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Definition and measurement of the circular economy's regional impact

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It has been argued that the circular economy (CE) represents an opportunity to achieve a paradigm shift in territory from the current linear model to a low-carbon, zero-waste economy. In this context, the implementation of the CE is holistically analysed to measure its impact and contribute to the debate about regional environmental management from the different perspectives of society, public administrations, and the private sector. Through a qualitative case study of a Spanish region, the main barriers of CE, such as the lack of funding for undertaking investments and the supply of recycled products, are identified, and the organisation of a waste-exchange system between companies or awareness campaigns concerning the CE are considered relevant incentives to be included in regional planning and management. This study confirms the economic and social win for CE that will be more effective as more CE activities are implemented at regional level.

Keywords: circular economy; environmental indicators; environmental management accounting; environmental planning

1. Introduction

The circular economy (CE) is a development model that seeks to minimise the negative impact of human activities by applying principles related to the “3 Rs”: reduce, reuse, and recycle (Li *et al.* 2010), to maintain the highest utility and value of products, components, and materials at all times (Ellen MacArthur Foundation 2015b).

The CE prioritises actions that have clear repercussions for the environment, such as the use of recyclable packaging; the promotion of ecological products; the reduction of emissions and waste; the assessment of renewable and alternative energies; energy saving; the use of low-environmental-impact consumer goods; eco-design; waste recovery; and dematerialisation (Ghisellini, Cialani, and Ulgiati 2016). In short, the CE is concerned with minimising the environmental impact on a territory.

In an economic context, the CE aims to ensure promotion of commercial relationships with companies, strengthen stable relationships with suppliers, improve price

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levels in relation to quality offered, and deliver detailed information to customers about products and services. Simultaneously, the CE model can include generating new jobs, improving employees' quality of life, and linking a system's functioning with the social dimension of management in organisations (Mathews and Tan 2011). Major schools of thought related to the circular economy emerged in the 1970s and were introduced by Pearce and Kerry Turner (1990), but gained prominence in the 1990s. They include the functional service economy, natural capitalism, or 'cradle to cradle' principles (Urbinati, Chiaroni, and Chiesa 2017). In more developed stages, the CE falls within the field of industrial ecology (Li *et al.* 2010; Pitkänen *et al.* 2016), as within the industrial symbiosis between local companies with different production processes (Andersen 2007). Territoriality is one of the key issues of the CE, because it is based on the principle that waste should be processed close to its point of origin (Kama 2015).

It has been argued that the CE represents an opportunity to achieve a paradigm shift from the current linear model to a low-carbon, zero-waste economy. In this model, local and regional authorities can play an important role in both the launch of and transition to a CE (Yi and Liu 2015). Therefore, the CE should be translated into environmental regional planning, which means a long-term economic restructuring of the territory. Taking such a path would facilitate the establishment of integrated markets. In the European Union (EU), for example, the CE would result in limited circulation of waste within the European borders (Kama 2015; Prendeville *et al.* 2016). Different factors, such as the industrial situation, regional business, innovation level, and legislative profile at the regional or local level, condition the development of the CE in a territory (Coats and Benton 2015; Fang, Côté, and Qin 2007).

In general terms, definition of CE development policies in the medium- and long-term in the EU is part of the multilevel interaction of environmental legislation, and different actors in the institutional, social, and business environments are considered in this planning process. The implications of the CE's deployment in terms of regional governance are also highlighted (Matti, Consoli, and Uyarra 2016). However, certain authors have warned that integrated planning of environmental and social aspects, combined with economic aspects, may lead to situations where economic factors take precedence over local development (Datta 2012; Pickvance 2000).

To date, studies that have addressed the implementation of the CE from a regional standpoint (Ernst and Young 2016; Ellen MacArthur Foundation 2015b; Pitkänen *et al.* 2016), or those that have experienced rapid development, such as China (Geng *et al.* 2009; Geng, Haight, and Zhu 2007; Su *et al.* 2013), are still scarce; and methodologies that can be applied to measure the introduction of the CE in a specific territory are still under investigation. Thus, analysis of the CE's impact from a regional approach is considered a relevant line of inquiry for the environmental planning required to promote the CE. Because the focus in the European Union (EU) has been on regions, measuring CE–eco-innovations is an especially relevant issue at the regional level (Smol, Kulczycka, and Avdiushchenko 2017).

In order to measure the CE, Elia, Grazi Gnoni, and Tornese (2017) provide a list of macro, meso, and micro indicators for the CE, and the Ellen MacArthur Foundation has developed a metric that assesses circularity at the product and company levels (Ellen MacArthur Foundation 2015b). Macro-level indicators that measure the socio-metabolic impact of the CE are generally better developed than micro-level indicators (Geng *et al.* 2012; Linder, Sarasini, and van Loon 2017) that have been applied to measure the CE implementation in business, mainly through case studies. For regional

environmental policy and management, Smol, Kulcycka, and Avdiushchenko (2017) developed indicators that are mainly based on the interrelationship between the CE and eco-innovation, with particular emphasis on the development of regions. Nevertheless, there are few specific empirical investigations of the relationship between awareness and the level of introduction of CE activities in a territory.

Since this is a less researched area, the main objective of this study is to measure the adoption of CE activities and its impact to increase knowledge about the territorial dimensions of the CE. The approach used in this study is not specifically theory-driven and the research objective is generating knowledge about how to measure the CE's impact and its penetration in a territory. Nevertheless, a summarised theoretical approach is presented in the following section to outline the general scope of the research.

A qualitative case study based on a Spanish region is described in the third section, which focuses on the background to this research. Finally, the results are discussed, followed by the main conclusions.

2. Background

In general terms, we can state that the CE exists at the intersection of the environmental and economic aspects of the sustainable development framework (Bina 2013; Van Griethuysen 2002). The introduction of the concept has been attributed to the seminal works of Pearce and Turner (1990), where the term CE was applied to explain how economies work while considering the important implications of the environment-economy interaction. In this sense, they consider that the environment provides three economic functions: resource supplier, waste assimilator, and a direct source of utility.

The shift from the linear model to a circular one involves consideration of the waste that appears in all phases of the productive process (resources-processes-products). Waste should be considered an additional economic resource with economic value that must be properly managed in a sustainable way (recycle, reuse, reduce), because excess generation of waste hinders the three environmental functions that must be served.

The Ellen MacArthur Foundation (2015b) conceptualises the CE as an alternative to the current take-make-dispose extractive industrial model based on the provision of large amounts of energy and other cheap and easily accessible resources. At the core of the CE is the need to close the circular flow of materials; the use of raw materials and resources is repeated throughout multiple phases (Yuan, Bi, and Moriguchi 2006). Therefore, based on the theoretical premise that the economic system is an open subsystem of the ecological system of land and limited resources, a certain environmental capacity is related to the CE (Li *et al.* 2010).

Starting from the broader definitions available in the literature, the CE is defined in this study through its objectives, the activities that are necessary to implement it, or the results obtained in a CE model. The main objective of the CE is the integration of resources and environmental factors into the economy; this objective is reached by proposing a defined material metabolism of 'resource-product-resource' that is compatible with the ecosystem through which mechanisms for the efficient use of waste are interspersed (Li *et al.* 2010). Thus, from the perspective of environmental economics, the CE uses the principle of material equilibrium (Kneese 1973), which implies that all material flows should be considered, although economic values rather than physical flows will guide their management (Andersen 2007).

The activities included in the CE are mainly performed within the framework of industrial ecology (Andersen 2007; Isenmann 2003; Yuan, Bi, and Moriguchi 2006),

which involves re-manufacturing (Veleva and Bodkin 2017) and recycling waste and by-products through closed loops. An example of such an activity is industrial symbiosis (Ehrenfeld and Gertler 1997; Gibbs 2008; Jacobsen 2006; Mirata and Emtairah 2005). In a broad sense, the CE promotes activities aimed at resource minimisation and adoption of cleaner technologies (Andersen 1999) in the application of eco-efficiency (Huppel and Ishikawa 2005).

From another point of view, the outcomes of the CE include waste minimisation, environmental conservation, and energy efficiency (Liu *et al.* 2009), which are applicable to all human activities (Yuan, Bi, and Moriguchi 2006), as well as the social dimensions of these activities (Zhijun and Nailing 2007; Geng *et al.* 2009). In summary, we may consider the CE to be a type of environmental management at different levels: national or regional (macro), industrial (meso), and company or single process (micro) (Ghisellini, Cialani, and Ulgiati 2016; Mathews and Tan 2011; Portillo-Tarragona *et al.* 2017).

The communication “Towards a Circular Economy: A Zero Waste Programme for Europe” (European Commission 2014) laid the foundations for the promotion of the CE in EU member countries, along with the European Commission communication entitled “Closing the Loop: An EU Action Plan for the Circular Economy” (European Commission 2015). These communications suggest that the CE can maintain the added value of products as long as possible by minimising the waste generated. In summary, the CE in EU countries makes it possible to boost competitiveness and growth, acting as a stimulus for local and regional development, creating new opportunities and jobs, and avoiding irreversible environmental damage (European Commission 2015).

In this field, the European regulation of waste has increased in recent decades, and this process stemmed from the need to transform waste into resources (Hultman and Corvellec 2012; Watson 2009). In the EU territory, good practices were selected to foment selective waste collection (European Commission 2016a); and energy valorisation in the CE framework has been promoted to optimise raw material consumption. The EU’s waste and environmental policy is implemented through the European Waste Hierarchy (European Commission 2008), in addition to other rules on implementation of waste management and classification (European Commission 2005, 2011; Haas *et al.* 2015). In fact, environmental issues have become part of the wider European debate on how a regional government (Connick and Innes 2003; Setzer 2014; Van Zeijl-Rozema *et al.* 2008) can improve local and regional economic competitiveness (Gibbs and Jonas 2001) within broader institutional policy processes (Brenner 1998, 2009; Pearce 1992). It should be noted that the national view is relegated to the background, particularly in relation to the European regulation of environmental issues and territorial management (Bachmann 2015; Lenschow 1999).

With these premises, the implementation of the CE at the regional level could be carried out through integrated waste management and other local initiatives for industrial symbiosis or eco-parks, to progressively close the loops and equalise the inputs and outputs of all processes in a territory, englobing all of society (Yuan, Bi, and Moriguchi 2006).

2.1. Regional measurement of the circular economy and its impact

At a regional level, different conceptual positions can be noted in the literature, which should be considered at the territorial level when defining a model to be applied in a

territory. In research on sustainable consumption and production, certain approaches can be classified as 'reformist' (Geels *et al.* 2015). The 'reformist' position represents political and academic orthodoxy, proposes a change towards environmental sustainability, but without urgency, and maintains some features of the current status quo (Geels *et al.* 2015). This approach could be considered as adequate for the CE at a regional level for environmental planning.

We should note, however, that the landscape of regional governance in environmental settings is heterogeneous (Andrews and Boyne 2008; Gibbs and Jonas 2001; Romero, Jiménez, and Villoria 2012) and is linked to the spatial planning debate (Schaffrin, Sewerin, and Seubert 2014; Schafer and Gallemore 2016) on the availability and management of resources because of industry (Chen *et al.* 2010; Danson and Lloyd 2012; Hughes and Pincetl 2014; Brinkley 2014). This dependence requires decentralised territorial solutions that are based on new strategies and integrated policies and that have been developed in cooperation with different economic sectors (Hovik *et al.* 2015; van Straalen, Janssen-Jansen, and van den Brink 2014).

The debate on the competence and effectiveness of regional administrations, which is linked to existing disparities, spatial economic policy, and the process of decentralisation in European countries, remains open (Pike *et al.* 2012). Undoubtedly, the CE should be implemented at a regional level and measures to promote CE are classified in Table 1 according to the CE barriers pointed out by different authors (Morlet *et al.* 2016; Su *et al.* 2013; Xue *et al.* 2010).

Starting with the studies analysed, as shown in Table 1, the introduction of CE indicators at a regional level could be focused on the technological improvements that are necessary (eco-innovation and industrial ecology) for businesses, and the financial resources needed to undertake investments (resources and economic benefits), as well as the incentives for CE promotion carried out by public administrations, and social interests as stakeholders who are related to the territorial aspects intrinsic to the CE and, finally, to the society. These considerations seek to analyse CE from three different perspectives: private sector, public administration and society to define regional barriers and drivers to be considered for CE measurement in a territory and the consequent regional environmental planning activity. However, to the best of our knowledge, there is no theoretical framework that can be applied to all CE principles in a spatial context and the measurement methods that have been applied at regional levels have achieved segmented or partial results.

Among indicators and main tools that could be applied to the measurement of CE at regional level, LCA has been highlighted as a method for linking territorial sustainability to European environmental policy (Loiseau *et al.* 2014), and Genovese *et al.* (2017) apply LCA in an input-output model and carbon emission indicators in a regional context. Daddi, Nucci, and Iraldo (2017) consider lifecycle assessment (LCA) an adequate method for identifying the advantages and benefits of common resources for different impact categories concerning the regional environment, and Geissdoerfer *et al.* (2017) analyse studies focused on geographic regions that consider the main aspects of the CE to be environmental impact, resource scarcity, and economic benefits.

Indicators and methodologies such as material flows accounting (MFA) have been applied to measure industrial symbiosis and other forms of industry collaboration (Linder and Williander 2017). Material flows have been used to measure the CE within specific regions or industrial ecosystems in the framework of industrial ecology

Table 1. Classification of measures to promote CE at regional level.

Studies	Description	Measures
Technological (Geng <i>et al.</i> 2007; Su <i>et al.</i> 2013; Van Berkel <i>et al.</i> 2009)	The businesses' technological profile conditions the implementation of CE processes.	-Programmes to stimulate changes in industrial fabrication. -Promotion of high technology and clean technology industries. -Programmes to stimulate the development, registration, commercialisation, and acquisition of green patents.
Financial (Geng <i>et al.</i> 2009; Pajunen <i>et al.</i> 2013; Su <i>et al.</i> 2013; Van Berkel <i>et al.</i> 2009)	Accessing adequate financial resources (quantity, cost, and maturity) to finance investments conditions the viability of the CE.	-Access to adequate financial resources (quantity, cost, and maturity) to finance investments in the CE. -Creation of special funds, loans, and financial services that permit risk sharing with local industries. -Financial advisory services to reduce risks and improve productivity.
Social (Ellen MacArthur Foundation 2015a; Geng <i>et al.</i> 2012; Geng <i>et al.</i> 2009; Yuan, Bi, and Moriguchi 2006)	Participation in and raising awareness of different economic and social agents that favour the CE.	-Training programmes in different environments. -Disclosure of best practices. -Disclosure of information about environmental, financial, and social results obtained by implementing the CE.
Localisation (Coats and Benton 2015; Fang, Côté, and Qin 2007; Lee, Pedersen, and Thomsen 2014; Mirata and Emtairah 2005; Pitkänen <i>et al.</i> 2016)	The industrial, business, innovation, and legislative profile at the regional or local level conditions the development of the CE.	-Homogeneous regional legislative framework for the development of the CE. -Regional collaboration programmes on technological and financial level.

(Genovese *et al.* 2017), optimising materials and energy flows among facilities in a territory based on long-term economic growth and innovation (Braungart, McDonough, and Bollinger 2007).

Other specific indexes have been proposed to assess CE adoption at the regional level, such as the index method developed by Jiang (2011) to measure social development originating from the adoption of the CE paradigm. In the regional CE development index proposed by these authors, resource consumption is studied based on reduction principles, as well as recycling, and social development that covers economic and social components of CE. In this line, Huysman *et al.* (2017) propose indicators based on the technical quality of plastic waste by defining four options from less to more circularity of the technology applied.

From another perspective, Smol, Kulcycka, and Avdiushchenko (2017) developed regional indicators of eco-innovation as a first step in the elaboration of specific CE measurements and to offer a systematic and integrated approach for the CE concept at the regional level. These authors affirm that eco-innovation indicators can be used in

the current transition stage for assessing the implementation of regional policy and as a base for creating CE indicators. Despite these studies, we can affirm that to the best of our knowledge, there is no analysis that addresses the main objective of this paper.

Finally, regarding measurement of CE impacts in a regional context, Korhonen, Honkasalo, and Seppälä (2018) study the economic gain from the CE through reductions in raw material and energy costs as well as emissions, and the social gain in terms of employment and the implementation of a sharing economy. Franklin-Johnson, Figge, and Canning (2016) present performance metrics (called “the longevity indicator”) that measure contribution to material retention based on the time a resource is in use.

In the private sector, business has demonstrated an increasing interest in a circular model, but deep research on CE assessment and indicators for companies located in a specific region is still lacking.

Smol, Kulcycka, and Avdiushchenko (2017) propose different metrics to measure exports of products from eco-industries in a region, employment generated by eco-industries and the CE (% of total employment across all companies), and revenue in eco-industries that is considered directly related to the CE. Nevertheless, there are a few specific empirical investigations on the relationship between the awareness and behaviour of firms and the CE, in particular on the micro level (Elia, Gnani, and Tornese 2017).

Based on the literature related to the CE and regional development policy, a multidisciplinary analysis is posed as a methodological contribution that aims to define the main activities underpinning the CE at regional level from a holistic perspective and the points of view of society, public administrations, and private companies.

For the purposes of this study, the main CE activities have been classified and used to measure the CE in a regional case study by answering the following research questions based on previous literature: (a) How can the level of adoption of the CE be measured in a specific territory? (b) What is the impact of the CE in a territory and how can it be estimated?

Due to the interest of the EU in promoting the CE and its relevance in territorial and local scope, it is important to know how the principles and actions of the CE have been implemented in the regions that make up the EU. For this reason, and due to the scarcity of regional studies within the EU, this study conducts specific measurement of the CE and its impact in a regional case study of the Spanish region of Aragón to increase knowledge about the territorial dimensions of the CE and assess the impact of applying the CE in quantitative terms through a measurement method that is explained in the following section.

3. Regional case study

The Spanish region of Aragón was selected as a case study, given a commitment by the regional government to the authors that enabled an analysis of the territorial impact of the CE and definition of the main actions to be implemented to foment the circular model¹.

This region comprised 1,317,847 inhabitants in 2015, distributed among 731 municipalities; more than 50% of the population was concentrated in the region’s

capital (the city of Zaragoza). The region has a low population density (25 inhabitants/km²) and the negative migration balance should also be noted – since 2005, the population in 75% of its municipalities has fallen (Portillo-Tarragona *et al.* 2017). Its territorial characteristics and the abundance of resources (CESA 2016) that characterise this region make it suitable for analysing the deployment of the CE at a regional level and it can be considered as an adequate case study to apply the methodology to measure the level of CE in the territory.

Aragón is classified as NUTS2 and represents a fairly standard territory in terms of economic figures; its GDP and economic productivity are on a par with the Spanish average, while the employment rate and per capita income are slightly above average. Economic activity is quite diversified, and Aragón is considered a strategic region in logistics due to its proximity to France and the largest industrial centres in Spain. The region is an interesting case to study similar regions within the EU (Marco-Fondevila, Moneva Abadía, and Scarpellini 2018).

3.1. Methodological focus

In this case study, a double-focus qualitative methodology was applied to investigate the research questions. Semi-structured (in-depth) interviews were conducted in the second semester of 2016 to analyse perceptions of the adoption of CE-related main activities in the region at different levels: society, public administrations, and the private sector. Parallel desk research was carried out to estimate the impact of the CE in the region with a set of indicators. The initial literature review was made through the Scopus database to search for previous studies that relate the regional scope with the circular economy. Secondly, specific journals were also analysed to find studies on regional environmental planning and policy. Finally, the literature related to other topics, such as the methodology to be applied and metrics for CE, were also analysed.

The questions in the interviews were designed in accordance with other studies that have concentrated on the regional level (Böhringer and Bortolamedi 2015; Murphy, Huggins, and Thompson 2015; Mehmet 1995; Picazo-Tadeo and García-Reche 2007). Specifically, the methodology for the analysis was adapted to fit the regional context in which CE were in an incipient state of implementation (Everingham *et al.* 2013).

Semi-structured interviews have also been regarded as a valuable instrument (Hovik *et al.* 2015) for data compilation, enabling the analysis of territories and local units with different characteristics. Semi-structured interviews have also been used in other CE-specific studies because they allow for processing information that otherwise could not be systematically collected through key informants (Geng *et al.* 2009).

In this field, Hultman and Corvellec (2012) conducted open-ended interviews to discuss the policy of preventing the production of waste. Likewise, in the renewables sector, the purpose of the 12 in-depth interviews carried out by Matti, Consoli, and Uyarra (2016) was to gain insights into energy-policy implementation, technological development, and regional strategies. From a different perspective, this sort of interview has been used for data triangulation, both with company data and information about policies, regulation, and the business environment (Zhu and He 2015) for local governance.

Table 2. Estimated impact of activities related to the CE in Aragon for the year 2015 (Instituto Aragonés de Estadística, 2014, <http://www.aragon.es/DepartamentosOrganismosPublicos/Institutos/InstitutoAragonesEstadistica>).

Estimation of current situation (for the year 2015 using 2014 data)			
	Turnover (thousands of euros)	Total jobs	Total raw material purchases (thousands of euros)
Total Aragon industrial sectors	23,219,450	85,099	9,129,947
Direct CE impact on treatment and waste-recycling sectors	210,637	4,065	131,229
Estimated indirect impact of CE activities on sensitive sectors	1,147,611	4,007	401,631
Total estimated impact	1,358,248	8,072	532,860
% of total volume of Aragon industrial sector	5.8%	9.5%	5.8%

The CE in the region was measured through 21 interviews with experts selected by the authors as key informants, according to the guidelines of the commitment. Due to the general objective of the study, one-third of the interviewees represents the regional public administrations, one-third represents society, and one-third represents companies or the business sector. Owing to confidentiality agreements with the interviewees, their identities remain with the authors; however, the complete list of the organisations for the interviewees is provided in the Annex to this study (Table A1 [online supplementary data]).

The interviews were organised into three sections, and each section was mainly composed of five open-ended questions provided in Table A2 (Annex [online supplementary data]), where the sources of the variables used to define the questions are cited (Table A2 [online supplementary data]), in addition to some authors that used these main variables. Some of the questions were answered by experts using a Likert scale². For the desk research on the measurement of the regional impact of the CE, different metrics were elaborated and applied to the case study. Three basic indicators were selected to synthesise the estimation of direct and indirect impacts of the CE in these sectors at the regional level: the businesses turnover, the employment related to CE activities and the volume of raw materials consumption in selected industries (Table 2). These metrics have been applied in this study to define the impact of the CE in the region being analysed. This is consistent with previous studies, especially those proposed by Korhonen, Honkasalo, and Seppälä (2018) and Smol, Kulcycka, and Avdiushchenko (2017).

These metrics were measures in the business sector through a complementary analysis based on the consideration that waste industries are directly related to the CE and other industrial sectors can be considered as 'sensitive to introduce the CE activities', because they operate in sectors related to those technologies described in the documents about the best available technologies (EIPPCB-TWG 2003; European Commission 2003, 2009; European IPPC Bureau 2006). Thus, the indirect impact of the CE can be estimated by analysing CE adoption by industries in the sectors described in the BREF (European Directive 2010/75/EU), and the direct impact of the CE at regional level would be generated by businesses operating in the waste treatment and recycling sectors.

4. Main results

The first part of the analysis summarises the perception of experts about the level of penetration of CE main activities in the region from the points of view of public administrations, society, and private companies. The interviews were segmented, as appropriate, according to the answers provided by the experts in the three study areas.

The opinions of the interviewees about the position of regional administrations with regards to the CE reveal there is an incipient engagement of the public sector limited by the lack of a specific budget for promotion of the CE and the inadequate regulation in the regions for this model. The majority of interviewees representing public administrations noted the public sector's favourable predisposition towards the CE, but the principal limitations to its effective implementation are the administrative procedures and limited inclusion of CE principles in the specifications of public contracts.

The inclusion of CE in political programmes on national and regional levels in the EU was considered a positive indicator for CE adoption in the near future, although greater coordination is demanded. The majority of the respondents suggested that administrations must foment the traceability of by-products, even though there are some problems related to multi-competition for environmental regulation between administrations at the regional, national, and EU levels. Competencies exist in regions within the EU for promoting CE activities, although a quarter of the interviewees indicated that the existing subsidiarity in the EU, the central government, and the regional government undoubtedly hinder the attainment of some objectives related to the CE and the environment.

Another section of the semi-structured interview was focused on adoption by society of the most relevant and feasible activities that could be pursued by the region's consumers in the framework of the CE, as follows:

- To implement high-quality separation of waste at home (SEPW)
- To implement the 'economy of services', which implies substituting renting for buying (SERV)
- To develop a wide market for second-hand products (SECO)
- To consume products made from completely recycled materials (TOTR).

Analysis of consumer perceptions in the region about adopting these activities to introduce the CE allows us to identify feasible habit changes in the near future. The results indicate that the CE activities considered more viable and relevant at present for the region's society are high-quality separation of waste (SEPW) in the home and a market for second-hand products (SECO). In fact, both activities attained a score of 3 and 4 from most of the experts. The results obtained in terms of the relevance of these activities are shown in [Figure 1](#), where 4 indicates the highest relevance of the activity and 1 indicates "least relevant".

It can be observed that the lowest score was assigned to the use of products totally manufactured using recycled materials (TOTR), since most of the interviewees (55%) considered it a least relevant activity. The experts' opinion regarding these CE activities is that the sharing economy will increase in the near future in municipalities and private companies, because those entities are already using services rather than property of goods if it is economically feasible. Nevertheless, this is a long-term issue that will be accepted much more slowly in households. One interviewee (a representative of a

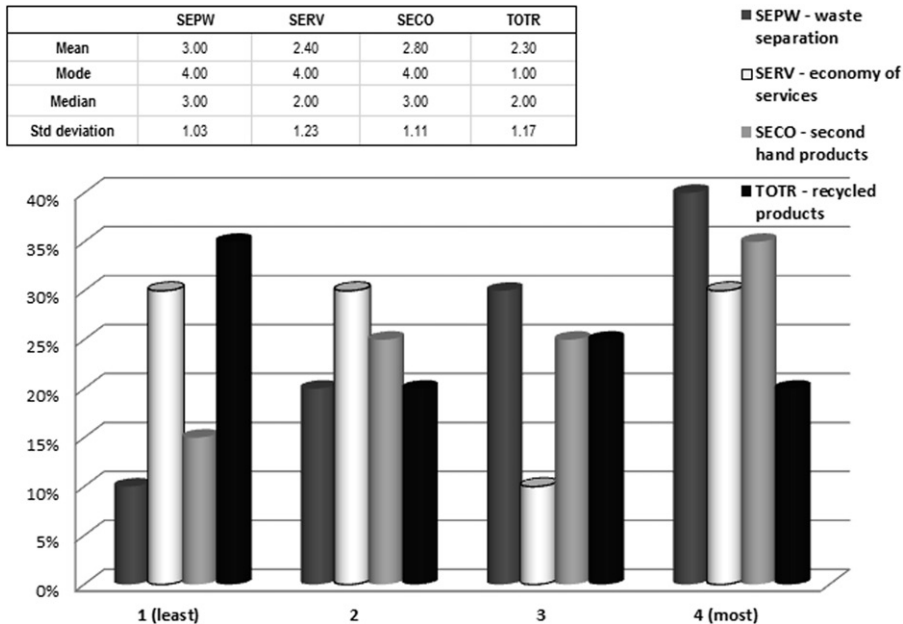


Figure 1. Relevance of the principal CE measurements for the domestic sphere at regional level.

private firm) pointed out that “in a Mediterranean society, there is still a lack of standards for the provision of these services and it is difficult to understand relative prices.”

With regard to the sale of products made using recycled materials, the opinion expressed by some respondents was that “the purchase of these products should be encouraged and more detailed information about product lifecycle analysis, their ecological footprint, and other environmental indicators would have to be provided to consumers, rather than specific actions in regard to only the materials recycled.”

Most of the interviewees believe the second-hand market already exists and does not need special stimulus. However, in the region’s households, although recycling is practised at noticeable levels, high-quality separation requires other logistical collection systems, particularly in urban areas and the regional capital. Some interviewees noted the need to apply progressive taxes for the collection and management of household waste.

The majority opinion of the interviewees is that education in schools is fundamental for implementation of the CE and that, despite being a very slow process, this method increases sustainability and, therefore, the CE in the region. In addition, it was clarified that there was little social interest in this type of economy. It may be inferred that, in the opinion of the interviewees, social interest will increase, albeit gradually, provided that it does not excessively influence the price of products.

In the third section of the semi-structured interviews, specific questions were asked about CE implementation in the private sector, to determine the most relevant and feasible CE activities that have been adopted by companies in the region. The selected activities for this part of the analysis are described as follows:

- Waste valorisation (VALW)
- Carrying out dematerialisation and product eco-design (DES)
- Consumption of secondary raw materials for production (recycled) (REC)

- Putting in practice solutions of industrial ecology/industrial symbiosis (SIM)

The CE is considered to be of little relevance at present for the private sector in the region. The reason may be that the activities considered most viable mainly apply to industrial sectors, which do not contribute to the bulk of the regional GDP. The interviewed experts closest to the private sector emphasised how companies have progressively adopted CE principles when this has led to an improvement in performance, the environment, and competitiveness. The results are consistent with the contributions of other authors regarding cost-saving practices and raw materials, and resource-saving processes already applied by industries (Agrawal, Singh, and Murtaza 2015; Ortas, Moneva, and Salvador 2014).

However, the general perspective expressed by key informants was that a high percentage of companies do not have detailed knowledge of CE activities and the introduction of the CE might entail improvements at the business level. Undoubtedly, the CE is considered an opportunity for companies in terms of competitiveness (85% of responses) but, depending on the industrial sector, CE incorporation can be difficult for businesses (e.g. in the building sector). This means that it is easier for large companies and more difficult for small- and medium-sized companies, which are largely unaware of what the CE proposes.

4.2. Regional CE barriers and drivers

In addition to measuring the degree of penetration of CE activities in the region, analyses of the main barriers and incentives of the CE at a regional level were also included in the interviews. The following six main barriers were considered from the literature analysis (EIO 2015; Ghisellini, Cialani, and Ulgiati 2016; Morlet *et al.* 2016; Su *et al.* 2013; Xue *et al.* 2010):

- Lack of funding for the investments (BARR-01)
- Price increase not appreciated by consumers (BARR-02)
- Lack of standards for actions (BARR-03)
- Difficulty supplying recycled products (BARR-04)
- Lack of interest from shareholders and stakeholders (BARR-05)
- Lack of trained specialised personnel (BARR-06)

The results indicate that almost all barriers are considered relevant in the region (Figure 2).

The lack of financing for undertaking investments (BARR-01) was considered as a very relevant barrier at regional level because almost 60% of experts assigned a rate around 6 points (on a Likert scale of 10) and the mean was 6.14 points. Barriers related to the price increasing (BARR-02) and the supply of recycled products (BARR-04) were also considered as relevant by experts. The lack of interest by shareholders and stakeholders is not considered a relevant barrier (BARR-05) with a mean of 5.3, and the lack of specialised professionals (BARR-06) was identified as a moderately relevant barrier for CE in the region.

When noting other relevant barriers to adoption of CE principles by businesses, key informants pointed to technological and economic barriers, and stressed the need for a substantial change in the business model. For such change to occur, managers

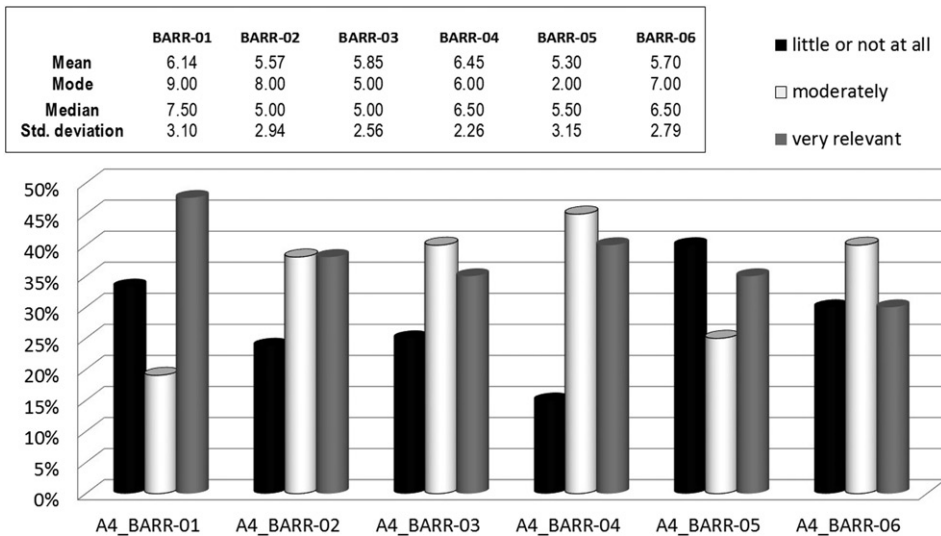


Figure 2. Relevance of barriers to the adoption of CE principles.

who are aware of environmental management are necessary, and the business must consider the CE to be of interest for its business strategy.

Some experts also pointed out “other barriers as those derived from regulations and public administrations and the lack of a stable regulatory framework that favours the long-term investments required by the CE”. A representative of the private firms surveyed stated that “the most relevant difficulties are related to the supply of the volume of recycled raw materials required for manufacturing and the standards of the recycled materials”. However, informants from the R&D institutes noted that “eco-innovative technologies make application of the CE possible in the future”.

One barrier considered relevant by some of the interviewees is the current ‘end of pipe’ environmental management model, according to which waste is treated at the end of processes. Additionally, ‘these principles are not properly considered in product design, and the resistance to change found in some companies is considered a barrier’.

As another step to define the priorities to be considered in the regional environmental policy to promote CE among businesses, the following incentives to overcome the detected barriers were studied through the experts’ answers:

- Subsidies or bonuses to promote the CE in business (INCE-01)
- Awareness-raising campaigns to promote the CE (INCE-02)
- Creation of a regional waste-interchange system (INCE-03)
- Dissemination of good practices and green procurement (INCE-04)
- Certification of products and/or companies (INCE-05)
- Subsidised training plans for employees (INCE-06)

The results are illustrated in Figure 3 to analyse the relevance assigned to each incentive by the experts for regional planning to promote CE in businesses.

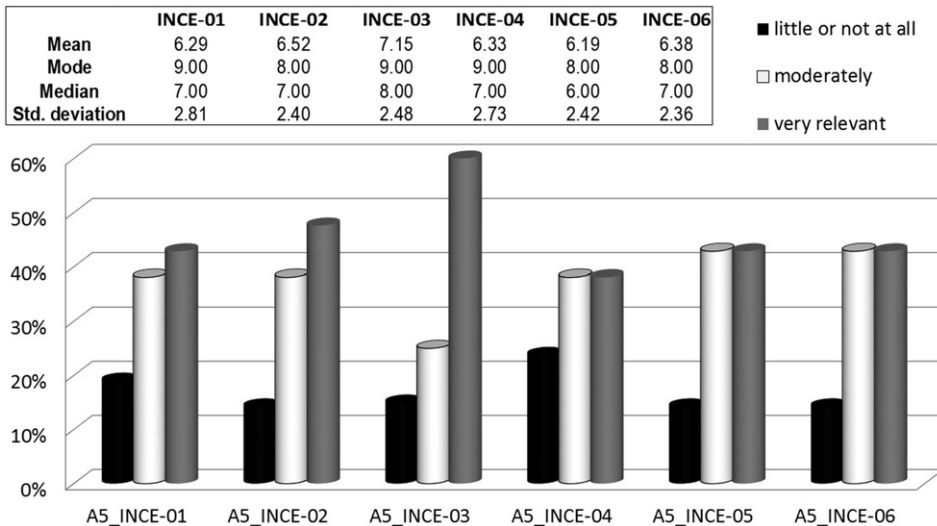


Figure 3. Relevance of incentives in promoting the adoption of CE principles.

The opinions of the experts were quite uniform with regard to the relevance of incentives to promote CE among companies in the region. The majority of the interviewees value economic incentives and consider subsidised training (INCE-03) and public recognition of CE good practices as important (INCE-04), although the greatest importance was placed on the need to organise a waste-exchange system between companies (INCE-03), and awareness campaigns and outreach concerning the CE (INCE-02).

Most experts stated that subsidies for companies to implement new CE production processes could be very effective and assigned a positive assessment of incentive systems or fiscal bonuses tied to improvements in environmental terms for businesses was noted. In particular, some of the experts suggested increasing taxes for the most polluting companies could incentivise CE adoption in companies. An increase in tax rates was also proposed by interviewees, depending on the volume and characteristics of waste that companies take to landfills to promote 'zero landfill' in line with the EU proposal.

5. Regional planning implications and discussion

In response to the regional government's commitment to define specific actions for CE promotion in environmental regional planning, the impact of CE was estimated in the region using desk research, the selected key indicators and the results obtained through the interviews.

5.1. Estimation of the CE impacts

It can be argued that implementation of the CE in the regional study case will be effective in the long-term. Thus, its impact from all points of view of the closed loops driven by the CE model and the entire set of CE activities can only be measured after its effective implementation. Impacts of CE at regional level were analysed at present and in the medium-term, the direct impact of the CE on the territory is mainly linked to the recycling and waste-treatment sectors. In private business, some of the CE-

related activities have mainly been adopted by industrial sectors because they are most sensitive to the changes related to new and more efficient technologies.

Regarding measurement of the economic impact, most informants opined that CE implementation will not significantly increase in the next 3–5 years but will rather develop slowly. Some of the interviewees suggested raw materials consumption and materials prices, the availability of secondary raw materials, and energy prices as main indicators to measure the evolution of the CE in the territory.

For social impact, informants considered that implementation of the CE would generate different jobs, but would not increase the total number of jobs in the region. They pointed out that the CE would require professionals trained in advanced techniques of industrial product recycling from different scientific backgrounds, particularly chemists, biologists, physicists, specialised technicians, and specialised lawyers and economists, in order to achieve durability and reparability. In general terms, the relationship between employment and CE was clearly stated.

In summary, from the analysis of the semi-structured interviews and the previous results obtained through the desk research (Portillo-Tarragona *et al.* 2017), it is estimated that approximately 5.85% of the turnover in the industrial ‘sensitive’ sectors of Aragón is directly or indirectly linked to CE activities, which suggests the potential for improvement in the coming years, but little economic impact in the territory at present. Thus, it is considered that 6% of the activity in these sectors is related to activities included in the CE model (Figure 1), and this percentage of their turnover is linked to activities included in the CE model (Table 2). Turnover of sectors directly linked to the CE, such as waste treatment and waste valorisation that are considered totally circular is added for the total amount because it is linked to the CE.

The analysis of the impacts carried out using the selected indicators confirms the opinion of the experts that the relevance of the CE in the region is still quite limited.

Different scenarios were estimated based on the potential evolution of the CE achieved in the region depending on future availability and prices of raw materials and the introduction of specific public incentives. The results can be observed in Table 3:

The estimation of the CE impacts in the region allows the prediction that if the prices of raw materials and resources increase, the volume of secondary raw materials used in productive processes also increases, which would urge development and improvement of standards related to the recycled materials that industries demand at present. The introduction of limits in the regional volume of waste would also increase the level of penetration of the CE in the region. As a general consideration, related technologies could mature through eco-innovation, especially with investments in waste recovery.

Figure 4 illustrates the estimated evolution of the CE’s regional impact in different scenarios.

Analysis of the selected indicators confirms the opinion of interviewees who considered the current relevance of the CE in the region as very low in socio-economic terms.

In terms of jobs, the expected evolution is summarised in Table 4, which illustrates a very moderate increase in the percentage of jobs related to CE activities, in the context of the total number of jobs in the sectors analysed. The estimated impact in terms of new jobs in the region is less optimistic than that disseminated by the European Union's 2015 Circular Economy Action Plan (European Commission 2015).

Table 3. Definition of the increasing and decreasing impacts estimated depending on the hypothetical levels of adoption of the CE in the region.

Hypothetical events	Expected impacts for the CE
Increase in price of raw materials and resources (<i>↑upward estimation</i>)	<i>↑Increase in the volume of secondary raw material (recycled) – AND ↑Increase in the level of the CE</i>
Increase in availability of secondary raw materials (<i>↑upward estimation</i>)	<i>↑Improvement in standards and the volume of secondary raw materials (recycled) - AND ↑Increase in the level of the CE</i>
Increase in difficulty of supplying raw materials and resources (<i>↓downward estimation</i>)	<i>↓Decrease in consumption of raw materials AND ↑Increase in the level of the CE</i>
Stimulus of the regional CE (<i>↑moderate upward estimation</i>)	<i>Moderate increase in EC incentives - AND ↑Increase in the level of the CE</i>
Introduction of limits to the regional volume of waste (<i>↓downward estimation</i>)	<i>↓Decrease in the volume of waste in the landfill – AND ↑Increase in the level of the CE</i>
Higher maturity of technology (<i>↑moderate upward estimation</i>)	<i>↑Increase in eco-innovation for waste recovery – AND ↑Increase in the level of the CE</i>

Table 4. Estimation of the impact of activities directly and indirectly related to the CE on employment in Aragon (Authors' compilation using data from the Instituto Aragonés de Estadística, 2014).

	Year 2015	Year 2020	Year 2025	Year 2030
Total expected jobs Aragon Industrial sectors	85,099	89,354	93,822	98,513
No. direct jobs estimated ('waste' sector)	4,065	5,894	8,943	11,179
No. indirect jobs sensitive sectors	4,007	5,810	8,815	11,019
Total estimated CE jobs	8,072	11,704	17,758	22,198
% of total Aragon industrial sector	9.5%	13.1%	18.9%	22.5%

Thus, according to the analysis summarised in Table 1, introduction of the CE at a regional level can be estimated using the necessary technological improvements (eco-innovation and industrial ecology), financial resources needed to improve the turnover related to CE activities (economic benefits), social interest and the relative stakeholders (in terms of jobs), and the territorial aspects that are intrinsic to the CE (planned by public administrations). This procedure to estimate the impact of CE can be applied to other territories in which waste sectors that are considered the primary-related industries to CE, can be dimensioned. Other industrial sectors located in the region, considered as 'sensitive sectors for CE', generate an indirect impact measured through the percentage of their turnover that is related to CE activities that have been introduced by businesses. Thus, the economic impact of CE is measured through the activities introduced by industries, the related jobs and is influenced by the flow and price of materials and resources at the territorial level.

At the micro-level, due to the incipient level of CE adoption by businesses in the region, an appropriate incentive is to improve recycling and waste recovery in the companies, because these activities are scarcely considered in regional regulations, leaving much scope for growth. The main activities that must be included in environmental planning are support for an organised waste-exchange system,

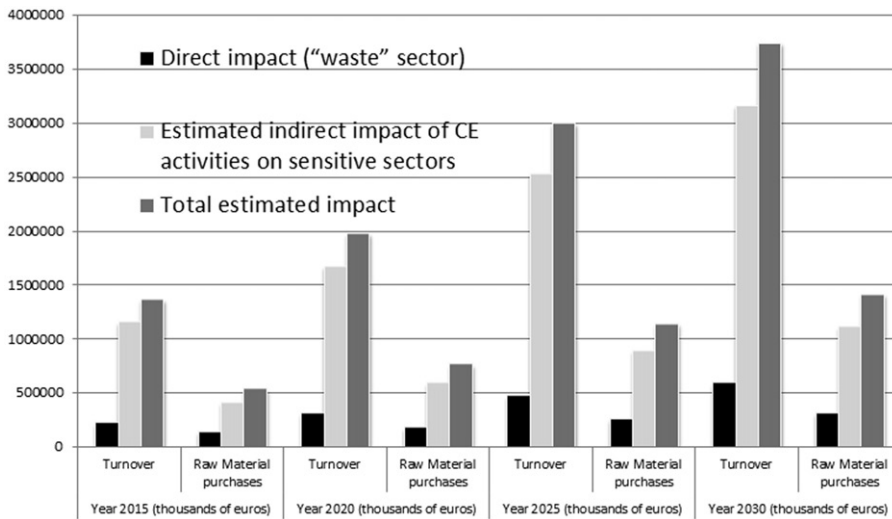


Figure 4. Estimation of the economic impact of activities related to the CE on the region (authors' compilation from data from the Instituto Aragonés de Estadística, 2014).

reduction of waste in landfills, and the introduction of specific standards for secondary raw materials at the regional level. Public recognition of best practices in applying the CE principles and financing for specific training programmes are also considered relevant proposals, as are the promotion of specific funds for R&D and collaborative eco-innovation.

Regional governments in Spain can favour certain CE processes in the framework of their competences, but the limited use of "soft-law", which is not widespread in Mediterranean countries, makes it difficult to start a dialogue with companies and increase adoption of the CE in the short term. In this context, the limited hierarchical competence in environmental regulation with respect to municipalities should be noted. The measures considered potentially suitable for promoting the CE in public administration include modification of the specifications of the terms of public procurement to promote their adaptation to the CE model, and the introduction of CE principles into local waste-management plans and, in particular, the design of coordinated multifaceted actions for promotion of the CE at the regional level, including all administrations and the public sector.

At the social level, real CE implementation requires consumer empowerment to better value the efforts of companies that move towards circularity and increase the degree of public awareness regarding green products. To that end, the plans must include specific dissemination campaigns and the introduction of indicators and new business models for the economy of services for households.

A region's environmental sustainability is affected by various factors and could be a crucial concern for planners and policy-makers, but existing studies do not consider a CE approach or connect such an approach to sustainability and eco-innovation at a regional level (Smol, Kulcycka, and Avdiushchenko 2017). Elia, Grazia Gnoni, and Tornese's (2017) proposed taxonomy of index-based methodologies does not include territorial measurement of the CE. Thus, the measurement carried out in this regional case study complements the indicators proposed by Smol, Kulcycka, and Avdiushchenko

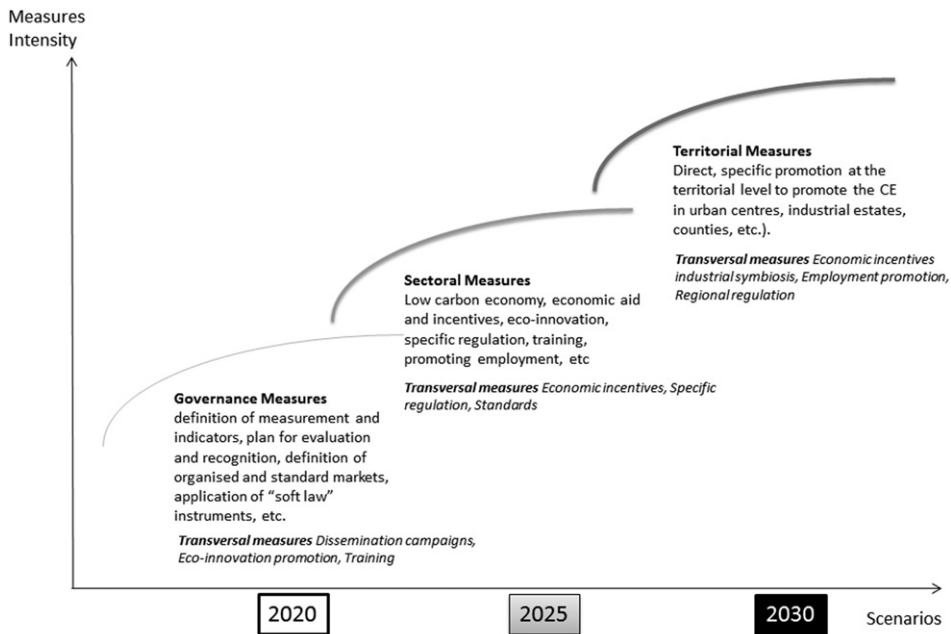


Figure 5. Main measures to be included in the environmental regional plans for different scenarios depending on the intensity of the level of CE adopted at regional level.

(2017) because direct and indirect impacts are considered directly related to the CE without encompassing the Eco-Innovation Scoreboard indicators.

In addition, in response to Korhonen, Honkasalo, and Seppälä (2018), this study confirms that the economic win related to the CE can be achieved by reducing raw materials; and the social win related to employment will be more effective as CE activities are implemented at all regional levels.

Using the drivers and barriers defined through the interviews and the explored impact of CE implementation in the region, the main measures to be included in regional environmental plans are described in Figure 5, organised in different scenarios depending on the intensity with which CE activities are introduced at the regional level.

As a general consideration resulting from the qualitative analysis performed in the case study, an action plan for the CE in the region should include: cross-cutting measures (economic grants and incentives, promotion of eco-innovation, training for new professionals' skills, etc.); sectoral measures (particularly those aimed to foment the CE in all business sectors); territorial measures (specifically designed at the territorial level); and governance measures (indicators, standards, planning, organised markets, etc.).

Given the difficulty of defining and measuring a comprehensive economic system such as that which arises with the CE, proposing an analysis of the level of implementation of CE activities in different scenarios can guide institutional intervention at the regional level to reflect the connections between the CE and related spheres of society, business, and public administrations. This consideration confirms the heterogeneous landscape of regional governance in environmental settings (Andrews and Boyne 2008; Gibbs and Jonas 2001; Romero, Jiménez, and Villoria 2012) and the idea that introduction of the CE in industries is affected by the availability and management of raw resources. Thus, decentralised territorial solutions are needed and must be

developed in cooperation with different economic sectors, consistent with the previous contributions in this field summarised in [Section 2](#) (Hovik *et al.* 2015; van Straalen, Janssen-Jansen, and van den Brink 2014).

For private businesses, regional planning could foster the eco-design of products with the aim of facilitating recovery of their components and materials; for public administrations, planning activity can introduce public procurement and promotion of new and innovative business models for collecting waste and products; and for society, sharing economy models and implementation of inverse logistical solutions through which consumer products are collected to be returned to the supply chain could be promoted through environmental planning.

The effective implementation of the CE at the territorial level will undoubtedly require generation of certain favourable conditions to help businesses transition towards closed loops, and regions must play a role in aiming for these objectives.

6. Conclusions

In this study, the definition and measurement of the CE penetration at the regional level and its main impacts are discussed through a qualitative case study of a Spanish region. The main results confirm that the CE will be relevant in the future, but its effective implementation in the EU at regional level is long-term and requires intervention by territorial administrations. In this context, the success of implementing CE models will partly depend on local and regional environmental planning that must be designed to respond to the needs of different spheres. However, knowledge of CE measurement and its impacts at the regional level is still limited, and more territorial planning policies are needed for broader deployment in the mid- and long term.

The main contribution of this study is the method of measuring regional adoption of the CE (the activities, barriers and incentives), and further the impact of the CE. Definitions of the adoption of the CE have been analysed from the different perspectives of society, public administrations, and the private sector dimensioning and ranking main CE activities that are considered as relevant in territory. The measurement of CE-related impacts in the regional study case was calculated using the three main indicators of employment, turnover, and the volume of raw materials consumption over the medium- and long-term.

The results highlight that the impact of the CE in the region is considered very low at present and is going to increase gradually, despite the introduction of moderate incentives by the regional government, an increase in the price of raw materials, and a predictable increase in the availability of secondary raw materials that meet the standards necessary for introduction into manufacturing processes in a scenario of greater waste technology maturity. The method and framework applied for this study can be used in many regions, even with different contexts to the regional case.

The contributions achieved in this study in terms of measurement are not without limitations: in particular, we should note the limited number of both experts interviewed and variables. In addition, the empirical evidence used in the study is primarily qualitative in nature and therefore further effort is needed to measure the CE impact in a territory.

Therefore, this study provides information that is of interest at different levels, both for policy makers and public administrations (for decision making and defining regional policies and plans), as well as for business practitioners (for defining adequate strategies for future implementation of the CE at the territorial level). For academics, the contributions centre on important methodological aspects that may be used when

analysing CE measurement in a territory, and, in particular, with regard to the debate on local and regional governance; this work can be used to co-determine CE implementation in a territory based on its spatial and organisational structure.

Supplementary materials

Supplementary data for this article can be accessed [here](#).

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes

1. It has to be taken into account that the results analysed in this paper are based on a section of a regional study promoted and financed by the Economic and Social Council of the Regional Government of Aragón (Consejo Económico y Social de Aragón – CESA) in the framework of the contract “Level of implementation of circular economy principles in businesses and public administration in Aragón: actions for its socioeconomic promotion and impact in the Autonomous Community of Aragón” during the second semester of 2016.
2. All the interviews were analysed in an aggregated manner using a qualitative method. In addition, experts were asked to assign a value to each opinion using a Likert scale ranging from 0 to 10, with 0 being the score that expresses total disagreement or that the interviewee believes the statement to be of no relevance, and 10 being the highest valuation, expressing total agreement or that the interviewees believed the statement to be highly relevant. From the Likert scale thus constructed, the opinions expressed were divided into three levels, with 0–3 being “slightly or not at all relevant”, 4–7 “moderately relevant”, and equal to or greater than 8 “very relevant”.

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