Evaluating Transition towards Circular Economy in European Union

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The term circular economy (CE) has existed in the literature since the 1960s. In recent years, it gained significant notability in Europe with the introduction of the circular economy concept into the policy and strategy of the European Union (EU) in 2014 (COM/2014/0398) and the launch of the first Circular Economy Action Plan of the European Commission (COM/2015/0614 Final) in 2015 continued by a new Circular Economy Action Plan: For a cleaner and more competitive Europe (COM(2020)0098). One important step towards CE mainstreaming is the development of suitable indicators that would help measure the state of transition in both absolute and relative/comparative terms. Assessing countries' performance in achieving the goals of the circular economy is a challenge due to the lack of a generally accepted methodology, the multitude of indicators, and the insufficient data. Countries may be compared in a narrow way, according to single indicators, but a more holistic synthetic assessment of countries is also needed to determine their position against each other.

Data Envelopment Analysis (DEA) circular economy (CE) sustainability

1. Introduction

The growing impact of human activities on the environment makes the search for viable modes of sustainable development especially urgent [1]. The term circular economy (CE) has existed in the literature since the 1960s [2]. In recent years, it gained significant notability in Europe with the introduction of the circular economy concept into the policy and strategy of the European Union (EU) in 2014 (COM/2014/0398) [3] and the launch of the first Circular Economy Action Plan of the European Commission (COM/2015/0614 Final) in 2015 [4] continued by a new Circular Economy Action Plan: For a cleaner and more competitive Europe (COM(2020)0098) [5]. The growing interest in CE is also reflected by the rapid increase in the number of scientific research and reports [6].

Transition towards the circular economy demands a whole new logic of designing economic processes and running businesses. In the traditional linear model of production and consumption, resources are mined or grown, then transformed into goods which are then used and finally turned into waste (the so called 'produce-use-dispose', 'make-take-dispose', or 'take-make-waste' paradigms). In the circular economy, materials are repeatedly recovered and recycled—they remain in circulation for as long as possible.

Despite a noticeable change in the political discourse, academic discussion, and the public awareness, the current globally dominant economic model essentially remains focused on the efforts to increase consumption constantly, which until now was always related to the increase in production and further depletion of Earth's resources. Improvement in welfare is typically associated with an increased production and consumption. Especially now, as the world is trying to cope with the economic consequences of the coronavirus pandemic and with the unfolding geopolitical crisis, it is not easy to win the public's heart by calling for the fundamental rethinking of lifestyles, and for efforts to reconcile profitability with sustainability [7][8]. As Kirchherr notes, discussions between business practitioners, policy makers, and scholars rest upon the CE's

promise to reconcile sustainability and growth [9]. At the same time, there is no consensus, neither among scholars nor among practitioners, that the CE paradigm guarantees social well-being for this generation and the future ones [10][11]. The European Union would need to cut off its ideological roots in the trade union for coal and steel and to prioritise long-term environmental sustainability [12].

Even though a completely circular economy is not possible in complex advanced economies [13][14], some researchers view the CE as the most comprehensive and mature model capable of reconciling economic growth with sustainability and even boost the competitiveness of countries and enterprises by protecting businesses against scarcity of resources [15]. It remains to be seen, however, to what extent the paradigm shift actually occurs. As long as the old linear paradigm shapes the national economic policies (in real terms, not in rhetoric figures), there will be no single country that could come close to the ideal of a truly circular economy. Transition towards a CE must go hand in hand with the shift of the innovation paradigm [16][17] towards models such as Responsible Research and Innovation [18][19][20][21][22], Restorative Innovation [23], or Future-Oriented Technology Analysis [24][25], focusing not only on what is marketable but what is socially desirable and environmentally viable.

A common and widely accepted framework and the standard set of indicators measuring the CE maturity are not established yet. Assessment of the transition towards a CE based on selected indicators is the content of numerous publications that include simple and complex comparisons, qualitative and quantitative evaluation approaches [26]. One of the most exploited methods to assess sustainability, comparing the ability to transform labour, capital, and energy (including from renewable energy sources) and taking into account pollutants (e.g., greenhouse gas emissions) into the GDP, is Data Envelopment Analysis (DEA) [27]. Assessment of the state of development of the circular economy is also carried out using DEA.

2. Circular Economy and Multitude of Related Concepts

Circular economy is a concept that has not been clearly defined in the literature so far. However, different propositions share much in common and converge towards the same paradigm [28]. Kirchherr et al. (2017) [29] view the CE as a market-based economic system that supports business models implementing the ideas of reducing, alternatively reusing, recycling, and recovering materials in the production, distribution, and consumption processes. Such reorientation of the economic system at all levels (products, companies, consumers, cities, regions, countries) shall lead to the environmental viability, welfare, and social equity for the current and future generations. The circular economy is defined in opposition to the linear ‘make-take-waste’ model and is understood as an extension of the concept of green economy or bioeconomy [30][31][32][33] and linked to a cleaner economy, a low emission economy, industrial symbiosis [34], industrial ecology, eco-industry [35][36], cradle-to-cradle economy [37], Tech-Ökonomie [38], zero-waste economy, ‘regenerative by design’ economy [39], natural capitalism [40], green engineering, ecological modernisation [41], or sustainable development in general [42][43][44][45][46].

The bio-based CE is an economy where materials and energy are produced and derived from renewable biological sources [47][48]. Moreover, biological resources are managed in a way that their value is maintained at the highest level as long as possible [49]. Bioeconomic orientation of the CE is particularly suitable in sectors such agriculture [50], fertilizers [51], forestry [52], marine economy, pulp and paper, food production and retail [53], feedstock [54], cosmetics, biofuels, bioplastics [55], construction, furniture as well as bio-waste management [56][57], and wastewater treatment [58]. Metic et al. propose a concept of dual circularity, noting the existence of distinct, yet overlapping, thematic areas of a technology-focused CE and bio-based CE [59]. The area where ‘bio’ fuses with ‘tech’ includes, among others, such topics as microbial production, enzyme technology, and Green Chemistry [60].

Regardless of the definition, the implementation of the principles of a circular economy and the transformation towards less wasteful systems, a more effective and sustainable use of natural resources, and the reduction of pollutant emissions, including greenhouse gases, is becoming one of the key challenges worldwide [61]. Institutional, economic, environmental, organisational, social, technological, supply chain related drivers, barriers, and critical success factors determining the transition to a CE are discussed from different perspectives and at different levels of analysis [62]. Changing the economic systems is not possible in the short term horizon, and the practices that lead to the implementation of the circular economy postulates are introduced gradually [63]. Monitoring the progress of the performance at micro, meso, and macro levels [64] towards the circular economy is a complex and demanding task, mainly because of the multidimensionality and vagueness of the concept [65][66].

3. Macro and Meso Levels of CE Analysis

At the macro and meso levels, researchers study sectoral or spatial (national, regional [67], municipal/urban [68][69]) aspects of CE. Those aspects were divided by Martinho and Mourão [70] into the following categories: (1) efficiency and sustainability [71][72][73], (2) policies, governance, and management [41][74][75][76][77][78], (3) product life-cycle [79][80], (4) resources and waste [81][82], (5) innovation and opportunities [83], (6) sectoral topics, (7) bioeconomy. Mhatre et al. [84] offer an exhaustive list of CE-oriented activities characteristic to different sectors of national economies. Those activities are, among others, related to: bio-based materials, by-products' utilisation, cascading materials, community involvement, design for disassembly, design for modularity, down-cycling, eco-design, eco-labelling, element recovery, energy recovery, extended producer responsibility, bio-chemicals' extraction, functional recycling, green procurement, high-quality recycling, incentivised recycling, material substitution, optimising packaging, product as a service, refurbishment, adaptable manufacturing, restoration, reuse, redistribution and resell, sharing, take back and trade-in, upcycling, maintenance and repair, virtualisation.

4. Micro Level of CE Analysis

At the micro level, forward-looking enterprises and organisations anticipate the emerging shift towards the CE and try to transform their operations with the aim at boosting innovation, penetrating new markets, and securing customer loyalty. Interface of entrepreneurship and the CE is an extensively explored topic [85]. Incentivising adoption of CE activities by companies (with a special focus on small and medium enterprises [86]) is also a priority of the European Union [87]. Public sector entities are also evaluated against the circularity criteria, especially with regards to public procurement procedures, internal process and operations, and public service delivery [88]. Eco-innovations [89] and new business models are proposed and validated in various sectors [90][91][92][93]. Discussion on incorporating digital technologies (Industry 4.0, Big Data, Internet of Things, Artificial Intelligence, Blockchain) into CE frameworks is currently a dynamic field [94]. Interaction between governmental policies and different business models conducive to the CE is also analysed [95].

Four macro-categories of business models aligned with the CE paradigm are distinguished: net-zero emission innovation, servitisation, sharing, product life extension, product residual value recovery [96][97]. In the CE assessment of single organisational entities, such aspects as greenhouse gas emissions, air pollution, nitrogen release, phosphorus release, water pollution, release of harmful substances, biodiversity loss, real estate maintenance, transport, space/land usage, and the procurement of electricity, energy, food, and other materials, are considered [37]. Intangible aspects of business alignment to CE principles labelled as values, mission, culture, or mindset are also studied [98].

Several frameworks of CE assessment applied at the macro level may also be used at the micro level, in single businesses and non-profit organisations: Life Cycle Assessment (LCA), social life cycle assessment (S-LCA), BS 8001:2017 Standard [99] material flow analysis (MFA), Life Cycle Sustainability Assessment (LCSA), Ecological Footprint (EC), Product Circularity Data Sheet [100]. Accounting and accountability reporting models are also indicated as important mechanisms through which enterprises and stakeholders can measure the progress, costs, and gains from the transition towards a CE [101][102]. The focus here is clearly on fulfilling certain requirements rather than benchmarking (understood as a specific management practice oriented at achieving excellence described in [103]) and comparison with other entities [104]. Depending on the chosen CE assessment approach, different groups of intended end-users may be identified: specific organisations, entities from a particular sector, managers, designers, customers, policy makers [105].

5. CE Metrics and Indicators

One important step towards CE mainstreaming is the development of suitable indicators that would help measure the state of transition in both absolute and relative/comparative terms [26][65][106][107][108]. Research on CE metrics and indicators is ongoing at all levels of analysis (micro, meso, macro), with different indicators trying to capture different dimensions of sustainability (environmental, economic, social) and core principles of the CE (‘reduce, reuse, recycle, recover, remanufacture, redesign’) [109]. Examples of a quantitative analysis of the CE in the European Union concern individual member states [110][111], groups of member states [112][113], regions [114][115], economic sectors [116][117], or all EU member states [118][119][120][121][122][123][124][125].

The recommended indicators measure different aspects of the CE at the company, regional, and national level [126]. Measures proposed by the EU to progress towards a circular economy at the EU and national level are composed of a set of key indicators that cover production and consumption, waste management, secondary raw materials, and competitiveness and innovation [127]. In the typology of the European Environment Agency (EEA), the indicators are divided into five groups: descriptive indicators, performance indicators, efficiency indicators, policy effectiveness indicators, and total welfare indicators [128]. Different methodologies of clustering and classification are proposed, both conceptual and empirical, to deal with the humongous number of available sustainable development indicators (SDI) [65][129][130][131][132][133][134].

6. DEA Method in the Evaluation of CE Goals Achievement

The DEA method plays an important role in comparative performance assessment. It allows the comparison of the efficiency of countries, regions, organisations, enterprises, and other entities characterised by the same set of inputs and outputs. DEA is broadly applied in various fields of public policy and business endeavours. It is recognised as a useful instrument of efficiency improvement and competitiveness increase [135]. In the case of CE transition evaluation, DEA may be successfully used.

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