REGION
The Journal of ERSA
Powered by WU

Volume 10, Number 3, 2023, 105–136
DOI: 10.18335/region.v10i3.498
journal homepage: region.ersa.org
ISSN: 2409-5370

Quantifying the Circular Economy in European Regions: a Bridge towards Smart Specialisation?

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Received: 26 May 2023/Accepted: 24 October 2023

Abstract. Circular Economy (CE) aspects are becoming increasingly relevant for a sustainable transition and regional development. Still, a methodology to assess regional performance and interregional differences is exclaimed to be missing at least in the European context. This gap makes it difficult to assess policies and evaluate development patterns. The authors present a methodology to overcome this research gap by including several dimensions of social, environmental, and economic CE aspects. The methodology consists of 29 indicators grouped in six dimensions with data obtained from various data bases. A static and a trend index are calculated to compare European NUTS 2 regions in terms of their current CE status and its development over the last years. The new insights paint a more differentiated picture of regional CE transition highlighting that a segregation is observable not so much between North and South or East and West but more between urban and rural regions. Regarding the practical CE implementation in European regions, the instrument of smart specialisation is discussed.

JEL classification: O18, P48, R1, R11

Key words: Circular Economy, Smart Specialisation, Transformation, Assessment Methodology, Regional Development

Declaration of Interest: The authors report there are no competing interests to declare.

1 Introduction

The challenge of a sustainable transition has two sides. The first is related to the output side of production, namely the generation of greenhouse gas (GHG) emissions and their reduction. Whereby the policy focus is strongly concentrated on this aspect, the second side which is related to the material input of production, still leads a relative niche existence. However, the relevance of this neglected perspective is highlighted by facts such as the tripling of global extraction of materials between 1970 and 2017 (IPCC 2015, 2020, Oberle et al. 2019, United Nations 2021). At the same time, global population and global income levels tend to rise in parallel with changing consumption patterns following a Global Northern standard. This has placed additional pressure on material extraction and consumption.

As the majority of this material stream is not recycled, composted, or reused after it has served its primary objective, it is turned into waste. While raw materials become increasingly scarce and more expensive to extract, waste of unrecycled material accumulates in equal measure and leads to new problems such as the pollution of biospheres (Deus et al. 2017, Haas et al. 2020, Nikolaou, Tsagarakis 2021). One substantial approach to reduce extraction and waste generation is the decoupling of economic growth from environmental exploitation. One of the central levers to achieve this decoupling is the transformation towards a Circular Economy (CE). The concept of a CE is based on developing circular systems of material and energy that maintain the value of resources as long as possible to realign environmental boundaries with economic activity (Muñoz, Navia 2021). The idea of circularity is becoming increasingly popular and is promoted by national governments supranational organisations such as the EU, as well as many business organisations and business around the world (Korhonen, Honkasalo,, Seppälä 2018). Regarding the practical implementation of a CE, activities will not only involve the product level but also administrative levels, particularly regions. This is by reason that facilitating factors for a CE such as stakeholder cooperation or the establishment of closed cycles are positively related to proximity. Accordingly, many political strategies are implemented on a regional level (Vanhamäki et al. 2020). However, the role of regions in a CE is not covered as extensively in the scientific debate as its relevance would justify. Since the successful implementation of circular measures in regions needs to recognise regional characteristics rather than proposing a one-size-fits-all solution, the missing regional focus also constitutes a political problem. Addressing this apparent gap is even more urgent for Europe as the Green Deal sets a new development paradigm of climate-neutrality until 2050 that involves CE as a central building block for EU policy in the coming decade (European Commission 2019, 2021, McCann, Soete 2020, Arsova et al. 2022).

The article at hand fills a gap by addressing the topic of CE in European regions. One of the central weaknesses is the availability of a quantitative framework to measure the implementation and effects of CE at the regional level. Such an extensive framework is missing in Europe, thus we propose a multi-dimensional methodology that combines existing approaches and introduces new aspects to overcome shortcomings of earlier models (European Commission 2011, Elia et al. 2017, Mitrovic, Veselinov 2018, OECD 2020, Mazur-Wierzbicka 2021, Arsova et al. 2022). To do so, both a static and a trend index are calculated to assess the state and the recent development of CE in European NUTS 2 regions. This analysis answers which regions can serve as an example for others, which regional policies have been successful, and highlights how to shape the process in the future. These findings are then integrated into the framework of regional innovation policy in Europe, particularly the regional innovation strategies for smart specialisation (RIS3). This instrument has been promoted as the primary policy measure for regional policy in Europe and is increasingly discussed in terms of a green transition. Accordingly, article discusses how CE and smart specialisation are related and make a claim that their mutual relevance for regional development should be further analysed (Doranova et al. 2012, Gianelle, Kleibrink 2015, Montresor, Quatraro 2018, Gerlitz et al. 2020). Applying such a framework of regional CE measurement (1) allows policy makers and scientists to track progress of regional CE development, (2) highlights geographical patterns, (3) identifies target regions for further analysis, and (4) helps to focus support schemes to those regions that need support.

Against this background, the article is structured as follows: Section 2 provides an overview about the concept of CE and its relevance, particularly for Europe. Afterwards, the geographical dimension of CE is presented before the linkages between CE and smart specialisation are discussed. In Section 3, an overview of the state-of-the-art assessment of CE in regions is presented and research gaps are identified. Section 4 addresses these gaps and reveals the development of a multi-dimensional framework of CE assessment. The results are presented in Section 5 and discussed in Section 6. The article closes with a conclusion and a discussion of the policy relevance (Section 7).

2 The concept of CE

CE as a concept has emerged from integrating different scientific disciplines from economics to natural sciences and is anchored in the broader waste and resource debate (Blomsma, Brennan 2017). These diverse origins lead to a certain level of confusion regarding the definition of CE and its embedding in different research streams. The current discussion about CE in practice requires a solid foundation of the concept's intellectual roots which will be illustrated in the corresponding subsections.

2.1 Theoretical foundations

The origins of circularity considerations trace back to the 1960s with the recognition of planet Earth as a closed system of circular relationships (Boulding 1966, Haas et al. 2020, Nikolaou, Tsagarakis 2021). CE as a particular topic was first introduced by Pearce, Turner (1990), but a steady shift could be recognised over the previous decades when attention transferred to a greater industrial and societal focus regarding controlling pollution and resource treatment (e.g., Meadows et al. 1972). CE then gathered further pace in the 1990s with the emergence of several environmentally related research streams developing in parallel, merging, and then separating over time. Among these research streams were fields such as industrial ecology which is based on the idea to learn from material and energy flows in nature, industrial symbiosis focusing on actor networks, cradle-to-cradle design centring on adapting societal flows to natural flows and sharing economy approaches emphasising the role of individual behaviour (Korhonen et al. 2018, Domenech et al. 2019, Bourdin et al. 2022).

The concept which evolved from this melange of ideas and that later became known as CE has recently gained urgency in light of mitigation of climate change with a particular drive derived from policymakers such as the EU, individual countries such as China or Sweden, as well as business development bodies such as the Ellen MacArthur Foundation (Chizaryfard et al. 2021). CE as a concept was developed and led by practitioners with a scholarly position and is still emerging. This is one of the reasons of conceptual confusion about CE definitions (Korhonen et al. 2018). The multitude of CE variants in the scientific literature in terms of concept, approach, and scope underlines the development the concept has undergone (Kirchherr et al. 2017, Wilts 2017). The fact that CE is an evolving concept influenced by different scientific disciplines and shaped by different stakeholder groups provides an explanation why the process of developing a definition is not completed and probably never will be. Until now, there is no consensus on how to clearly define CE so that several definitions exist in parallel (Korhonen, Honkasalo,, Seppälä 2018, Kovacic et al. 2020, Chizaryfard et al. 2021). Even if one wanted to provide a single definition, this endeavour would be doomed to fail as it would always exclude some interests and could not recognise the dynamic and evolving discussion on CE (Korhonen et al. 2018). Accordingly, we do not claim to present a universal definition here. However, the development of a quantitative methodology requires an understanding of what a CE is and entails.

Generally, definitions are divided based on different assumptions. Korhonen et al. (2018) identify two lines of thought based on a business and a scientific perspective on CE. Opposing that, Hachaichi, Bourdin (2023) name two streams with one focusing on a product level of restorative design and another on an economic level of creating cycles along production, distribution, and consumption processes (Hachaichi, Bourdin 2023). Methodologically, a product-level oriented CE regards material flows inspired by biological cycles. This is done so that each cycle of material use is complemented by another cycle, rather than seeing the materials being disposed after use (Kiser 2016, Braungart et al. 2007, Braungart, McDonough 2009, Braungart 2011). To "design out" waste, the input side of production is adapted by focusing on biological ingredients or "nutrients" which should be at least non-toxic but possibly even beneficial when returned to the biosphere. The concepts of recycling (1) and reuse (2) are complemented by the third factor of reducing (3), thereby forming the "3R principles". These principles have recently been supplemented by recovering (4) to create the "4R principles" (Ellen MacArthur Foundation 2013, 2015, Heshmati 2015). A broader definition of CE, which is the one that will be applied in this article, combines the previous aspects, and embeds them into a multidimensional framework encompassing economic, environmental, and social aspects. From this perspective, CE is not only a production variant but a concept that also covers societal aspects and economy-level implications.

Accordingly, the benefits of CE can be divided into economic, social, and ecological aspects. From an economic point of view, CE promises potential net savings of material and energy costs, competitive advantages, and increased competitiveness for companies, as well as improvements in selection and product quality for consumers. Additionally, local industries, a category to which CE companies commonly belong, have proven to perform better in times of economic recession which might indicate a stronger resilience through circularity (Greenovate Europe 2012, Ellen MacArthur Foundation 2013, Ketels, Protsiv 2017). Niang et al. (2023) highlight that growth in employment in CE-related sectors was higher than the growth of total employment, indicating an economic benefit of CE. Moreover, the preservation of high-quality materials can reduce the demand and therefore the dependence on the import of raw materials and intermediate consumption. Regional cycles make value chains less vulnerable to price fluctuations and to the insecurity of supply potentially arising from resource scarcity or geopolitical factors (European Commission 2014, 2016, Ketels, Protsiv 2017, Wilts 2017, Bourdin, Torre 2020).

From an environmental point of view, CE reduces the pressure on the extraction of raw materials by increasing the supply of recyclates. Moreover, negative externalities of waste production and inappropriate disposal can be addressed by recycling, designing for repair, and extending the life-cycle of products. However, the concept of CE is limited by fundamental laws of thermodynamics stating that certain quantitative and qualitative losses are unavoidable. Moreover, maintaining the high quality of virgin materials is almost impossible since all processes of recycling involve a certain amount of quality loss and down-cycling. It is therefore required to notice that the promise of a CE will not solve the problem of an unsustainable economy on its own through technological innovation and new institutional frameworks. This is even more true as rebound effects are a well-known phenomenon and have in many cases, undermined the efficiency gains of CE (Georgescu et al. 2014, Gregson et al. 2015, Gonçalves Castro et al. 2022). It is this aspect that is primarily addressed in the social dimension of CE. While CE involves social benefits such as job creation, stronger societal cooperation, or lower expenditures for households, an exclusively technical or economic focus will fail to deliver behavioural changes and neglects governance and management challenges required for a successful CE implementation. Aspects of cooperation and multidimensional interactions between different stakeholders come into play. Cultural and social aspects such as stakeholder relations, institutions, and policies are inevitable building blocks for a holistic transition perspective (Korhonen et al. 2018, Beaurain et al. 2023, Chembessi et al. 2023). While a large part of CE literature deals with product or company perspectives, the geographical perspective, particularly the regional level must not be neglected as it will play a major role in the implementation of CE policy. Social factors of CE implementation are especially related to sub-national levels such as regions as they provide the conditions for stakeholder cooperation, the set-up of innovation systems of diverse actors, administrative capacity, as well as beneficial conditions for the development, widespread use, and diffusion of environmental innovations (Van den Heiligenberg et al. 2017, Losacker et al. 2021, Chembessi et al. 2021a, Arauzo-Carod et al. 2022). Accordingly, the neglect of the regional aspect in scientific articles and practical policy of CE underestimates the role played by governance structures, and institutional requirements to design appropriate CE policies (European Commission 2019, 2021, Vanhamäki et al. 2020, Dagilienė et al. 2021, Henrysson, Nuur 2021, Arsova et al. 2022, Morales, Dahlström 2022, Williams 2022, Rezaie et al. 2022). This research gap is one of the reasons why the potential to leverage green transition is so far not exploited. Leveraging regional development potential for the run-up of CE might benefit both. Moreover, the regional perspective allows for the identification of success factors and regional requirements for a successful CE implementation.

In this context, current research indicates that CE development is geographically highly diversified. For instance, the share of adoption of CE principles in high-income

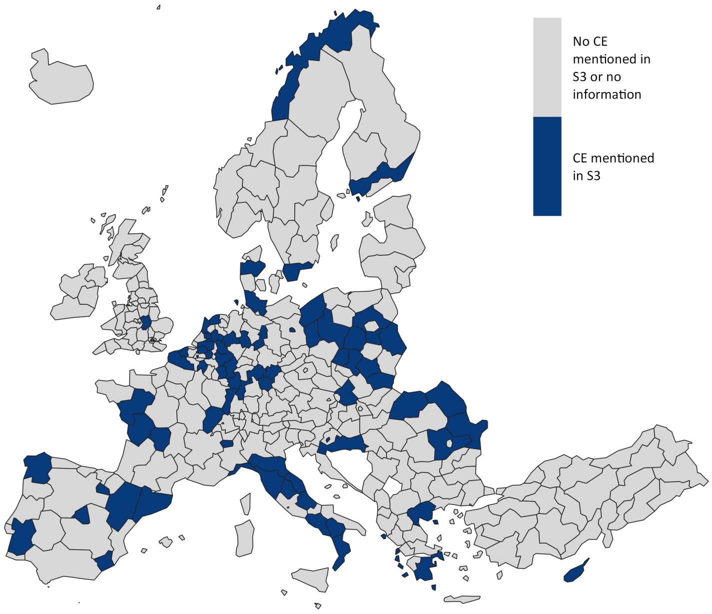
EU countries tends to be larger than in less developed EU countries (Mitrovic, Veselinov 2018). At the regional level, urban areas are particularly highlighted when it comes to CE transition. This is justified by the argument that these regions suffer more from typical urban downsides of waste generation and therefore benefit most from CE measures. These findings imply that spatial factors such as an urban structure shape the formation of CE. However, it remains unclear whether the divide between highly- and less-developed regions in terms of CE is an objective fact or a misunderstanding based on limited data availability (Bačová et al. 2016, Muñoz, Navia 2021, Mazur-Wierzbicka 2021). These questions will be further addressed below.

2.2 CE in Europe

Geographically, research on CE is strongly rooted in parts of Asia and Europe from where research has gradually spread (Hachaichi, Bourdin 2023). In particular, China has introduced CE measures on a large scale and promoted CE to an economic development strategy to mitigate the environmental challenges associated with strong economic growth (Heshmati 2015, Silvestri et al. 2020). The EU has also recognised the relevance of CE to align economic growth and sustainability. Stating that raw materials are *"the lifeblood of the EU economy"* (European Commission 2016, p. 3) and identifying a high import dependency when it comes to certain resources, a transformation towards a more regenerative and resource-sensitive growth model is required (Ragossnig, Schneider 2019, WEF 2014, European Commission 2010, 2020a, EEA 2016, 2020). Steps towards the integration of CE in European policy have been institutionalised since 2008 with relevant directives and strategy formulations (Avdiushchenko 2018, Mazur-Wierzbicka 2021). The adoption of a Circular Economy Action Plan in 2020 has officially promoted CE to a main building block of the sustainability agenda of the European Commission. This Action Plan is also embedded in the larger picture of establishing a new growth strategy, framed as the EU Green Deal, as well as the aspiration to improve resource efficiency and reduce European import dependence on raw materials (Wilts 2017, Salvatori et al. 2019, Domenech et al. 2019, Borett et al. 2020, European Commission 2011, 2019, 2020a). However, the EU economy is still considered too linear and certain policies have taken extended time until being pursued by European and national policies (European Commission 2019, Reike et al. 2018, Mazzanti, Zoboli 2009). Compared to the original idea of CE, certain aspects are regularly lost in transition towards practical policy. One of these is the social aspect of changing consumption and production patterns whereby CE is often reduced to an instrument of maintaining an unsustainable model of economic growth (e.g., Dunlap, Laratte 2022).

2.3 CE and smart specialisation

As indicated above, it is claimed that the regional aspect of CE is highly relevant for successful policy implementation (e.g., Gibbs, O'Neill 2017, Arsova et al. 2022) (e.g. Gibbs and O'Neill, 2017; Arsova et al., 2022). In this context, Fusillo et al. (2021) underline that trajectories of regional CE innovation systems resonate with regional capabilities. Thereby, the regional level has become a focal point of European policy over the last decade as a consequence of previous strategies being too generic and too removed from regional requirements and capacities (e.g., Fedeli et al. 2020). One of the central instruments is smart specialisation. This approach has risen to be the pivotal European policy instrument for cohesion and regional policy. The strategy behind the instrument is to guide regions in their process of identifying and developing their competitive advantages by concentrating regional resources accordingly. Identifying economic growth areas via bottom-up processes under the premise of structural renewal rather than structural conservation shall help to overcome interregional gaps in terms of productivity or research and development (R&D) in Europe by supporting less-developed regions. Theoretically, the concept is embedded in the frame of innovation systems and economic geography (Foray, Goenaga 2013, Foray et al. 2009, 2011, 2021, Isaksen, Trippl 2014, Asheim et al. 2016, D'Adda et al. 2018, Tödtling, Trippl 2018). By now, smart specialisation has become the central pillar for economic development and growth policy in Europe (McCann,



Source: Computations by the authors based on data from Joint Research Centre (2022).

Figure 1: CE focus in smart specialisation strategies (S3), 2022

Ortega-Argilés 2015, Lopes et al. 2019, Gómez Prieto et al. 2019).

In recent years, there is an ongoing discussion about updating smart specialisation after the instrument has existed for about a decade. One stream of discussion argues in favour of extending the original smart specialisation concept to better suit the requirements of a green transition. However, others call for a refocusing on the initial targets of smart specialisation (Foray et al. 2012, Doranova et al. 2012, Benner 2020, Tödtling et al. 2021, Isaksen et al. 2022). In relation to the current sustainability discussion, an extension of S3 has been discussed in order to combine sustainability and innovation policy (McCann, Soete 2020, Larosse et al. 2020, Arsova et al. 2021, Landabaso 2020, Kruse 2023). The latter stream of discussion is particularly interesting in terms of CE. When discussing CE at regional level, the question arises whether the existing European instruments recognise CE as a target, whether they represent appropriate delivery channels for CE implementation, or which adaptions might be required to combine both concepts.

In practice, several European regions have already combined their smart specialisation strategies (S3) with CE goals. For instance, exemplary regions from Spain and Slovenia present strategies on smart specialisation for addressing process and product innovations in the CE transition (Smart Specialisation Platform 2020a,b). Also, certain Finnish regions have identified CE as an important economic domain of activities in the priorities of industry, construction, and waste sectors (Council of Tampere Region 2021). In this context, Figure 1 provides an overview of European regions that already refer to CE topics as a focal point in their S3. The information was extracted from the database of regional S3 (Joint Research Centre 2022) by screening it for terms indicating the implementation or support of CE ("circular", "sustainable production", "recycling", "resource efficiency", "cradle to cradle"). The picture shows a relatively even distribution of regions that refer to CE in their S3 (dark grey) and highlights that the instrument of smart specialisation and the purpose of CE are increasingly merged in regional political strategies.

In current research, CE in S3 and European regional development are increasingly addressed in qualitative case studies. For instance, Harding et al. (2021) find that many European case studies on smart specialisation to foster a green transition have chosen a focus on CE. A perspective on renewable energy transition and the facilitating role of smart specialisation in this context is presented by Steen et al. (2018). Morales, Dahlström (2022) analyse smart specialisation for a green path renewal in Finnish and

Swedish regions. Apart from that, it is analysed how various regions have concretised S3 thematic priority areas related to the CE priorities within the regional context (Vanhamäki et al. 2021). Tsipouri et al. (2020) claim that the transformation towards a CE can be accelerated and become beneficial when CE is a strategic focal point for regional innovation strategies. Accordingly, Stanojev, Gustafsson (2021) suggest smart specialisation to strengthen innovation for CE, a claim that is also formulated by Hristozov, Chobanov (2020). However, the combination of the two EU priority strategies and policies, namely CE and smart specialisation, represents a challenge in terms of methodology, prioritisation, and coordination. Although the topic has been raised by several researchers and policy makers, a notable research gap remains when it comes to implementation on a larger scale.

3 Regional CE assessment in Europe

Studies have rated the existing monitoring and assessment tools for CE transition, particularly at the regional level, to be inadequate. While most methodologies were developed and applied in China, these remain geographically specialised and are hardly transferable to other world regions with different structural environments (Zhang et al. 2008, Quing et al. 2011, Geng et al. 2012, Su et al. 2013, Avdiushchenko, Zajac 2019, Ye et al. 2021). Therefore, the lack of tools to monitor and evaluate CE implementation in European regions remains *"one of the clearest gaps in the CE literature"* (Silvestri et al. 2020, p. 3). Although the need for an assessment methodology is highlighted (e.g., Blomsma, Brennan 2017, Virtanen et al. 2019, Borett et al. 2020), the number of publications on regional assessment has remained limited and frequently focused on single aspects of circularity rather than a broader notion. This fact hampers the transition towards a CE as crucial information is missing.

Current gaps of CE assessment involve, for instance, a lack of suitable indicators and data accessibility, particularly on sub-national levels. Thereby, the gap refers particularly to accessibility and transferability as the number of metrics and indicators is steadily increasing. Here, the absolute number of adequate metrics is not considered a weakness but rather the availability of data at the regional or local levels. For instance, the circular material use rate, an indicator measuring the share of material recovered and returned to the cycle, is available only for the national level (EASAC 2016, Saidani et al. 2019, 2022, Avdiushchenko, Zajac 2019, Arsova et al. 2022). Moreover, indicators on socio-institutional aspects such as consumption, governance, or political sensitivity are under-represented compared to more technological indicators. However, the quality and variety of indicators is less of a problem than the availability of data on lower aggregated levels. These data-related gaps have also been recognised by the European Commission, which has initiated a process of reviewing the existing indicators (Vercalsteren et al. 2018, European Commission 2018, 2020a).

Methodologies to assess CE in Europe have been developed but limitations remain. The following will provide/provides an overview of the most relevant papers and articles focusing on CE quantification in Europe whereby their weaknesses, when it comes to the construction of a new index, are identified and addressed in the next section. Until now, several circularity indices were developed on the country level, but these cannot be transferred to the regional level. This is due to the absence of regional data or country-specific indicators. Moreover, it is a common occurrence to neglect the social dimension of CE in favour of a more economic and technical focus (e.g., Hervey 2018, Mitrovic, Veselinov 2018, Avdiushchenko 2018, Mazur-Wierzbicka 2021, Banjerdpaiboon, Limleamthong 2023). Several other papers propose extensive methodologies without applying them practically, sometimes due to the identified data being unavailable on a larger scale (e.g., EASAC 2016, Saidani, Kim 2022). Work like this provides an overview of available indicators and potential calculation techniques but does not provide regional insights or raise political implications.

Other papers neglect certain aspects of CE. Among the neglected factors are those of a social, economic, or ecological nature (e.g., Ketels, Protsiv 2017, Taelman et al. 2020). Another sort of research articles offers a limited focus on individual aspects such as job creation (Niang et al. 2023) or technological patterns (Fusillo et al. 2021), while ignoring others. This research provides an additional academic value of CE in their specific niche. However, the CE as a complex and diverse concept is not adequately represented in that the findings are hardly robust when it comes to a comparative perspective. Additionally, several papers suffer from limitations such as non-transferability of regional indicator sets (e.g., Avdiushchenko, Zajac 2019, Virtanen et al. 2019, Heshmati, Rashidghalam 2021), a limited numbers of indicators (e.g., Silvestri et al. 2020, Skare et al. 2023), or a limited number of regions (e.g., Bianchi et al. 2022). In addition to the problem of missing comparability when only certain regions are analysed, the weakness is not so much the indicator design but the problem of non-transferability due to specific indicators that exist exclusively in certain countries.

The development of CE measurement methodologies at sub-regional levels such as cities is discussed and applied by Papageorgiou et al. (2021), Bote Alonso et al. (2022), and Henrysson et al. (2022), revealing the same limitations for the regional level, namely a lack of suitable indicators and data availability. However, it needs to be recognised that the existence of weakness does not understate the scientific value of the described articles. They simply do not suffice on their own for our purpose, so we pursued a synopsis of the state of research with individual complements.

4 Data and methods

4.1 Data

For this paper, the authors applied a broad definition of CE, meaning that environmental, social, and economic aspects are regarded as relevant for a CE (see Section 2.1). As a foundation, we conducted an extensive literature review that led to the identification of a set of dimensions including traditional dimensions of circularity such as waste and consumption as well as employment statistics, innovation, and political indicators associated to S3 (see Table 1). These dimensions cover environmental aspects (waste statistics), economic aspects (innovation, circular employment), behavioural patterns (consumption and production), and aspects of regional policy. The final set of 29 indicators in six dimensions is the result of a pragmatic approach to select consistent, harmonised, and standardised data adhering to three requirements: (1) The data must cover all of Europe rather than only certain countries, (2) the data must be available for a time span rather than only a point in time so that development is shown, and (3) the data must be available on a regional level.

It had to be decided whether to apply an analysis exclusively based on indicators with a broad data coverage, potentially leading to the same results as other papers, or to construct an analysis with new indicators that consist of data gaps but potentially reveal new insights. The authors decided to apply new indicators even when the data coverage was not optimal. However, certain databases and indicators were not included as they violated at least one of the three basic requirements, which mostly referred to data availability. The chosen administrative level for the analysis was NUTS 2, which refers to the regional level in Europe. This choice was motivated by data availability and relatively high coverage but does not come without disadvantages. The NUTS 2 level is responsible for the development of regional strategies for most European regions, but certain regions have allocated this responsibility to the more granular NUTS 3 level. Additionally, it needs to be remarked that an assessment on the national level (NUTS 1) would allow for the use of more detailed and targeted CE indicators that are not available on regional NUTS 2 level (see Appendix A).

Most indicators used for the analysis were obtained from the Eurostat (2022) database. Patent statistics were obtained from the PATSTAT database whereby a four-digit search strategy was applied to identify patents related to waste management and recycling (Eurostat 2023). The year 2018 was selected as the base year by reason of being the most recent year with the highest data availability for EU regions. Rather than choosing the most recent year for each indicator, it was decided to keep a common base year to provide a coherent CE analysis for that point in time. The selected base year to calculate the trend of CE development was 2012. This base year was also chosen by Banjerdpaiboon, Limleamthong (2023) for a comparison to 2018 values. 2012 stood out as the year with a relatively high data coverage for the relevant indicators. Moreover, no major crises were observed in the time frame that could have distorted the results. Finally, the time span of six years between 2012 and 2018 exceeds the duration of legislative periods in EU regions, ensuring a certain autonomy from political trends. However, the strict focus on 2012 and 2018 had to be softened in some cases. For instance, the statistics on waste production and treatment in European regions are based on a pilot project conducted in 2011 so data is limited to this time. Moreover, data regarding the regional generation of different kinds of waste from ESPON (2022) was included due toits high data quality. However, the time frames (2006 and 2014) did not fully correspond to the standard of the methodology.

The applied policy indicators reflect the fact that monitoring schemes often neglect more qualitative indicators such as circular strategies (Reich et al. 2023). However, an exclusive focus on traditional quantitative indicators such as recycling rates ignores important social and political aspects of CE and neglects aspects such as the leverage exerted by public authorities (Wijayasundara et al. 2022). These policy indicators are qualitative in their basic form and have been transformed to become quantitatively usable by applying a binary coding system (0: does not have a strategy, 1: does have a strategy). This kind of transformation is accompanied by the danger of a selection bias resulting from a non-random selection of cases. Consequently, certain cases may be overrepresented in this case due to the binary design of 0 and 1 (Collier 1995). This limitation also applies to the approach in this paper as it could not be overcome. This methodological limitation needs to be recognised.

Regarding the qualitative data sources, information on green procurement was obtained from the European Commission (2020b) and the status of cities as a signatory of the "Circular City Declaration" functions as an additional indicator of regional recognition of CE (Circular Cities Declaration 2022). The existence of a regional CE strategy is based on research undertaken by Jonker, Montenegro Navarro (2018) and Salvatori et al. (2019). The indicator "smart specialisation strategies" is based on a dataset by the Joint Research Centre (2022) for the 2014-2020 programming period that was examined for words that indicate the implementation or support of CE ("circular", "sustainable production", "recycling", "resource efficiency", "cradle to cradle"). The indicator can be questioned since CE in regional strategies can be both a prerequisite and a result of a strong regional CE. Despite that ambiguity, it was decided to include the indicator as an additional measure of CE awareness in regional policy.

4.2 Methods

To calculate a benchmark value that allows for a comparison of European regions in terms of CE, we set up two indexes(indices): first a "static" index based on the most recent data and second, a "trend" index covering the development in past years. The division is derived from Silvestri et al. (2020). Two steps: (1) normalisation of the original data and (2) aggregation of the normalised values to receive a composite measure were applied for the index. The first step was necessary due to different scales and dimensions. Thanks to this normalisation, each variable is expressed in an interval between 0 and 1. A value closer to 1 corresponds to a superior CE performance, whereby a value approaching 0 indicates a lower performance. Relatively better values in each indicator lead to a higher value in the overall index and indicate a more developed CE system. The normalisation function is given below, where X_{jk} represents the value of the k-th variable for region j.

$$Y_{jk} = \frac{X_{jk} - \min(X_{1k}, \dots, X_{Jk})}{\max\left(X_{1k}, \dots, X_{Jk}\right) - \min(X_{1k}, \dots, X_{Jk})}$$

Variables with a negative impact on the CE performance were calculated as follows:

$$Y_{jk} = \frac{\max\left(X_{1k}, \dots, X_{Jk}\right) - X_{jk}}{\max\left(X_{1k}, \dots, X_{Jk}\right) - \min\left(X_{1k}, \dots, X_{Jk}\right)}$$

In Step 2, the normalised variables were aggregated using an arithmetic average. First, the arithmetic average was calculated for the six dimensions individually, before

Table 1: Indicators for CE assessment on NUTS 2 level in Europe

Dimension	No.	Indicator	Base Year Static	Base Year Trend	Index	Data Source
Policy	1.1	Regional circular economy strategies	2022	2012	(+)	Jonker, Montenegro Navarro (2018)
	1.2	Circular city declaration	2022	2012	(+)	Circular Cities Declaration (2022)
	1.3	Green public procurement	2020	2012	(+)	European Commission (2020b)
	1.4	Smart specialisation strategies	2021	2012	(+)	Joint Research Centre (2022)
Innovation	2.1	GERD per capita	2017	2011	(+)	Eurostat
	2.2	Patents per employee	2018	2012	(+)	PATSTAT
	2.3	Patents in CE-related technologies	2018	2012	(+)	PATSTAT
	2.4	Gross fixed capital formation	2018	2012	(+)	Eurostat
	2.5	Employees in scientific R&D	2018	2012	(+)	Eurostat, SBS data
Circular Employment	3.1	C33 repair and installation of machinery and equipment	2018	2012	(+)	Eurostat, SBS data
	3.2	E38 waste collection, treatment and disposal activities, materials recovery	2018	2012	(+)	Eurostat, SBS data
	3.3	E39 employees in remediation activities and other waste management services	2018	2012	(+)	Eurostat, SBS data
	3.4	G45 wholesale and retail trade and repair of motor vehicles and motorcycles	2018	2012	(+)	Eurostat, SBS data
	3.5	S95 repair of computers and personal and household goods	2018	2012	(+)	Eurostat, SBS data
Consumption and Production	4.1	total waste generated by households	2014	2006	(-)	ESPON
	4.2	food waste generation	2014	2006	(-)	ESPON
	4.3	electric and electronical waste colledted	2014	2006	(-)	ESPON
	4.4	plastic waste generation	2014	2006	(-)	ESPON
	4.5	waste generated by construction acitivties	2014	2006	(-)	ESPON
	4.6	waste generated by manufacturing activities	2014	2006	(-)	ESPON
Waste Management	5.1	Disposal - incineration	2018	2010	(-)	Eurostat
	5.2	Recovery - energetic recovery	2018	2010	(+)	Eurostat
	5.3	Disposal - landfill and other	2011	2010	(-)	Eurostat
	5.4	Recycling - material	2011	2010	(+)	Eurostat
	5.5	Recycling - composting and digestion	2011	2010	(+)	Eurostat
Socio-Economic Development	6.1	GDP per Capita	2018	2012	(+)	Eurostat
	6.2	Tertiary education	2018	2012	(+)	Eurostat
	6.3	Unemployment rate	2018	2012	(-)	Eurostat
	6.4	Households with broadband access	2018	2012	(+)	Eurostat

Source: Computations by the authors.

the results were combined for the final index. This intermediate step allows for a more detailed view of how the final index is composed and acknowledges the fact that the indicators in each dimension might be correlated. This potential drawback is minimised by separating the dimensions. Also, it was decided to abstain from applying different weights to the individual variables and dimensions since an objective relevance of each indicator for circularity cannot be identified. The function is given below whereby a higher Z_j value indicates a stronger CE performance in region j.

$$Z_j = \frac{1}{K} \sum_{k=1}^{K} Y_{jk}$$

For the trend index, the static index was calculated for an earlier year to measure the development in between the two points in time. The difference between the two static indices is calculated to be the trend index.

5 Results

To calculate the static index of CE performance, the methodology was applied to 278 European NUTS 2 regions with 2018 as the general base year. Country-specific gaps in different indicators have been observed due to data being classified as "confidential" in the Eurostat database or changes of the statistical NUTS classification between 2013 and 2018 that did not allow for a comparison of data. Significant gaps were observed in employment data in Italian regions as data was not available at all. Gaps in French, Irish, and several Polish regions are also observed in the consumption and production dimension. In terms of waste management, Finland, Sweden, Slovenia, Spain, Greece, Ireland, Czech Republic, Denmark, and some French regions had to be excluded due to a lack of data. Applying a weighted average to calculate the total index considered these gaps. The findings reveal a concentration of strong circular performance in Central European and Scandinavian regions (see Table 2). The best performing regions are predominantly regions with a strong urban character. It is worth noting that the indicator set gives too much weight to development and innovation indicators, but excluding this dimension did not significantly change the results.

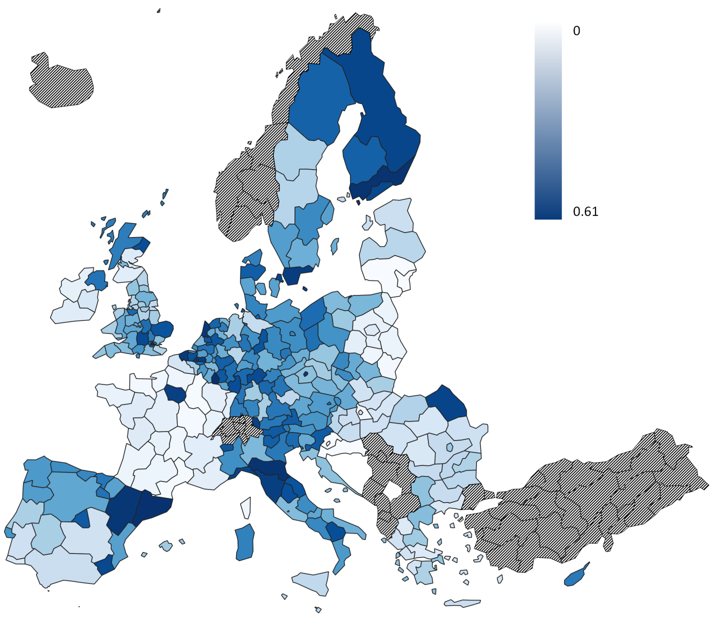
The pattern of strong CE performance in certain regions is illustrated in Figure 2. In countries such as England or France, the capital regions acquire a higher CE performance than the rest of the country while the picture in Spain is constituted by a comparable pattern but with more than one centre. The map reflects existing economic disparities, e.g., between Northern and Southern Italy or between Northern UK and the central London region. The largest concentration of CE performance can be observed in Scandinavian regions as well as large parts of Central Europe, while Eastern European regions are performing worse in terms of CE. The apparently low performance in France is primarily explained by data gaps in one dimension. Striped regions did not provide sufficient data for calculation.

The results are in line with other studies conducted on the environmental and economic performance of European regions. For instance, the strong CE performance in Central European countries such as Netherlands, Germany, Austria, or Belgium, accompanied by parts of Scandinavia as presented by Banjerdpaiboon, Limleamthong (2023) is confirmed in our study. However, the low performance that the authors attributed to Finland, or Czechia is contradicted by our analysis. Apart from this, our findings can provide new insights, focuses, and differentiations to enrich the general discussion about regional CE performance in Europe. For instance, the findings of Mazur-Wierzbicka (2021) of locating the most advanced countries in terms of CE principles in Central Europe with the lowest-ranking countries in Eastern and Southern Europe are complemented by a more differentiated perspective. Our analysis reveals that certain countries such as Romania do not perform generally worse but individual Romanian regions perform above average. Therefore, the previous finding of particularly less developed EU countries continuing to focus on linear rather than CE principles cannot be confirmed (Mitrovic, Veselinov 2018). In comparison to Silvestri et al. (2020), who chose a similar methodological approach, the structural findings in this paper are similar. However, the larger data set

Table 2: Top 20 European regions – static index

Rank	NUTS ID	Region	Index Value
1	LU00	Luxembourg	0.6140
2	ES51	Cataluña	0.5921
3	FI1C	Etelä-Suomi	0.5858
4	ITH5	Emilia-Romagna	0.5774
5	UKI3	Inner London — West	0.5731
6	ES24	Aragón	0.5663
7	NL32	Noord-Holland	0.5662
8	CZ01	Praha	0.5661
9	BE25	Prov. West-Vlaanderen	0.5651
10	BE24	Prov. Vlaams-Brabant	0.5634
11	SE22	Sydsverige	0.5633
12	ITI1	Toscana	0.5620
13	FR10	Ile-de-France	0.5619
14	AT34	Vorarlberg	0.5590
15	ITC3	Liguria	0.5522
16	RO21	Nord-Est	0.5518
17	DK01	Hovedstaden	0.5507
18	FI1D	Pohjois- ja Itä-Suomi	0.5499
19	FI1B	Helsinki-Uusimaa	0.5435
20	ES62	Región de Murcia	0.5430

Source: Computations by the authors.



Source: Computations by the authors.

Figure 2: Map of European regions - static index

and the inclusion of regions that were missing (e.g., Scandinavia or the UK), as well as the inclusion of new indicators and new dimensions with more recent data, allow this paper to paint a more complete picture of CE in European regions. Moreover, the CE performance in Eastern Europe, particularly in urban regions, is found to be stronger than what Silvestri et al. (2020) assumed. This can be attributed to the inclusion of different data bases.

Generally, the new methodology does not contradict previous findings but helps to explain them in a more reflected manner. For instance, national level analyses often assumed that countries in Eastern Europe were underdeveloped when it comes to CE whereby it could be shown that certain regions in Eastern Europe perform above average when it comes to CE. This is easily overseen when all regions of a country are accumulated. Our findings combine and refine previous approaches, which explains why no major contradictions have been identified.

6 Discussion

For the trend index, the static index values were compared with the values in 2012 as the general base year. The indicator set (see Table 1) was applied to 278 European NUTS 2 regions whereby those regions that revealed missing data in more than two dimensions had to be excluded. Consequently, the trend index consists of 264 European NUTS 2 regions (see Appendix B). The missing data have either occurred due to changes in the statistical NUTS classifications that did not allow for a comparison of regions over time or gaps in the data availability. In terms of waste management statistics, Bulgaria, Czechia, Denmark, Germany, Ireland, Greece, Spain, France, Italy, Finland, Sweden, as well as some Polish and British regions had to be excluded. This was done either because they did not report any data or because there were missing data in the trend index so that no comparison could be conducted. The same holds for French regions in the consumption and production dimension. The indicator "circular city declaration" in dimension 1 (Policy) was removed for the trend index since the initiative was not in place in 2012.

In terms of the trend index, a relatively even geographical distribution among Europe is observable when examining the top 20 best performing regions. Eastern European regions are reflected as well as Scandinavian, Southern, or Central European regions (see Table 3).

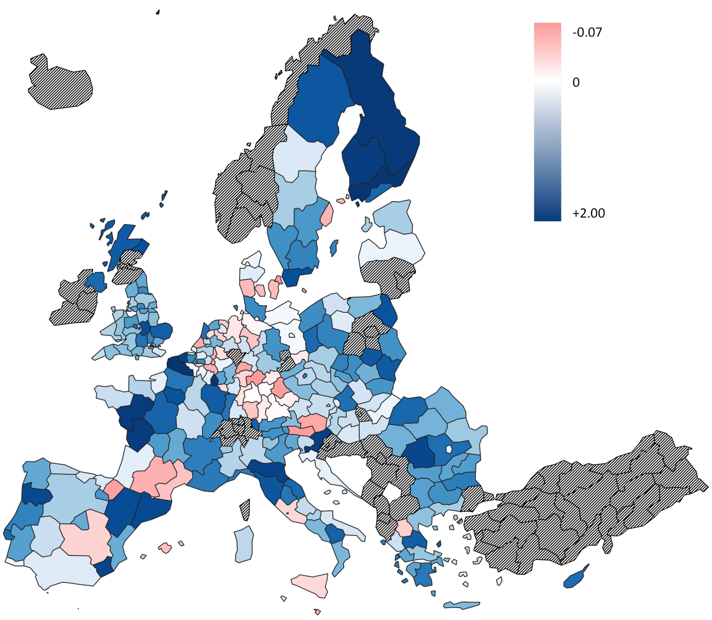
Figure 3 provides a geographical overview of the trend index in European regions. While a relatively even distribution can also be observed, the light red regions have faced negative development in terms of CE in recent years. These regions are also evenly distributed, while large parts of Germany stand out in a negative way. Generally, the figure highlights that positive developments over the period under review are also found in those regions that rank comparable low in the static index which indicates a catch-up process. Comparing the static and the trend index reveals that Finnish regions rank particularly high in both indexes. The favourable position in which Finnish regions are situated in the static index corresponds to a remarkable development in the trend index rather than a structural advantage over other regions. Starting from a worse position than others, Finland proves that catching up in terms of CE performance is possible. Structurally, countries like France tend to move towards regional convergence with a positive trend in regions that do not rank high in CE performance; while the structure in England appears to be structurally preserving with particularly positive development in already prospering regions around the capital. Striped regions did not provide sufficient data for calculation.

Although the CE performance tends to be positively related to agglomeration areas which combine a high level of infrastructure with a critical mass of stakeholders, the analysis shows that also sparsely populated areas such as Finnish regions can perform extraordinarily well. While the CE concentration in strong urban and industrial regions is not surprising (and has also been acknowledges by other studies, e.g., Niang et al. 2023), it is noticeable that not all capital regions rank high in terms of their CE index. Instead, also non-capital regions with a lower centrality and more rural structure appear

Table 3: Top 20 European regions – trend index

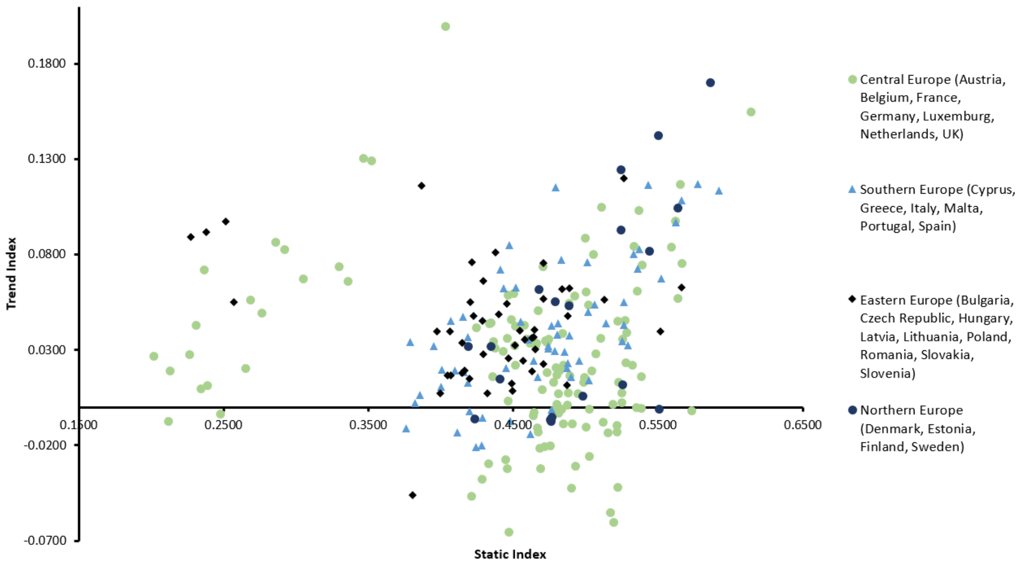
Rank	NUTS ID	Region	Index Increase
1	FRE1	Nord-Pas de Calais	0.1998
2	FI1C	Etelä-Suomi	0.1705
3	LU00	Luxembourg	0.1551
4	FI1D	Pohjois- ja Itä-Suomi	0.1428
5	FRG0	Pays de la Loire	0.1307
6	FRI3	Poitou-Charentes	0.1292
7	FI19	Länsi-Suomi	0.1246
8	SI03	Vzhodna Slovenija	0.1199
9	BE25	Prov. West-Vlaanderen	0.1170
10	ITH5	Emilia-Romagna	0.1168
11	ES62	Región de Murcia	0.1165
12	RO41	Sud-Vest Oltenia	0.1160
13	PT11	Norte	0.1151
14	ES51	Cataluña	0.1137
15	ES24	Aragón	0.1083
16	UKF2	Leicestershire, Rutland and Northamptonshire	0.1049
17	SE22	Sydsverige	0.1047
18	UKM5	North Eastern Scotland	0.1033
19	FR10	Ile-de-France	0.0975
20	PL84	Podlaskie	0.0973

Source: Computations by the authors.



Source: Computations by the authors.

Figure 3: Map of European regions – trend index



Source: Computations by the authors.

Figure 4: Static and trend index

in the top-20. It appears that the CE performance is not fully explained by structural characteristics but qualitative factors such as regional policy and governance. While it is beyond the scope of this article to further elaborate on these factors, certain authors have started looking into institutional factors as influencers of regional CE (see e.g., Ranta et al. 2018, Budde Christensen 2021) and the role of structural factors for CE-compliant individual behaviour (Neves, Marques 2022). Domenech, Bahn-Walkowiak (2019) analysed national strategies on CE and identify Germany, Austria, and Finland as frontrunners. Regions from these countries also rank highly in our static index. Generally, several of the top-20 regions in the static index are also known for their regional circular strategies, for instance London, Prague, Helsinki, and Paris (Mairie de Paris 2017, City of Helsinki 2020, Circular Prague 2022, ReLondon 2023). Although we cannot concretely assume a causal correlation, our study confirms the important role that policies play for the CE transition and the role of governments in this context (see also Chembessi et al. 2021b, Hartley et al. 2023, Niang et al. 2023). Moreover, the distribution of strong CE regions among Europe can be understood as a promising signal as CE can be successfully implemented in different socio-economic and geographical contexts. Also, it needs to be recognised that the assessment methodology does not quantify phenomena such as outsourcing of urban metabolisms, which provides an additional perspective on rural-urban interactions (Tanguy et al. 2020, Bahers, Rosado 2023).

Another perspective to compare the static and trend indices is a scatter-plot provided in Figure 4. To achieve a clearer picture in terms of geographical trends, four regional groups were distinguished: Central Europa (Austria, Belgium, France, Germany, Luxemburg, Netherlands, UK), Southern Europe (Cyprus, Greece, Italy, Malta, Portugal, Spain), Eastern Europe (Bulgaria, Czechia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia), and Northern Europe (Denmark, Estonia, Finland, Sweden).

Eastern European regions (represented by black diamonds) generally find themselves in a modest position with an average performance in the static index and a slightly positive development in the trend index. Central European regions (represented by light green dots) do not present a clear picture, which can be attributed to the diversity of the group consisting of some of the worst and some of the best performing regions. In Northern European regions (represented by darker blue dots) there appears to be a trend that those regions ranking high in the static index also perform above average in the trend index. A similar development pattern is observed in Southern Europe (represented by lighter blue triangles). Geographically speaking, several regions in Central and Southern

Europe appear to lose touch with the other regions in case that the negative development trend continues. These regions come under relative pressure from catching-up regions and leading regions expanding their position. Generally, Eastern or Southern European regions do not perform worse than Central or Northern European regions. However, it appears that high-performing regions with an urban character have an advantage when it comes to CE. This might be due to structural characteristics such as the availability of an established infrastructure for waste collection and the treatment or the existence of environmentally conscious social groups in urban centres that push regional governments for more CE action.

7 Conclusion

The benefits of a CE range from economic and environmental up to social benefits. However, when it comes to implementation, the role of regions in the transition towards CE is still under-researched even though the regional perspective is becoming increasingly important. For Europe, it is particularly striking that a thorough methodology to quantify CE on a regional level is missing. The article at hand proposes a multi-dimensional framework of 29 indicators in six dimensions to overcome previous limitations (see Table 1). While several of these dimensions have been chosen for CE measurement before, the methodology at hand is the first to combine them for a regional analysis. The data selection followed a pragmatic approach to select consistent, harmonised, and standardised data which were used to calculate a static and a trend index. Since monitoring schemes are a necessary instrument to quantify the effective implementation of policies and to identify their regional implications, the framework provides policy makers with an objective and adaptable methodology to develop CE instruments for Europe. It also highlights the current gaps in data availability on the regional level that need to be addressed to improve monitoring instruments in the future to gain deeper insights into CE development.

The results of quantifying regional CE performance in European regions partly confirm previous studies conducted on the environmental and economic performances of European regions but also draw a more differentiated picture: As some studies suggest, Eastern and Southern European countries are not utterly uncoupled from Central and Northern Europe but show a high level of interregional differentiation. Certain regions, particularly the urban capital regions, reveal a relatively high CE performance while more rural regions perform worse. The inner-country development patterns also differ among countries so that the differentiating line would not be drawn between North and South or West and Eastern Europe but rather between individual regions. The assumption of a natural correlation between urban areas and high CE performance can be rejected as a result from the findings. Instead, regional CE performance appears to be determined by regional policy rather than structural characteristics alone. Further research could involve qualitative case studies on why structurally similar regions perform that different in terms of CE. A first hint is identified by examining the instrument of smart specialisation. This European strategy for innovation and regional development has been used by some regions, particularly in Scandinavia, to facilitate regional CE development. These regions have proven to perform well in terms of CE, which might support previous claims that CE and smart specialisation might have the potential to benefit from each other. Comparing the regions focusing on CE in their S3 and the regions with high CE performance values reveals some overlaps (see Figure 1 and 2). Although it is hard to derive whether CE has been named in regional strategies as a result of strong CE performance or whether the policy has been the foundation for strong CE development, there appears to be a relation between both that should be further analysed. It has been shown that both policy makers and researchers increasingly discuss S3 and CE together but to derive a recommendation for European policy in general, the separated case studies need to be scaled up and a more holistic approach is required (Vanhamäki et al. 2021).

Generally, the analysis at hand can help policymakers to track their regional performance and progress in terms of CE so that it can be used as a basis for the design and enhancement of regional strategies. The instrument of smart specialisation can particularly be a relevant tool in this regard as it focuses on the identification of regional capabilities and the exploitation of development potentials. The integration of CE knowledge into this process can help to improve CE visibility and create incentives for directed investments as also claimed by Fusillo et al. (2021). On a superior level, CE policy in Europe should recognise the disparate development trends particularly when urban and rural regions are compared. To avoid a further deepening of regional inequality, tailored support is required to support the worse-performing regions, so they do not lose ground in the transition towards CE and sustainability. However, the presented methodology cannot raise a claim for completeness. The identification of dimensions is based on a literature review to assess the CE performance in regions but relies on a high level of pragmatism related to the limited availability of data on regional level. Therefore, drawbacks had to be accepted when it came to regional coverage and data gaps, as well as the years analysed. Improving data quality and the development of new indicators will allow for a revision and fine tuning as well as potential complements of the methodology.

Acknowledgements

The authors would like to express their sincere gratitude towards the anonymous reviewers for their helpful comments and recommendations, the editor of the journal for his continuous support and everyone else involved from the journal side for their accurate and professional work.

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A Appendix: Potential additional indicators for CE benchmarking on NUTS1-level

Dimension	No.	Indicator
Policy	1.1	Expenditure on environmental protection
Innovation	2.1	Private investment, jobs and gross value added related to CE sectors
	2.2	Total investment in environmental protection
	2.3	Patents related to recycling and secondary raw materials
	2.4	Energy productivity
	2.5	Water productivity
Employment	3.1	Gross value added in environmental goods and services sector
Consumption and Production	4.1	Generation of waste excluding major mineral wastes per GDP unit
	4.2	Generation of waste excluding major mineral wastes per domestic material consumption
	4.2	Generation of packaging waste per capita
	4.3	Generation of waste electrical and electronic equipment (WEEE)
	4.4	Generation of biological waste
	4.5	Material consumption
	4.6	Resource productivity
Waste Management	5.1	Recycling rate of all waste excluding major mineral waste
	5.2	Recycling rate of e-waste
	5.3	Recycling of biowaste
	5.4	Recovery rate of construction and demolition waste
	5.5	Circular material use rate
	5.6	Contribution of recycled materials to raw materials demand
	5.7	Trade of recyclable raw materials between EU member states and with the rest of the world
Regional Sustainability	6.1	Exposure to air pollution
	6.2	Air emissions accounts by NACE Rev. 2 activity
	6.3	Settlement area
	6.4	Share of busses and trains in total passenger transport
	6.5	Population living in households considering that they suffer from noise
	6.6	Share of renewable energy in gross final energy consumption
	6.7	Soil sealing index

B Appendix: CE performance in Europe, static and trend index, NUTS2 regions, 2018, 2012-2018

NUTS ID	Region	Static Index	Trend Index
BE10	Région de Bruxelles-Capitale/ Brussels Hoofdstedelijk Gewest	0.5345	0.0000
BE21	Prov. Antwerpen	0.4775	0.0133
BE22	Prov. Limburg (BE)	0.4817	0.0193
BE23	Prov. Oost-Vlaanderen	0.5352	0.0609
BE24	Prov. Vlaams-Brabant	0.5634	0.0573
BE25	Prov. West-Vlaanderen	0.5651	0.1170
BE31	Prov. Brabant Wallon	0.5213	-0.0095
BE32	Prov. Hainaut	0.4459	0.0033
BE33	Prov. Liège	0.4633	-0.0041
BE34	Prov. Luxembourg (BE)	0.4696	0.0095
BE35	Prov. Namur	0.4810	0.0074
BG31	Severozapaden	0.4226	0.0480
BG32	Severen tsentralen	0.4289	0.0455
BG33	Severoiztochen	0.4401	0.0487
BG34	Yugoiztochen	0.4291	0.0663
BG41	Yugozapaden	0.4560	0.0464
BG42	Yuzhen tsentralen	0.4203	0.0553
CZ01	Praha	0.5661	0.0628
CZ02	Střední Čechy	0.4568	0.0244
CZ03	Jihozápad	0.4630	0.0364
CZ04	Severozápad	0.4645	0.0405
CZ05	Severovýchod	0.4466	0.0258
CZ06	Jihovýchod	0.4651	0.0302
CZ07	Střední Morava	0.4580	0.0356
CZ08	Moravskoslezsko	0.4879	0.0479
DK01	Hovedstaden	0.5507	-0.0007
DK02	Sjælland	0.4761	-0.0070
DK03	Syddanmark	0.4754	-0.0063
DK04	Midtjylland	0.5251	0.0122
DK05	Nordjylland	0.4975	0.0062
DE11	Stuttgart	0.4467	-0.0651
DE12	Karlsruhe	0.5023	-0.0256
DE13	Freiburg	0.4988	0.0158
DE14	Tübingen	0.4903	-0.0085
DE21	Oberbayern	0.5017	-0.0549
DE22	Niederbayern	0.4283	-0.0375
DE23	Oberpfalz	0.5023	-0.0006
DE24	Oberfranken	0.4929	-0.0306
DE25	Mittelfranken	0.5188	-0.0602
DE26	Unterfranken	0.5383	-0.0003
DE27	Schwaben	0.4454	-0.0320
DE30	Berlin	0.4900	-0.0420
DE40	Brandenburg	0.4869	0.0013
DE50	Bremen	0.5214	-0.0128
DE60	Hamburg	0.5220	-0.0417
DE71	Darmstadt	0.5153	-0.0132
DE72	Gießen	0.4778	-0.0018
DE73	Kassel	0.4888	0.0165
DE80	Mecklenburg-Vorpommern	0.4795	0.0018
DE91	Braunschweig	0.5320	0.0223
DE92	Hannover	0.4842	-0.0085
DE93	Lüneburg	0.4207	-0.0463
DE94	Weser-Ems	0.4442	-0.0273
DEA1	Düsseldorf	0.4680	-0.0215
DEA2	Köln	0.5244	0.0078
DEA3	Münster	0.4845	0.0221
DEA4	Detmold	0.5040	0.0193
DEA5	Arnsberg	0.4326	-0.0293
DEB1	Koblenz	0.5098	0.0365
DEB2	Trier	0.5268	0.0459
DEB3	Rheinhessen-Pfalz	0.5380	0.0161
DEC0	Saarland	0.4751	-0.0202
DED2	Dresden	0.4686	-0.0318
DED4	Chemnitz	0.4815	:
DED5	Leipzig	0.5021	:

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NUTS ID	Region	Static Index	Trend Index
DEE0	Sachsen-Anhalt	0.4884	0.0546
DEF0	Schleswig-Holstein	0.4923	0.0584
DEG0	Thüringen	0.4657	0.0336
EE00	Eesti	0.4184	0.0322
IE04	Northern and Western	0.2772	:
IE05	Southern	0.3444	:
IE06	Eastern and Midland	0.3972	:
EL30	Attiki	0.4551	0.0448
EL41	Voreio Aigaio	0.4006	0.0196
EL42	Notio Aigaio	0.3999	0.0106
EL43	Kriti	0.4185	0.0367
EL51	Anatoliki Makedonia, Thraki	0.3952	0.0320
EL52	Kentriki Makedonia	0.4601	0.0354
EL53	Dytiki Makedonia	0.3760	-0.0109
EL54	Ipeiros	0.4095	0.0193
EL61	Thessalia	0.4475	0.0851
EL62	Ionia Nisia	0.4519	0.0629
EL63	Dytiki Elláda	0.4066	0.0455
EL64	Sterea Elláda	0.3788	0.0343
EL65	Peloponnisos	0.4412	0.0722
ES11	Galicia	0.4807	0.0441
ES12	Principado de Asturias	0.4872	0.0250
ES13	Cantabria	0.4896	0.0157
ES21	País Vasco	0.5020	0.0141
ES22	Comunidad Foral de Navarra	0.4762	-0.0011
ES23	La Rioja	0.5059	0.0538
ES24	Aragón	0.5663	0.1083
ES30	Comunidad de Madrid	0.5265	0.0430
ES41	Castilla y León	0.4741	0.0320
ES42	Castilla-La Mancha	0.4114	-0.0131
ES43	Extremadura	0.4448	0.0205
ES51	Cataluña	0.5921	0.1137
ES52	Comunitat Valenciana	0.4766	0.0429
ES53	Illes Balears	0.4476	-0.0071
ES61	Andalucía	0.4189	0.0128
ES62	Región de Murcia	0.5430	0.1165
ES63	Ciudad de Ceuta	0.4200	-0.0022
ES64	Ciudad de Melilla	0.4244	-0.0210
ES70	Canarias	0.4789	0.0296
FR10	Ile-de-France	0.5619	0.0975
FRB0	Centre — Val de Loire	0.2919	0.0827
FRC1	Bourgogne	0.2126	0.0192
FRC2	Franche-Comté	0.2682	0.0562
FRD1	Basse-Normandie	0.2260	0.0278
FRD2	Haute-Normandie	0.2343	0.0099
FRE1	Nord-Pas de Calais	0.4030	0.1998
FRE2	Picardie	0.2363	0.0724
FRF1	Alsace	0.3295	0.0741
FRF2	Champagne-Ardenne	0.2017	0.0268
FRF3	Lorraine	0.2857	0.0865
FRG0	Pays de la Loire	0.3465	0.1307
FRH0	Bretagne	0.2651	0.0205
FRI1	Aquitaine	0.2384	0.0115
FRI2	Limousin	0.2761	0.0494
FRI3	Poitou-Charentes	0.3516	0.1292
FRJ1	Languedoc-Roussillon	0.2119	-0.0074
FRJ2	Midi-Pyrénées	0.2477	-0.0032
FRK1	Auvergne	0.2309	0.0433
FRK2	Rhône-Alpes	0.3354	0.0661
FRL0	Provence-Alpes-Côte d'Azur	0.3049	0.0677
FRM0	Corse	0.2353	:
FRY1	Guadeloupe	0.1315	:
FRY2	Martinique	0.2635	:
FRY3	Guyane	0.1425	:
FRY4	La Réunion	0.2771	:
FRY5	Mayotte	:	:
HR02	Panonska Hrvatska	:	:
HR03	Jadranska Hrvatska	0.4574	0.0094
HR05	Grad Zagreb	:	:
HR06	Sjeverna Hrvatska	:	:

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NUTS ID	Region	Static Index	Trend Index
ITC1	Piemonte	0.4853	0.0291
ITC2	Valle d'Aosta/Vallée d'Aoste	0.5293	0.0326
ITC3	Liguria	0.5522	0.0674
ITC4	Lombardia	0.4638	0.0243
ITF1	Abruzzo	0.4876	0.0232
ITF2	Molise	0.4743	0.0308
ITF3	Campania	0.4888	0.0378
ITF4	Puglia	0.4670	0.0157
ITF5	Basilicata	0.5368	0.0830
ITF6	Calabria	0.4803	0.0380
ITG1	Sicilia	0.4279	-0.0198
ITG2	Sardegna	0.4953	0.0245
ITH1	Provincia Autonoma di Bolzano/Bozen	0.5263	0.0552
ITH2	Provincia Autonoma di Trento	0.5250	0.0347
ITH3	Veneto	0.5015	0.0502
ITH4	Friuli-Venezia Giulia	0.5140	0.0440
ITH5	Emilia-Romagna	0.5774	0.1168
ITI1	Toscana	0.5620	0.0969
ITI2	Umbria	0.5358	0.0725
ITI3	Marche	0.5330	0.0805
ITI4	Lazio	0.4619	-0.0142
CY00	Kýpros	0.5011	0.0762
LV00	Latvija	0.4321	0.0073
LT00	Lithuania	0.3806	-0.0461
LT01	Sostinės regionas	:	:
LT02	Vidurio ir vakarų Lietuvos regionas	:	:
LU00	Luxembourg	0.6140	0.1551
HU11	Budapest	0.4059	:
HU12	Pest	0.2296	:
HU21	Közép-Dunántúl	0.4163	0.0193
HU22	Nyugat-Dunántúl	0.4295	0.0276
HU23	Dél-Dunántúl	0.4199	0.0151
HU31	Észak-Magyarország	0.4048	0.0168
HU32	Észak-Alföld	0.3997	0.0073
HU33	Dél-Alföld	0.4147	0.0178
MT00	Malta	0.4285	-0.0055
NL11	Groningen	0.4664	-0.0106
NL12	Friesland (NL)	0.5217	0.0455
NL13	Drenthe	0.4983	0.0133
NL21	Overijssel	0.4667	-0.0128
NL22	Gelderland	0.5282	0.0393
NL23	Flevoland	0.4714	-0.0204
NL31	Utrecht	0.5276	0.0234
NL32	Noord-Holland	0.5662	0.0754
NL33	Zuid-Holland	0.4638	-0.0024
NL34	Zeeland	0.4877	0.0076
NL41	Noord-Brabant	0.5069	0.0282
NL42	Limburg (NL)	0.4809	-0.0028
AT11	Burgenland	0.4796	0.0170
AT12	Niederösterreich	0.4794	0.0208
AT13	Wien	0.5001	-0.0101
AT21	Kärnten	0.4834	-0.0006
AT22	Steiermark	0.4813	-0.0021
AT31	Oberösterreich	0.4731	0.0186
AT32	Salzburg	0.5253	0.0361
AT33	Tirol	0.5016	0.0539
AT34	Vorarlberg	0.5590	0.0840
PL21	Małopolskie	0.4647	0.0400
PL22	Śląskie	0.4710	0.0568
PL41	Wielkopolskie	0.4837	0.0618
PL42	Zachodniopomorskie	0.5127	0.0562
PL43	Lubuskie	0.5079	0.0787
PL51	Dolnośląskie	0.4509	0.0323
PL52	Opolskie	0.4885	0.0624
PL61	Kujawsko-pomorskie	0.4491	0.0124
PL62	Warmińsko-mazurskie	0.4643	0.0369
PL63	Pomorskie	0.4630	0.0187
PL71	Łódzkie	0.3056	:
PL72	Świętokrzyskie	0.2381	0.0918

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NUTS ID	Region	Static Index	Trend Index
PL81	Lubelskie	0.2573	0.0552
PL82	Podkarpackie	0.2276	0.0892
PL84	Podlaskie	0.2514	0.0973
PL91	Warszawski stołeczny	0.3598	:
PL92	Mazowiecki regionalny	0.2739	:
PT11	Norte	0.4791	0.1151
PT15	Algarve	0.3823	0.0021
PT16	Centro (PT)	0.4431	0.0624
PT17	Área Metropolitana de Lisboa	0.4834	0.0775
PT18	Alentejo	0.4153	0.0474
PT20	Região Autónoma dos Açores	0.3857	0.0064
PT30	Região Autónoma da Madeira	0.4157	0.0186
RO11	Nord-Vest	0.4375	0.0812
RO12	Centru	0.3973	0.0397
RO21	Nord-Est	0.5518	0.0398
RO22	Sud-Est	0.4148	0.0338
RO31	Sud-Muntenia	0.4215	0.0759
RO32	Bucureşti-Ilfov	0.4495	0.0088
RO41	Sud-Vest Oltenia	0.3868	0.1160
RO42	Vest	0.4061	0.0398
SI03	Vzhodna Slovenija	0.5261	0.1199
SI04	Zahodna Slovenija	0.4710	0.0225
SK01	Bratislavský kraj	0.4872	0.0117
SK02	Západné Slovensko	0.4706	0.0756
SK03	Stredné Slovensko	0.4071	0.0166
SK04	Východné Slovensko	0.4453	0.0542
FI19	Länsi-Suomi	0.5241	0.1246
FI1B	Helsinki-Uusimaa	0.5435	0.0818
FI1C	Etelä-Suomi	0.5858	0.1705
FI1D	Pohjois- ja Itä-Suomi	0.5499	0.1428
FI20	Åland	0.4232	-0.0060
SE11	Stockholm	0.4763	-0.0049
SE12	Östra Mellansverige	0.4882	0.0536
SE21	Småland med öarna	0.4676	0.0618
SE22	Sydsverige	0.5633	0.1047
SE23	Västsverige	0.4789	0.0556
SE31	Norra Mellansverige	0.4344	0.0322
SE32	Mellersta Norrland	0.4404	0.0149
SE33	Övre Norrland	0.5239	0.0932
UKC1	Tees Valley and Durham	0.4501	0.0598
UKC2	Northumberland and Tyne and Wear	0.4333	0.0441
UKD1	Cumbria	0.4514	0.0426
UKD3	Greater Manchester	0.4345	0.0445
UKD4	Lancashire	0.4374	0.0314
UKD6	Cheshire	0.5183	0.0019
UKD7	Merseyside	0.4507	0.0324
UKE1	East Yorkshire and Northern Lincolnshire	0.4240	0.0420
UKE2	North Yorkshire	0.4653	0.0325
UKE3	South Yorkshire	0.4482	0.0460
UKE4	West Yorkshire	0.4459	0.0589
UKF1	Derbyshire and Nottinghamshire	0.4363	0.0345
UKF2	Leicestershire, Rutland and Northamptonshire	0.5108	0.1049
UKF3	Lincolnshire	0.4455	0.0363
UKG1	Herefordshire, Worcestershire and Warwickshire	0.4744	0.0357
UKG2	Shropshire and Staffordshire	0.4667	0.0508
UKG3	West Midlands	0.4704	0.0738
UKH1	East Anglia	0.5330	0.0845
UKH2	Bedfordshire and Hertfordshire	0.4997	0.0606
UKH3	Essex	0.4575	0.0433
UKI3	Inner London — West	0.5731	-0.0016
UKI4	Inner London — East	0.5244	0.0024
UKI5	Outer London — East and North East	0.4945	0.0073
UKI6	Outer London — South	0.5117	-0.0076
UKI7	Outer London — West and North West	0.5226	0.0132
UKJ1	Berkshire, Buckinghamshire and Oxfordshire	0.5386	0.0746
UKJ2	Surrey, East and West Sussex	0.4612	0.0338
UKJ3	Hampshire and Isle of Wight	0.4837	0.0391
UKJ4	Kent	0.4355	0.0162
UKK1	Gloucestershire, Wiltshire and Bristol/Bath area	0.4728	0.0340

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NUTS ID	Region	Static Index	Trend Index
UKK2	Dorset and Somerset	0.4588	0.0357
UKK3	Cornwall and Isles of Scilly	0.4510	0.0222
UKK4	Devon	0.4616	0.0361
UKL1	West Wales and The Valleys	0.4426	0.0293
UKL2	East Wales	0.4718	0.0352
UKM5	North Eastern Scotland	0.5362	0.1033
UKM6	Highlands and Islands	0.4995	0.0887
UKM7	Eastern Scotland	0.3681	:
UKM8	West Central Scotland	0.4640	:
UKM9	Southern Scotland	0.3378	:
UKN0	Northern Ireland	0.5050	0.0805