European Planning Studies

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ceps20

Towards a territorial definition of a circular economy: exploring the role of territorial factors in closed-loop systems

Carlos Tapia , Marco Bianchi , Georg Pallaske & Andrea M. Bassi

To cite this article: Carlos Tapia , Marco Bianchi , Georg Pallaske & Andrea M. Bassi (2021): Towards a territorial definition of a circular economy: exploring the role of territorial factors in closed-loop systems, European Planning Studies, DOI: 10.1080/09654313.2020.1867511

To link to this article: https://doi.org/10.1080/09654313.2020.1867511

EUROPEAN PLANNING STUDIES
https://doi.org/10.1080/09654313.2020.1867511

Routledge
Taylor & Francis Group

OPEN ACCESS Check for updates

Towards a territorial definition of a circular economy: exploring the role of territorial factors in closed-loop systems

Carlos Tapia [a,b], Marco Bianchi [b,c], Georg Pallaske[d] and Andrea M. Bassi[d]

[a]Nordregio, International Research Centre for Regional Development and Planning, Stockholm, Sweden; [b]TECNALIA, Basque Research and Technology Alliance (BRTA), Astondo Bidea, Bizkaia, Spain; [c]Department of Applied Economics, University of the Basque Country. Avda. Lehendakari Agirre, Bilbao, Spain; [d]KnowlEdge Srl, Olgiate Olona, Italy

ABSTRACT

This paper deals with the territorial dimension of a circular economy. We review the territorial factors shaping closed-loop systems, upon which a territorial definition of a circular economy is developed. We consider six categories of territorial factors: (1) Land-based factors emphasize the significance of physical endowment to satisfy the growing demand of secondary and biotic materials in a circular economy; (2) agglomeration factors are important determinants for a circular economy, as these provide circular businesses with the necessary access to resources, knowledge and collaboration, as well as viable markets; some of these functions are enabled by (3) hard territorial factors, in particular by accessibility and connectivity infrastructures as well as by (4) access to state-of-the-art technologies; softer territorial factors, including (5) knowledge-related factors and (6) governance and institutional arrangements, support collaboration among companies and between them, as well as among consumers and public institutions. Our review shows that agglomeration and land-based factors contribute to define the framework conditions of circular transformations, the harder territorial factors (accessibility and technologies) enable the circular economy in practice, and the softer factors (knowledge, awareness, governance and milieus) contribute to catalyse circular transformations. These findings base and complement research done in the ESPON CIRCTER project.

ARTICLE HISTORY
Received 1 July 2020
Revised 27 October 2020
Accepted 14 December 2020

KEYWORDS
Circular economy; closed-loop systems; resource-efficiency; territorial factors; place-based policies

Introduction

The circular economy, as established in present practice and policy discourses, is driven by two fundamental goals, namely (1) to retain value, keeping materials circulating in the economy for a longer time, and thereby (2) to increase the overall material efficiency of the economy. These principles are rooted in industrial ecology concepts emerged during the 1970s (Murray, Skene, and Haynes 2017). However, presently there is no single and universally accepted characterization of a circular economy. Kirchherr, Reike, and

CONTACT Carlos Tapia carlos.tapia@nordregio.org Nordregio, International Research Centre for Regional Development and Planning, Box 1658, SE-111 86 Stockholm, Sweden

Hekkert (2017) collected more than 100 definitions. In Europe, the most widely used definition is provided by the European Commission (EC), which presents the circular economy as 'an economy where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised' (EC 2015).

Regardless of the growing interest on the circular economy concept among policy makers and researchers, the social and business implications of a circular economy have not been yet explored (Merli, Preziosi, and Acampora 2018). Even if the implementation of circular economy solutions may have an obvious spatial expression, and albeit some of the existing definitions emphasize the relevance of scales, connectivity and other spatial attributes for a circular economy (Korhonen et al. 2018; Stahel and Clift 2016), the territorial implications of a circular economy still remain broadly unexplored (Bahers and Durand 2017). In this regard, the paper addresses the following research questions: Which territorial factors can affect the development of a circular economy at various scales? How territorial factors may contribute to the development closed-loop systems at regional and local levels? Which aspects should be taken into consideration by urban and regional planners when shaping their spatial strategies?

The paper is organized as follows: we firstly identify and discuss the fundamental and definitory elements of a circular economy; secondly, we present a collection of territorial factors that according to theoretical and empirical observations may potentially influence the way in which closed-loop systems are materialized on the regional and local scales; thirdly, we explore how these factors may interfere with the development of circular economic loops, enabling or hindering their diffusion. Even this work focuses on the European context, many of the aspects addressed may bear relevance for other geographies as well. The work is based on research done in the ESPON CIRCTER project (ESPON 2020).

Materials and methods

This work has been completed by means of a comprehensive literature review. The references have been identified by performing recursive searches for the expressions 'circular economy' and 'territory', as well as related terms. The exact search was as follows: ((KEY ('circular econom*' OR ('closed*' AND 'loop*')) AND TITLE-ABS (('city' OR 'cities' OR 'urban*' OR 'rural' OR 'island' OR 'mountain' OR 'region*' OR 'territor*' OR 'spat*' OR 'space*' OR 'geogr*' OR 'distance ' OR 'proximity' OR 'accessibility')) AND ('europ*' OR 'EU'))).

The search was initially performed in 2018 and subsequently updated in March 2020. We used the Scopus abstract and citation database of peer-reviewed literature. A total of 215 articles were identified in our review. In addition to the main collection, a number of cross-citing searches were conducted as well. These allowed to identify a smaller subset of potentially relevant papers and seminal works. The review also considered a limited number of unpublished reports and other forms of grey literature, including legal and administrative documents.

The circular economy: definitions, scope and scales of operation

The circular economy has been promoted as mainstream policy solution enabling sustainable economic development, particularly among industrial economies (Korhonen et al. 2018). The principles of a circular economy are rooted in the classic industrial ecology concepts and approaches (Socolow et al. 1994), particularly in Stahel's performance economy (Stahel and Reday-Mulvey 1976) and related concepts. These include inter alia industrial metabolism (Ayres 1989), industrial symbiosis (Frosch and Gallopoulos 1989), remanufacturing (Kutta and Lund 1978), the three Rs (Hayes 1978), the waste management hierarchy (EEC 1975), servitization and product-service systems (Goedkoop and Spriensma 1999), resource cascading (Sirkin and ten Houten 1994) and Design for Environment (Graedel and Allenby 1996).

There is not consensus on how to define a circular economy. The most wide-spread characterization is perhaps the one proposed by the Ellen MacArthur Foundation, which defines the circular economy as an '*industrial system* that is restorative and regenerative by intention and design' (Ellen MacArthur Foundation 2015). In Europe, the most used definition is provided by the EC in its Communication 'Closing the loop', which passed the EU Action Plan for a Circular Economy: 'an economy' 'where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised' (EC 2015). These popular conceptions are drops in the ocean of more than hundred definitions of a circular economy that can be found in the literature (Kirchherr, Reike, and Hekkert 2017). Korhonen, Nuur, Feldmann, and Birkie (2018b) conclude that existing definitions tend to agree on the means and goals of the circular economy concept but disagree on how to characterize it. Even if the diversity of standpoints makes it difficult to find commonalities among the various definitions, some elements are present across most of them. These fundamentals can be summarised as follows:

(1) *Aspirational component*: Virtually all definitions present the circular economy as either a means to achieve a pre-defined *aspirational societal model*, typically 'sustainable development' (Dobrotă, Dobrotă, and Petrescu 2017; Ghisellini, Cialani, and Ulgiati 2016) or 'economic decoupling' (Corona et al. 2019). But some definitions also present the circular economy as an aspirational model by itself (Scarpellini et al. 2019). The extent to which the circular economy can be considered a new sustainable development paradigm or rather an instrumental concept to achieve sustainability has been thoroughly discussed. Most authors conclude that the circular economy should be considered one among the most recent and concomitant solutions for fostering sustainable development rather than a goal in itself (Geissdoerfer et al. 2017; Murray, Skene, and Haynes 2017).
(2) *Strategic dimension*: Some authors present the circular economy as an instrumental concept geared at the achievement of *policy or managerial goals* (Haas et al. 2015; Ma et al. 2014). This aspect is highlighted in particular by those authors that put the emphasis on the socio-technical innovations stemming from circular transformations, of which many have the capacity to disrupt a number of business sectors (Singh and Ordoñez 2016).
(3) *Restorative and regenerative aspects*: Virtually all definitions underline the capacity of a circular economy to expand the *restorative capacity* of economic processing. The emphasis is placed on its potential to avoid waste by closing material loops, reinterpreting end-of-life stages in light of a recursive use of materials instead of linear flows (Geissdoerfer et al. 2017; Hobson 2016; Moreau et al. 2017).

(4) *Efficiency principles*: Most definitions emphasize the role of a circular economy to drive a more efficient use of materials and energy in comparison to the linear economy (Corona et al. 2019; Ghisellini, Cialani, and Ulgiati 2014). Several forms of socio-technical innovations are mentioned in the reviewed papers as critical to achieve greater levels of efficiency. These include for example alternative business models that focus on product use rather than product ownership (Lahti, Wincent, and Parida 2018; Rizos, Tuokko, and Behrens 2017), the use of biological materials in 'cascades' (Mair and Stern 2017), as well as the application of reverse logistics and closed-loop supply chains (Braun et al. 2018). These innovations are complemented by more traditional strategies such as the use of renewable energy sources (Dobrotă, Dobrotă, and Petrescu 2017).
(5) *Design elements*: The role of design is introduced both as a strategic component ('restorative by intention and design') as well as an operational element that can be applied on materials, products, systems and business models (Hobson 2016). Some authors emphasize the role of product design for material efficiency through 'circular design' (Moreno et al. 2016). Other definitions underline the role of conscious product design for extended product durability and repairability (Vanegas et al. 2018).
(6) *Cooperation mechanisms* between societal actors. Several papers acknowledge the need for cooperation mechanisms between the various economic actors in order to establish circular flows, and stress the relevance of inter-sectoral and inter-organizational management and governance models (Merli, Preziosi, and Acampora 2018). Cooperation within and between value chains is also mentioned in the Circular Economy Communication as a requisite to support design and innovation for a more circular economy (EC 2014).
(7) *System's perspective*: This aspect is evinced by the interactions between production and consumption systems and on their mutual flows. It is explicitly mentioned by most definitions (Corona et al. 2019; Lazarevic and Valve 2017; Nogueira, Ashton, and Teixeira 2019; Stahel and Clift 2016), and it has also been picked up by the institutional characterization by the EC definition (EC 2015). In general, it is widely accepted that a materialization of a circular economy requires a systems perspective (Geissdoerfer et al. 2017; van Buren et al. 2016)

From the definitions and the operational elements reviewed above it emerges that the strategies in a circular economy necessarily operate at various scales, both in terms of organizational widths as well as geographical scope. Kalmykova, Sadagopan, and Rosado (2018) propose a classification of circular economy strategic areas based on the former. They differentiate a small organizational level, which refers to practices implemented by single firms i.e. cleaner production, energy efficiency or eco-design, and a large organizational scale that refers to a systemic economy-wider implementations, like an industrial cluster. Ghisellini, Cialani, and Ulgiati (2014) and Merli, Preziosi, and Acampora (2018) developed comparable classifications. In general, authors agree that broader organizational widths are those better placed to accommodate the inter-sectoral and inter-organizational transformations required to close material loops. Circularity strategies adopted at smaller organizational levels seem more appropriate for the introduction of intra-firm innovations, be these product-based (den Hollander, Bakker, and Hultink 2017) or business-based innovations (Lewandowski 2016).

The geographical scope of closed-loop systems has been explored from a performance economy perspective. Stahel and Clift (2016) define three material loops and scales of operation in a performance economy. Loop 1 focuses on product reuse, through second-hand markets (e.g. flea markets) as well as commercial and private reuse of goods (e.g. refilling of beverage containers). Most activities in this loop are typically carried out at local and regional scales. Loop 2 includes product repair, remanufacturing to meet new technical requirements and upgrading to meet new uses and markets. These activities may be carried out locally (e.g. refurbishing of domestic appliances) or show an unspecific geographical adscription (e.g. remanufacturing of industrial equipment). In Loop 3 residual products and materials are reprocessed to recover secondary materials for return to the production system for further use (recycling) or energy recovery. Processes in this loop may take place on a regional scale or may be part of a global supply system. In a case study in Brussels, Zeller et al. (2019) found that less than 1% of the total collected waste is used in a way that closes material cycles at the city level.

Even though the theoretical and practical elements underpinning the circular economy and its materialization are rooted on long-standing concepts and epistemic, the literature agrees on the fact that the basic assumptions concerning the economic and social structures, cultures, norms and everyday habits surrounding the development of closed-loop systems still remain largely unexplored (Hobson 2019; Korhonen, Honkasalo, and Seppälä 2018; Marin and Meulder 2018; Merli, Preziosi, and Acampora 2018). An aspect that remains under-researched is the spatial and territorial dimension of closed-loop systems, in particular the relational logic of geographical norms and scales as factors for adequate management of resources (Barles 2009). Understanding such processes calls for the identification of spatial regimes and territorial dynamics linked to circular economic transformations. More specifically, it requires the exploration of how territorial factors may influence the different strategies towards closed-loop systems, including the adoption of circular innovations by companies, public institutions and citizens.

The role of territorial factors in a circular economy

In spite of globalization, territories (nations, regions and cities) still exhibit notorious differences in economic specialization, competitiveness, convergence/divergence patterns and overall socio-economic dynamism (Iammarino, Rodriguez-Pose, and Storper 2019). A multiplicity of structural conditions and contextual circumstances contribute to shape regional economies. Regional economics has historically recognized the influence that 'factor conditions' exert on local economies (Porter 1990). Neoliberal and evolutionary economics often present these as factors of regional competitiveness in a global economic circuit, endorsing regional specialization as a development virtue (Grillitsch and Asheim 2018).

According to this narrative, specialized factors of production are formed over historical periods through dynamic interactions between firms and institutions. Such long-term processes ultimately determine the availability of local infrastructures, resources and skills, hence shaping the capacity of certain regions to attract specific types of economic activity more than others (Porter 1998). Such spatially bound assets, here referred to as 'territorial factors', include elements related to the physical endowment, like infrastructures, but also immaterial assets stemming from social constructs, including political and administrative jurisdictions, institutions, cultural values, etc.

Following, we explore the role that territorial factors play in shaping circular economic transformations at lower spatial scales, as potential drivers of economic competitiveness and resilience. We focus on six factors that, according to the reviewed literature, show higher relevance from a circular economy perspective. Such factors are: (1) land-based resources, (2) agglomeration factors, (3) accessibility conditions, (4) technical and technological capacity, (5) knowledge-related factors, and (6) governance and institutional drivers. Figure 1 provides a schematic representation of the territorial factors discussed here.

Land-based factors and natural endowment

Land-based factors emphasize the relevance of natural endowment to satisfy the growing demand for raw materials and biomass feedstock for a circular economy. While energy and circular economy transitions might curb the consumption of certain types of primary raw materials, the demand for metals and biotic materials is expected to expand significantly in the following decades as a result of the substitution of fossil-based fuels and materials by alternative sources (Bell et al. 2018; Teubler, Kiefer, and Liedtke 2018).

Even if biobased materials also carry an environmental burden, they are key in a circular economy because of their multifunctionality (Corrado and Sala 2018). Unlike inert materials that need to be recovered and used in closed-loops, biotic materials in a biobased economy shall be used in cascades. This refers to the efficient utilization of resources by using residues and recycled materials sequentially to extend total biomass availability within a given system (Vis, Mantau, and Allen 2016). Potentially, this expands the capacity of biobased economies to create synergistic effects and act as multipliers for other economic activities, particularly in rural areas.

In Europe and elsewhere, high hopes are placed on the biobased economy as a driving development force in the rural setting (EC 2018; Philp and Winickoff 2018). However,

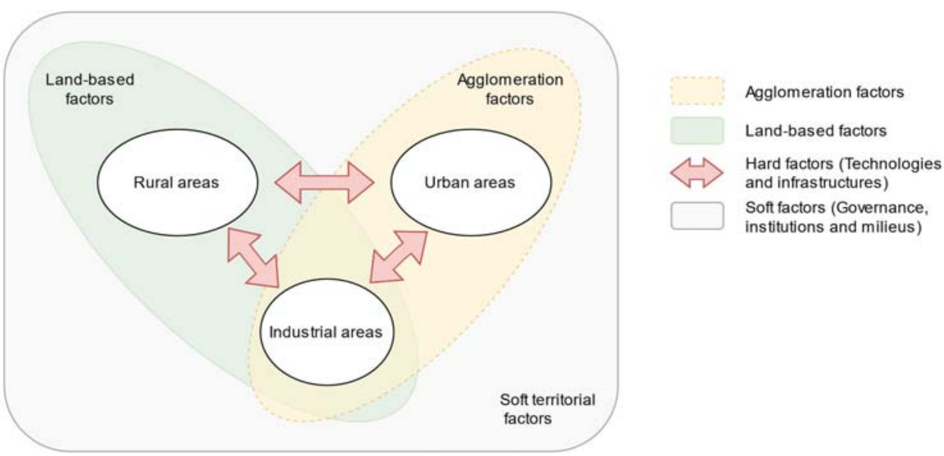

Figure 1. Territorial factors and their interactions in different types of territories. *Source: own elaboration.*

the fuel substitution processes that occurred during the first decade of the century showed that the relation between competing land functions can be problematic, both in terms of social as well as ecological impacts (Gomiero, Paoletti, and Pimentel 2010; Hertel, Steinbuks, and Baldos 2013). These effects are likely to occur in the future too, particularly if bioenergy cropland expansion remains a major component of climate change mitigation strategies (Hof et al. 2018). In general, the technical feasibility and environmental neutrality of transitioning towards a biobased economy still seem far from being assured (Corrado and Sala 2018).

Agglomeration factors

Agglomeration factors are here understood as the concentration of businesses, consumers and/or production factors required to perform certain circular economy activities. Industrial agglomerations create the right conditions for all circular economy initiatives whenever diversity and complementarity are important enabling factors, such as for industrial symbiosis programmes (Domenech et al. 2019; Lombardi 2017). Economies of scale in urban areas can also enable recovery of low-value materials that require significant volumes to ensure financial sustainability of the reclamation plants (Chen et al. 2012, 2014; Zeller et al. 2019). In general, the lower the value of materials, the higher the quantities needed to enable profitable operation (Cucchiella et al. 2015). For example, Wang et al. have estimated that current recovery rates of lithium-ion batteries would only generate enough batteries to enable four recycling facilities to operate with profit in the whole US (Wang et al. 2014).

But economies of scale are not only important for recycling economies. Urban agglomerations also create the right conditions for the development of business models that are based on product sharing, pooling and other forms of collaborative consumption (Brown, Bocken, and Balkenende 2019; Cohen and Kietzmann 2014). Frequently, urban areas are the only possible setting for profit-driven circular business models, as most of them require a certain 'critical mass' to become financially sustainable (Acquier, Carbone, and Massé 2019). Moreover, cities also attract a range of community-led initiatives that operationalize circular economy strategies on a non-for-profit level (Suau Ibáñez 2019). These include sharing platforms, repair associations, maker movements and other forms of social and grassroot innovation with a strong sustainability (Charter 2018; Cohen and Muñoz 2016; Jaeger-Erben, Rückert-John, and Schäfer 2015). Even if these activities tend to proliferate in cities (Angelidou and Psaltoglou 2017), grassroot innovations are by no means an exclusive of urban areas (Ensign and Leupold 2018). Last but not least, cities themselves have experimented new forms of 'circular planning' and governance for 'circular cities' (Bolger and Doyon 2019), even if quite frequently such interventions remain on a rather discursive level with limited implications for on-going spatial development practices (den Berghe and Vos 2019).

Proximity and accessibility factors

Big markets are not the only requirement for strong circular economy networks. Closing material loops also require good access to secondary materials and by-products by economic actors. Accessibility to used products and secondary materials can greatly affect operational costs of firms adopting circular business models (Holgado and Aminoff 2019) or participating in industrial symbiosis schemes (Domenech et al. 2019). Connectivity between companies and customers that produce and consume key products can also contribute to create effective links between them, thereby contributing to operationalize the circular economy at a global scale (Geng, Sarkis, and Bleischwitz 2019).

Accessibility is mostly driven by geographical proximity and the availability of infrastructure. Proximity is defined in different ways according to contexts, actors involved and research perspective. Bahers and Durand (2017) identified up to nine different forms or manifestations of proximity with circular economy implications, including spatial, functional, access, environmental, organizational, institutional, socio-economic, relational and disputed forms of proximity. Non-physical expressions of proximity can be important enablers for different strategies of a circular economy, sometimes acting as substitution of physical proximity (Prosman, Wæhrens, and Liotta 2017). Infrastructure enables the transportation and re-allocation of stocks in an efficient way. In general, areas located close to transportation hubs, like airports, ports, railway stations, and/or having in place effective intermodal transportation systems and logistic hubs can be significantly advantaged when it comes to triggering the economies of scale related to for example the processing of secondary raw materials, for example low-value waste collection-recycling (Malinauskaite et al. 2017). This infrastructure is also required for the establishment of circular business models based on for example reverse logistics and take-back programmes (Dhakal, Smith, and Newbery 2016).

Technologies and innovation

Decision-makers in a globalized economy are often confronted with the challenge of developing a competitive edge over peers. Such competitive advantage is often sought and promoted through technology-driven innovation-based competition strategies (Grillitsch and Asheim 2018). The role of emerging technologies in support of circular transformations and as a key enabler for industrial diversification has been thoroughly investigated, particularly for digital technologies (Pagoropoulos, Pigosso, and McAloone 2017) and industry 4.0 (Nascimento et al. 2019). Technologies enable the implementation of circular economy processes not only along the value chain (e.g. cleaner production and eco-design) but also have a critical role for unlocking the market for secondary low-value material streams (Jawahir and Bradley 2016). However, circular solutions and technologies like refurbishment and remanufacturing often compete with traditional, often cheaper, alternatives (Korhonen, Honkasalo, and Seppälä 2018). Moreover, technologies may also create path dependences and lock-in in specific areas (Kalkuhl, Edenhofer, and Lessmann 2012; Wilts and von Gries 2015), including the bioeconomy (Marsden and Farioli 2015).

It is widely accepted that closing material loops are as much favoured by the application of the right technologies, as it is by an enabling framework supporting softer forms of innovation (Leipold and Petit-Boix 2018). Circular transitions ultimately rely on a limited range of technological, business and social innovations (Bocken et al. 2016), many of which have been introduced long ago, albeit often in a sub-optimal and fragmented way (de Jesus and Mendonça 2018). If anything, circular economy transformations seem to require a great deal of innovation capacity and a prone-to-change attitude by all economic actors (Edbring, Lehner, and Mont 2016; Planing 2015).

Knowledge-related factors

Knowledge factors refer to the availability of legal and technical capacity, skills and information, including access to guidance and ability to assemble and absorb knowledge. Knowledge factors are equally relevant for businesses, institutions and individuals. In the private sector, these factors become crucial for the development of more sustainable products and services through strategies such as eco-design, life-cycle-thinking and the adoption of circular business models (de Jesus et al. 2018). Furthermore, a circular economy calls for heterogeneous skills (Burger et al. 2019), which can be particularly relevant for SMEs (Bourguignon 2016).

Based on extensive communication strategies, clarity over circular products and services, and a set of transparent and exhaustive quality criteria, consumers can be further integrated in the circular business strategy development (Porter and Kramer 2019). In fact, citizen awareness and alignment between citizen and policy understandings is fundamental for the operationalization of circular transitions and ensure uptake of circular consumption (Borrello et al. 2017; Repo et al. 2018; Smol et al. 2018).

In the public sector knowledge and awareness are important to generate institutional capacity governing circular and clean economic transitions (de Abreu and Ceglia 2018; Haley 2016). Knowledge can also become a requisite for policy design and implementation. For instance, effective regulations are strongly influenced by the specialized knowledge owned by the actors within territories, and by the intensity of the cooperation they can put in place (Marra, Mazzocchitti, and Sarra 2018). The most innovative regions are those showing the most balanced composition of knowledge bases, including symbolic and analytical dimensions of knowledge (Květoň and Kadlec 2018).

Governance, institutions and milieus

Governance and institutional factors contribute to create the necessary conditions for circular economy activities to root and materialize in concrete actions (Kanda et al. 2019). Governance and institutional arrangements not only promote circular economy principles, but also favour the establishment of other factors, such as knowledge diffusion and increased collaboration between firms (Niesten et al. 2017). Cultural and symbolic aspects of social elements, such as values, norms, cognitive repertoires, are also viewed as strategic assets affecting innovation because of their capacity to enhance small firms' action and to provide opportunities to compete in the knowledge economy (Fernández-Esquinas, van Oostrom, and Pinto 2017). These factors are intrinsically localized, embodied in human capital and relational networks, in labour market, and in the local context that has a clear territorial expression.

Territorial milieus refer to the inter-personal and inter-firm networks formed in a limited geographical area as a result of the information and knowledge flowing through trustworthy and repetitive interactions (Maillat 1995). Closed networks and rigid cooperation mechanisms can sometimes lead to undesired effects, including exclusiveness, lock in-effects or closed-shop-strategies, which may create barriers to structural change (Grillitsch and Asheim 2018). However, in general interactions between societal (value attitude, life-style, perceptions), institutional (regional policy context) and market components (networks, cooperation, etc.) have the capability to relate physical resources with local actors, facilitating the circulation of information and agent coordination within a region (Capello et al. 2007). Thereby, milieus may also promote circular economy transformations, as circular solutions require intense collaboration between actors throughout the entire value chain (Lahti, Wincent, and Parida 2018).

Table 1 provides an overview of the inter-linked relationships occurring between territorial factors and a subset of strategic areas or materializations of the circular economy. The first column summarizes the nine circular economy strategies proposed by Potting et al. (2017). They are labelled R0 to R9 and represent a range of approaches to resource material consumption throughout value chains. R-strategies build on the traditional waste strategies (EC 2010), but unlike the latter, circular economy strategies place the emphasis on waste prevention instead of waste management. As discussed in the introduction, this is a distinctive feature of circular systems, in contrast to linear models. Circular Rs are ordered from high to low capacity to increase circularity within value chains. The second column in the matrix lists circular economy innovations, including citizen behaviours, technologies, business strategies, integrated solutions and circular business models. These provide concrete examples of the various strategies. Following, the scales of operation of the circular economy innovations as well as the relevance of territorial factors described on previous sections are characterized based on the references found in the literature.

Discussion and conclusions

Even if the spatial dimension of closed-loop systems, including aspects like flows of secondary materials and the so-called 'recycling boundaries', have attracted significant attention by previous research, the topic is still far from being well understood. Still, the debate on the territorial definition of a circular economy goes well beyond the delimitation of the scales of operation in closed-loop systems. Territorial factors, as described by regional economics, may condition the way a circular economy is operationalized at all spatial scales, particularly at regional and local levels. These factors include land-based aspects, agglomeration economies, accessibility conditions, knowledge- and technology-based enablers, governance and institutional drivers and milieus.

Land-based factors determine the capacity of regional and local economies to satisfy the demand for biotic materials in a circular bioeconomy. Unlike inert materials, that need to be kept in closed-loops, biotic materials in a biobased economy are to be used in cascades, providing economic systems with greater degree of flexibility and adaptive capacity. However, the uncertainties surrounding massive transformations of product segments from fossil-based to biobased alternatives require careful valuation of sustainability risks (Biber-Freudenberger et al. 2020).

Urban and industrial agglomerations represent the most important carriers for an integrated and organized circular economy. Industrial clusters play a key role in unfolding the innovative potential for green technologies and circular practices related to synergistic relations between companies. In this setting, urban agglomerations ensure the necessary critical mass to for example adopt low-value material recovery schemes,

Table 1. Relevance of territorial factors for the circular economy strategic areas.

Main circular economy strategies according to Potting et al. (2017)	Illustrative examples of circular economy innovations	Main scales of operation*	Territorial factors						Relevance
			Land-based	Agglomeration	Accessibility	Knowledge	Technology	Governance	
R0 (Refuse)	Non-transactional forms of consumption (e.g. freecycling movement, repair-cafes, allotments, maker collectives, etc.)	Micro, Meso		✓	✓	✓		✓	Holmes (2018), Charter (2018), Prendeville, Cherim, and Bocken (2018) and Hobson (2019)
R0 (Refuse), R1 (Rethink), R2(Reduce)	Socially responsible consumption, collaborative consumption and innovation (e.g. sharing platforms)	Micro, Meso, Macro		✓		✓	✓	✓	Jurgilevich et al. (2016), Edbring, Lehner, and Mont (2016), Marra, Mazzocchitti, and Sarra (2018), Hobson (2019) and Brown, Bocken, and Balkenende (2019)
R1 (Rethink), R3 (Re-use), R4(Repair)	Second-hand markets, access-based consumption (e.g. renting and leasing), product-service-systems	Micro, Meso		✓	✓	✓		✓	Hobson (2016), Prendeville, Cherim, and Bocken (2018) and Edbring, Lehner, and Mont (2016)
R1 (Rethink), R2 (Reduce)	Cleaner Production & eco-design (including material substitution and energy efficiency/ reduction)	Micro, Meso, Macro	✓	✓		✓	✓	✓	Braun et al. (2018), Stahel (2013), Nascimento et al. (2019) and Pagoropoulos, Pigosso, and McAloone (2017)
R4 (Repair), R5 (Refurbish)	Upgrading maintenance, repairing and restoration	Micro		✓	✓		✓	✓	Franklin-Johnson, Figge, and Canning (2016), van Rhijn and Bosch (2017) and Nascimento et al. (2019)
R6 (Remanufacture), R7 (Repurpose)	Design for modularity, circular design	Micro, Meso		✓	✓	✓	✓	✓	den Hollander, Bakker, and Hultink (2017), Lieder and Rashid (2015) and Nogueira, Ashton, and Teixeira (2019)
R3 (Re-use), R4 (Repair), R5 (Refurbish), R6 (Remanufacture), R7 (Repurpose)	Remanufacture, refurbishing, take-back systems, reverse logistics	Micro, Meso	✓	✓	✓		✓	✓	Singh and Ordoñez (2016), Accorsi et al. (2015), van Buren et al. (2016), Gregson et al. (2015) and Nascimento et al. (2019)

(*Continued*)

Table 1. Continued.

Main circular economy strategies according to Potting et al. (2017)	Illustrative examples of circular economy innovations	Main scales of operation*	Territorial factors						Relevance
			Land-based	Agglomeration	Accessibility	Knowledge	Technology	Governance	
R1 (Rethink), R7 (Repurpose), R8 (Recycle), R9 (Recover)	Urban/(eco)industrial symbiosis (cross-sector linkages)	Meso		✓	✓	✓	✓	✓	Lombardi (2017), Chen et al. (2012), Accorsi et al. (2015), Breure, Lijzen, and Maring (2018), Braun et al. (2018), Domenech et al. (2019), Suau Ibáñez (2019),
R8 (Recycle)	Upcycling, recycling, composting	Micro, Meso, Macro	✓	✓	✓		✓	✓	Bahers, Durand, and Beraud (2017), Corvellec, Campos, and Zapata (2013), Chen et al. (2014), Borrello et al. (2017), Breure, Lijzen, and Maring (2018) and Zeller et al. (2019)

Source: *Own elaboration*.
Notes: * Most relevant scales of operation; Micro**:** single firms, communities, small cities; Meso: industrial clusters, intermediate and large cities, small regions; Macro: large regions, national, international, global.

enable circular business models and host a range of innovative community-based circular initiatives. Cities themselves are major providers of domestic waste streams and secondary materials, such as building debris and WEEs. Additionally, urban areas also provide a fertile ground for the dissemination of circularity strategies with strong social component like responsible consumption, and/or business models resting on behavioural change. Accessibility and connectivity factors further reinforce agglomeration effects by e.g. enabling collaborative economic models based on product sharing and enabling reverse logistics. Circular economy strategies such as product reuse and repair are directly dependent on the accessibility to these services by consumers. Accessibility and connectivity are also key enablers for the establishment of industrial symbiosis and other industrial ecosystems.

Although agglomerations generate knowledge spillovers, these exhibit spatial selectivity and suffer from strong distance-decay effects. Hence, it is expected that agglomeration forces per-se will not contribute to ensure harmonious territorial development under a circular economy perspective. On the contrary, inertia towards the geographical concentration of certain circular economy activities is likely to occur.

The extent to which the abovementioned forces enable circular economy transformations at regional and local levels is also conditioned by softer territorial factors. Intangible features embedded in governance, cultural and social aspects, which are accumulated through process of regional collective learning (Keeble 2018), contribute to the definition of the innovation capacity of territories. Governance and institutional factors, together with territorial milieus, act as transversal forces that facilitate and create the necessary conditions for circular economy transformations to materialize. From this, it can be inferred that political vision and leadership are essential requirements to put in place governance systems that not only promote circular economy principles, but also favour a successful operation of other territorial factors.

In a nutshell, whereas agglomeration and land-based factors contribute to determine the framework conditions of circular transformations at the regional and local levels, the 'hard' territorial factors (accessibility and technologies) contribute to define the effectiveness of circular economy strategies, and the 'soft' factors (knowledge, awareness, governance and milieus) contribute to **catalyse** the transformation. Hence, understanding the territorial specificities of different areas becomes crucial to envisage a successful transition to a circular economy. This endeavour calls for place-based policy approaches that take account of the installed capacity within each territory and promote inclusive and participatory policy design and implementation as the best way to unlock the territorial potentials. Given the multidimensional nature of circular systems and the complexity of circular transformations, even the best strategies face potential trade-offs between policy priorities and require careful assessment of potential rebound effects.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by ESPON 2020 Cooperation Programme.

ORCID

Carlos Tapia http://orcid.org/0000-0002-0075-4668
Marco Bianchi http://orcid.org/0000-0001-8407-6499

References

Accorsi, R., R. Manzini, C. Pini, and S. Penazzi. 2015. "On the Design of Closed-loop Networks for Product Life Cycle Management: Economic, Environmental and Geography Considerations." *Journal of Transport Geography* 48: 121–134. doi:10.1016/j.jtrangeo.2015.09.005

Acquier, A., V. Carbone, and D. Massé. 2019. "How to Create Value(s) in the Sharing Economy: Business Models, Scalability, and Sustainability." *Technology Innovation Management Review* 9: 2, 5–24. doi:10.22215/timreview/1215

Angelidou, M., and A. Psaltoglou. 2017. "An Empirical Investigation of Social Innovation Initiatives for Sustainable Urban Development." *Sustainable Cities and Society* 33: 113–125. doi:10.1016/j.scs.2017.05.016

Ayres, R. 1989. "Industrial Metabolism." In *Technology and Environment*, edited by J. H. Ausubel and H. E. Sladovich, 23–49. Washington, DC: National Academy Press.

Bahers, J., and M. Durand. 2017. "Le retour de la proximité ! Quelles implications pour les services urbains en réseau?" *Flux* 109–110 (3): 1. doi:10.3917/flux1.109.0001.

Bahers, J., M. Durand, and H. Beraud. 2017. "Quelle Territorialité Pour L'économie Circulaire? Interprétation des Typologies de Proximité Dans la Gestion des Déchets." *Flux* 109-110 (3): 129. doi:10.3917/flux1.109.0129

Barles, S. 2009. "Urban Metabolism of Paris and Its Region." *Journal of Industrial Ecology* 13 (6): 898–913. doi:10.1111/j.1530-9290.2009.00169.x

Bell, J., L. Paula, T. Dodd, and S. Németh. 2018. "EU Ambition to Build the World's Leading Bioeconomy – Uncertain Times Demand Innovative and Sustainable Solutions." *New Biotechnology* 40: 25–30. doi:10.1016/j.nbt.2017.06.010

Biber-Freudenberger, L., C. Ergeneman, J. Förster, T. Dietz, and J. Börner. 2020. "Bioeconomy Futures: Expectation Patterns of Scientists and Practitioners on the Sustainability of Bio-based Transformation." *Sustainable Development*. doi:10.1002/sd.2072.

Bocken, N., I. de Pauw, C. Bakker, and B. van der Grinten. 2016. "Product Design and Business Model Strategies for a Circular Economy." *Journal of Industrial and Production Engineering* 33 (5): 308–320. doi:10.1080/21681015.2016.1172124

Bolger, K., and A. Doyon. 2019. "Circular Cities: Exploring Local Government Strategies to Facilitate a Circular Economy." *European Planning Studies* 27 (11): 2184–2205. doi:10.1080/09654313.2019.1642854

Borrello, M., F. Caracciolo, A. Lombardi, S. Pascucci, and L. Cembalo. 2017. "Consumers' Perspective on Circular Economy Strategy for Reducing Food Waste." *Sustainability* 9 (1): 141–141. doi:10.3390/su9010141

Bourguignon, D. 2016. "Closing the Loop New Circular Economy Package." *European Parliamentary Research Service*, 9. doi:10.1111/j.1742-1241.2010.02575.x.

Braun, A., P. Kleine-Moellhoff, V. Reichenberger, and S. Seiter. 2018. "Case Study Analysing Potentials to Improve Material Efficiency in Manufacturing Supply Chains, Considering Circular Economy Aspects." *Sustainability* 10 (3). doi:10.3390/su10030880.

Breure, A., J. Lijzen, and L. Maring. 2018. "Soil and Land Management in a Circular Economy." *Science of The Total Environment* 624: 1125–1130. doi:10.1016/j.scitotenv.2017.12.137

Brown, P., N. Bocken, and R. Balkenende. 2019. "Why do Companies Pursue Collaborative Circular Oriented Innovation?" *Sustainability* 11 (3): 635–635. doi:10.3390/su11030635

Burger, M., S. Stavropoulos, S. Ramkumar, J. Dufourmont, and F. Oortd. 2019. "The Heterogeneous Skill-Base of Circular Economy Employment." *Research Policy* 48 (1): 248–261. doi:10.1016/j.respol.2018.08.015

Capello, R., R. Camagni, B. Chizzolini, and U. Fratesi. 2007. "*Modelling Regional Scenarios for the Enlarged Europe: European Competiveness and Global Strategies*." *Springer Science & Business Media*. doi:10.1007/978-3-642-17940-2.

Charter, M. 2018. "Repair Cafes." *The Journal of Peer Production* 3 (12): 37–45.

Chen, X., T. Fujita, Y. Hayashi, H. Kato, and Y. Geng. 2014. "Determining Optimal Resource Recycling Boundary at Regional Level: A Case Study on Tokyo Metropolitan Area in Japan." *European Journal of Operational Research* 233 (2): 337–348. doi:10.1016/j.ejor.2013.01.054.

Chen, X., T. Fujita, S. Ohnishi, M. Fujii, and Y. Geng. 2012. "The Impact of Scale, Recycling Boundary, and Type of Waste on Symbiosis and Recycling." *Journal of Industrial Ecology* 16 (1): 129–141. doi:10.1111/j.1530-9290.2011.00422.x.

Cohen B and Kietzmann J (2014) Ride On! Mobility Business Models for the Sharing Economy. *Organization & Environment* 27(3). 279–296. doi:10.1177/1086026614546199

Cohen, B., and P. Muñoz. 2016. "Sharing Cities and Sustainable Consumption and Production: Towards an Integrated Framework." *Journal of Cleaner Production* 134: 87–97. doi:10.1016/j.jclepro.2015.07.133

Corona, B., L. Shen, D. Reike, J. Rosales Carreón, and E. Worrell. 2019. "Towards Sustainable Development Through the Circular Economy – A Review and Critical Assessment on Current Circularity Metrics." *Resources, Conservation and Recycling* 151: 104498. doi:10.1016/j.resconrec.2019.104498.

Corrado, S., and S. Sala. 2018. "Designing Sustainable Technologies, Products and Policies." *Designing Sustainable Technologies, Products and Policies*, 49–59. doi:10.1007/978-3-319-66981-6_6

Corvellec, H., M. Campos, and P. Zapata. 2013. "Infrastructures, Lock-in, and Sustainable Urban Development: The Case of Waste Incineration in the Göteborg Metropolitan Area." *Journal of Cleaner Production* 50: 32–39. doi:10.1016/j.jclepro.2012.12.009

Cucchiella, F., I. D'Adamo, S. Lenny Koh, and P. Rosa. 2015. "Recycling of WEEEs: An Economic Assessment of Present and Future e-Waste Streams." *Renewable and Sustainable Energy Reviews* 51: 263–272. doi:10.1016/j.rser.2015.06.010.

de Abreu, M., and D. Ceglia. 2018. "On the Implementation of a Circular Economy: The Role of Institutional Capacity-Building Through Industrial Symbiosis." *Resources, Conservation and Recycling* 138: 99–109. doi:10.1016/j.resconrec.2018.07.001

de Jesus, A., P. Antunes, R. Santos, and S. Mendonça. 2018. "Eco-innovation in the Transition to a Circular Economy: An Analytical Literature Review." *Journal of Cleaner Production* 172: 2999–3018. doi:10.1016/j.jclepro.2017.11.111.

de Jesus, A., and S. Mendonça. 2018. "Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy." *Ecological Economics* 145: 75–89. doi:10.1016/j.ecolecon.2017.08.001

den Berghe, K., and M. Vos. 2019. "Circular Area Design or Circular Area Functioning? A Discourse-Institutional Analysis of Circular Area Developments in Amsterdam and Utrecht, The Netherlands." *Sustainability (Switzerland)* 11 (18). doi:10.3390/su11184875.

Dhakal, M., M. Smith, and R. Newbery. 2016. "Secondary Market: A Significant Aspect in Reverse Logistics and Sustainability." *The International Journal of Sustainability in Economic, Social, and Cultural Context* 12 (1): 25–35. doi:10.18848/2325-1115/CGP/v12i01/25-35

Dobrotă, G., D. Dobrotă, and V. Petrescu. 2017. "Circular Economy – Foundament of Challenges for Business Environment." *Balkan Region Conference on Engineering and Business Education*, 432–439. doi:10.1515/cplbu-2017-0056

Domenech, T., R. Bleischwitz, A. Doranova, D. Panayotopoulos, and L. Roman. 2019. "Mapping Industrial Symbiosis Development in Europe_ Typologies of Networks, Characteristics, Performance and Contribution to the Circular Economy." *Resources, Conservation and Recycling* 141: 76–98. doi:10.1016/j.resconrec.2018.09.016.

EC. 2010. *Being Wise with Waste: The EU's Approach to Waste Management*. European Commission (EC). doi:10.2779/93543.

EC. 2014. *COM(2014) 398 Final/2 – Towards a Circular Economy: A Zero Waste Programme for Europe*. Brussels: European Commission.

EC. 2015. *COM(2015) 614 – Closing the Loop: An EU Action Plan for the Circular Economy. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions*. Brussels: European Commission (EC). Available at: http://ec.europa.eu/environment/circular-economy/index_en.htm

EC. 2018. *A Sustainable Bioeconomy for Europe: Strengthening the Connection Between Economy, Society and the Environment: Updated Bioeconomy Strategy*. European Commission. Directorate-General for Research and Innovation. doi:10.2777/792130.

Edbring, E., M. Lehner, and O. Mont. 2016. "Exploring Consumer Attitudes to Alternative Models of Consumption: Motivations and Barriers." *Journal of Cleaner Production* 123: 5–15. doi:10.1016/j.jclepro.2015.10.107

EEC. 1975. *European Union's Waste Framework Directive (1975/442/EEC)*.

Ellen MacArthur Foundation (2015) *Growth Within: A Circular Economy Vision for a Competitive Europe*. Isle of Man: Ellen Macarthur Foundation.

Ensign, P., and P. Leupold. 2018. *Grassroots Opportunities for Innovation, Technology, and Entrepreneurship: Makerspaces in Non-Urban Communities*. In: 2018 Portland International Conference on Management of Engineering and Technology (PICMET), Honolulu, HI, pp. 1–7. IEEE. doi:10.23919/PICMET.2018.8481850.

ESPON. 2020. *Circular Economy and Territorial Consequences (CIRCTER)*. Luxembourg: ESPON EGTC. Available at: https://www.espon.eu/circular-economy

Fernández-Esquinas, M., M. van Oostrom, and H. Pinto. 2017. "Key Issues on Innovation, Culture and Institutions: Implications for SMEs and Micro Firms." *European Planning Studies* 25 (11): 1897–1907. doi:10.1080/09654313.2017.1364770

Franklin-Johnson, E., F. Figge, and L. Canning. 2016. "Resource Duration as a Managerial Indicator for Circular Economy Performance." *Journal of Cleaner Production* 133: 589–598. doi:10.1016/j.jclepro.2016.05.023

Frosch, R., and N. Gallopoulos. 1989. "Strategies for Manufacturing." *Scientific American* 261 (261): 144–152. doi:10.1038/scientificamerican0989-144

Geissdoerfer, M., P. Savaget, N. Bocken, and E. Hultink. 2017. "The Circular Economy – A new Sustainability Paradigm?" *Journal of Cleaner Production* 143: 757–768. doi:10.1016/j.jclepro.2016.12.048.

Geng, Y., J. Sarkis, and R. Bleischwitz. 2019. "How to Globalize the Circular Economy." *Nature* 565 (7738): 153–155. doi:10.1038/d41586-019-00017-z

Ghisellini, P., C. Cialani, and S. Ulgiati. 2016. "A Review on Circular Economy: The Expected Transition to a Balanced Interplay of Environmental and Economic Systems." *Journal of Cleaner Production* 114: 11–32. doi:10.1016/j.jclepro.2015.09.007

Goedkoop, M., and R. Spriensma. 1999. *The Eco-Indicator 99 – A Damage Oriented Method for Life Cycle Impact Assessment*.

Gomiero, T., M. Paoletti, and D. Pimentel. 2010. "Biofuels: Efficiency, Ethics, and Limits to Human Appropriation of Ecosystem Services." *Journal of Agricultural and Environmental Ethics* 23 (5): 403–434. doi:10.1007/s10806-009-9218-x

Graedel, T., and B. Allenby. 1996. *Design for Environment*. Upper Saddle River, NJ: Prentice Hall.

Gregson, N., M. Crang, S. Fuller, and H. Holmes. 2015. "Interrogating the Circular Economy: The Moral Economy of Resource Recovery in the EU." *Economy and Society* 44 (2): 218–243. doi:10.1080/03085147.2015.1013353.

Grillitsch, M., and B. Asheim. 2018. "Place-based Innovation Policy for Industrial Diversification in Regions." *European Planning Studies* 26 (8): 1638–1662. doi:10.1080/09654313.2018.1484892

Haas, W., F. Krausmann, D. Wiedenhofer, and M. Heinz. 2015. "How Circular is the Global Economy?: An Assessment of Material Flows, Waste Production, and Recycling in the European Union and the World in 2005." *Journal of Industrial Ecology* 19 (5): 765–777. doi:10.1111/jiec.12244.

Haley, B. 2016. "Getting the Institutions Right: Designing the Public Sector to Promote Clean Innovation." *Canadian Public Policy*. doi:10.3138/cpp.2016-051.

Hayes, D. 1978. *Repairs, Reuse, Recycling–First Steps Toward a Sustainable Society. Worldwatch Paper Series (Vol. 23)*. Washington, DC: ERIC.

Hertel, T., J. Steinbuks, and U. Baldos. 2013. "Competition for Land in the Global Bioeconomy." *Agricultural Economics* 44 (Suppl. 1): 129–138. doi:10.1111/agec.12057

Hobson, K. 2016. "Closing the Loop or Squaring the Circle? Locating Generative Spaces for the Circular Economy." *Progress in Human Geography* 40 (1): 88–104. doi:10.1177/0309132514566342

Hobson, K. 2019. "'Small Stories of Closing Loops': Social Circularity and the Everyday Circular Economy." *Climatic Change*. doi:10.1007/s10584-019-02480-z.

Hof, C., A. Voskamp, M. Biber, K. Böhning-Gaese, E. Engelhardt, A. Niamir, S. Willis, and T. Hickler. 2018. "Bioenergy Cropland Expansion may Offset Positive Effects of Climate Change Mitigation for Global Vertebrate Diversity." *Proceedings of the National Academy of Sciences* 115 (52): 13294–13299. doi:10.1073/pnas.1807745115.

Holgado, M., and A. Aminoff. 2019. "Closed-loop Supply Chains in Circular Economy Business Models." *Sustainable Design and Manufacturing*, 203–213. doi:10.1007/978-981-13-9271-9_19.

den Hollander, M., C. Bakker, and E. Hultink. 2017. "Product Design in a Circular Economy: Development of a Typology of Key Concepts and Terms." *Journal of Industrial Ecology* 21 (3): 517–525. doi:10.1111/jiec.12610

Holmes, H. 2018. "New Spaces, Ordinary Practices: Circulating and Sharing Within Diverse Economies of Provisioning." *Geoforum; Journal of Physical, Human, and Regional Geosciences* 88 (Nov.): 138–147. doi:10.1016/j.geoforum.2017.11.022

Iammarino, S., A. Rodriguez-Pose, and M. Storper. 2019. "Regional Inequality in Europe: Evidence, Theory and Policy Implications." *Journal of Economic Geography* 19 (2): 273–298. doi:10.1093/jeg/lby021

Ingrao, C., N. Faccilongo, L. Gioia, and A. Messineo. 2018. "Food Waste Recovery into Energy in a Circular Economy Perspective: A Comprehensive Review of Aspects Related to Plant Operation and Environmental Assessment." *Journal of Cleaner Production* 184: 869–892. doi:10.1016/j.jclepro.2018.02.267.

Jaeger-Erben, M., J. Rückert-John, and M. Schäfer. 2015. "Sustainable Consumption Through Social Innovation: a Typology of Innovations for Sustainable Consumption Practices." *Journal of Cleaner Production* 108: 784–798. doi:10.1016/j.jclepro.2015.07.042

Jawahir, I., and R. Bradley. 2016. "Technological Elements of Circular Economy and the Principles of 6R-Based Closed-Loop Material Flow in Sustainable Manufacturing." *Procedia Cirp* 40 (1): 103–108. doi:10.1016/j.procir.2016.01.067

Jurgilevich, A., T. Birge, J. Kentala-Lehtonen, K. Korhonen-Kurki, J. Pietikäinen, L. Saikku, and H. Schösler. 2016. "Transition Towards Circular Economy in the Food System." *Sustainability* 8 (1): 69. doi:10.3390/su8010069.

Kalkuhl, M., O. Edenhofer, and K. Lessmann. 2012. "Learning or Lock-in: Optimal Technology Policies to Support Mitigation." *Resource and Energy Economics* 34 (1): 1–23. doi:10.1016/j.reseneeco.2011.08.001

Kalmykova, Y., M. Sadagopan, and L. Rosado. 2018. "Circular Economy – from Review of Theories and Practices to Development of Implementation Tools." *Resources, Conservation and Recycling* 135 (Feb.): 190–201. doi:10.1016/j.resconrec.2017.10.034

Kanda, W., P. del Río, O. Hjelm, and D. Beinkowska. 2019. "A Technological Innovation Systems Approach to Analyse the Roles of Intermediaries in eco-Innovation." *Journal of Cleaner Production* 227: 1136–1148. doi:10.1016/j.jclepro.2019.04.230.

Keeble, D. 2018. "Collective Learning Processes in European High-Technology Milieux." In *High-Technology Clusters, Networking and Collective Learning in Europe*, edited by D. Keeble and F. Wilkinson, 199–229. New York, USA: Routledge.

Kirchherr, J., D. Reike, and M. Hekkert. 2017. "Conceptualizing the Circular Economy: An Analysis of 114 Definitions." *Resources, Conservation and Recycling* 127 (Sept.): 221–232. doi:10.1016/j.resconrec.2017.09.005

Korhonen, J., A. Honkasalo, and J. Seppälä. 2018a. "Circular Economy: The Concept and its Limitations." *Ecological Economics* 143 (Jan.): 37–46. doi:10.1016/j.ecolecon.2017.06.041

Korhonen, J., C. Nuur, A. Feldmann, and S. Birkie. 2018b. "Circular Economy as an Essentially Contested Concept." *Journal of Cleaner Production* 175: 544–552. doi:10.1016/j.jclepro.2017.12.111.

Kutta, R., and R. Lund. 1978. *Remanufacturing: A Preliminary Assessment*. Cambridge: Center for Policy Alternatives, Massachusetts Institute of Technology.

Květoň, V., and V. Kadlec. 2018. "Evolution of Knowledge Bases in European Regions: Searching for Spatial Regularities and Links with Innovation Performance." *European Planning Studies* 26 (7): 1366–1388. doi:10.1080/09654313.2018.1464128

Lahti, T., J. Wincent, and V. Parida. 2018. "A Definition and Theoretical Review of the Circular Economy, Value Creation, and Sustainable Business Models: Where Are We Now and Where Should Research Move in the Future?" *Sustainability* 10 (8): 2799–2799. doi:10.3390/su10082799

Lazarevic, D., and H. Valve. 2017. "Narrating Expectations for the Circular Economy: Towards a Common and Contested European Transition." *Energy Research and Social Science* 31 (Oct.): 60–69. doi:10.1016/j.erss.2017.05.006

Leipold, S., and A. Petit-Boix. 2018. "The Circular Economy and the bio-Based Sector – Perspectives of European and German Stakeholders." *Journal of Cleaner Production* 201: 1125–1137. doi:10.1016/j.jclepro.2018.08.019

Lewandowski, M. 2016. "Designing the Business Models for Circular Economy—Towards the Conceptual Framework." *Sustainability* 8 (1). doi:10.3390/su8010043

Lieder, M., and A. Rashid. 2016. "Towards Circular Economy Implementation: A Comprehensive Review in Context of Manufacturing Industry." *Journal of Cleaner Production* 115: 36–51. doi:10.1016/j.jclepro.2015.12.042

Lombardi, R. 2017. "Non-technical Barriers to (and Drivers for) the Circular Economy Through Industrial Symbiosis: A Practical Input." *Economics and Policy of Energy and the Environment* 2017 (1): 171–189. doi:10.3280/EFE2017-001009

Ma, S., W. Zong-guo, J. Chen, and Z. Wen. 2014. "Mode of Circular Economy in China's Iron and Steel Industry: a Case Study in Wu'an City." *Journal of Cleaner Production* 64: 505–512. doi:10.1016/j.jclepro.2013.10.008.

Maillat, D. 1995. "Territorial Dynamic, Innovative Milieus and Regional Policy." *Entrepreneurship & Regional Development* 7 (2): 157–165. doi:10.1080/08985629500000010

Mair, C., and T. Stern. 2017. "Cascading Utilization of Wood: a Matter of Circular Economy?" *Current Forestry Reports* 3 (4): 281–295. doi:10.1007/s40725-017-0067-y

Malinauskaite, J., H. Jouhara, D. Czajczyńska, P. Stanchev, E. Katsou, P. Rostkowski, R. Thorne, et al. 2017. "Municipal Solid Waste Management and Waste-to-Energy in the Context of a Circular Economy and Energy Recycling in Europe." *Energy* 141: 2013–2044. doi:10.1016/j.energy.2017.11.128.

Marin, J., and B. Meulder. 2018. "Interpreting Circularity. Circular City Representations Concealing Transition Drivers." *Sustainability* 10 (5): 1310–1310. doi:10.3390/su10051310

Marra, A., M. Mazzocchitti, and A. Sarra. 2018. "Knowledge Sharing and Scientific Cooperation in the Design of Research-Based Policies: The Case of the Circular Economy." *Journal of Cleaner Production* 194: 800–812. doi:10.1016/j.jclepro.2018.05.164

Marsden, T., and F. Farioli. 2015. "Natural Powers: From the bio-Economy to the eco-Economy and Sustainable Place-Making." *Sustainability Science* 10 (2): 331–344. doi:10.1007/s11625-014-0287-z

Merli, R., M. Preziosi, and A. Acampora. 2018. "How Do Scholars Approach the Circular Economy? A Systematic Literature Review." *Journal of Cleaner Production* 178: 703–722. doi:10.1016/j.jclepro.2017.12.112

Moreau, V., M. Sahakian, P. van Griethuysen, and F. Vuille. 2017. "Coming Full Circle: Why Social and Institutional Dimensions Matter for the Circular Economy." *Journal of Industrial Ecology* 21 (3): 497–506. doi:10.1111/jiec.12598.

Moreno, M., C. de los Rios, Z. Rowe, and F. Charnley. 2016. "A Conceptual Framework for Circular Design." *Sustainability* 8 (9). doi:10.3390/su8090937.

Murray, A., K. Skene, and K. Haynes. 2017. "The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context." *Journal of Business Ethics* 140 (3): 369–380. doi:10.1007/s10551-015-2693-2
Nascimento, D., V. Alencastro, O. Quelhas, R. Caiado, J. Garza-Reyes, L. Rocha-Lona, and G. Tortorella. 2019. "Exploring Industry 4.0 Technologies to Enable Circular Economy Practices in a Manufacturing Context." *Journal of Manufacturing Technology Management* 30 (3): 607–627. doi:10.1108/JMTM-03-2018-0071.
Niesten, E., A. Jolink, A. Lopes de Sousa Jabbour, M. Chappin, and R. Lozano. 2017. "Sustainable Collaboration: The Impact of Governance and Institutions on Sustainable Performance." *Journal of Cleaner Production* 155: 1–6. doi:10.1016/j.jclepro.2016.12.085.
Nogueira, A., W. Ashton, and C. Teixeira. 2019. "Expanding Perceptions of the Circular Economy Through Design: Eight Capitals as Innovation Lenses." *Resources, Conservation and Recycling* 149: 566–576. doi:10.1016/j.resconrec.2019.06.021.
Pagoropoulos, A., D. Pigosso, and T. McAloone. 2017. "The Emergent Role of Digital Technologies in the Circular Economy: A Review." *Procedia CIRP* 64: 19–24. doi:10.1016/j.procir.2017.02.047
Philp, J., and D. Winickoff. 2018. "Realising the Circular Bioeconomy." *OECD Science, Technology and Industry Policy Papers* 60. doi:10.1787/31bb2345-en.
Planing, P. 2015. "Business Model Innovation in a Circular Economy Reasons for non-Acceptance of Circular Business Models." *Open Journal of Business Model Innovation* 1 (11): 1–11.
Porter, M. 1990. "The Competitive Advantage of Nations." *Harvard Business Review* 68 (2): 73–93.
Porter M. (1998) Clusters and the New Economics of Competition. *Harvard Business Review* (November-December): 77–90.doi:10.1042/BJ20111451.
Porter, M., and M. Kramer. 2019. "Creating Shared Value." edited by G. G. Lenssen, and N. C. Smith, 323–346. Springer Netherlands. . doi:10.1007/978-94-024-1144-7_16.
Potting, J., M. Hekkert, E. Worrell, and A. Hanemaaijer. 2017. "Circular Economy: Measuring Innovation in the Product Chain - Policy Report." *PBL Netherlands Environmental Assessment Agency* 2544: 42.
Prendeville, S., E. Cherim, and N. Bocken. 2018. "Circular Cities: Mapping Six Cities in Transition." *Environmental Innovation and Societal Transitions* 26: 171–194. doi:10.1016/j.eist.2017.03.002
Prosman, E., B. Wæhrens, and G. Liotta. 2017. "Closing Global Material Loops: Initial Insights Into Firm-Level Challenges." *Journal of Industrial Ecology* 21 (3): 641–650. doi:10.1111/jiec.12535
Repo, P., M. Anttonen, J. Mykkänen, and M. Lammi. 2018. "Lack of Congruence Between European Citizen Perspectives and Policies on Circular Economy." *European Journal of Sustainable Development* 7: 1. doi:10.14207/ejsd.2018.v7n1p249.
Rizos, V., K. Tuokko, and A. Behrens. 2017. Circular economy: A review of definitions, processes and impacts. CEPS Research Report. CEPS. Available at: http://www.eesc.europa.eu/sites/default/files/files/ceps_report_the_circular_economy_a_review_of_definitions_processes_and_impacts.pdf http://ecologic.eu/sites/files/publication/2017/2809-circular-impacts_0.pdf
Scarpellini, S., P. Portillo-Tarragona, A. Aranda-Usón, and F. Llena-Macarulla. 2019. "Definition and Measurement of the Circular Economy's Regional Impact." *Journal of Environmental Planning and Management* 62 (13): 2211–2237. doi:10.1080/09640568.2018.1537974.
Singh, J., and I. Ordoñez. 2016. "Resource Recovery from Post-consumer Waste: Important Lessons for the Upcoming Circular Economy." *Journal of Cleaner Production* 134: 342–353. doi:10.1016/j.jclepro.2015.12.020
Sirkin, T., and M. ten Houten. 1994. "The cascade chain." *Resources, Conservation and Recycling* 10 (3): 213–276. doi:10.1016/0921-3449(94)90016-7
Smol, M., A. Avdiushchenko, J. Kulczycka, and A. Nowaczek. 2018. "Public Awareness of Circular Economy in Southern Poland: Case of the Malopolska Region." *Journal of Cleaner Production* 197: 1035–1045. doi:10.1016/j.jclepro.2018.06.100.
Socolow, R., C. Andrews, F. Berkhout, and V. Thomas. 1994. *Industrial Ecology and Global Change*. Cambridge University Press.

Stahel, W. 2013. “Policy for Material Efficiency—Sustainable Taxation as a Departure from the Throwaway Society.” *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 371 (1986): 20110567. doi:10.1098/rsta.2011.0567

Stahel, W., and R. Clift. 2016. “Stocks and Flows in the Performance Economy.” In *Taking Stock of Industrial Ecology*, 137–158. Springer International Publishing. doi:10.1007/978-3-319-20571-7_7.

Stahel W. and Reday-Mulvey G. (1976) *The Potential for Substituting Manpower for Energy: A Report to the Commission of the European Communities*. Brussels: European Commission.

Suau Ibáñez, C. 2019. “Circular Design in Everyday Urbanism: Towards Regenerative and Restorative Dynamic Spaces in Cities.” *Visions for Sustainability*, no. 11. doi:10.13135/2384-8677/3390.

Teubler, J., S. Kiefer, and C. Liedtke. 2018. “Metals for Fuels? The Raw Material Shift by Energy-Efficient Transport Systems in Europe.” *Resources* 7 (3): 49–49. doi:10.3390/resources7030049

van Buren, N., M. Demmers, R. van der Heijden, and F. Witlox. 2016. “Towards a Circular Economy: The Role of Dutch Logistics Industries and Governments.” *Sustainability* 8 (7): 647–647. doi:10.3390/su8070647.

van Rhijn, G., and T. Bosch. 2017. “Operator-oriented Product and Production Process Design for Manufacturing, Maintenance and Upgrading.” In *Dynamics of Long-Life Assets*, 133–149. Springer International Publishing. doi:10.1007/978-3-319-45438-2_8.

Vanegas, P., J. Peeters, D. Cattrysse, P. Tecchio, F. Ardente, F. Mathieux, W. Dewulf, and J. Duflou. 2018. “Ease of Disassembly of Products to Support Circular Economy Strategies.” *Resources, Conservation and Recycling* 135: 323–334. doi:10.1016/j.resconrec.2017.06.022.

Vis, M., U. Mantau, and B. Allen, eds. 2016. *CASCADES: Study on the Optimised Cascading use of Wood. No 394/PP/ENT/RCH/14/7689. Final Report*. Luxembourg: Publications Office of the European Union. doi:10.2873/827106.

Wang, X., G. Gaustad, C. Babbitt, and K. Richa. 2014. “Economies of Scale for Future Lithium-ion Battery Recycling Infrastructure.” *Resources, Conservation and Recycling* 83: 53–62. doi:10.1016/j.resconrec.2013.11.009.

Wilts, H., and N. von Gries. 2015. “Europe’s Waste Incineration Capacities in a Circular Economy.” *Proceedings of the Institution of Civil Engineers - Waste and Resource Management* 168 (4): 166–176. doi:10.1680/warm.14.00009

Zeller, V., E. Towa, M. Degrez, and W. Achten. 2019. “Urban Waste Flows and Their Potential for a Circular Economy Model at City-Region Level.” *Waste Management* 83: 83–94. doi:10.1016/j.wasman.2018.10.034.