,977	1,047	1,012	0,913	1,107
North Macedonia	0,995	1,028	1,078	0,914	1,076	1,003	1,058	1,047	1,125	0,914	1,125
Serbia	1,020	1,046	0,746	1,009	1,025	1,210	0,925	1,037	1,307	0,792	1,052
EU-27	1,025	0,980	1,001	1,000	0,999	0,998	1,022	1,014	1,021	0,957	1,048

Source: Author's calculation based on MaxDEA 9.0

If you compare the maximum, minimum and mean values of the Malmkvist index for each individual year in the specified period, certain conclusions are reached regarding the reasons for the changes in the values of this index (Table 5). Looking at the mean values of the Malmqvist index, an oscillating trend is observed (growth until 2020 and then a slight decrease). During the period 2010-2021, selected countries recorded, on average, an increase in efficiency in the implementation of the circular economy concept (2013 can be seen as a turning point due to the beginning of a significant presence of the circular economy concept in the official national industrial development strategies of the European Union countries, which also had an impact on the countries of the Western Balkans).

Table 5. Efficiency scores – descriptive statistics

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Minimum	1,003	0,932	0,746	0,933	0,997	0,998	0,835	0,674	0,932	0,409	0,961
Maximum	1,030	1,046	1,338	1,057	1,108	1,210	1,068	1,069	1,307	0,971	1,078
Average	1,018	1,007	1,036	0,988	1,034	1,063	0,980	0,963	1,052	0,781	1,037
Standard deviation	0,012	0,044	0,188	0,044	0,044	0,077	0,085	0,147	0,133	0,278	0,045

Source: Author's calculation

6. Conclusion

In the last ten years, the circular economy concept has become increasingly represented in scientific papers and among the creators of various public policies (economic, environmental…). However, many scientific papers are based on practical case studies of applying the concept of circular economy at the micro level. In contrast, analyses of the factors of its development at the economic level are very few present. Using the DEA methodology to calculate the Malmquist index, it is possible to point out to economic policymakers the weak and strong sides of its national socio-economic development strategies that include the concept of circular economy, as well as factors that lead to an increase or decrease in the mutual gap. Expanding the presented DEA analysis by selecting a larger number of indicators as inputs would enable economic policymakers in the Western Balkan countries to notice areas of circular economy that are necessary to increase efficiency. This methodology was used in assessing the efficiency of the circular economy development in the Western Balkan countries during the analysed period 2010-2021. The results confirmed the statements and conclusions of earlier research on developing the circular economy in the countries of the European Union, for example.

The most effective are countries with higher GDP per capita, better infrastructure, education and research and development activities. Although less efficient countries carry out certain activities in the direction of development and application of the concept of circular economy in the economy officially supported by the respective state institutions,

they are unsystematically implementing activities to introduce the concept of circular economy. Here it is necessary to take into account the fact that the results of the implementation of institutional activities on the development of the circular economy are not immediately visible and applicable to most enterprises and households for a number of reasons (some or more of which are present not only in developing countries, but also in the European Union): the objectives and indicators for measuring and monitoring their achievement are not defined, appropriate solutions in production and business models are not aligned with practical needs, insufficient orientation towards the end user, lack of public awareness of the economic and environmental effects of circular economy principles, insufficient purchasing power of end users, investment in incompatible technology due to the occurrence of rent seeking or corruption, lack of competition in the markets (existence of monopolies or oligopoly), underdevelopment of environmental inspection and appropriate penalties for non-compliance with environmental standards and the like. Therefore, introducing this concept within the framework of a national economy is a long and demanding process, which requires a clear commitment of a particular country's political and economic elites towards a serious turning in the development of the economy and society. Given that modern digital technologies significantly impact the implementation of the circular economy, developing convergent national strategies for creating the digital and circular economy is crucial.

The results obtained by applying the DEA analysis and the Malmquist Productivity Index indicate that those countries of the Western Balkan countries, through economic policy (primarily fiscal policy), but also other public policies (educational and environmental), have implemented some of the principles of circular economy (more favourable values of the individual CE indicators), at the same time achieved higher values of GDP per capita and a better global competitive position. It means that the application of the circular economy principles leads to the improvement of the country's economic position, which is why it should become a priority in various national strategies of the country (education, industrial...) and economic policies (fiscal). It directly enables the accelerated development of the circular economy and the consequent increase of general social welfare, as well as the convergence of countries with each other. On the other hand, a society that operates according to such principles quickly becomes self-conscious of the importance of resource conservation and more efficient management of the global economy, which is still deeply based on exploiting natural resources. At the same time, this also strengthens the concept of sustainable development, which positively affects the application of the principles of circular economy while also functioning as a factor of its development precisely on the principle of feedback.

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