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José Alfonso Aranda Usón

Definición y medición de la adopción de la economía circular en empresas en el marco de la contabilidad de gestión medioambiental

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TESIS POR COMPENDIO DE PUBLICACIONES

La presente tesis doctoral, con el título "Definición y medición de la adopción de la economía circular en empresas en el marco de la contabilidad de gestión medioambiental", ha sido realizada por el doctorando José Alfonso Aranda Usón, codirigida por el Dr. José Mariano Moneva Abadía y la Dra. María Pilar Portillo Tarragona y desarrollada en el marco del programa de doctorado de Contabilidad y Finanzas de la Universidad de Zaragoza. Se trata de una tesis que se presenta como compendio de los artículos previamente publicados o aceptados para su publicación que se detallan a continuación, siendo el doctorando autor de todos ellos:

Scarpellini, S., Portillo-Tarragona, P., Aranda-Usón, A., & Llena-Macarulla, F. (2019). Definition and measurement of the circular economy's regional impact. *Journal of Environmental Planning and Management*, *62*(13), 2211–2237. https://doi.org/10.1080/09640568.2018.1537974

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José Alfonso Aranda Usón, con D.N.I. 17735657N expone:

Siendo el tercer autor del artículo *titulado "Definition and measurement of the circular economy's regional impact"*, afirmo haber contribuido en todo el proceso de elaboración de este trabajo de investigación, incluyendo la definición del estudio, el diseño de las encuestas y de las entrevistas semi-estructuradas, la realización del trabajo empírico de recopilación de los datos y el análisis cualitativo, así como la redacción del manuscrito. Además, hago constar que, siendo todos los autores poseedores del título de Doctor, este trabajo de investigación no formará parte de ninguna otra tesis en modalidad de compendio de publicaciones.

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Siendo el primer autor del artículo titulado "*Measurement of the circular economy in businesses: Impact and implications for regional policies"*, afirmo haber contribuido en todo el proceso de elaboración de este trabajo de investigación, incluyendo la definición del estudio, el desarrollo del enfoque teórico, el diseño de las encuestas y de las entrevistas semi-estructuradas, la realización del trabajo empírico de recopilación de los datos y el análisis cualitativo, así como la redacción del manuscrito y su posterior revisión en la fase de publicación. Además, hago constar que, siendo todos los autores poseedores del título de Doctor, este trabajo de investigación no formará parte de ninguna otra tesis en modalidad de compendio de publicaciones.

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Índice

Resumen

En los últimos años, el término economía circular (EC) está siendo utilizado por gobiernos, investigadores y empresas para describir un enfoque de desarrollo sostenible que no restringe el crecimiento económico. Una EC implica la transformación de un modelo económico lineal en uno circular para reducir la dependencia de las materias primas y la energía y para mitigar el impacto ambiental de la producción y el consumo.

La literatura académica en EC a nivel micro se ha centrado principalmente en el análisis del modelo de negocio circular (en inglés *circular business model*) y en la implementación de diversas acciones relacionadas con el cierre de círculos de materiales, pero el proceso de adopción por parte de las empresas de la EC todavía está en una fase incipiente de investigación. Específicamente, la introducción de la EC en las empresas y la transformación de una economía lineal tradicional a una circular, requiere la implantación de procesos evolutivos en los que se establezcan vínculos gradualmente dinámicos en el tiempo que han sido poco estudiados hasta la fecha, y la medición del nivel de adopción de la EC por parte de la empresa en su conjunto ha sido escasamente investigada.

Ante este contexto, el objetivo principal de esta tesis es llenar este "gap" en la investigación para contribuir al conocimiento acerca de la medición de la introducción de la EC en empresas en el marco específico de la contabilidad de gestión medioambiental y las finanzas corporativas. Asimismo, otro objetivo de esta investigación es la definición y medición de los recursos y de las capacidades aplicadas por las empresas a las actividades relacionadas con la EC, como aportación específicamente en la medición de recursos financieros y de capacidades relacionadas con la contabilidad medioambiental.

Cabe mencionar además que los estudios empíricos sobre de la introducción de la EC en diferentes sectores tampoco han sido abordados desde la perspectiva territorial. Por lo tanto, un objetivo complementario de esta tesis es ampliar el conocimiento sobre la EC empresarial a nivel territorial desde una perspectiva regional, como un tema aún poco estudiado en la literatura académica.

El método de investigación aplicado en esta tesis se ha desarrollado para proporcionar una doble perspectiva metodológica, siendo integrado por un análisis cuantitativo basado en una muestra de empresas, y por un análisis cualitativo basado en un caso de estudio de ámbito

regional para la medición espacial de la EC en empresas ubicadas en la Comunidad Autónoma de Aragón. Para el análisis estadístico, la población de la que se recabó la muestra de empresas se definió a través de un proyecto colaborativo de Investigación y Desarrollo (I+D) y de una campaña específica que promueve la eco-innovación, la EC y el eco-diseño, en las regiones del noreste español de Aragón, Cataluña, Navarra y País Vasco, al considerarse áreas con altas tasas de eco-innovación, y de las que disponen de resultados previos sobre empresas eco-innovadoras a nivel regional.

La muestra de empresas así obtenida proporciona datos relevantes para esta investigación y para dar respuesta a las principales preguntas formuladas en esta tesis: (a) ¿Cómo se puede medir el nivel de adopción de la EC por parte de las empresas en un territorio específico y qué sectores son más sensibles a la EC?; (b) ¿Cuáles son las actividades relacionadas con la EC más extendidas entre las empresas de los sectores más sensibles a la EC y cómo se puede estimar su impacto socioeconómico en el territorio?; (c) ¿Qué características de los recursos financieros están relacionadas con el alcance de EC de las empresas?; (d) ¿Cuáles son las capacidades relacionadas con la contabilidad medioambiental y cuál es su impacto en el alcance de la EC de las empresas?

La tesis está integrada por cinco artículos estrechamente relacionados entre sí. A partir de un análisis en profundidad de la literatura en EC a nivel micro y la política de desarrollo regional para la EC, en el primer artículo se plantea un análisis multidisciplinar, como una contribución metodológica que tiene como objetivo definir las principales actividades que sustentan la EC a nivel regional desde una perspectiva holística, integrando los puntos de vista de la sociedad, de las administraciones públicas y de las empresas privadas. En particular, en esta primera parte de la tesis, los sectores empresariales a analizar se definen en función de la consideración de que las industrias de residuos están directamente relacionadas con la EC y que algunos sectores industriales son más sensibles a la introducción de las actividades de EC en el territorio. Estos sectores son los relacionados con las tecnologías descritas en los documentos sobre las mejores tecnologías disponibles (BREF). Además de la definición de los sectores más directamente relacionados con la EC y de la elaboración de un primer grupo de actividades de EC a nivel micro, otra de las aportaciones de este primer artículo es una reflexión acerca de las políticas a nivel regional destinadas a la promoción de la EC.

En el segundo artículo, en el que se aplican directamente los resultados obtenidos en el primero, se realiza un análisis de las principales actividades relacionadas con la EC que están implementando las empresas en la actualidad, desarrollándose de este modo un listado de

actividades que implican una mejora en términos de EC para las empresas que las adopten. En este segundo artículo que integra la tesis se incluye además un análisis de las medidas para promover la EC en empresas ubicadas en un territorio y el desarrollo y medición de los impactos socioeconómicos de la actividad de EC realizada por las empresas. Los resultados alcanzados en esta fase de la investigación sientan las bases para la medición interna de la circularidad en las empresas y para la evaluación de la actividad económica generada, en términos de inversión y volumen de negocio.

Estos resultados se aplican empíricamente en el tercer artículo para definir el nivel de adopción de las actividades que realizan las empresas en la actualidad relacionadas con la EC. A través del tercer artículo se define el carácter progresivo de la adopción de la EC por parte de las empresas, de un menor a un mayor número de actividades. Esta definición del progreso de introducción de la EC en empresas resulta de especial interés, dado que no se disponía hasta la fecha de iniciar esta tesis de indicadores específicos a nivel de empresa para medir el cierre de círculos en términos de EC de una organización en su conjunto.

A partir de la definición de las principales actividades de EC en empresas y el desarrollo de indicadores a tal efecto, el objetivo principal del cuarto artículo de esta tesis es definir el alcance de EC de las empresas, siendo un tema poco explorado en la literatura. El resultado de esta actividad de investigación se concreta en un constructo en el que se integran cuatro grupos de indicadores y que permite medir el alcance de EC en una empresa en su conjunto, siendo esta una de las aportaciones más relevantes de esta tesis. El análisis de la relación entre el nivel de EC de las empresas así medido y los recursos financieros aplicados por las empresas a la EC es otra de las aportaciones alcanzadas. Esto permite ampliar el conocimiento para la definición y medición de los recursos financieros necesarios para las inversiones en EC en el marco teórico de Recursos y Capacidades. Más concretamente, en este cuarto artículo se detallan las características de los recursos financieros y se demuestra que la disponibilidad y especialmente la calidad de los recursos financieros suponen un efecto positivo en el nivel de EC de las empresas. En este sentido, es importante el papel desempeñado por la financiación propia, así como la posibilidad de poder contar con incentivos financieros públicos, como subvenciones, en el proceso de desarrollo empresarial de la EC.

Finalmente, el quinto y último artículo de este compendio tiene como principal objetivo definir y medir las capacidades internas relacionadas con la contabilidad de gestión medioambiental que se aplican a la introducción de la EC en las empresas. En este artículo, desarrollado sobre la base teórica de las *Capacidades dinámicas (Dynamic Capabilities)*, como

evolución del enfoque basado en recursos *(Resource-based View)*, se analizan las diferentes capacidades medioambientales que las empresas aplican a los recursos para introducir la EC. Los sistemas de gestión medioambiental, la responsabilidad social corporativa, la elaboración de memorias de sostenibilidad, la rendición de cuentas y otras prácticas de contabilidad medioambiental se han estudiado en el mismo marco de análisis como parte integrante de un conjunto de capacidades dinámicas de la empresa que influyen en su alcance circular.

En resumen, esta investigación contribuye a llenar un "gap" existente en la investigación académica en el momento emprender esta tesis sobre la medición del nivel de adopción de la EC a nivel micro, y, en particular, en el ámbito de la contabilidad de gestión medioambiental. Los indicadores desarrollados propician una gestión más eficiente de los diferentes recursos de la empresa para el desarrollo de actividades de EC y un crecimiento más sostenible, contribuyendo así a una mejor relación de la empresa con el entorno social, ambiental y económico en el que desarrolla su actividad. En síntesis, sobre la base teórica de la *Resource-based View* y su derivación de *Dynamic Capabilities*, se han logrado nuevos conocimientos respecto a los estudios anteriores en EC a nivel micro. El conjunto de indicadores para medir el cierre de círculos de materiales propugnado por la EC en empresas representa otra contribución relevante, que resulta de interés para el *reporting* en el marco de la responsabilidad social corporativa. Además, la aportación metodológica realizada en cuanto a la medición interna de los recursos y las capacidades estratégicas aplicadas a las inversiones de EC resulta relevante para las finanzas corporativas, en la medida en que contribuye a valorar las decisiones de inversión y su contribución a los objetivos sostenibles que se hayan marcado, y a la planificación de los recursos financieros necesarios para la puesta en marcha de actividades circulares en la empresa. En este sentido, los recursos financieros se convierten en un elemento estratégico, por lo que su capacidad para gestionarlo, así como la estructura financiera corporativa, puede determinar el comportamiento financiero de la empresa ante las inversiones de carácter medioambiental, que se suelen caracterizar por horizontes temporales más largos y por niveles de riesgo por encima de la innovación convencional. Finalmente, la medición espacial de los impactos de EC, de aplicación para la política regional y la información dirigida a los *Stakeholders* pueden señalarse como otra contribución relevante lograda a través de esta tesis.

Abstract

In recent years, the term circular economy (CE) is used by governments, researchers, and companies to describe an approach to sustainable development that does not constrain economic growth. A CE involves the transformation of a linear economic model into a circular one to reduce dependency of raw materials and energy and to mitigate the environmental impact of production and consumption.

Academic literature about CE at micro-level has been mainly focused on the analysis of the circular business model. The implementation of different circular-related practices has also been analysed, but the process of circular economy adoption by companies is still being researched. Specifically, regarding the adoption of the CE in companies, the transformation from a traditional linear economy to a circular one requires evolutionary processes in which dynamic linkages are established gradually over time. Nonetheless, there has been limited research on the indicators for measuring the CE adoption by a company as a whole.

In this context, the main objective of this thesis is to fill this gap in order to contribute to the base of knowledge about the measurement of the engagement of companies in the CE in the framework of the environmental management accounting and the corporate finance. Other additional objectives of this research are the definition and measurement of the resources and capabilities applied by firms to the CE-related activities, the investment appraisal and their contribution to the companies' sustainability objectives and the evaluation and planning of the financial resources and the environmental accounting.

Only a few empirical studies have measured the introduction of the CE-related activities in different industrial sectors in a region. Thus, a complementary objective of this thesis is to fill this gap from a regional perspective, as a subject that has been scarcely explored in the academic literature.

The research methodology of this thesis was designed to provide a double perspective: a quantitative analysis based on a sample of firms, and a qualitative analysis based on a regional case study of firms located in Aragón through a spatial measurement of the CE. For the statistical analysis, the population from which the sample of firms was selected was defined through a research and development (R&D) project and a specific campaign promoting eco-innovation, CE and eco-design, in the North-eastern Spanish regions of Aragon, Catalonia, Navarre, and the Basque Country. It is indeed an area with high eco-innovation rates which offers available results about eco-innovative firms at regional level.

This sample of firms provides relevant data in order to examine four main questions: (a) How can the level of CE adoption be measured in a specific territory and which business sectors are more sensitive to the CE?; (b) What are the most widespread the CE-related activities among the most CE-sensitive economic sectors?, how can their socio-economic impact in a territory be calculated?; (c) What characteristics of financial resources are related to the level of investment in the CE?; (d) Which are the environmental accounting and management capabilities that are related to the circular scope of firms?

This thesis is composed of five closely-related articles. In the first article, a multidisciplinary analysis is proposed as a methodological contribution, based on the literature about the CE and its regional policy. This analysis aims at defining the main activities underpinning the CE at regional level from a holistic perspective and reveals the points of view of the society, the public administrations, and the private companies. In this first part of the thesis the business sectors to be analysed are defined based on the premises that waste-treatment industries are directly related to the CE while other industrial sectors may be sensitive to introduce the CE-related activities. These sectors are related to those technologies described in the best available technologies (BREF) documents. Main initiatives to promote the CE among industries are also a result of this first approach to the CE.

In the second article, the selection of the current corporate CE-related activities is done. This paper includes an analysis and a selection of the measures to promote CE in companies located in a territory. The achieved results lay the foundations for the internal measurement of circularity in private firms and for the assessment of the economic activity generated, in terms of investment and income. This second article of the thesis also includes an analysis of the measures to promote the CE in companies located in a territory and the measurement of the socio-economic impacts of the CE-related activities carried out by companies. The results achieved in this phase of the research set the basis for the internal circularity measurement in companies and the definition of the economic impact of the CE, in terms of investment and turnover.

The aforementioned results are applied to the third article of this thesis aiming at analysing the CE-related activities that companies are introducing at present. In this article, the progressive adoption of the CE by companies is described, from a smaller to a greater number of activities. This analysis of the progressive introduction of CE-related activities is interesting because the specific indicators to measure the CE of a company were not available at the beginning of this thesis.

The definition of main CE-related activities in companies and the indicators developed in the previous phases, have been applied to the forth article in order to define the circular scope of businesses at micro level in more detail. The resources applied by firms to the CE-related circular scope is also a result of this article, to enhance the knowledge about the definition and measurement of the financial resources needed for the investments in the CE in the framework of the Resource-based View (RBV). The characteristics of financial resources are detailed and it is demonstrated that availability of funds, quality of the firm's financial resources and public subsidies have a positive effect in stimulating the implementation of the CE initiatives in businesses.

Finally, the fifth article aims at defining and measuring the environmental capabilities that are relevant for the introduction of the circular economy in businesses. Different environmental competences that firms apply to introduce the CE are analysed in this study using the dynamic capabilities theoretical approach. Environmental management systems, corporate social responsibility, reporting and accountability and other environmental accounting practices are studied in the same framework of analysis as a set of dynamic environmental capabilities that influence the circular scope of firms.

In summary, this thesis contributes to filling a gap in academic research concerning the measurement of the level of adoption of the CE at micro level for the environmental management accounting. These results contribute to a more efficient management of the available resources dedicated to the introduction of the CE for a sustainable growth and to improve the company relations with their environmental, social and economic context where they develop their activities. Founded on the RBV and the dynamic capabilities theoretical approach, new insights to recent studies of this topic at micro level have been achieved.

Another contribution is the set of indicators to measure the material loop-closing of firms, that can be applied for reporting, as another contribution. The internal measurement of strategic resources and capabilities applied to the CE by businesses is another useful result of this thesis for the corporate finance because it influences the investment decisions to implement the CE-related activities. Thus, financial resources are considered as strategic. The resource management and its capabilities to manage them jointly with the financial structures of the company may determine the environmental investment of firms. Finally, the definition of spatial impacts for the regional policy and the stakeholders is another relevant contribution achieved in this thesis.

1 Parte primera. Introducción

1.1 Introducción

En la actualidad, el término Economía Circular (EC) está siendo utilizado por políticos, académicos y profesionales para describir un modelo económico de desarrollo sostenible que no comprometa el crecimiento económico (Pratt et al., 2016). En el marco del paradigma emergente de la sostenibilidad y en los Objetivos de Desarrollo Sostenible (ODS), la EC plantea un modelo en el que los flujos de materiales, recursos, trabajo e información sean efectivos al objeto de que el capital natural y social pueda ser restaurado constantemente. El núcleo de la EC es conseguir que el flujo de materiales sea circular (cerrado) y el uso de materias primas y recursos se repita una y otra vez a través de múltiples fases (Yuan et al., 2006), permitiendo mantener el mayor tiempo posible el valor añadido de los productos, a través de la reducción de residuos (Mathews y Tan, 2011; Murray et al., 2017).

Existe cierto consenso acerca de que la EC puede representar una alternativa atractiva y viable al modelo lineal de "tomar, usar y tirar" y generar valor tanto para las empresas como para la sociedad, ya que la competitividad empresarial pasa por lograr un compromiso entre productividad y utilización de recursos para maximizar la eficiencia y "obtener más con menos" en sus operaciones (Ellen MacArthur Foundation, 2015). Es por ello que este modelo está siendo impulsado a nivel internacional por numerosas instituciones y gobiernos, tanto en la Unión Europea (UE) (European Commission, 2015) como en otros continentes (Aranda-Usón et al., 2018).

En el ámbito académico, la EC está siendo objeto de investigación en el ámbito económico, siendo cada vez mayor el número de estudios y revisiones de investigación que ponen de relieve que esta materia está adquiriendo más relevancia (Ghisellini et al., 2016; Ghisellini y Ulgiati, 2020; Kirchherr et al., 2017; Korhonen et al., 2018; Merli et al., 2018; Pomponi y Moncaster, 2017; Urbinati et al., 2017).

El interés por parte de las empresas hacia la EC también se ha incrementado en los últimos años (Lewandowski, 2016). No obstante, la introducción del modelo de negocio circular en las organizaciones está aun escasamente a estudiado a nivel micro (Stewart y Niero, 2018). Mientras que a nivel macro la investigación en EC se ha incrementado rápidamente en esta década, los estudios llevados a cabo hasta la fecha en ámbito micro han centrado principalmente en los factores que influyen en el compromiso de las organizaciones privadas con la EC, en las barreras e incentivos (Demirel y Danisman, 2019), y en algunos de los aspectos que la EC supone en la estrategia empresarial y en el modelo de negocio circular (Bocken et al., 2017; Witjes y Lozano, 2016). Más concretamente, la investigación de ámbito contable ha

abordado sólo parcialmente y de manera fragmentada la implantación de la EC en la empresa (Aranda-Usón et al., 2019). El desarrollo de métricas para la medición interna de la EC en el ámbito de la contabilidad de gestión medioambiental se encuentra en una fase incipiente y no ofrece resultados unívocos acerca de cómo este modelo se esté implantando en las empresas en un territorio determinado y los correspondientes impactos.

Son las premisas anteriormente descritas las que motivaron esta tesis doctoral y la investigación que se detalla en los siguientes apartados.

1.1.1 Medición interna de la economía circular en empresas e inversiones

En relación a su implantación en empresas, la EC puede plantearse para la reducción del uso de materiales y de energía, para una producción más limpia, para la disminución de materiales y recursos en la producción, la disminución de la contaminación, o aumentar la eficiencia con altas tasas de circulación, posibilitando que los recursos alcancen así un uso completo durante la producción (Jun & Xiang 2011; Van Berkel 2010). En el nivel de estudio micro se incluyen además las interacciones sinérgicas entre empresas, definidas también como simbiosis industrial, y las iniciativas que convierten los residuos de los procesos productivos en recursos para ser nuevamente empleados en otro proceso industrial (Mathews y Tan, 2011).

En las distintas fases de implantación de la EC, los flujos de materiales, energía y agua, así como de residuos y sub-productos pueden medirse a través de indicadores (Van Berkel, 2010), y para cada sistema (recursos no renovables, las emisiones al medio ambiente, uso de la tierra, el impacto en la salud humana y la sociedad), se han ido proponiendo métricas (Pakarinen et al., 2010). No obstante, cabe precisar que en la actualidad no se dispone de indicadores específicos desarrollados para la medición del nivel de EC alcanzado por una organización en su conjunto. Así como para productos y procesos podemos encontrar metrologías muy avanzadas de Análisis de Ciclo de Vida (ACV) para la definición del nivel de circularidad (Daddi et al., 2017), no hay consenso en cuanto a una metodología integrada que permita capturar las distintas actividades de EC de una empresa. Asimismo, las fuentes de datos son limitadas, y los estudios empíricos en la materia son aún escasos. Además, cabe destacar la relevancia que tiene en la EC empresarial los diferentes actores locales, tales como la estructura del territorio que tienen que ser tenidos en cuenta en los modelos circulares en la intervención gubernamental (Jacobsen, 2006a).

Ante este desafío, y una vez constatada la ausencia de indicadores integrados de EC a nivel micro, resulta de interés investigar acerca de cómo puede medirse su adopción por parte de las

empresas, para así definir y analizar la relación entre la introducción del modelo circular y diferentes aspectos de contabilidad de gestión medioambiental y finanzas corporativas, a través del estudio de los recursos financieros, su disponibilidad, su calidad (en términos de costes, y garantías) ante futuras necesidades financieras al objeto de que las nuevas oportunidades de inversión en proyectos de EC, con beneficio medioambiental, sean perfectamente identificadas en términos económicos. Esto permite que las consiguientes ventajas competitivas se traduzcan en rentabilidades futuras, y que la planificación de la financiación para el crecimiento, permita que las empresas accedan a recursos financieros de diferente naturaleza, bien mediante endeudamiento (Myers, 1984; Palenzuela et al., 2007) cuando la empresa no pueda generar internamente suficientes recursos, bien mediante recursos propios de la empresa (Rajan y Zingales, 1995). De este modo, estrategia empresarial y finanzas corporativas caminan inevitablemente a la par (Brealey et al., 2015). Por lo tanto, la medición interna de los recursos y las capacidades estratégicas aplicadas a las inversiones de EC resulta relevante para las finanzas corporativas, en la medida que afecta a la toma de decisiones sobre inversiones necesarias para la puesta en marcha de actividades circulares en la empresa. En este sentido los recursos financieros se convierten en un elemento estratégico por lo que su capacidad para gestionarlo, así como la estructura financiera corporativa, puede determinar el comportamiento financiero de la empresa ante las inversiones de carácter medioambiental (Aranda-Usón et al., 2019; Marín-Vinuesa et al., 2018), puesto que se suelen caracterizar por horizontes temporales más largos y por niveles de riesgo por encima de la innovación convencional (Ghisetti et al., 2017; Scarpellini et al., 2016).

Si nos referimos a las inversiones en eco-innovación, como ámbito interrelacionado con la EC, puede considerarse aceptado que para alcanzar el valor óptimo de un proyecto de inversión en la empresa, existe un vínculo entre los resultados obtenidos a través de los proyectos, la estrategia y las características propias de la organización (Too y Weaver, 2014). Esta relación ha sido explorada para la eco-innovación por algunos autores a través de la aplicación de metodologías, tanto de tipo cuantitativo (Halila y Rundquist, 2011), como aplicadas al estudio del caso (Kemp y Pontoglio, 2011). Este ámbito de análisis está estrechamente relacionado con las inversiones innovadoras necesarias para la adopción de la EC y con los recursos financieros necesarios a tal efecto. Es por ello, que en esta tesis se presente avanzar en el conocimiento de los recursos financieros aplicados a la EC, siendo un ámbito aún poco estudiado en la literatura.

La financiación de las oportunidades de inversión y la disponibilidad de recursos financieros mantiene una estrecha relación con la actividad innovadora que se considera absolutamente

necesaria en esta etapa de despliegue de la EC. Por lo tanto, las posibles restricciones a las cuales los recursos pueden estar expuestos afectarían particularmente este tipo de inversiones (Brown et al., 2009; Lee et al., 2015). Las empresas realizarán estas inversiones si pueden acceder a recursos financieros suficientes a un coste razonable, y esta circunstancia está vinculada al riesgo, no sólo el asociado a la propia naturaleza de la inversión en EC que se pretende financiar, también dependerá de las características económico-financieras de cada empresa, del sector en el que opere, del ciclo económico que atraviese o del área geográfica en la que desarrolle su actividad. Por lo tanto, la disponibilidad de recursos financieros se convierte en un elemento estratégico para la eco-innovación (Ociepa-Kubicka y Pachura, 2017; Zulfiqar y Thapa, 2018) y, por lo tanto, para la EC.

La relevancia de los recursos financieros para el desempeño medioambiental de las empresas, la eco-innovación y las energías renovables ha dado lugar al estudio de diferentes aspectos financieros de las inversiones, como son los costes y garantías de la financiación externa, la disponibilidad del recurso y las restricciones, la incertidumbre acerca de los flujos de caja generados por la inversión, etc. (Aranda-Usón et al., 2019) Sin embargo, en la literatura, antes de emprenderse esta tesis, las diferentes dimensiones de los recursos financieros no habían sido objeto de análisis con el alcance y el grado de detalle aquí propuestos para las diferentes inversiones necesarias para lograr una EC.

Es por lo anterior, que se considera relevante proceder a la medición de los recursos financieros y de las capacidades necesarias para su aplicación desde el ámbito de análisis de la contabilidad de gestión medioambiental, tal y como se analiza en el siguiente apartado.

1.1.2 Contabilidad de gestión medioambiental y economía circular

Ante el cambio tecnológico propiciado por la EC, la aplicación de la *triple bottom line* (Elkington, 2001) permite ampliar la información contable y financiera tradicional a través de la incorporación de indicadores medioambientales y sociales. Así, la contabilidad puede dar respuesta a la presión ambiental para una creación de valor a través de la EC al implicar el respeto de los recursos naturales y un desarrollo humano equilibrado entre los ejes de la sostenibilidad. Es previsible por lo tanto que, en la dimensión económica micro, la adopción de la EC conlleve determinadas acciones con una clara repercusión para la gestión medioambiental e interna y que suponga la implantación paulatina de métodos y procesos de medición, además del desarrollo de indicadores específicos y la inclusión de las mejoras en

términos de circularidad de las empresas en la actividad de *reporting* (Marco et al., 2019) y en el marco de la responsabilidad social corporativa (RSC) (Adams, 2008; Moneva y Ortas, 2009), pudiendo ser objeto de análisis de contabilidad social y medioambiental (Larrinaga et al., 2019). De hecho, en el modelo circular se intensifican las relaciones comerciales con empresas locales, se potencian las relaciones estables con proveedores de cara al cierre de círculos, y resulta necesario definir los niveles de precio para los subproductos y los residuos que se convierten en recursos para otras empresas.

Asimismo, la EC plantea la aplicación de estándares voluntarios y normas medioambientales específicas (Bonilla-Priego et al., 2011), la introducción de nuevas actividades para la circularidad del modelo dentro de la propia empresa o en colaboración con otras organizaciones, la gestión de actividades o instalaciones comunes, la entrega a los clientes de información completa acerca de los productos y servicios para su reciclaje, así como la implantación de una estructura de costes acorde al modelo circular en el marco de la contabilidad medioambiental.

Podemos encontrar distintas definiciones de contabilidad medioambiental. Tanc y Gokoglan (2015) ofrecen una definición exhaustiva de este concepto y su génesis en la literatura y la definen como una combinación de prácticas contables utilizadas en el estudio de las relaciones mutuas entre los contables y la ecología, el conocimiento de la información de los costes relacionados con el medioambiente y asignados a los productos y procesos. Aunque se han estudiado algunos aspectos de la adopción de procesos de contabilidad medioambiental por parte de las empresas (Wilmshurst y Frost, 2001), antes de iniciar la investigación planteada en esta tesis apenas se contaba con estudios específicos de EC en ámbito contable a nivel micro (Stewart y Niero, 2018).

Ante estas premisas, resulta de interés plantear el estudio específico de los métodos y prácticas de medición y el control de las actividades que la EC implica para las empresas, que previsiblemente supondrán una mayor implementación de niveles de contabilidad de gestión medioambiental o *Environmental Management Accounting* (EMA en sus siglas en inglés).

En términos más generales, la EMA se desarrolla para la identificación, la asignación y el control de los costes medioambientales de manera separada de los costes que no estén relacionados con los impactos medioambientales de la actividad (Qian et al., 2018). Una importante característica de la EMA es su énfasis en la medición de flujos monetarios y físicos en un ciclo de vida de un producto o sistema. Esto incluye procedimientos físicos para el consumo de materiales y energía, flujos y la fase de uso, así como los procedimientos para el

cálculo de costes, ahorros e ingresos relacionados con las actividades o flujos de materiales que tengan un impacto ambiental (Christ y Burritt, 2015; Qian et al., 2018). Aspectos que ayudan a conocer el grado de exposición al riesgo de la empresa en términos medioambientales, permitiendo establecer el diseño de su estrategia climática de manera que la EMA se convierte en una herramienta estratégica (Schaltegger et al., 2016). Así, medir el nivel de adopción de la EC a nivel micro en el ámbito de la EMA, contribuye a una gestión más eficiente de los diferentes recursos de la empresa para el desarrollo de actividades de EC que propicien un crecimiento más sostenible, permitiendo una relación de la empresa con el entorno social, ambiental y económico en el que desarrolla su actividad (Gallego-Alvarez et al., 2017; Moneva-Abadía et al., 2019).

En el marco de la EMA se pueden emplear herramientas como las de Análisis de Ciclo de Vida (LCA en sus siglas en inglés de *Life Cycle Asessment*), o el *Life Cycle Costing* (LCC) (Bierer et al., 2015), implantar normas como la ISO 14040 2006 o la ISO14044 2006, o aplicar metodologías de cálculo de huella ecológica (Manfredi et al., 2015). Estas herramientas pueden complementar la información medioambiental necesaria a nivel contable, de particular interés para empresas que adopten un modelo de negocio circular (Daddi et al., 2017; Qian et al., 2018).

En una extensa revisión bibliográfica Pomponi and Moncaster (2017) afirman que a nivel micro la investigación interdisciplinar es una excepción y que la mayor parte de los estudios tratan de cuestiones técnicas en la aplicación de la EC, y no contemplan en su análisis aspectos de contabilidad medioambiental, aunque introducen la aplicación de las herramientas cercanas a la EMA como el *Material Flow Cost Accounting* (MFCA) para entornos de .EC

En resumen, las técnicas de MFCA, recogidas posteriormente en la norma ISO 14051 (Christ y Burritt, 2016), se implantaron sobre todo como una consecuencia lógica de proyectos de gestión ambiental a finales de los años '80 y comienzo de los '90 aunque derivaran de los balances input/output de los flujos de materiales causados por la producción industrial iniciados en Alemania en la primera mitad del siglo veinte (Wagner, 2015). Asimismo, hay que mencionar que la MFCA depende del acceso a la información de los flujos físicos en los procesos, especialmente de aquellos ligados a los flujos de materiales y energía en un enfoque de gestión de corto plazo aunque ha resultado ser una herramienta de utilidad para la fase presupuestaria (Christ y Burritt, 2015), al permitir la evaluación de la eficiencia y las pérdidas en dichos flujos (Nakajima et al., 2015). Por lo tanto, el rango de aplicación de la MFCA es muy amplio, al poderse aplicar a la detección de ineficiencias y oportunidades de ahorro de costes

contribuyendo a la mejora no sólo del desempeño medioambiental sino también de la rentabilidad económica, y a la vez favorecer la implantación de política de ahorro de recursos y, por lo tanto, una producción más limpia (Schmidt et al., 2015).

Cabe añadir que la MFCA difiere de otras herramientas de gestión medioambiental al tener como objetivo la conciliación del medio ambiente con los aspectos económicos y permitir una comprensión más profunda de los procesos de fabricación. Cabe señalar además que puede ser aplicada de forma continua y rutinaria si se plantea de acuerdo a los sistemas de gestión de la compañía (Kokubu y Kitada, 2015). En aplicación a la EC, las metodologías orientadas a la medición de los flujos de materiales como el MFCA pueden aplicarse para medir la entrada de recursos naturales, el uso de materiales reciclables. Sin embargo, se consideran insuficientes para medir otras categorías de impacto relativas a las emisiones, al igual que la metodología relacionadas con la *Material Input Per Service* (MIPS) que permite cuantificar la intensidad del material aplicados a los productos, no proporciona información sobre las emisiones relacionadas o el uso de recursos reciclables (Elia et al., 2017).

Aunque en esta tesis no se aborde en profundidad la aplicación de MFCA, ya que requieren de un caso de estudio para su análisis, entre los indicadores planteados para la medición interna de la EC se contemplan algunos dirigidos al control de la intensidad de materias primas y al flujo de materiales y residuos (Aranda-Usón et al., 2018). Es por ello que se ha introducido su definición al tratarse además de una metodología de análisis de aplicación a la EC.

En una línea similar, ha quedado refrendada en la literatura la relación entre la EMA y la eco-eficiencia en su objetivo de aumentar la productividad y, por lo tanto, reducir los costes, a la vez que se mejora el desempeño ambiental (Bebbington, 2001; Burnett y Hansen, 2008). La eco-eficiencia (Huppes y Ishikawa, 2005) tiene implicaciones significativas para la contabilidad de gestión ambiental al permitir que las empresas aíslen y cuantifiquen los costes, los beneficios y los resultados operacionales de una gestión ambiental proactiva (Burnett y Hansen, 2008) e introduzcan el paradigma eco-eficiente en sus sistemas de control de gestión (Figge et al., 2002).

Korhonen et al. (2018) destacan el *material flow* como análisis esencial en este marco y resumen los ámbitos de análisis explorados a nivel micro en economía ecológica hacia la eco-eficiencia (Huppes y Ishikawa, 2005) y la ecología industrial (Ehrenfeld y Gertler, 1997) para diferencias los objetivos de tipo económico de la EC, resumidos en la reducción de materiales y recursos para el control de emisiones así como los riesgos y costes asociados

(medioambientales), y el objetivos social que la EC también entraña, centrado en la economía compartida y la toma de decisiones en colaboración para el valor compartido.

Desde otra perspectiva, las herramientas más propias de la EMA han sido aplicadas para el análisis y la gestión de las emisiones de gases de efecto invernadero (Qian et al., 2018) a través de técnicas de recopilación, análisis y comunicación de información específica para la contabilidad de costes medioambientales, de aplicación a la toma de decisiones de eco-inversiones. Para ello, la EMA ofrece información acerca de los impactos medioambientales de las empresas, el uso de recursos renovables y otras cuestiones sociales que resulta necesarias en un marco de EC y que no puede recabarse de la información contable convencional centrada principalmente en la los aspectos económico-financieros (Schaltegger et al., 2013).

Más propiamente en términos de EC, puede desprenderse que, a través de la aplicación de la EMA, el control de los costes medioambientales permitirá el análisis necesario para la reducción del impacto y la mejorar de la performance medioambiental de la empresa, así como de los productos (Bennett et al. 2003; Gibson and Martin, 2004), factores de gran interés para la implantación de la EC.

A partir de esta reflexión acerca de las principales aplicaciones de la EMA, puede considerarse adecuada su aplicación en entornos de EC ya que en la EMA también se incluye la parte contable de la evaluación de inversión de tipo medioambientales al objeto de valorar los costes en términos medioambientales de distintos proyectos de inversión en lo que concierne al consumo de recursos, el reciclado y revaloración de materiales u otras cuestiones relacionadas con los costes y, en su caso, riesgos de diferentes alternativas de inversión en términos medioambientales (Parker, 2000). En particular, esta vertiente de la EMA resulta de interés para la evaluación en términos medioambientales y económicos de las inversiones que requiere la implantación del modelo circular (Burrit 2009), y para analizar la relación las inversiones y la mejora el desempeño ambiental a largo plazo (Qian et al., 2018). De allí que sea de aplicación a esta tesis doctoral para la el análisis y medición de los recursos financieros aplicados a inversiones en EC.

En resumen, la EMA ofrece ventajas para las empresas en lo que concierne a la identificación, clasificación y asignación de costes e impactos relacionados con la actividad medioambiental para la toma de decisiones (Adams, 2002; Contrafatto y Burns, 2013; Dong y Burritt, 2010; Lohmann, 2009; Schaltegger et al., 2012), y por lo tanto resulta un ámbito de investigación aún poco estudiado pero de actualidad para la implantación de la EC.

Se puede afirmar que a pesar de las ventajas y aplicaciones que podría suponer para la implementación con la EC, su relación con la contabilidad medioambiental no ha sido aún analizada en profundidad en la literatura, salvo por los aspectos más ligados a la medición interna de los factores y la aplicación de herramientas a tal efecto que hacen ver cómo la EMA sea probablemente la más cercana al modelo circular en esta fase. Es por ello que esta tesis tiene como objetivo definir y medir el alcance de la EC en empresas en el ámbito de la EMA. A tal fin, a la hora de analizar de forma sistemática la EC y sus vínculos con la EMA, resulta de utilidad detallar aquellas actividades o principios que se consideran aceptados como parte integrante de la EC y ver la relación de los arquetipos principales del modelo respecto a las actividades circulares, haciendo lo mismo posteriormente con las prácticas más extendidas de la EMA.

Cabe destacar que los análisis apuntan a que la EMA supone unas ventajas para las empresas que la apliquen que incluyen la identificación de nuevas oportunidades, las mejoras en la reputación y en los procesos de toma de decisiones (Ferreira et al., 2010). No obstante, hay que tener en cuenta que, en la actualidad, las propias aplicaciones de esta contabilidad medioambiental están aún en una etapa temprana de desarrollo y las organizaciones se encuentran en una fase inicial de este proceso evolutivo hacia la denominada *Social and Environmental Accounting and Reporting* (SEAR) y la *Sustainability Accounting* (Bebbington y Larrinaga, 2014), lo que facilitaría la planificación de la explotación de recursos a través de la integración de información económica, ambiental y social (Burritt y Schaltegger, 2010).

A partir de estas consideraciones, y una vez constatado el incipiente desarrollo en el que se encuentra la medición interna de la actividad de cierre de círculos empresarial y que los estudios en ámbito contable son aún poco numerosos, se plantea esta tesis doctoral. El marco teórico en el que desarrolla la investigación se describe en siguiente apartado.

1.2 Marco teórico

Desde sus inicios, la ecología industrial y la economía industrial ofrecen un marco teórico para el análisis de la EC, al considerar el sistema económico como un subsistema dentro del sistema ecológico de la tierra, que tiene limitados tanto los recursos como la capacidad medioambiental. En este contexto, Liu et al. (2009), en línea con Pearce y Turner (1990), ubican el inicio del desequilibrio entre el ecosistema y el sistema económico en la época de la revolución industrial, señalando cómo la EC puede representar una potencial solución al

desequilibrio a través de la reducción de los flujos de materiales y propugnando que estos sean equilibrados y más sostenibles (Su et al., 2013).

Como se ha resumido en la introducción, la EC es un modelo económico en el marco del desarrollo sostenible que plantea la intersección efectiva de los aspectos ambientales y económicos que se incluyen y cuyo objetivo es la producción de bienes y servicios, reduciendo el consumo y el desperdicio de materias primas, agua y recursos. Estos procesos de ecología industrial requieren una planificación, medición y gestión de recursos y capacidades específicos que están en una fase incipiente de análisis en la investigación en economía financiera y contabilidad.

En la literatura a nivel micro, algunos estudios relacionados con la EC se han llevado a cabo en el marco de la teoría de *Stakeholders* (Walls y Paquin, 2015), la teoría institucional (Zeng et al., 2017), o se han centrado en la teoría de recursos y capacidades (de ahora en adelante citada como RBV por sus iniciales en inglés (*Resource-Based View*) (Aranda-Usón et al., 2019), en su evolución teórica de capacidades dinámicas (de ahora en adelante citada como *Dynamic Capabilities* (Katz Gerro y López Sintas, 2019). En este marco teórico, cabe mencionar que en el ámbito de la investigación en el ámbito contable el uso explícito de la RBV como base teórica no es muy frecuente, a pesar de su utilidad para cuantificar los recursos con los que cuentan las empresas y su organización para conseguir ventajas competitivas que deben tenerse en cuenta y señalarse en los informes, mejorando la transparencia y la rendición de cuentas (Mkumbuzi, 2015).

El desarrollo teórico de la EC en empresas está en una fase incipiente, y el conocimiento acerca de cómo las empresas entienden e introducen el modelo de EC todavía es limitado en la literatura actual. No es fácil por lo tanto optar por un enfoque teórico a la hora de analizar el desempeño ambiental de la empresa en términos de EC, ya que este modelo incluye acciones que afectan a todas las áreas funcionales de las empresas. Por lo tanto, en la fase inicial de esta tesis se tomó en consideración la estrecha relación que tiene la EC con la eco-innovación (Portillo-Tarragona et al., 2018) y se optó por adoptar la RBV como base teórica también para el estudio de la EC a nivel micro, supliendo así el "gap" existente en la literatura. Así, ante el desafío que conlleva el estudio de factores internos, como los recursos y capacidades relacionados con la EC en las empresas, se opta en esta tesis por explorar los recursos y las capacidades aplicadas a la EC por las empresas desde el enfoque teórico de la RBV y su evolución de *Dynamic Capabilities*.

Desde el marco teórico de la RBV (Barney, 2001, 1991), se ha demostrado que los recursos y las capacidades difícilmente imitables son relevantes para el éxito de la estrategia de la empresa (Penrose, 1959). En síntesis, la RBV resulta de interés para el ámbito de esta investigación ya que potencialmente puede explicar los principales motivos de la ventaja competitiva sostenida o los rendimientos obtenidos a través del acceso a recursos (Toms, 2010) en las fases de adopción de la EC por las empresas.

En esta tesis, la RBV se aplica para explicar por qué algunas empresas logran un mayor nivel de EC respecto a otras a través del análisis de los recursos disponibles y, en particular, de los recursos financieros para la obtención de un mejor desempeño ambiental, tal y como se desprende del análisis realizado en uno de los artículos que integran esta tesis (Artículo 4).

Asimismo, la perspectiva de *Dynamic Capabilities* (Teece, 2016; Teece et al., 1997) se aplica como base teórica en esta tesis para el análisis de la ventaja competitiva que la empresa obtiene a través de la aplicación de sus capacidades estratégicas en la gestión de recursos al objeto de alcanzar mejoras de tipo medioambiental y, en este caso, para la implantación de la EC. En el marco de las *Dynamic Capabilities*, la ventaja competitiva radica en la capacidad de la empresa para integrar, construir y reconfigurar sus capacidades para lograr un mejor ajuste con el entorno cambiante. De este modo, desde la perspectiva de la EC, las capacidades dinámicas se consideran adecuadas para el estudio de patrones circulares en las empresas (Katz Gerro y López Sintas, 2019) ya que este enfoque teórico permite capturar la estrategia ambiental proactiva relacionada con la sostenibilidad y que proporciona ventaja competitiva en entornos dinámicos (Garcés-Ayerbe et al., 2019).

Por lo anterior, en esta tesis se opta por adoptar el marco teórico de la RBV para el análisis de los recursos de la empresa aplicados a la EC, mientras que la investigación en las capacidades relacionadas con la EMA en las empresas se desarrolla sobre la base teórica de las *Dynamic Capabilities*.

1.3 Objetivos, Justificación y estructura de la tesis

Ante las consideraciones teóricas expuestas en el anterior apartado, el principal objetivo de investigación de esta tesis es definir y medir las actividades para el cierre de los círculos de materiales y recursos que las empresas están introduciendo y conceptualizar el nivel de adopción de la EC a nivel micro para realizar una aportación teórica y metodológica en el ámbito

de la contabilidad medioambiental y la EMA (medición para su posterior reporting) y su aplicación a las finanzas corporativas (toma de decisiones de inversiones en EC y su financiación).

Hasta el momento de emprender el desarrollo de esta tesis, la investigación de la EC a nivel micro sigue en una fase incipiente y representa un ámbito poco desarrollado en la literatura en la materia. Es por ello que para contribuir al conocimiento de la medición interna de la EC en empresa y su aplicación en el marco de la EMA, en esta tesis se plantea en primer lugar definir cómo las empresas pueden introducir las actividades de EC en función del territorio en el que operan, al considerar el marcado componente territorial para los flujos de materiales y recursos que la EC conlleva.

El principal objetivo planteado para esta tesis requiere de un trabajo previo de caracterización de empresas a nivel territorial para la medición interna de las actividades de cierre de círculos en distintos procesos y sectores. Asimismo, a partir de la definición de las actividades relacionadas con la EC que las empresas estén introduciendo, pueden desarrollarse indicadores para dimensionar el impacto socioeconómico que la EC empresarial a nivel regional. Esto permite medir internamente la actividad circular de las empresas en términos de la EMA y su comunicación en la actividad de reporting dirigida a los stakeholders. La definición y medición del nivel de adopción de la EC en la empresa abre además otro campo de investigación aún poco estudiado en la literatura como son los recursos financieros específicos, su tipología, calidad y disponibilidad para conceptualizar su aplicación a través de las capacidades específicas medioambientales de las empresas, en particular aquellas capacidades relacionadas con el ámbito contable para la gestión medioambiental.

A tal fin, tal y como se ha planteado en el marco teórico, en esta tesis la definición de los recursos y capacidades que las empresas aplican para el proceso de adopción de la EC se analizan sobre la base de la RBV en cuanto a los recursos, y desde el enfoque de las *Dynamic Capabilities* en lo que concierne a la definición inédita de las capacidades relacionadas con la EMA que las empresas despliegan para la adopción de la EC.

En resumen, esta tesis permite avanzar en el conocimiento sobre la medición interna de la EC y los recursos y capacidades relacionadas con su adopción por parte de las empresas, tal y como puede observarse de forma esquemática en la siguiente Figura en la que se describen los principales fines de la investigación y sus diferentes fases y las contribuciones alcanzadas:

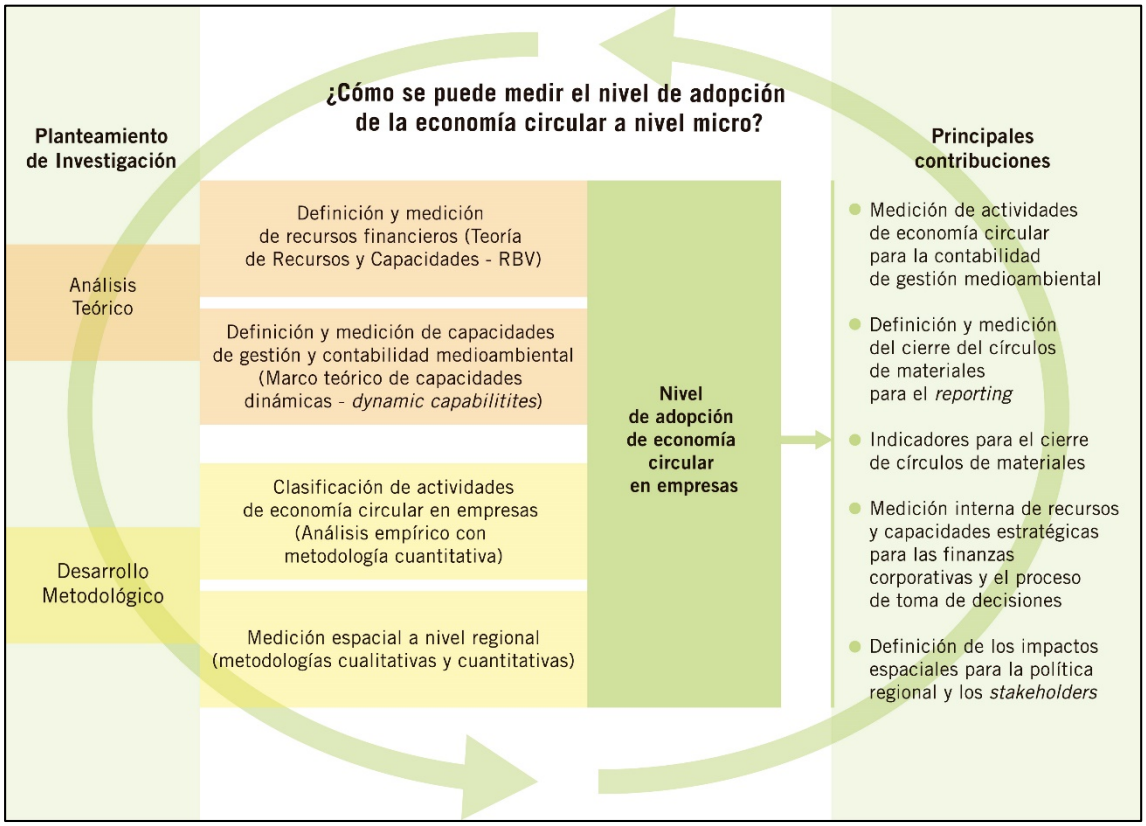

Figura 1.1. Esquema conceptual de la tesis

A través de este planteamiento conceptual resumido en la figura anterior, se contribuye al debate académico que sigue abierto en el ámbito de la contabilidad de gestión acerca de cómo medir el nivel de cierres de círculos a nivel micro para definir los mecanismos de decisión de inversión para el despliegue de la EC y de la movilización de los recuros financieros que son gestionados estratégicamente a través de las capacidades dinámicas de las empresas.

Para alcanzar los objetivos de investigación, se opta por diseñar una metodología de doble índole, cuantitativa y cualitativa, que se desarrolla a partir de la colaboración con empresas pro-activas en eco-innovación, eco-diseño y/o en EC., y se pretende así aportar herramientas metodológicas de medición interna de aplicación a disitintos sectores y procesos.

En resumen, a partir del análisis en profundidad de la literatura y al objeto de realizar una aportación al conocimiento en aquellas cuestiones aún objeto de debate en el ámbito de la economía financiera y la contabilidad para la implementación de actividades de EC a nivel micro, se desarrollan distintas preguntas de investigación para profundizar en los ámbitos anteriormente resumidos y que dieron lugar al desarrollo de los diferentes estudios publicados en los artículos científicos que conforman esta tesis doctoral. La estructura de la misma, organizada en 5 artículos relacionados entre sí por un hilo lógico de investigación, se resumen en la figura siguiente.

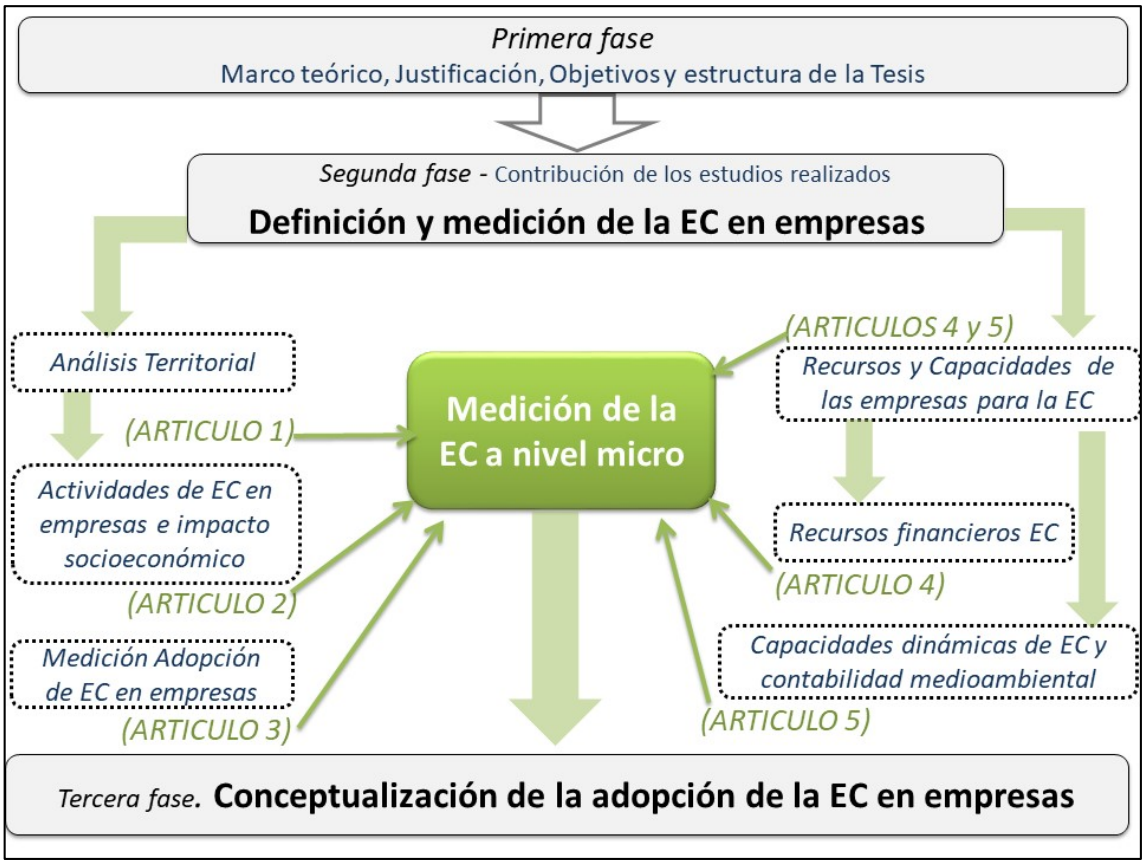

Figura 1.2. Esquema de la tesis

En los cinco artículos citados en la figura anterior se desarrolla una serie secuencial de preguntas de investigación que se respondieron a través de la aplicación metodológica y de la investigación descrita para cada publicación en los siguientes apartados.

1.3.1 Definición del papel de las empresas en la implantación de la economía circular a nivel territorial

A partir de la revisión de la literatura, podemos afirmar que la actividad de EC desarrollada por las empresas tiene una componente territorial aún poco estudiada en relación a los flujos de materiales, recursos y productos y que implica el necesario dimensionamiento del nivel de adopción de las empresas de la EC en un territorio determinado, tanto por su directa relación con el cierre de círculos a nivel local, como para el impacto socio-económico correspondiente.

Smol et al. (2017) proponen diferentes métricas para medir las exportaciones de productos de eco-industrias a nivel regional y miden el empleo generado por estas empresas en relación con la EC, así como su volumen de negocio, que se considera directamente relacionado con la actividad circular. Otros autores han analizado empíricamente la concienciación ciudadana y el comportamiento de las empresas en términos EC, en particular a nivel micro (Elia et al., 2017).

Sin embargo, el análisis espacial de la actividad empresarial dirigida al cierre de círculos en un territorio determinado no se había realizado hasta la publicación de esta tesis, que trata por lo tanto de responder a un "gap" de la literatura.

Así, a partir de otros estudios de política regional para la EC, aunque indirectamente relacionados con el ámbito de investigación micro objeto de esta tesis, en el primero de los artículos se realiza una contribución metodológica que tiene como objetivo definir las principales actividades que sustentan la EC a nivel regional desde una perspectiva holística, conceptualizando su adopción a nivel social, empresarial y en la administración pública. Como resultado para los fines de esta tesis, las principales actividades de EC en las empresas se han clasificado a través de un estudio de caso regional en la Comunidad Autónoma de Aragón en respuestas a las siguientes preguntas de investigación: (a) ¿Cómo se puede medir el nivel de adopción de la EC en un territorio específico? (b) ¿Cuál es el impacto de la EC y cómo puede medirse en un territorio?

Gracias a los resultados obtenidos en el primer artículo, se definieron los principios de EC que estaban siendo introducidos en las empresas y su fase de adopción. Además, a través de entrevistas semi-estructuradas realizadas a diferentes grupos de interés, se obtuvo una visión preliminar de las actividades empresariales más relevantes de cara a la EC para su posterior medición en el segundo artículo que se resume en el siguiente apartado.

1.3.2 Medición de las actividades de economía circular, nivel de adopción en empresas y su impacto a nivel regional

Los resultados obtenidos en el primero de los artículos, sirvieron de base para el desarrollo del segundo trabajo que integra esta tesis y en el que se plantea, además de un análisis más desarrollado de la implantación de la EC en las empresas a nivel regional un listado de actividades directamente relacionadas con la de EC y una metodología simplificada de estimación de los impactos regionales derivados de las actividades circulares llevadas a cabo por las empresas.

A pesar de las limitaciones señaladas anteriormente, algunos autores han propuesto indicadores para la medición de los flujos de material, energía y agua en las diferentes etapas de implementación de la EC (Van Berkel, 2010). A partir del análisis de los sistemas que podrían ser de aplicación a los objetivos planteados en esta tesis, podemos afirmar que hasta la fecha no se disponen de sistemas de medición integrados para determinar el nivel de circularidad alcanzado por una empresa en su conjunto. Los indicadores propuestos en la literatura tienen

fortalezas y debilidades, y ninguna metodología específica para medir la EC empresarial ha ganado un amplio apoyo académico. Además, cabe destacar que las fuentes de datos son limitadas, ya que se requiere de datos recabados directamente desde las empresas que no pueden obtenerse a través de bases de datos en la actualidad. Además, también es importante tener en cuenta la relevancia de los factores relacionados con la estructura territorial, las variables socioeconómicas y el impacto de las iniciativas gubernamentales a nivel regional y local (Jacobsen, 2006b).

Ante estas premisas, las preguntas de investigación desarrolladas en la segunda etapa de la investigación fueron las siguientes: (a) ¿Cuáles son las actividades relacionadas con la EC más extendidas en las empresas que operan en sectores sensibles a la adopción de la EC en un marco territorial?; (b) ¿Cuál es el impacto del cierre de círculos alcanzado por las empresas en un territorio?

Para contestar a las preguntas de investigación, en este segundo artículo se estudia, en un mismo marco analítico, la implementación de EC en empresas y el impacto que supone la actividad llevada a cabo para el cierre de círculos a nivel territorial, planteándose que la EC se está analizando en la literatura a distintos niveles (Franco, 2017). Para alcanzar este objetivo, tras realizar un análisis de la literatura, se amplía a una segunda fase el caso de estudio regional en la Comunidad Autónoma de Aragón, al que se añade el análisis cuantitativo de una muestra de empresas, tal y como se explica en detalle en el apartado dedicado a la metodología de este capítulo. Gracias a la investigación realizada, en este segundo artículo de la tesis se ha realizado una aportación tanto teórica como metodológica para la definición y medición de la EC en el territorio desde la óptica de la actividad empresarial y se ha podido dimensionar el impacto socio-económico que el cierre de círculos alcanzado en las empresas supone en la región, siendo una metodología simplificada de gran interés.

A partir de los resultados anteriores, se plantearon nuevas preguntas de investigación que se enumeran a continuación y que fueron abordadas en el tercero de los artículos que integran esta tesis: (a) ¿Cómo están introduciendo las actividades relacionadas con la EC las empresas a nivel territorial); (b) Influye la situación territorial en la adopción de las actividades de EC por parte de las empresas?

Al objeto de ampliar los resultados obtenidos en las fases anteriores de la investigación, en este artículo se ofrece un análisis inédito de las actividades relacionadas con la EC que las empresas están adoptando a nivel territorial que se clasifican en cuatro niveles, a partir de la consideración del impacto que suponen estas actividades en términos de cierre de círculos de

materiales en la EC a nivel micro. Las actividades incluidas en el primer grupo, definido como nivel I 'REC', están relacionadas principalmente con el reciclaje y la eficiencia energética y se consideran como la primera etapa de la adopción de la EC porque se han introducido ya en numerosos sectores. El grupo de actividades definido como "SIM" que integran el nivel IV incluye soluciones de simbiosis industrial o tecnologías de ecología industrial y, dado que no se suelen implementar con frecuencia, se considera la etapa más avanzadas de la adopción de la EC. El grupo definido como nivel III "VALW", incluye actividades de desmaterialización, energías renovables y materias primas secundarias, mientras que otras actividades como la eco-innovación y el eco-diseño se incluyen en el segundo grupo definido de nivel II "DES".

Esta agrupación permite definir y medir el progreso de las empresas hacia la EC por utilizando un conjunto de indicadores de aplicación a las realizadas por las empresas que se consideran relevantes en términos de EC en un territorio determinado. Como principal resultado se pudo apreciar una tendencia incremental en la adopción de las actividades a nivel micro. Aun quedando de manifiesto el carácter progresivo de la introducción de la EC, no quedó demostrado que las empresas estén adoptando la EC con el objetivo principal de cerrar los círculos de materiales, siendo el proceso influido por diferentes factores del contexto regional en el que se localizan las empresas. Los avances obtenidos en la medición y en los indicadores aplicados permitieron ampliar el conocimiento en el ámbito de la EMA para la EC.

1.3.3 Caracterización y medición de recursos financieros para las inversiones en economía circular empresarial

A partir de la revisión de la literatura y de los resultados alcanzados en los dos artículos anteriores, en el cuarto de los trabajos publicados que integran esta tesis, se perfila la medición del nivel de EC alcanzado por una muestra de empresas que se detalla en el siguiente apartado de metodología. La medición empírica de las actividades e inversiones que las empresas realizan en la actualidad directamente relacionadas con el cierre de círculos propugnado por la EC ha permitido el diseño de un constructo de indicadores que representa uno de los resultados de la tesis de mayor alcance en términos de EMA, ya que proporciona el definido como "circular scope" de una empresa en su conjunto (Artículo 4).

En resumen, el marco teórico de la RBV se aplica en el estudio que dio lugar a la cuarta publicación para ampliar el conocimiento en las finanzas corporativas en ámbito de EC a nivel micro. Asimismo, este enfoque teórico, permite analizar si la cantidad de recursos financieros está relacionada con la mejora medioambiental y el desempeño en términos de EC de las

empresas. La definición y medición de los recursos financieros específicos aplicados a las inversiones de EC se desarrolló a partir de las siguientes preguntas de investigación: (a) ¿A un mayor nivel de inversión corresponde un mayor nivel de EC en las empresas?; (b) ¿Qué características de los recursos financieros están relacionadas con el nivel de inversión en EC en las empresas?; (c) ¿Las decisiones financieras sobre la naturaleza de los recursos están relacionadas con el nivel de inversión en EC en las empresas?; (d) ¿Qué actividades de carácter medioambiental están influyendo en el alcance circular de las empresas?

La relación entre el nivel de circularidad introducido por las empresas ("circular scope") y los recursos financieros movilizados representa el resultado principal de esta fase de la tesis, conllevando una aportación tanto de carácter metodológico en cuanto a la medición y caracterización de recursos financieros y del nivel de introducción de las actividades de EC en las empresas, como de carácter teórico ya que explora un campo de análisis inédito hasta la publicación de esta tesis aplicando la teoría de RBV a la EC. El constructo de indicadores aplicado a la medición del "circular scope" se aplicó también al estudio de otras capacidades de la empresa relacionadas con la contabilidad medioambiental.

1.3.4 Definición y medición de capacidades específicas de contabilidad medioambiental para la adopción de la economía circular en empresas

Al objeto de ampliar el análisis de la relación de la EC también con las capacidades de las empresas, la investigación expuesta en el quinto artículo se fundamenta en el marco teórico de las *Dynamic Capabilities.* Los sistemas de gestión ambiental, la RSC, el *reporting* y otras prácticas de contabilidad medioambiental se estudian en el mismo marco de análisis para medir su impacto en el alcance circular ("circular scope") de las empresas.

En el contexto de las capacidades más propiamente ligadas al ámbito contable y otras capacidades relacionadas con la gestión medioambiental aplicadas por las empresas para introducir la EC, el estudio de la EMA bajo el marco teórico de las *Dynamic Capabilities* es bastante original y representa una aportación de esta tesis ya que permite explorar la relación entre la EC y la EMA que, en estudios anteriores, se había estudiado en relación con la gestión de residuos y las actividades de reciclaje (Qian et al., 2011), los flujos energéticos, de agua y materiales (incluidos los residuos); los costes, los beneficios y los ahorros derivados de las actividades de mejora medioambiental.

Con la introducción de actividades relacionadas con la EC, se experimentan cambios en las empresas que implican una modificación de los mecanismos de control en el ámbito de la

sostenibilidad (Qian et al., 2018). Por lo tanto, en este artículo, se refuerza la idea de que el uso de herramientas de EMA está asociado con la gestión de EC y la calidad en el *reporting*. Las capacidades relacionadas con la EMA medidas en este artículo incluyen la disponibilidad de recursos humanos para actividades de gestión medioambiental, lo que confirma los resultados anteriores obtenidos para la eco-innovación (Scarpellini et al., 2017), y están parcialmente conectados con los valores de los administradores pro-ambientales analizados por Luque-Vílchez et al. (2019) para garantizar la calidad de la divulgación medioambiental.

Los resultados obtenidos demuestran una relación positiva entre el alcance circular de las empresas, sus prácticas de contabilidad medioambiental y su nivel de RSC. La ejercida por los *stakeholders*, que tiene un efecto mediador en el "circular scope" de las empresas, también se aborda en esta fase de la tesis, aportando nuevos conocimientos a los estudios recientes sobre la EC a nivel micro.

Con estos resultados, esta tesis contribuye a cerrar la brecha entre la investigación académica en el ámbito de la contabilidad ambiental y la investigación académica de EC a nivel micro, ya que se definen unas capacidades específicas de tipo contable de carácter inédito.

1.4 Enfoque metodológico

Para dar respuestas fundamentadas a las preguntas formuladas, se opta por aplicar un doble enfoque metodológico, cualitativo y cuantitativo. Cabe mencionar que en la actualidad no se dispone de un indicador integrado que resume el nivel de "circularidad" alcanzado por una empresa a nivel corporativo, tal y como se detalla posteriormente en los artículos que integran esta tesis. Por consiguiente, para la medición interna del alcance de la EC resulta necesario obtener información específica directamente desde aquellas empresas que se hallen inmersas en un cambio pro-ambiental, siendo esta una de las principales limitaciones existentes para la investigación en este campo al tratarse a menudo de datos de carácter confidencial. A su vez, los indicadores existentes no pueden aplicarse a la medición espacial de la introducción de la EC empresarial a nivel territorial, representando uno de los campos de investigación aún abierto a nivel micro.

Ante estas premisas, en la primera fase de la investigación se plantea realizar un estudio de caso a nivel regional del nivel de implantación de la EC en el territorio y así definir las principales actividades empresariales relacionadas con el cierre de círculos. El estudio del caso resulta de

utilidad para una investigación preliminar pensada para generar ideas, hipótesis o preguntas de investigación que posteriormente se someten a comprobación empírica, permitiendo así una generalización al tener en cuenta el poder explicativo del análisis cualitativo. El análisis de un caso específico empleando la teoría permite comprender la unicidad del alcance territorial de la EC.

Para responder a la primera de las preguntas de investigación y definir qué principios de EC son de interés a nivel micro y están siendo introducidos en las empresas, se aplicó un doble enfoque metodológico en un caso de estudio regional en Aragón y se llevaron a cabo 21 entrevistas semi-estructuradas (en profundidad). Estas entrevistas permitieron analizar la percepción acerca del nivel de adopción de la EC y de actividades de cierre de círculos en los diferentes ámbitos social, empresarial y de la administración pública. Más concretamente, en esta tesis se profundiza en los resultados obtenidos de las entrevistas para la definición de las los principios y actividades de interés para las empresas en cuanto a EC (ARTÍCULO 1) y en la definición de los sectores de interés para el análisis cuantitativo. Cabe mencionar que las entrevistas semi-estructuradas también han sido consideradas como un instrumento valioso (Hovik et al., 2015) para la compilación de datos, permitiendo el análisis de territorios y unidades locales con diferentes características. Las entrevistas semiestructuradas también se han utilizado en otros estudios específicos de EC porque permiten procesar información que de otro modo no podría recopilarse sistemáticamente a través de informantes clave (Geng et al., 2009).

En síntesis, las fuentes de los datos empleados para esta tesis son los que se detallan a continuación:

<table>
<tr><th></th><th>Recursos financieros</th><th>Capacidades medioambientales</th><th>Medición territorial y stakeholders</th></tr>
<tr><td>Características económico-financieras</td><td>DB SABI</td><td>ENCUESTAS</td><td rowspan="2">Entrevistas semi-estructuradas y datos estadísticos</td></tr>
<tr><td>Inversiones y actividades relacionadas con la economía circular</td><td colspan="2">ENCUESTAS</td></tr>
</table>

Figura 1.3. Fuentes de datos empleados para la investigación

En una segunda fase de investigación, al objeto de delimitar el alcance circular por sectores y los principios de EC se realiza una clasificación en el territorio por la que, a partir de la

definición de "sector ambiental" propuesta por la OECD (2009) y Eurostat (2009), se consideran los sectores o sub-sectores de residuos como estratégicos para la EC, los que integran las agrupaciones 37, 38 y 39 de la clasificación CNAE (2009) y que reúnen a las empresas de tratamiento y reciclado de residuos, de gestión de los procesos de tratamiento y depuración de aguas residuales, gestión y tratamiento de residuos y otros servicios de gestión de residuos.

A las empresas pertenecientes a los sectores de reciclado y residuo se añaden para el análisis regional empresas de los demás sectores industriales, considerados como 'sensibles' a la introducción de la EC. A partir de los datos estadísticos autonómicos de los sectores anteriormente descritos, se calcula el impacto socioeconómico (fundamentalmente empleo, materias primas y volumen de negocio) derivado de actividad relacionada con la EC en empresas, estimada a través del porcentaje de las actividades relacionadas con la EC que estas han introducido (aprox. 6%). Esto puede estimarse a partir de la definición de las actividades que las empresas hayan introducido en la actualidad que tenga impacto y/o relación con el cierre de círculos planteado por la EC (ARTÍCULO 2), como una de las aportaciones metodológicas de esta tesis (ARTICULOS 1 y 2). A continuación, se realiza un análisis empírico de las referidas actividades por parte de las empresas (Artículo 3).

En la tercera fase de investigación, se procede a realizar un análisis y medición de los recursos y capacidades específicas en el ámbito de conocimiento de la economía financiera y la contabilidad. A tal fin se opta por la aplicación de una metodología de ecuaciones estructurales (PLS-SEM) a una muestra de empresas, que permite caracterizar los recursos financieros aplicados a las actividades de EC de las empresas y la relación entre estos recursos y el alcance de EC empresarial.

El análisis se realizó a través de encuestas que se enviaron a empresas que colaboraron con un proyecto de I+D en el noreste de España. Las empresas seleccionadas tienen más de 50 empleados, al considerarse el tamaño como un factor que facilita los procesos eco-innovadores (Aboelmaged, 2018; Triguero et al., 2015; Wagner, 2007; Zhang y Walton, 2017) y se consideró como una característica relevante de las empresas para la transición de un modelo lineal a un modelo circular. Para la muestra se seleccionaron empresas que operan en sectores con mayor potencial para la incorporación de la EC en sus procesos y con proactividad hacia la eco-innovación, el eco-diseño y la EC. Se consideraron por lo tanto empresas de los sectores relacionados con las tecnologías incluidas en las "Mejores Técnicas Disponibles", los llamados "BREF": industrial, transporte y logística, residuos, industria extractiva, industria manufacturera, electricidad, gas, vapor y aire acondicionado, suministro de agua,

alcantarillado, gestión de residuos, y su transporte y almacenamiento. En estos sectores, la introducción de los principios de la EC es tanto necesaria como tecnológicamente factible (European Commission, 2017).

La muestra se obtuvo a partir de una población de 2.232 empresas elaboradas a partir de la base de datos SABI, que proporciona las principales cifras económicas y financieras de las empresas de la península ibérica. Se enviaron un total de 996 cuestionarios por correo electrónico a las empresas de la población inicial de las que se disponía de información de contacto detallada. Finalmente, se obtuvieron 110 respuestas, 87 de ellas se consideraron observaciones válidas a efectos de esta tesis, lo que representa una muestra del 8.8% del total. Cabe mencionar que al disponer del código de identificación fiscal (CIF) de estas empresas pudieron obtenerse sus datos económicos y financieros para el análisis. El desarrollo y aplicación de la metodología se detallan en los artículos cuarto y quinto.

A través de esta metodología se avanza en el conocimiento de la medición interna de la EC a través de la definición de un constructo que permite la medición del alcance de las actividades relacionadas con la EC a nivel de empresas ("circular scope"). Este constructo se relaciona con los recursos financieros, aún poco estudiados en la literatura, que las empresas aplican a las actividades de EC (ARTICULO 4) y con las capacidades de las empresas relacionadas con el nivel de adopción de EC. En particular, a través de la metodología de ecuaciones estructurales se definen y miden las capacidades de contabilidad medioambiental de las que disponen las empresas para gestionar de forma eficiente a los recursos aplicados a la EC, siendo esta una de las aportaciones metodológicas relevante en cuanto a su medición y análisis (ARTICULO 5). El enfoque metodológico planteado puede describirse gráficamente como se muestra en la Figura 1.4.

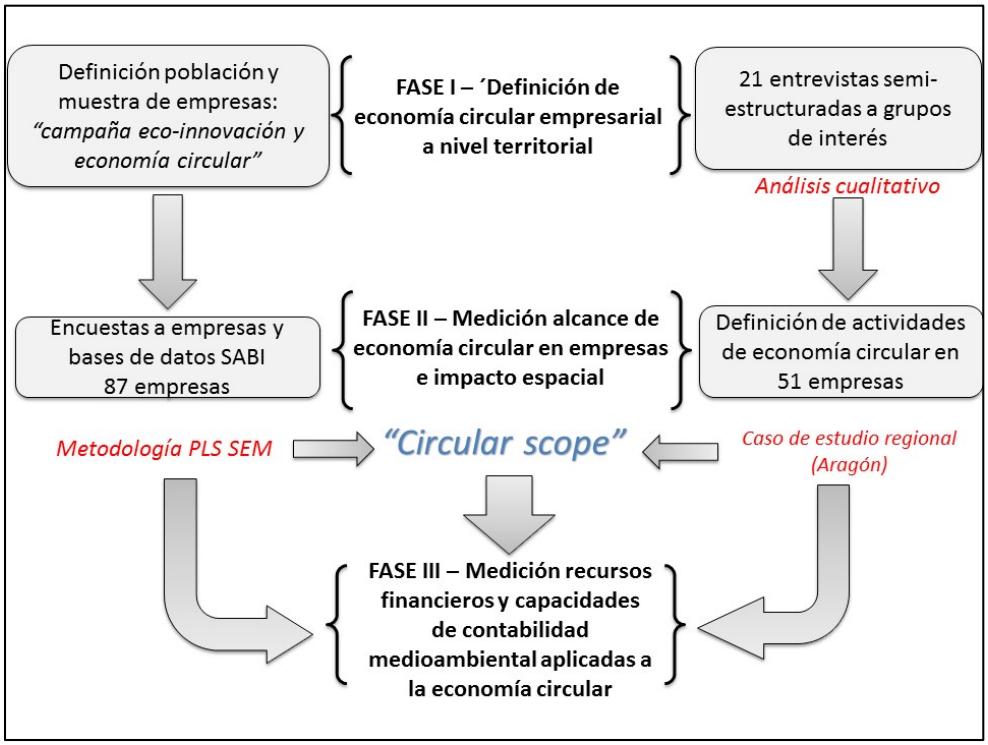

Figura 1.4. Doble enfoque metodológico a lo largo delas tres fases de la investigación

En resumen, en esta tesis se aplican varios métodos y enfoques de análisis. La metodología cualitativa de estudio de casos regional se aplica para obtener un primer nivel de resultados, dirigido a la definición de indicadores para la medición del alcance de la EC en empresas para su aplicación a la contabilidad directiva y al control de gestión. La información recabada de las entrevistas semi-estructuradas permite medir el impacto de la actividad empresarial ligada a la EC, como primer desarrollo metodológico novedoso que aporta esta tesis. A este se añade la definición de un constructo inédito para la medición del alcance de la EC implantada por las empresas, siendo un indicador integrado que no se había desarrollado con anterioridad.

Los resultados obtenidos a través de la aplicación de las metodologías descritas en este apartado se detallan en los artículos que integran esta tesis y que se incluyen en los siguientes apartados.

2 Parte segunda. Contribución de los estudios realizados

2.1 Definition and measurement of the circular economy's regional impact (Artículo 1)

ARTICULO: Scarpellini, S., Portillo-Tarragona, P., Aranda-Usón, A., & Llena-Macarulla, F. (2019). Definition and measurement of the circular economy's regional impact. *Journal of Environmental Planning and Management*, *62*(13), 2211–2237.

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JCR SOCIAL – Development Studies	1,855	16/41	Q2
JCR SOCIAL – Regional and Urban Planning	1,855	27/39	Q3

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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 Moriguichi 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 Moriguichi 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 (Huppes 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 Moriguichi 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 Moriguichi 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 highighted 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 *et al*. 2007; Su *et al*. 2013; Van Berkel *et al*. 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 *et al*. 2009; Pajunen *et al*. 2013; Su *et al*. 2013; Van Berkel *et al*. 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 *et al*. 2012; Geng *et al*. 2009; Yuan, Bi, and Moriguichi 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 *et al*. 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, Gnoni, 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 Aragon 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 model[1].

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/km^2) 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 scale[2]. 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

	SEPW	SERV	SECO	TOTR
Mean	3.00	2.40	2.80	2.30
Mode	4.00	4.00	4.00	1.00
Median	3.00	2.00	3.00	2.00
Std deviation	1.03	1.23	1.11	1.17

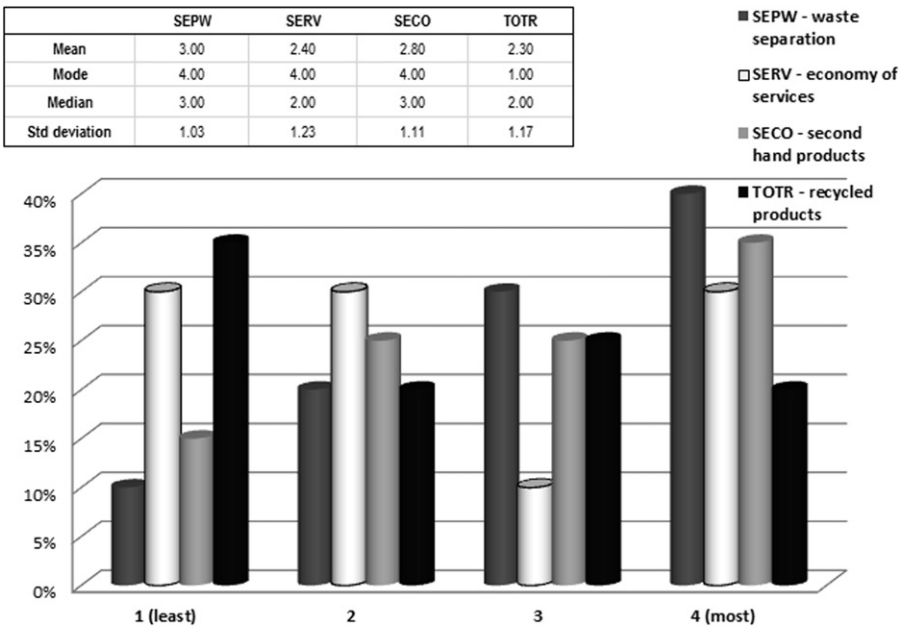

Figure 1. Relevance of the principal CE measurements for the domestic sphere at regional level.

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

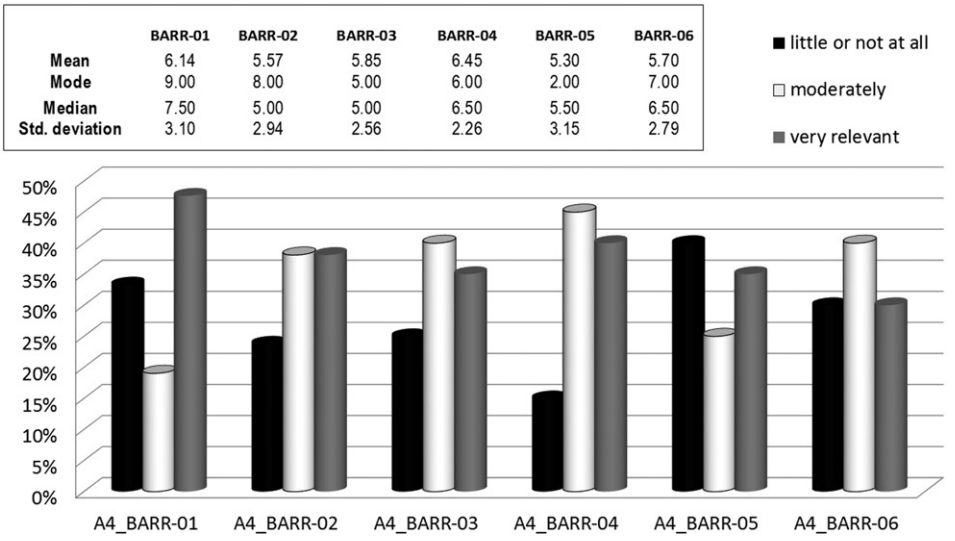

Figure 2. Relevance of barriers to the adoption of CE principles.

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.

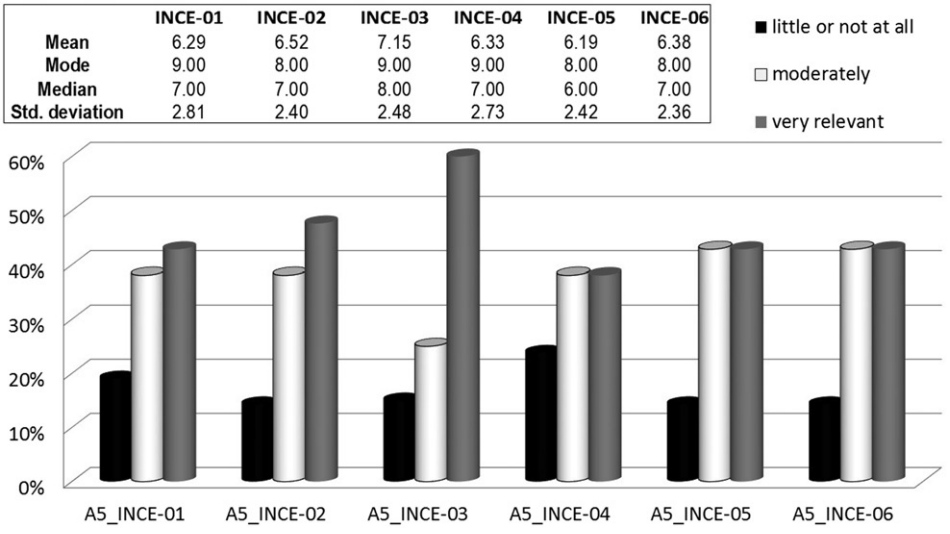

Figure 3. Relevance of incentives in promoting the adoption of CE principles.

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

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,

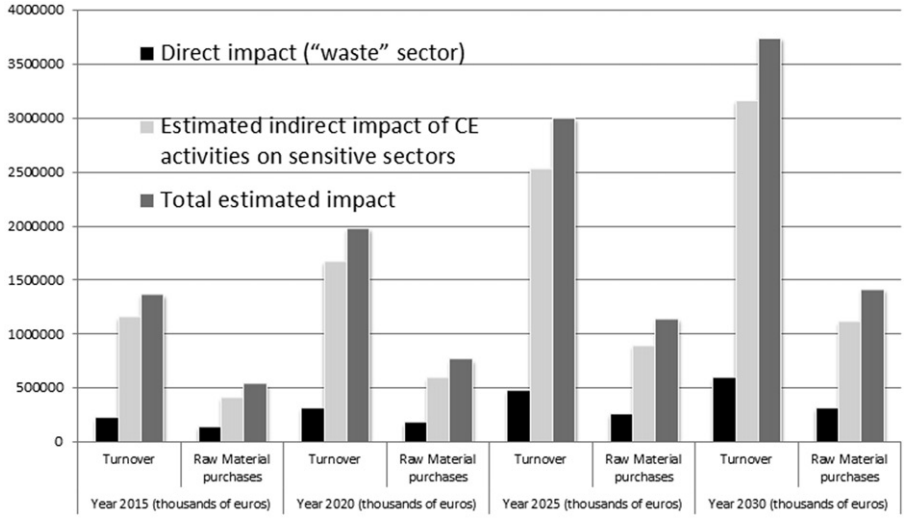

Figure 4. Estimation of the economic impact of activities related to the CE on the region (authors' compilation from data from the Instituto Aragonés de Estadística, 2014).

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

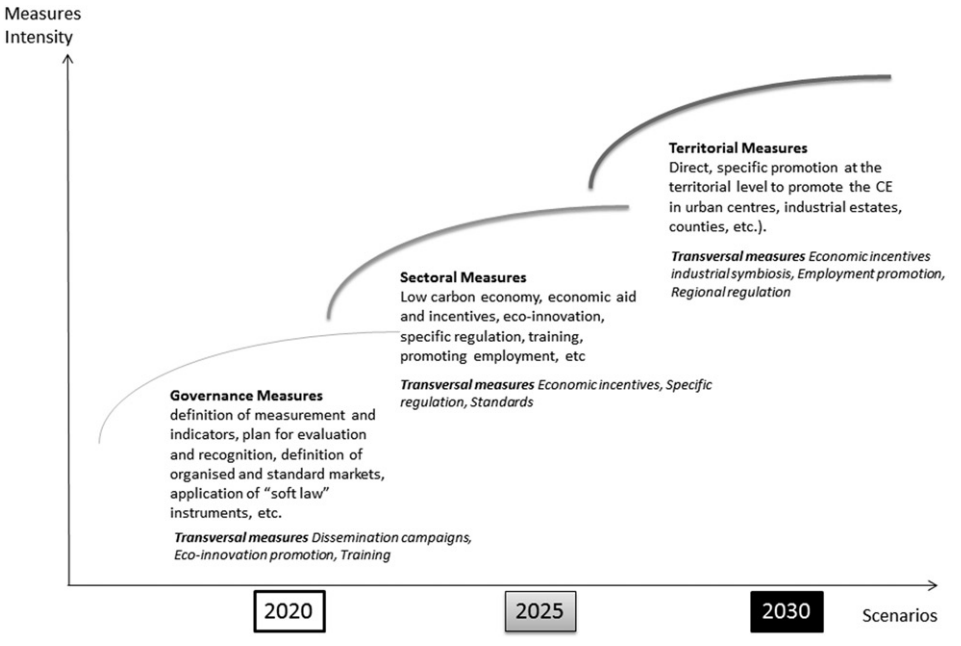

Figure 5. Main measures to be included in the environmental regional plans for different scenarios depending on the intensity of the level of CE adopted at regional level.

(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 Aragon (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 Aragon: actions for its socioeconomic promotion and impact in the Autonomous Community of Aragon" 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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2.2 Measurement of the circular economy in businesses: Impact and implications for regional policies (Artículo 2)

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Aportación inherente al área de conocimiento: Contabilidad medioambiental y social - Indicadores de impacto social, económico y medioambiental.

Measurement of the circular economy in businesses: Impact and implications for regional policies

Alfonso Aranda-Usón[*], *José M. Moneva*[**], *Pilar Portillo-Tarragona*[***] and *Fernando Llena-Macarulla*[****]

Abstract

Currently, numerous governments and international organisations are promoting the implementation of the circular economy – both within the EU and in other regions – as an alternative to lineal models, and in search of a compromise between competitiveness and the sustainable exploitation of resources.

The implementation of a circular business model is closely tied to the territory within which firms operate. As a result, firms are highly sensitive to the existence of favourable conditions at the regional level, which can greatly accelerate the transition towards circular models and regions play a relevant role in the adoption of the circular economy principles by the private sector.

Similarly, the adoption of models based on circular economy principles at the micro level has an effect on macro indicators at the regional level, especially concerning the flow of raw materials and other resources, and this contributes to ensuring that quality standards and resource availability are maintained throughout the value chain. The effects of the adoption of these models on a territory can be measured in terms of volume of transactions, generation of jobs and consumption of raw materials. In this context, this study aims to contribute to the measurement of the activities related to the circular economy that have been implemented at regional level by business. This allows us to improve the knowledge of the socioeconomic impact of the circular economy, and offer an empirical approach for the development of specific regional policies to improve the circular economy in businesses.

Keywords: circular economy, environmental accounting, environmental policy, business, corporate finance.

JEL classification: M21, M140, Q560

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1. Introduction

Today, the concept of circular economy (CE) is used by policy makers, academics and practitioners to refer to a sustainable economic model that does not compromise economic growth (Pratt, Lenaghan, & Mitchard, 2016). The CE paradigm is characterised by efficient flows of resources, waste, energy, materials, labour and information, which ensure that natural and social capital is constantly replenished. The aim of a CE is to create circular (closed) loops in which raw materials and other resources are used repeatedly in different phases (Yuan et al., 2006), allowing for the added value of products to be maintained for as long as possible while contributing to waste reduction.

There is wide agreement that the CE can offer an attractive and viable alternative to lineal 'take, use and discard' models, generating value both, for private firms and for society in general. In this regard, the competitiveness of private firms depends on reaching a compromise between productivity and the sustainable and efficient use of resources, prompting private firms to achieve 'more with less' in their transactions (Ellen MacArthur Foundation, 2015b). As such, these models are being promoted by numerous governments and international organisations in the EU and in other.

CE is becoming an increasing object of attention among academics of the social sciences field. A growing number of quantitative studies are contributing to examination and development of the model (Ghisellini, Cialani, & Ulgiati, 2016; Kirchherr, Reike, & Hekkert, 2017; Korhonen, Honkasalo, & Seppälä, 2018; Merli, Preziosi, & Acampora, 2018; Pomponi & Moncaster, 2017; Urbinati, Chiaroni, & Chiesa, 2017). Private firms are also showing a burgeoning interest in CE (Lewandowski, 2016), although the adoption of this model by private firms remains poorly understood (Stewart & Niero, 2018). To date, the literature has mainly been focused on the factors that affect the commitment of private firms to the CE, existing barriers and incentives to the adoption of the model, and the impact of CE on the organisation of firms. The measurement of CE on firm performance is still under discussion, and, to the best of our knowledge, no empirical results concerning the dissemination of the model within a given territorial framework or its impact, exists. For this reason, the present study focuses on the analysis of territorial promotion of the CE, with the ultimate aim of evaluating its impact at the micro level and its implications at the regional level.

As such, this article considers the adoption of the CE in the private sector and its impact at the regional level within the same analytical framework, while also considers the different analytical frameworks in which the issue is currently being examined in the literature (Franco, 2017). In order to do this, after investigating the general background, we shall analyse the adoption of the CE in businesses located on a Spanish region. This approach will result in theoretical and methodological considerations as to how to measure the adoption of the CE in the private sector within a given territorial framework. This private-sector focused perspective will give a specific context in which to introduce the concept of CE. Finally, we summarise the main results to state conclusions and to reflect on future perspectives and challenges in the mid- and long-term.

2. Background

In general, the principles of the CE were developed within the theoretical framework of ecological economics. In this framework, the economy is considered a subsystem of the ecological system, the environmental and material resources of which are limited. Liu et al. (2009), following Pearce and Turner (1990), consider that the unbalanced relationship between ecosystem and economy began with the industrial revolution, going on to argue that the CE is a potential solution as it contributes to more balanced and sustainable material flows (Su et al., 2013).

As noted in the introduction, a CE offers a sustainable growth-based model which advocates for the effective integration of environmental and economic factors, with the aim of achieving the production goods and services while reducing the consumption and waste of raw materials, water and other resources. With the adoption of the model by private firms (Li et al., 2010), the CE can contribute to a more efficient use of raw materials and resources (Liu et al., 2009), and to cleaner production and greater efficiency by increasing circularity and a fuller use of resources (Jun & Xiang, 2011; Van Berkel, 2010).

The effective implementation of a CE results in more innovative, resilient and efficient production models. Improved material flows limit firms' exposure to price volatility, while innovation generates jobs and increases economic resilience; conversely, territorial degradation, loss of fertile soils and biodiversity, is very costly in economic terms (Ellen MacArthur Foundation, 2015a).

The European Commission argues that in a CE the added value of products can be maintained for longer while reducing waste (European Commission, 2014), with repeated reuse of products that have otherwise reached the end of their life-cycle thus generating more value. The advantages of this productive model are leading numerous governments and organisations to promote its adoption at the territorial level. The development of the circular model is closely dependent on a regional system's ability to sustain innovation and enhance its industrial profile (Coats and Benton, 2015; Walendowski et al., 2014). As such, there is little doubt that regional and local public policies can contribute to promote development models such as that presented by the CE.

In the European Union (EU), the communication 'Towards a circular economy: A zero waste programme for Europe' and its annex (European Commission, 2014) laid foundations for the promotion of CE in the EU's member states. These recommendations were further developed the following year in the communication 'Closing the loop: An EU action plan for the circular economy' (European Commision, 2015). The key measures recommended in these communications chiefly addressed production (product and process design), consumption (consumers and collaborative economies), waste management (establishing a hierarchy of waste, among other considerations) and the transformation of waste into resources. Priority action areas included management of plastics, food waste, critical raw materials, construction sector waste, biomass and bio-products, as well as innovation, investment and other horizontal measures. Among the EU's ongoing initiatives are those concerning plastics (European Commission, 2018a), energy extraction from waste (European Commission, 2017) and critical raw materials (European Commission, 2018b), in addition to those concerning renewable energy, eco-design and energy efficiency.

The priorities set forth by the EU incorporate the measures that most developed countries promoting CE consider to be most relevant (Mathews & Tan, 2016). China led the way in enacting the Circular Economy Act (Republic of China, 2008) (Republic of China, 2008), which was the first time that the promotion of CE was elevated to the status of law. This Act is based on the '3R principle' (reducing, reusing and recycling), and considers re-manufacturing to be an effective way of promoting CE (Zhang et al., 2011). Similarly, other countries such as Japan and the United Kingdom (Despeisse et al., 2015) are using the principles of CE to promote recycling and product reuse. Other EU member states have adopted several measures conducive to the implementation of CE principles, including subsidies for eco-design, the public acquisition of products and services that meet CE-based environmental standards, tax breaks for green technologies, and the promotion of recycled or sustainable materials, etc. (Portillo-Tarragona, Scarpellini, Llena, & Aranda-Usón, 2017).

Promoting a circular economy has been identified as China's basic national policy since 2005 (Zhijun & Nailing, 2007). Nowadays, the development of China's CE is higher in such regions where governmental officials have better awareness and strong drivers to make changes (Xue et al., 2010). However, some challenges have been pointed out in order to improve the introduction of the CE in China, such as a lack of reliable information, shortage of advanced technology, poor enforceability of legislation, weak economic incentives, poor leadership and management, and lack of public awareness (Su et al., 2013).

At present, in Spain the promotion of CE is still under development, and a few public policies have focused on activities at the end of the economic cycle, such as waste management, for which a mid-term national plan is currently being implemented (Fundación COTEC para la Innovación, 2017). Regional and local initiatives that aim to promote the establishment of closed material loops within the framework of the National Strategy for the Promotion of Circular Economy for 2030 are also worth mentioning (Gobierno de España, 2018)[1]. However, although governments, private firms and wider society increasingly recognise the advantages of a CE, numerous barriers to its effective implementation still exist. The transition towards a CE needs to be encouraged both from the bottom up, as a result of changing social preferences, and from the top down, by government (EOI, 2016), so that all stakeholders – private firms, government and society – become fully involved.

Firms are highly sensitive to the existence of favourable conditions at the regional level, which can greatly accelerate the transition towards circular models (Yi & Liu, 2015). Regulation and public support increase the adoption of sustainable manufacturing practices such as the CE (Moktadir, Rahman, Rahman, Ali, & Paul, 2018). The CE is influenced by geographical proximity since the approach of activities at local and regional level helps to reduce the costs derived from broader circuits with a greater number of transactions (Stahel, 2013). Thus, local and regional authorities can also play an important role in both, the launch of and transition to a CE (Yi & Liu, 2015) because the implementation of a circular business model is closely tied to the territory within which firms operate.

[1] While the current paper was being prepared, the strategy was pending official endorsement.

As with all transitional processes, the CE-related benefits will not be evenly distributed: it is likely that some industrial sectors, firms, regions and social groups will be relatively worse off, while others benefit. The ability to reap these benefits will largely depend on the ability and the agility with which the relevant skills are acquired by both firms and public institutions, factors that are largely dependent on the regional setting (EEA, 2016).

The predicted environmental, economic and social advantages of the CE are summarised by the European Environment Agency (EEA, 2016). The main advantages have to do with resource-use efficiency (European Union, 2013) and the bridging of the current gap between economic growth resulting from the use of these resources and levels of social and environmental wellbeing. It is argued that a CE must go beyond the EUs current waste-reduction policies because keeping materials in the economic loop for longer will help to increase the resilience of ecosystems and avoid the environmental impact of resource extraction, which often takes place outside Europe. It is also argued that this could lead to a reduction in greenhouse gas emissions in the EU of 48% by 2030 and 83% by 2050, compared to 2012 levels, while cutting down €500 million in externality costs by 2030 (Ellen MacArthur Foundation, 2015b).

The economic advantages of adopting a CE relate to the substitution of circular models for linear models. The current linear model reduces economic opportunities, instead stunting the competitiveness of different economic sectors within the EU, which must compete for the same resources; this could be prevented by adopting innovative approaches and new circular business models. In economic terms, the CE can lead to a significant reduction of supply costs. In some sectors this reduction could range from 12% to as much as 23% (Ellen MacArthur Foundation, 2013).

The main social advantages of the adoption of the CE model are the generation of jobs and the promotion of more sustainable habits. New employment opportunities are largely related to recycling and the reuse of waste, sectors that generate direct employment (European Commision, 2015). It is expected that investment in new sectors will lead to further job creation, as the CE generates new employment opportunities both in the EU and Asia (Yuan, Bi, Moriguichi, & Zengwei Yuan, Jun Bi, 2006). Studies have analysed the impact of the CE on the labour market; it is predicted that the waste sector (preparation and classification of waste for reuse and recycling) will generate a large number of jobs, and that most CE-related employment opportunities will demand medium- or high-skilled workers (Morgan & Mitchell, 2015).

There is wide agreement that the adoption of a CE could result in job creation in some sectors and in job losses in others. For instance, in Spain, it is expected that the increase in the number of electric cars will lead to increased employment in the renewable electricity sector and to a likely decrease in employment in the mining and conventional electricity sectors; however, depending on the structure of economic sectors, the net employment balance can be positive (Wijkman, Skånberg, & Berglund, 2016).

2.1. The CE in the private sector

Firms play a crucial role in the development of the CE, promoting the efficiency of the economic system and allowing for resources to be used to the full in the productive cycle (Jun & Xiang, 2011). Initiatives and processes that lead to reduced energy and resource consumption by turning the waste from an industrial process into usable resources for another process must be analysed at this micro level (Mathews & Tan, 2011).

In order to analyse and select the measures to promote the CE in companies located in a territory, the results obtained by the European Commission in the public consultation on the CE in the EU in 2015 can be used[2]. Measures that are considered of special interest in this phase of implementation of the CE at the regional level are the promotion of initiatives led by industries (for example "self-regulation"), the development of voluntary standards and the promotion of eco-innovation and eco-design. Main measures that can increase the introduction of the CE in companies at a regional level are summarized in Table 1 that is based on the proposal of Su et al. (2013) in which the CE practices are organized into four groups.

Table 1 – Selection of the CE-related potential policy measures for firms at regional level (with references)

CE Practices at micro level	Potential Regional Policy Measures for firms	Regional/Local CE
Production area	• Eco-design • Investments and impacts on the manufacturing costs • Introduction of the CE in the value chain • Improvement of the resource efficiency in processes • Neutral technology promotion of technology and digital solutions	(Cao & Zhang, 2011; Geng, Tsuyoshi, & Chen, 2010; Jiang, 2011; Pratt et al., 2016)
Consumption area and products	• Prolong life through maintenance, repair and design for durability • Design for upgradability and adaptability. • Improve consumers' green awareness	(Liu & Bai, 2014; Lukman, Glavič, Carpenter, & Virtič, 2016)
Waste management area	• Improve chemical and waste regulation • Promotion of the public-private collaboration	(Cao & Zhang, 2011; Smol, Kulczycka, & Avdiushchenko, 2017)
Other supports	• Corporate reporting • Best practices and technology transfer • Quality of information and data of material flows along the value chain • Voluntary standards	(Baur, 2011; Geng, Zhu, Doberstein, & Fujita, 2009; Walendowski et al., 2014)

Despite existing limitations, various indicators allow us to follow material, energy and water flows in the different stages of implementation of the CE (Van Berkel, 2010). Each system (non-renewable resources, emissions, soil use, impact on human health, social impact) is attached to a specific set of indicators (Pakarinen, Mattila, Melanen, Nissinen, & Sokka, 2010). As such, the different measurement

[2] Please see: http://makeresourcescount.eu/wp-content/uploads/2014/11/Response-to-Circular-Economy-Consultation.pdf (assessed on December 2018).

systems available all have strengths and weaknesses, and no single methodology to measure the CE has gained widespread support. Furthermore, data sources are limited, while it is also important to take into consideration complicating factors as territorial structure, socio-economic variables and the impact of governmental initiatives (Jacobsen, 2006).

Our aim is to measure the dissemination of the CE among the private firms operating in a specific region selected as a case study. In this regard, it is useful to distinguish between firms that operate in sectors directly linked to the CE – e.g. recycling and waste management – and firms that operate in sectors that use the technologies highlighted in CE-related protocols – namely the BREF (Best available techniques Reference) documents (EIPPCB-TWG, 2003; European Comission, 2009; European Commission, 2003; European IPPC Bureau, 2006), which are regarded as more 'sensitive' to the adoption of circular models. Table 2 summarises the main activities related to a circular model, based on the existing literature.

Table 2 – Selection of the CE-related activities in the firms (with references)

Main activities	Authors
In thermal recycling of waste within the firm	(Dong-her et al., 2018; Liu & Bai, 2014; Ormazabal, Prieto-Sandoval, Puga-Leal, & Jaca, 2018; Stewart & Niero, 2018)
Renewable energy facilities in the firm	(European Commission, 2016)
Eco-design and modification of processes towards dematerialisation	(Liu & Bai, 2014; Mirosbnychenko, Barontini, & Testa, 2017; Ormazabal et al., 2018; Stewart & Niero, 2018)
Recycling-friendly product design	(Liu & Bai, 2014; Miroshnychenko et al., 2017; Stewart & Niero, 2018)
Use of secondary raw materials in production	(Fundación COTEC para la Innovación, 2017; Stewart & Niero, 2018)
Design for reliability and durability and design for extending product life(durability)	(Franco, 2017; Stewart & Niero, 2018)
Design for upgradability and flexibility(multifunction)	(Franco, 2017; Stewart & Niero, 2018)
Energy valorisation of waste	(Huysman, De Schaepmeester, Ragaert, Dewulf, & De Meester, 2017; Singh & Ordóñez, 2016)

In this context, our research questions are as follows:

R1: What are the most widespread the CE-related activities among the more CE-sensitive economic sectors in a given territorial framework?

R.2. What is the effect of closing material loops in a given territory?

In the following sections, we shall try to answer these questions by analysing the implementation of a CE at the micro and territorial levels.

3. Case study

At the territorial level, the CE is an important strategic tool, as it contributes to preventing environmental degradation and also help preserve scarce resources by efficiently managing solid waste and creating a closed materials loop flow within the regional economic system (Geng & Doberstein, 2008).

We shall focus our study on the Spanish region of Aragón,[3] which in recent years has witnessed an increase in the number of local, small-scale initiatives aiming towards the implementation of some of the principles of a CE (Portillo-Tarragona et al., 2017)[4]. Despite an increase in the number of such initiatives, CE principles remain underdeveloped in the region, and a key government target is to facilitate a gradual expansion of the model (Portillo-Tarragona et al., 2017). To date, the CE principles have been adopted in the waste management sector, but this is only one of the components that are needed for the integral implementation of all CE principles, according to the recommendations set forth by the EU. As such, the following section is an attempt to measure the adoption of the CE by businesses in Aragón at the firm level.

3.1. Measurement of CE in firms

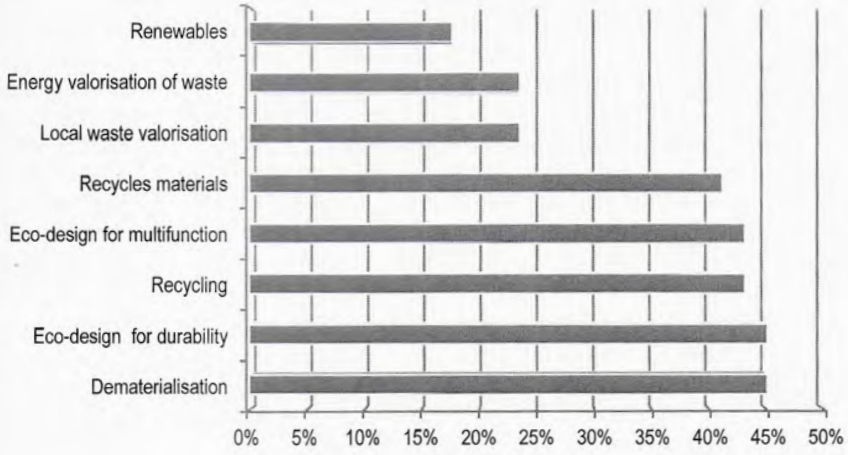
Since the recycling and waste management sectors can be directly related to a CE, it is necessary to measure the impact of the CE principles in other sectors in which different aspects of the model are being progressively implemented. The measurement of the CE-related activities in the firms operating in the most 'sensitive' sectors is carried out by means of a survey distributed within the framework of a collaborative research project involving firms interested in eco-innovation, eco-design and the CE in the Spanish north east. This study takes into consideration 51 firms in the region of Aragón.

Among the CE-related activities, we shall focus on those processes that take firms beyond environmental management and protection protocols, as described in Table 2. The most widespread among these are dematerialisation, eco-design (durability), recyclability, eco-design (multifunction) and use of secondary raw materials: all of these measures are implemented by approximately 40% of the firms within our sample. Other processes, however, have been adopted fewer of the firms, as illustrated in Figure 1. The five most widespread processes have been simultaneously adopted by approximately 20% of firms, while design-related activities (eco-design, dematerialisation and durability) are being implemented by approximately 30% of firms.

[3] While this paper was being written, a regional plan for the promotion of CE was in preparation.

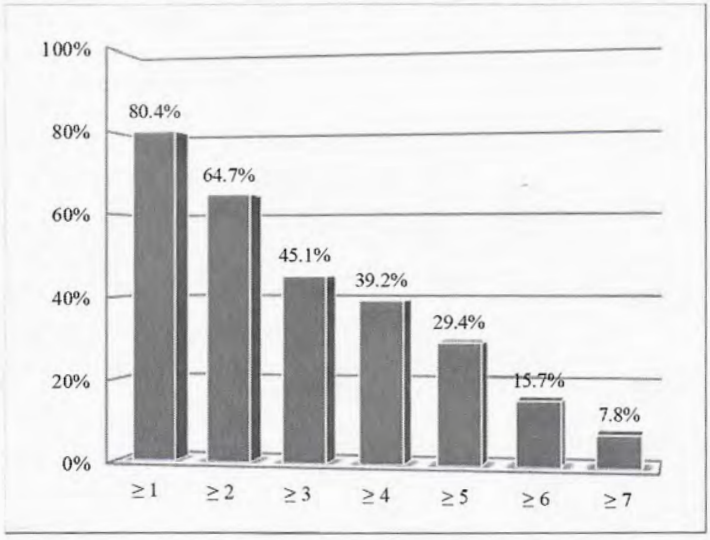
[4] For more details see: https://ecodes.org/coalicion-de-empresas#.W-tS1pNKjIU.

Figure 1 – Percentage of firms that implement the CE-related activities



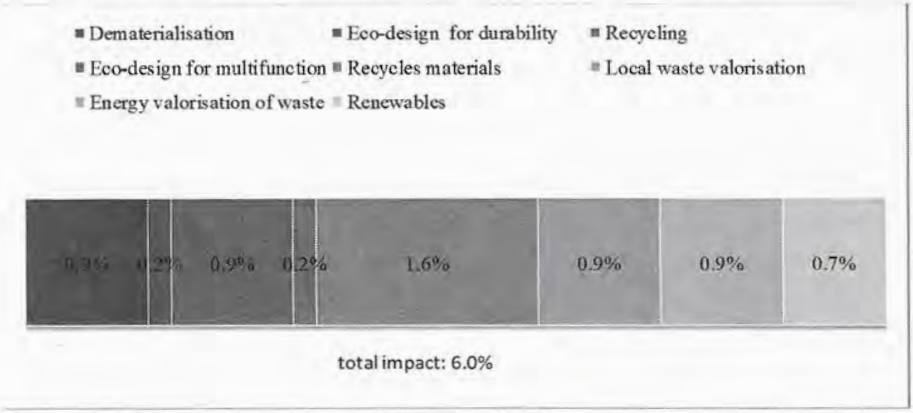
Most firms have adopted at least one the CE-related activity (80.4%), while over one-third have adopted at least four (39.2%). None of the firms in the sample carry out all the CE-related activities considered in this study, and only 7.8% (4 firms) carry out seven. The extent of the CE-related processes within the overall activity of the firms is illustrated in Figure 2.

Figure 2 – Implementation of the CE-related activities in the firms in the sample



In order to extrapolate the impact of the CE to the whole economy of the region, we have developed a specific methodology based on the data pertaining to each CE-related activity. Survey results, concerning both the number of activities carried out by each firm and the intensity with which they are implemented, have been normalised to a Likert value scale (0 = the activity is not being implemented; 1 = low implementation level; 2 = medium implementation level; 3 = high implementation level; 4 = very high implementation level). In order to determine what percentage of the firm's activity is connected with the CE-related processes, these values are added up and weighted according to their economic impact. It has been calculated that approximately 6% of the sample firms' activity is connected with the CE-related processes, as illustrated in Figure 3. These results are in line with previous studies, for instance Portillo-Tarragona et al. (2017).

Figure 3 – Estimate of the percentage of sample firms' activities related to the CE



3.2. Impact at the territorial level

In order to analyse the impact of the CE at the territorial level, three basic socio-economic indicators are taken into consideration: turnover of firms directly or indirectly involved in the implementation of the CE; the number of jobs created by the CE-related activities; and, the consumption of raw materials, intermediate products and other supplies.

These calculations consider different levels of commitment to the CE-related activities; waste management firms are considered the most closely involved with the CE, and we must also emphasise industrial sectors which are likely to implement technologies specified in the BREF documents (what were referred to as 'sensitive' sectors). As noted, it has been estimated that approximately 6% of the sample firms' activity is connected with the implementation of the CE principles.

Currently, the gross effect of the implementation of the CE on employment can only be estimated with very limited precision (Horbach, Rennings, & Sommerfeld, 2015). We can measure the evolution of employment in the waste and recycling

sectors, but changes undergone by professional profiles are hard to relate to the degree of dissemination of the CE model because these changes take place in already existing industrial sectors (Meyer & Sommer, 2014). Currently, the impact of the CE model in Aragón is being estimated on the basis of employment in the waste sector and the number of jobs in 'sensitive' sectors that are related to CE-related activities, calculated on the basis of the percentage of a firm's activity that is connected with these processes.

Based on the statistical-descriptive analysis carried out in this study, the impact of the adoption of the CE-related practices by firms at the territorial level is presented in Table 2.

Table 2 – Estimate of the impact of the CE-related (directly and indirectly) activities in Aragón in 2017

	Estimatel (for 2017 based on 2016 data)		
Area	**Turnover (€ million)**	**Total jobs**	**Total raw material consumption (€ million)**
All industrial sectors	25,842,114	89,832	13,017,067
Direct impact of the CE on waste management and recycling	352,858	3,623	77,381
Estimated impact the CE-related activities in 'sensitive sectors	1,244,199	4,315	593,298
Total estimated impact	1,597,057	7,938	670,679
% of overall industrial output	6.2%	8.8%	5.2%

These results suggest that the impact of the CE in Aragón is still limited in socio-economic terms, as only 6.2% of the overall industrial activity is in some way connected with the circular model, according to EU criteria.

In order to forecast the evolution of these indicators in the near future (5, 10 and 15 years), we need to identify the factors that could accelerate or slow down the implementation of the CE-related activities in the region. These factors need to be corrected by a coefficient λ_{CE} according to three different scenarios: business as usual, conservative forecast and optimistic forecast (Table 3).

The "business as usual" scenario would occur in a context of moderate upgrade of the factors that may improve the CE in the region, such as moderate increases in the price of raw materials and more availability of secondary raw materials, jointly with a moderate worsening in the supply of virgin raw materials.

Likewise, a moderate increase of the CE at regional level would respond to different factors such as an increase of the regional incentives for the CE, to limitations of the volume of waste to landfill or improved technological solutions for waste recovery. To replicate this scenario, the coefficient λCE would take a value equal to 1, so the expected variations for each of the above mentioned factors in the temporalis scenarios would not be modified.

In the optimistic scenario, the expected variations in each one of the temporal scenarios would be higher than the previous one, without the moderation on the factors that can foment the CE. In this case the variations are higher (λCE would take a value equal to 2), which would mean to increase the CE in the region to a greater extent.

This scenario would be considered if the region can lead a specific regional CE strategy to promote measures, tools and policies to foment the CE in different sectors and among society in terms for waste management, the development of voluntary standards, eco-innovation and eco-design, etc.

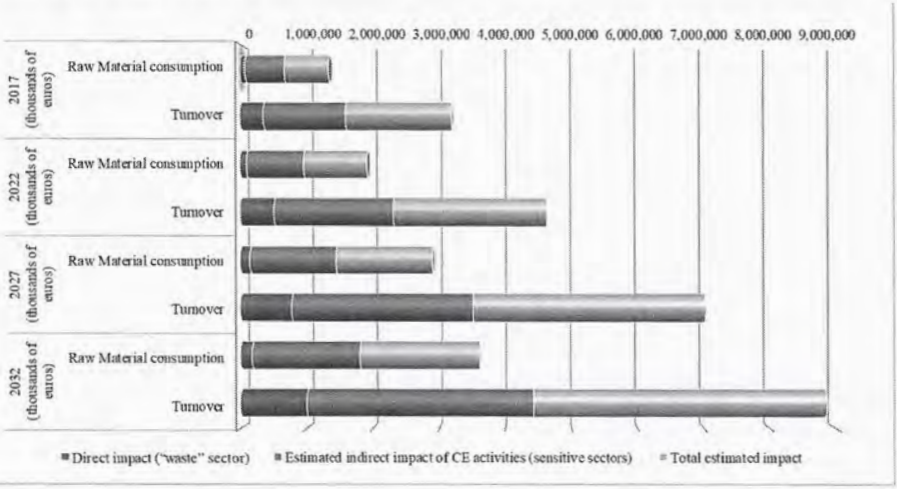
Table 3 – Matrix of the CE factors and scenarios

Factors for the CE analysis	Circular Economy Scenarios								
	Variation of scenarios (5, 10, 15 years)			Business as usual for a CE		Conservative scenario for the CE		Optimistic scenerario for the CE	
	$M_0 + 5$	$M_0 + 10$	$M_0 + 15$	Evolution of factors	λ_{CE}	Evolution of factors	λ_{CE}	Evolution of factors	λ_{CE}
a) Price of raw materials and resources	0,1	0,2	0,3	moderate increase	1	Stable (as at present)	0	high increase	2
b) Availability of secondary raw materials	0,1	0,2	0,3	moderate increase	1		0	high increase	2
c) Availability of raw materials and resources	0,05	0,1	0,15	moderate decrease	1		0	high decrease	2
d) Stimulus of the regional CE	0	0,2	0,3	moderate stimulus	1		0	high stimulus	2
e) Limits to the regional volume of waste	0	0,2	0,3	moderate increase	1		0	high increase	2
f) Maturity of technology	0,2	0,3	0,4	moderate improvement	1		0	high improvement	2

On the contrary, in a conservative scenario the factors do not change from the initial situation (λCE would take a value equal to 0), and it would mean not to improve the CE in the region.

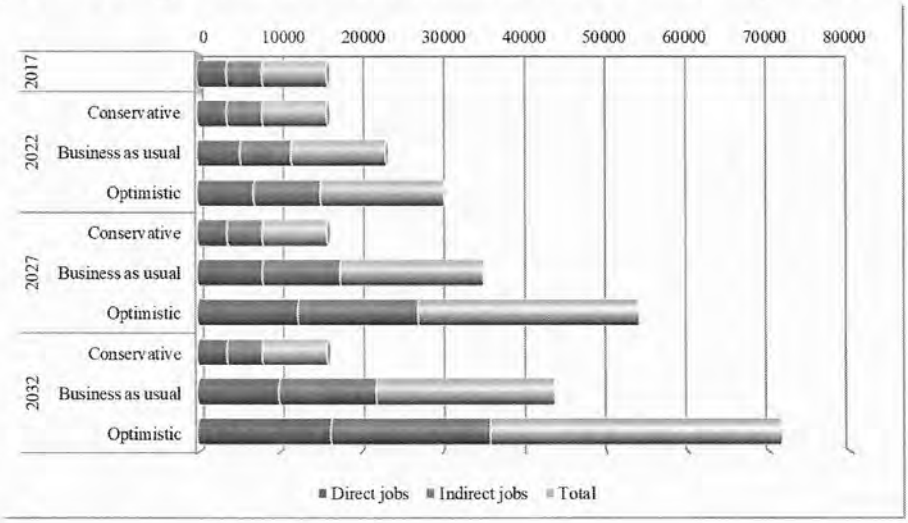
Figure 4 illustrates the results of these estimates for a 'business as usual' scenario, in terms of economic impact and raw material consumption.

Figure 4 – Estimate of economic impact directly and indirectly related to the CE in Aragón: " business as usual" scenario



In term of jobs, the CE is expected to have a moderate impact (8.8% of the industrial sector in the region for 2017). The forecasts are summarised in Figure 5, which presents the evolution of the CE-related employment in all three scenarios.

Figure 5 – Estimate of the impact of directly and indirectly the CE-related activities on employment in Aragón in all three scenarios (Business as usual, Conservative, Optimistic)



Despite the limitations of this first approximation, it can be predicted that the impact of the CE on employment will increase in proportion to the growth of the recycling and waste management sectors. This growth is expected to generate new employment opportunities in these sectors. On the other hand, employment in indirectly the CE-related activities carried out within the framework of 'sensitive' industrial sectors is expected to require different professional profiles.

As such, we can conclude that the introduction of the CE-related activities in Aragón is still at an incipient stage. The sectors in which these activities are most widespread include design and the use of secondary raw materials (R1). As such, the socioeconomic impact of the CE on the industrial sector at the regional level is limited. In the future, this variable will be affected by the existing stimuli and barriers to implementation of the CE-related activities (R2).

Policy makers could promote tools and measures to promote the CE and other initiatives to facilitate the introduction of industry-driven and/or collaborative models (for instance, 'self-regulation'); the establishment of voluntary standards, especially concerning the management and valorisation of resources; and, the promotion of eco-design and manufacturing standards that stimulate the closing of materials loops.

Concerning the most appropriate measures at the current incipient stage of implementation of the CE-activities, we may emphasise the beneficial effects of the CE on: manufacturing processes, the value chain and cost structures; the promotion of neutral technologies that allow market access to new agents.

The main challenge that the implementation of the CE poses to private firms is that it requires changes in the business model, as well as the monitoring of flows of raw materials and resources, especially as the progressive introduction of increasingly far-reaching collaborative models is to be expected.

4. Conclusions

The adoption of the CE-related activities by businesses depends on the decisive implementation of a number of key measures at the regional level. These include the design of products, so their components and materials may be reused; the promotion of innovative business models for the collection of these components and materials; and, the implementation of reverse-logistics solutions, with the ultimate aim of reintroducing these components and materials into the supply chain. Definitely, initiatives to facilitate the adoption of these activities include the introduction of industry-driven and/or collaborative models (for instance, 'self-regulation'); the establishment of voluntary standards, especially concerning the management and valorisation of resources; and, the promotion of eco-design and manufacturing standards that stimulate the closing of materials loops.

In order to meet these targets and help firms in the transition towards circular economic models, favourable conditions must be created; in this endeavour, regions must play a relevant role. Policy makers can act as a driver for the adoption of the CE at a regional level by providing tools and measures to help companies to close material loops, to control their efficiency, and to invest in new technologies to adopt new CE-related activities.

Our micro analysis has included qualitative and quantitative variables in order to assess the level of dissemination of CE-related activities within a given territorial framework. In general, we may conclude that there is much room for improvement concerning in-house recycling, including energy extraction from waste, once other hierarchically superior alternatives have been ruled out or whenever this is advisable in terms of environmental balance. At the present time, overcoming the barriers that hamper the implementation of these actions depends on public stimuli. For the firm, the adoption of the circular model involves creating new environmental management systems, introducing changes in the cost structure, applying collaborative models, improving reporting practices, and undertaking financial adjustments. In this regard, firms are also heavily reliant on public incentives, especially those concerning the introduction of collaborative models, which are in turn critical for the closing of materials loops.

The main findings of this study concern the methodology used to measure the dissemination of CE principles in the private sector and their impact at the territorial level. Our conclusions lay the foundations for the internal measurement of circularity in private firms and for the assessment of the economic activity generated, in terms of investment and income. As such, these results are valid for academics, to further the conceptualisation and measurement of CE at the micro level; for practitioners, in promoting internal measurement and definition of CE-specific indicators, internal organisation and reporting; and for public administration, as an aid to policy-making and the development of CE-specific incentives.

The proposed methodologies and the highlighted measures could be used for decision making support in order to implement the CE solutions in regions and to influence setting up regional priorities. The limitations of this study chiefly concern the size of the sample, the number of CE activities analysed and the fact that the data comes from a single European region. Future research should try to overcome these limitations and reach a better understanding of the adoption of CE-related criteria and their impact at the territorial level.

5. Acknowledgments

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2.3 The progressive adoption of a circular economy by businesses for cleaner production: An approach from a regional study in Spain (Artículo 3)

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The progressive adoption of a circular economy by businesses for cleaner production: An approach from a regional study in Spain

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ABSTRACT

The literature on the circular economy at the micro-level has mainly focused on the analysis of the circular business model and implementation of different circular-related practices, but the process of adoption by businesses of the circular economy is still under investigation. Therefore, through a study in the region of Aragón, Spain, the main circular economy-related activities implemented by a sample of 52 businesses are classified into four levels as an approach to the change process that firms can undergo to adopt the circular economy. In summary, it can be stated that circular economy-related activities are being introduced by businesses progressively, from a minor activity to a greater number of activities, but that these activities do not respond to the incremental closure of material loops within the circular economy framework. The applied indicators enhance the knowledge on the environmental management accounting applied to the CE for the reporting and the relations with stakeholders. In addition, the measurement of the introduction of the circular economy in different businesses is relevant for practitioners and for policy makers, in response to the institutional initiatives for the promotion of the circular economy at the territorial level.

1. Introduction

In response to global environmental degradation, some firms have become proactive in their attempts to introduce cleaner production processes and to adopt the principles of a circular economy (CE). The CE is an alternative to the linear model, allowing for the added value of products to be maintained for as long as possible while contributing to waste reduction.

The multiple articulations of the CE have made it difficult to converge on a single definition (Masi et al., 2017). Yuan et al. (2006) pointed out that the main objectives of the CE are the reduction of the flow of materials, the achievement of energy efficiency, and the idea that natural and social capital must be constantly renewed through multiple phases. In summary, in a CE, fewer materials are required to produce a constant level of products, either because of a reduction in the amount of resources used or because raw materials are replaced with recycled ones (Figge et al., 2017). The CE, once fully developed, will promote high value material cycles instead of recycling only for low value raw materials as in traditional recycling (Ghisellini et al., 2016).

In the literature, the CE is an emerging topic, and research has been gaining ground in academics, particularly at the macro-level (Merli et al., 2018). Scholars have also studied the role of firms in the development of the CE at the micro-level (Lewandowski, 2016). However, only a few authors have investigated how firms might integrate the principles of a CE into their business practices (Katz Gerro and López Sintas, 2019). To date, in studying the CE at the micro level, academics have focused their research on the factors that affect the commitment of private firms to a CE, existing barriers and incentives for its introduction (Garcés-Ayerbe et al., 2019; Govindan and Hasanagic, 2018; Zhu et al., 2014) and the impact of circularity on the business model (Pieroni et al., 2019).

Specifically regarding the adoption of the CE in businesses, Mathews and Tan (2011) indicated that the transformation from a traditional linear economy to a circular one requires evolutionary processes in which dynamic linkages are established gradually over time. It could therefore be assumed that a firm's process of adopting the CE will occur gradually to allow for meeting the need for organisational learning (Crossan et al., 1999). This pattern was experienced, for example, in environmental proactivity and in eco-innovation management (Garcés-Ayerbe et al., 2016). Nonetheless, there has been limited research on the components that are crucial to the success of the CE in businesses (Witjes and Lozano, 2016).

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Some research on metrics for quantifying circularity of products has been performed (Linder et al., 2017), but it does not incude the development of indicators for measuring the adoption of the CE by a company as a whole. This field of research is not without difficulties since there is still no consensus on how to measure the different CE-related activities implemented by companies. Therefore, an objective of this study is to analyse how companies adopt the CE principles internally to enhance the knowledge about the measurement of the engagement of businesses in the CE. Moreover, to the best of our knowledge, only a few empirical studies have measured the introduction of circular activities in different industries within a territory (Aranda-Usón et al., 2018). Thus, another objective of this study is to fill this gap measuring the CE introduction in businesses from a regional perspective, as a subject that has been little explored in the academic literature.

Based on the previous arguments, in this study, the adoption of the CE in businesses is analysed in Aragón, a region located in the northeast of Spain, which was selected with the aim of understanding how companies have undertaken actions towards implementing the CE.

The remainder of the article is structured as follows. Following a review of the literature summarised in the background section, the methodology of the analysis and the regional study are described. The results are summarised and discussed from a regional perspective to outline the main conclusions and potential avenues for future research.

2. Background

The approach used in this study is not specifically theory driven, and the research objective is to generate knowledge about how to measure the introduction of the CE in businesses in a territory. Nevertheless, a summarised theoretical approach is presented in the following paragraphs to outline the general scope of the research.

Conceptual discussions of the CE are still in their infancy among scholar, and the literature in the micro field is only emerging. Theory has been mainly approached for discussing the CE concept (Kalmykova et al., 2018) or its taxonomy (Urbinati et al., 2017), and there is a need for deeper study of the concept, its units of analysis, and the theoretical basis of the CE (Korhonen et al., 2018). Some of the most relevant theoretical influences are cradle-to-cradle and industrial ecology (Geissdoerfer et al., 2017). In the CE literature at the micro-level, some studies have been conducted in the framework of stakeholder theory (Walls and Paquin, 2015), institutional theory (Zeng et al., 2017), the resource-based view (Aranda-Usón et al., 2019), the dynamic capabilities theoretical framework (Katz Gerro and López Sintas, 2019) or the business model theory (Pieroni et al., 2019). Walls and Paquin (2015) pointed out that the industrial symbiosis specific literature also remains fragmented theoretically and has developed separately from corporate environmental strategy, in which the focus is mostly on intra-firm, rather than inter-firm, action. Thus, the CE could require significant re-examination of much of current theory and lead to new practice (Murray et al., 2017).

From another perspective, 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). At a theoretical level, Geng et al. (2009) stated that the CE model fits closely with ecological modernisation theory. However, the theoretical frameworks that can be applied to the CE principles in a spatial context has not clearly defined, and the measurement methods that have been applied at regional levels have achieved segmented or partial results to date. It has to be taken into account that the environmental behaviour of a company in a CE context is influenced not only by internal factors but also by its external context (Liu and Bai, 2014). Therefore, there is no doubt that stakeholders play important roles in the adoption by companies of the CE principles (Lieder and Rashid, 2016).

From a spatial perspective, the theoretical framework of analysis must consider the necessity of engaging with all relevant stakeholders (Pomponi and Moncaster, 2017), the collaborative requirements of the CE (Pieroni et al., 2019), the role of wider systems in business and accounting decisions within environmental management and sustainability reporting (Murray et al., 2017), and the importance of legitimacy among key stakeholders at different positions in the value chain needed for a CE (Linder et al., 2017).

It is not our intention to revisit these different bodies of literature; rather, we wished to examine the literature on these fields in a common framework of analysis, exploring the potential for adding something of substance to the debate over the measurement of the CE at the micro-level from a territorial perspective. Nevertheless, in this study, the consideration of multiple stakeholders beyond the firm-centric view (Reike et al., 2018) brings us closer to the stakeholders theory when contemplating research focusing on the adoption of the CE at the micro-level.

2.1. The challenges of adopting the circular economy by firms

Academics have mostly addressed the measurement of the CE from the perspectives of resource productivity, critical raw materials scarcity, or the reduction of solid waste, emissions and pollution (Lieder and Rashid, 2016). Although these aspects have been analysed in the CE literature, the development of an integrated indicator to measure the level of adoption of the CE by businesses at the organisation level is still under discussion.

In the absence of a recognised method for assessing how effectively a product or a whole company makes the transition from a linear model of operation to a circular model, Smol et al. (2017) recommended indicators based on eco-innovation, but they referred exclusively to technical cycles and materials from non-renewable sources. Elia et al. (2017) contributed to filling the current gap in the environmental evaluation of CE strategies at the micro-level with a taxonomy of index-based methodologies. These authors pointed out the so-called material circularity indicator (Ellen MacArthur Foundation and Granta Design, 2015) that can be adopted both at a product level and at a company level to measure how restorative flows are maximised and linear flows minimised. Di Maio and Rem (2015) introduced the 'circular economy index' to measure the circularity level of a product as the ratio of the material value produced by the recycler (market value) to the material value entering the recycling facility.

Katz-Gerro and López Sintas (2018) provided a picture of EU businesses engaged in CE-related activities and pointed out the heterogeneity in the 28 current EU countries regarding patterns of circular business. Franco (2017) noted the lack of research at the micro-level, especially when considering that essential activities pertinent to firms that can be considered pre-requisites for successful deployment of the CE (Lieder and Rashid, 2016). Urbinati et al. (2017) introduced a promotion dimension of the CE principle, which becomes part of a company's positioning against competitors, and Linder et al. (2017) added to the previous approach with plausible incentives for firms to attempt to present circularity values that are as high as possible. However, these researchers did not study the degree of adoption of the CE in firms located in a given region, and they confirmed the need to develop standardised methods for measuring circularity at the micro-level that include both businesses and products.

Some of the studies that partially described the activities that companies perform within the framework of the CE can be found in recent reviews of the literature in this field, summarised in Table 1. In summary, the CE-related activities performed by businesses that have been analysed in the literature can be classified into four groups: I) activities that have been implemented for waste treatment and recycling (Chen et al., 2010); II) activities including dematerialisation and eco-design (Winkler, 2011); III) activities related to secondary raw materials and waste recovery (Kama, 2015); and IV) activities in which industrial ecology and/or symbiosis is considered (Mathews and Tan, 2011; Winkler, 2011). However, there is no consensus regarding the best method of capturing distinct CE-related activities, nor has it dis-

Table 1
Main CE-related activities classified into four levels, the selected variables to measure the activities and a selection of authors who have studied them within the framework of the CE.

CE-related activities		Selection of contributions
Level REC′	01. Reduction of the environmental impact of the company	(Dong-her et al., 2018; Elia et al., 2017; Linder et al., 2017; Manninen et al., 2018)
	02. Energy efficiency	(Kalmykova et al., 2018; Katz Gerro and López Sintas, 2019; Stewart and Niero, 2018)
	03a. Waste recycling	(Katz Gerro and López Sintas, 2019; Santolaria et al., 2011)
Level II 'DES'	04. Renewable energy	(Elia et al., 2017; European Commission, 2016; Katz Gerro and López Sintas, 2019; Manninen et al., 2018; Stewart and Niero, 2018)
	05. Design for resource efficiency ("dematerialisation")	(Kalmykova et al., 2018; Katz Gerro and López Sintas, 2019; Liu and Bai, 2014; Manninen et al., 2018; Miroshnychenko et al., 2017; Moreno et al., 2016; Ormazabal et al., 2018; Stewart and Niero, 2018)
	06. Design for resource recovery	(Liu and Bai, 2014; Manninen et al., 2018; Miroshnychenko et al., 2017; Moreno et al., 2016; Stewart and Niero, 2018)
	07. "Secondary raw materials" (recycled)	(Manninen et al., 2018; Santolaria et al., 2011; Stewart and Niero, 2018)
Level III 'VALW'	08. Product-life extension	(Bakker et al., 2014; Bocken et al., 2016; Elia et al., 2017; Franco, 2017; Linder et al., 2017; Manninen et al., 2018; Moreno et al., 2016; Stewart and Niero, 2018)
	09. Design for upgradability and multifunctionality	(Bocken et al., 2016; De los Rios and Charnley, 2017; Kalmykova et al., 2018; Moreno et al., 2016; Santolaria et al., 2011)
	10. Eco-innovation	(de Jesus et al., 2018; Dong-her et al., 2018; Ormazabal et al., 2018; Portillo-Tarragona et al., 2018; Prieto-Sandoval et al., 2018; Walendowski et al., 2014)
Level IV 'SIM'	03b. Internal recycling	(Dong-her et al., 2018; Liu and Bai, 2014; Ormazabal et al., 2018; Stewart and Niero, 2018)
	11. Energy waste recovery	(Bocken et al., 2016; Huysman et al., 2017; Manninen et al., 2018; Ormazabal et al., 2018; Singh and Ordóñez, 2016)
	12. Industrial symbiosis and sharing (or similar)	(Daddi et al., 2017; Kalmykova et al., 2018; Stewart and Niero, 2018; Yang and Feng, 2008)

cussed how firms can in practice adapt their business models to this new paradigm (Urbinati et al., 2017).

Furthermore, the descriptions of the activities introduced by businesses do not reveal the process that firms undergo in adopting the CE. The literature does not elucidate whether the adoption of new CE-related activities by businesses is undertaken specifically to increase their level of circularity or to respond to other demands. To investigate the research gap, a first research question was formulated:

- *RQ1) How do companies in a region adopt activities related to the CE?*

In this scenario, it must also be considered that the CE is influenced by geographical proximity since the availability of activities at local and regional levels helps to reduce the costs associated with broader circuits involving greater numbers of transactions (Stahel, 2013). Local and regional authorities play important roles in both the launch of and the transition to a CE (Yi and Liu, 2015) since the implementation of a circular business model is so closely tied to the territories within which firms operate. Based on these considerations, a second line of inquiry focusing on the regional level analysis was defined and is developed in the following section.

2.2. The circular economy in businesses at the regional level

Although the introduction of the circular principles in organisations is increasing, the engagement of firms with the CE-related practices remains weak (Zamfir et al., 2017). In the micro-field, commitment to sustainable development and the CE has been consolidated with the help of environmental regulations and public incentives (Ghisellini et al., 2018; Hu et al., 2018). Different initiatives to promote the CE at the regional level have been launched in a number of geographical areas, including Europe (European Commision, 2015; Gharfalkar et al., 2015), Japan (Despeisse et al., 2015; Van Berkel et al., 2009), China (Mathews and Tan, 2011) and the United States (Zink and Geyer, 2017). In particular, China promulgated specific laws about the CE that had consequences at technological, economic and social levels (Dajian, 2008). Thus, at regional level, several studies have been focused on the Chinese development of the CE and the metrics than could be applied for its measurement in a territory (Geng et al., 2012, 2009), for waste management (Chen et al., 2010), or for the businesses' activity as agents of CE deployment (Ghisellini et al., 2018; Zhu et al., 2014).

In summary, different factors can influence the adoption of CE-related activities by businesses, such as the industrial situation, regional businesses, the innovation level, the legislative profile at the regional or local level and the state of CE development within a given region. In the area of waste management, Fletcher et al. (2018) emphasised the role of policies in the transition to a CE: governments facilitate the introduction of CE principles through incentives to facilitate resource recovery and to guarantee investment. Regulations and public support increase the adoption of sustainable manufacturing practices, such as the CE (Moktadir et al., 2018), and the introduction of broader circular principles related to the exchange of goods and services has been encouraged through policies promoting social responsibility in companies (Liu and Yang, 2018) and supporting CE-oriented strategies (Ormazabal et al., 2018). However, research about the uptake of the CE in businesses at the regional level remains limited. In an attempt to fill this gap in the research, the following research question was formulated:

- *RQ2) Is the adoption of the CE-related activities by companies influenced by the territories in which they are located?*

The line of inquiry drawn in this second research question focuses on the analysis of the CE at the micro-level in a specific region. To answer the two research questions and to enhance our knowledge about the measurement of the CE in businesses, a qualitative methodology was designed to be applied to a study described in the following section.

3. Research design and regional study

The research method was designed to provide a qualitative analysis of a regional study in Aragón in the northeast of Spain, in response to a commitment of the regional government.

Drawing on the available literature and the experience of the researchers, in the initial phase of this study, a selection of CE-related activities that could currently be implemented by companies in the region was made based on the proposal of Aranda-Usón et al. (2019). The variables designed to measure the selected activities and the main literature to justify this selection are summarised in Table 1.

In order to enhance the results obtained by Scarpellini et al. (2019) and Aranda-Usón et al. (2018), an innovative contribution of this study is the classification of the diverse CE-related activities that businesses are adopting in the region into four levels considering the material loops closure that could be achieved in terms of the CE. To this end, the activities included in group I, defined as level I 'REC', are mostly related to recycling and energy efficiency and are considered as the first stage of CE adoption because they are frequently introduced by industries, while the so-called level IV SIM group of activities includes industrial symbiosis solutions or collaborative circular practices that are not frequently implemented and are the most advanced stages of CE adoption (European Commission, 2018a, 2018b). The third group, defined as level III 'VALW', includes activities of dematerialisation, renewables and secondary raw materials. Finally, other eco-innovations and eco-design for circular thinking are classified into level II 'DES'.

This grouping of activities was tested through semi-structured interviews conducted to obtain the opinions of experts about the processes that firms implement when they introduce the CE in the region. In addition, a questionnaire was sent to a sample of firms located in the region as a complementary analysis to collect the opinions of managers about the introduction of CE-related activities. The validity of the integration of semi-structured interviews and questionnaires applied to a qualitative analysis has been demonstrated for regional studies (Marco-Fondevila et al., 2018; Marco et al., 2019). This integrated method responds to the possible limitations of interviews with stakeholders pointed out by Kirchherr et al. (2017).

In summary, multiple sources of data were obtained (Table 2).

The text of the interviews was based on the existing literature in this field and sent to a group of 21 experts considered key informants because of their knowledge about the CE at the regional level. The final list of interviewees was elaborated according to the guidelines of the regional government and it proportionally represented the main groups of stakeholders, including society (social agents), administration and the business sector, all of which contribute to the responsible behaviour of companies (Camilleri, 2017), in line with the three main stakeholder categories pointed out by Banaitė and Tamošiūnienė (2016) for a CE (Table 9). The interviews, each lasting approximately 30 min, were recorded, transcribed and analysed for trends and patterns of response (Dolowitz and Medearis, 2009).

The selection of the sample of businesses was based on firms that operate in sectors with potential for engaging with the CE, such as those related to technologies included in the 'Best Available Techniques' -- the so-called 'BREFs': industrial; transport and logistics; waste; extractive industries; the manufacturing industry; electricity, gas, steam and air conditioning supply; water supply; sewerage; waste management; transport; and storage. In these sectors, the introduction of the CE is currently considered technologically more feasible, in line with other studies focusing on pro-environmental change (Rivera-Torres et al., 2015) or eco-innovation (Garcés-Ayerbe et al., 2016). In addition, the strategic sectors in the region of environmental services and logistics and transport were also considered according to the RIS3 regional specialisation (Gobierno de Aragón, 2015).

This complementary analysis was conducted within the framework of a collaborative R&D project undertaken in the northeast of Spain. The surveys were sent to the managers of companies directly involved in eco-innovation, eco-design and environmental investments related to the CE or to the environmental managers of the companies. In the end, 52 valid observations were obtained from firms located in the region of Aragón, identified by their value added tax (VAT) identification numbers. Table 3 summarises the characteristics of the sample.

Table 2
Entries in data display and main variables.

Data Source	Questions	Description
Interviewees	• Relevance of the CE for businesses in the region • Level of introduction of the CE in regional businesses • Ranking of the 4 levels of CE-related activities • Opinions of experts about the CE-related activities that could be adopted by businesses • Opinions of experts about the evolution of the level of interest in the CE of regional businesses	Semi-structured/ open questions Likert scale [a] ranking (4 levels [b])
Questionnaires	• Measurement of the 4 levels of the CE-related activities introduced by businesses via the following variables: 1 % of company's total revenues invested in innovative equipment to reduce the company's environmental impact 2 % of equipment or facilities replaced and/or improved for energy efficiency 3 % of recycling waste (total) 4 % of processes/equipment replaced and/or improved to exploit renewables 5 % of the products' design or services modified to reduce the resource intensity 6 % of the products' design or services modified to increase their recyclability (waste prevention) 7 % of resources replaced by other fully recycled materials 8 % of the products' design or services modified to extend their durability and reparability 9 % of the products' design or services modified to increase their functions and upgradability 10 % of the company's total revenue invested in eco-innovation (other activities) 11 % of recycling waste within the company itself 12 % of total revenue invested in energy valorisation of waste 13 % of recycling waste in shared facilities with other companies and industrial symbiosis.	Likert scale and other scales

[a] To facilitate the analysis of the information using a Microsoft Excel spreadsheet, the interviewees were asked to classify some of their answers using a Likert scale, ranging from 0 to 10, with 0 expressing total disagreement or a perception of the statement's irrelevance and 10 expressing total agreement or a perception of the statement as highly relevant.

[b] To rank the CE-related activities, the opinions of the experts were classified into three categories: 'irrelevant or only slightly relevant' (from 0 to 3 points); 'moderately relevant' (from 4 to 7 points); and relevant' (8 or more points).

Table 9
List of the 21 entities that collaborated through semi-structured interviews, classified into three categories.

Interviewees' categories	Entities
Public Administration	Regional Government - Directorate-General for Industry
	Regional Government - Directorate-General for Structuring and Mgmt. of the Territory
	Regional Government - Directorate-General for the Economy
	Regional Government - Directorate-General for Sustainability and Rural Development
	Regional Technology Institute
	Public Institute for Electronic Administration
	Public Institute for Water Management
Society	Regional Media
	ONGs Specialising in Environmental Sustainability
	Consumers' Organisation
	Sustainable Buildings Expert
	R&D - University Institute
	Labour Union
	Sociology Expert
Private Company/Organisation	Large Private Industry - Manufacturing Sector
	Association of Firms in the Building Sector
	Medium Private Company - Chemical Sector

Table 9 (*Continued*)

Interviewees' categories	Entities
	Private company - Electronic Devices Sector
	Small Private Company - Industrial Sector
	Private Renewables Company
	Large Private Organisation - Waste Sector

4. Main findings and discussion

4.1. The circular economy in businesses at the regional level

The experts were asked to define the relevance of each group of CE-related activities when regional firms introduce the CE (Table 4).

In summary, the activities included in levels II and III were considered the most relevant and interesting for regional businesses by the majority of the respondents. Level I was classified as moderately relevant because the experts considered that the activities included in this group are the 'first stage of a CE in businesses'. The evaluation offered by the interviewees on this point confirms the predominance of levels II and III but reveals clear differences of opinion by category of interviewee (Table 5).

If the four groups of CE-related activities are ranked from those currently considered most relevant (4 points assigned by the respondents) to those considered least relevant (1 point assigned), intermediate levels are classified with 2 or 3 points (Fig. 1). Most of the activities included in the intermediate groups (levels I and II) are considered relevant for the introduction of the CE in regional businesses, with slightly greater relevance for the third group.

When the experts proceeded to order the four groups of activities, they confirmed that companies located in the region have not addressed the activities associated with the more advanced levels of circularity included in the last group (level IV 'SIM'). A representative of public administration answered at this point that 'the CE is not widely implemented at present in the region and is known only by 15% of private companies'. This opinion is endorsed by some business experts, who declare that 'the general concept of the CE is known by businesses, but only a few of them are implementing it' and that 'it is mostly unknown among SMEs'. In addition, some of the experts said that 'only some large companies are using recycled raw materials and recycling and/or recovering waste within the company itself'. In Table 6, it can be observed that the opinions of the representatives of society differ from the opinions of the representatives of administration and the private sector.

In summary, based on the opinion of experts, CE-related activities could be introduced by firms following a partially incremental path because the experts consider that the activities of the second group (level II) are currently the most relevant for the regional businesses, followed closely by those in group III. Based on analysis of the interviews, this result can be explained through the general opinion that the activities related to waste recycling, energy efficiency or similar (level I) had already been implemented by companies and so were not a priority in the region in terms of their relevance to the CE. The lower relevance assigned to the fourth group (level IV) was expected because the activities included in this group are not currently considered feasible in the region. In addition, some experts pointed out that the activities that it contains are expected to be implemented in the medium and long terms.

Table 3
Main characteristics of the firms integrated in the sample (number of firms).

Sector	No.	Size	No.	Age	No.	Legal form	No.
Food industry	5	Large	14	<20 years	3	Cooperative society	3
Industry sectors	5	Medium	23	≥20 and ≤39 years	19	Stock corporation	23
Manufacturing	20	Micro	9	≥40 and ≤59 years	17	Limited company	26
Waste sector	4	Small	6	>60 years	13		
Service sector	15						
Transport and logistics	3						

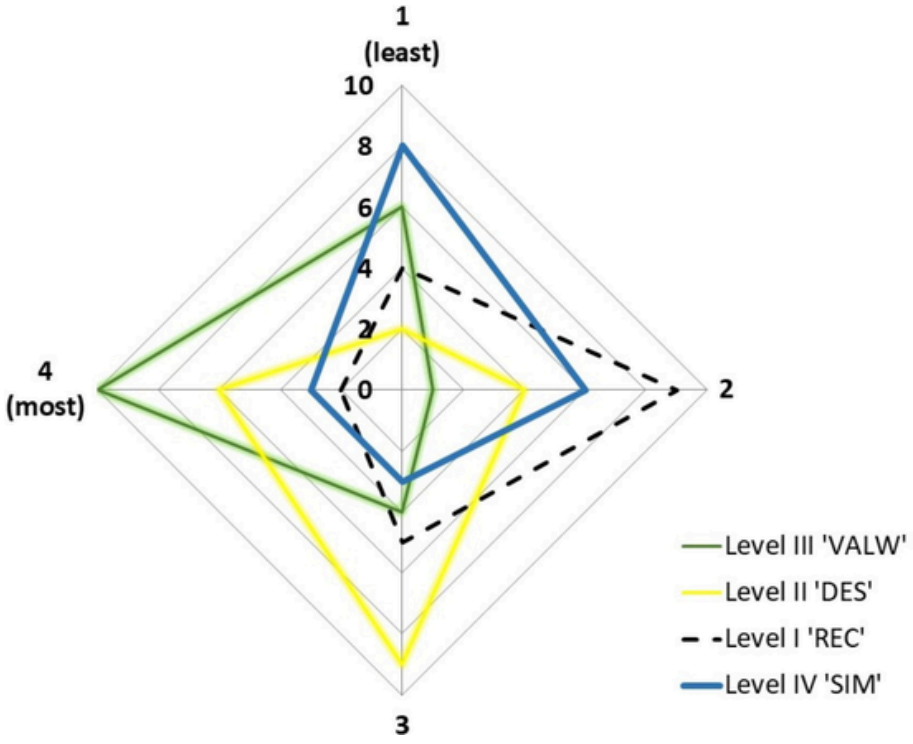
Table 4
Opinions about the relevance of the four groups of CE-related activities for the regional businesses provided by the experts (% of respondents).

	Level I - REC	Level II - DES	Level III - VALW	Level IV - SIM
Slightly relevant	20%	14%	29%	25%
Moderately relevant	55%	24%	24%	50%
Relevant	25%	62%	48%	25%

Table 5
Opinions about the relevance of the four groups of CE-related activities for the regional businesses according to the three categories of interviewees.

	Level I 'REC'	Level II 'DES'	Level III 'VALW'	Level IV 'SIM'
Public Administration	7.4	7.1	7.6	5.6
Private Sector	5.3	7.6	6.9	5.9
Society	4.8	5.9	4.9	5.0
Mean (Likert scale to 10 points)	5.85	6.86	6.43	5.48

Fig. 1



Ranking of the relevance of the four groups of CE-related activities provided by the experts.

Table 6
Ranking of the four CE-related groups of activities according to the three categories of interviewees.

	Level I 'REC'	Level II 'DES'	Level III 'VALW'	Level IV 'SIM'
Public Administration	2.6	3.1	2.3	2.0
Private Sector	2.7	3.4	1.9	2.0
Society	3.4	2.0	2.7	2,2
Mean (ranked from 0 to 4 points)	2.90	2.86	2.27	2.06

4.2. Measurement of the adoption of the CE by businesses

The level of adoption of CE-related activities in the sample of firms is shown in Table 7, indicating that most of the companies perform between three and eight activities simultaneously.

Table 7
Number of CE-related activities performed simultaneously by the firms of the sample.

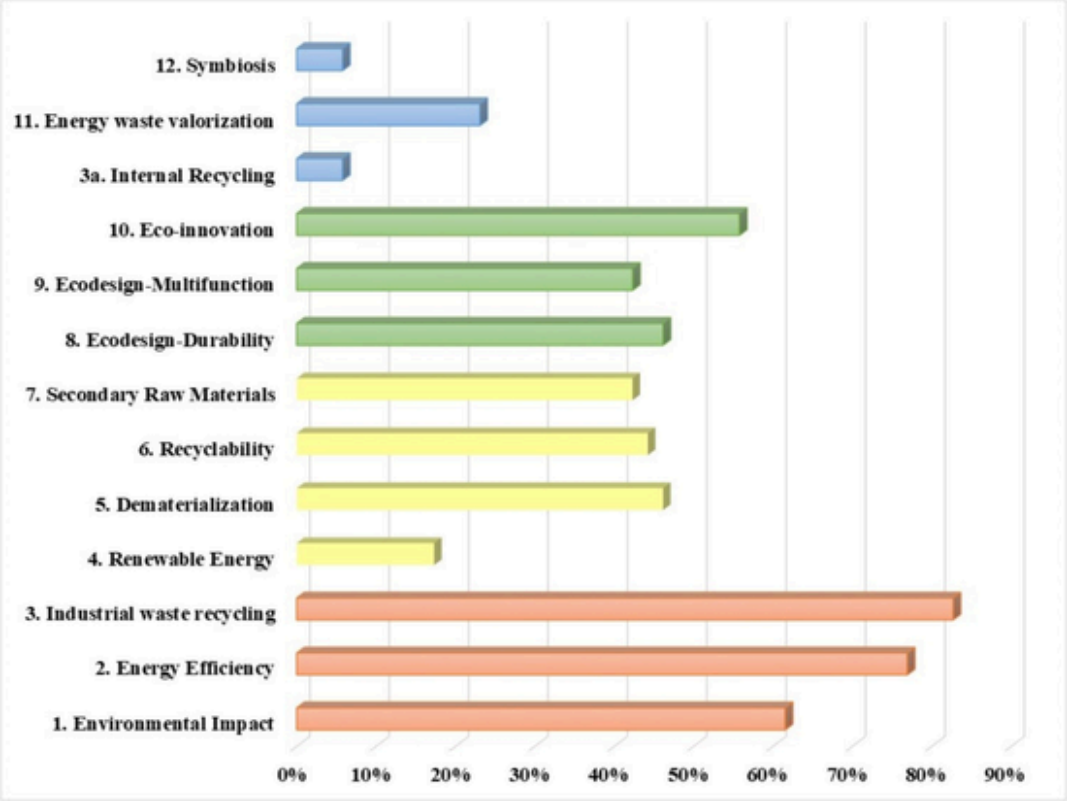
No. of CE-related activities	No. of Firms	%
0	7	13.46%
1	3	5.77%
2	4	7.69%
3	5	9.62%
4	5	9.62%
5	3	5.77%
6	7	13.46%
7	5	9.62%
8	6	11.54%
9	3	5.77%
10	4	7.69%
11	0	0.00%
12	0	0.00%
TOTAL	**52**	**100.00%**

It is observed that none of the companies in the sample performs more than 10 activities simultaneously, and almost 50% of the firms perform half or more of the CE-related activities. It is also interesting to analyse whether common behaviours can be detected among firms when they introduce these activities. To this end, the percentages of the companies that perform each CE-related activity are shown in Fig. 2 (level I: orange; level II: yellow, level III: green; level IV: blue).

The most frequently implemented activities are waste recycling and treatment, energy efficiency, reduction of the environmental impact of the company and eco-innovation (55.77%). Although the general activity of waste recycling and treatment is conducted by a large majority of firms, only a very small percentage of them perform this activity internally (which is a more complex activity, assigned to level IV).

The results obtained through the interviews regarding the relevance of the different groups of activities at the regional level are confirmed in this stage of the study, since the CE-related activities included in the second and third groups (levels II and III) show intermediate levels of adoption by businesses, being performed by 38% and 48% of the companies, respectively. The activities included in the first group (level I) are performed by 61.5% of the companies in the sample, and only 14.42% of them carry out the activities in the last group (level IV). The particular situation is emphasised of activity number 4 -- which measures the exploitation of renewables by firms, receiving less consideration than other activities of the second group because of a stringent national regulation of self-consumption facilities that limits the net bal-

Fig. 2



Percentage of firms that perform the CE-related activities classified into four levels.

ance and is considered to be a barrier to the exploitation of renewables, such as photovoltaics, in Spanish firms (Gimeno et al., 2018).

In Table 8, the level of adoption of different CE-related activities is analysed in relation to the average turnovers of the companies that implement each activity.

In summary, the data indicate that the average turnover of companies is not a significant variable when introducing the CE-related activities of the first group (level I) within the firm. However, for the intermediate-groups of activities (levels II and III), there is a significant relationship between the turnover and the number of companies that implement each activity. Therefore, a higher level of income does not indicate a greater number of activities adopted by the firms. It should be noted that, to invest in some of the activities, such as renewables, internal waste recycling, and energy waste valorisation, a higher level of income is needed.

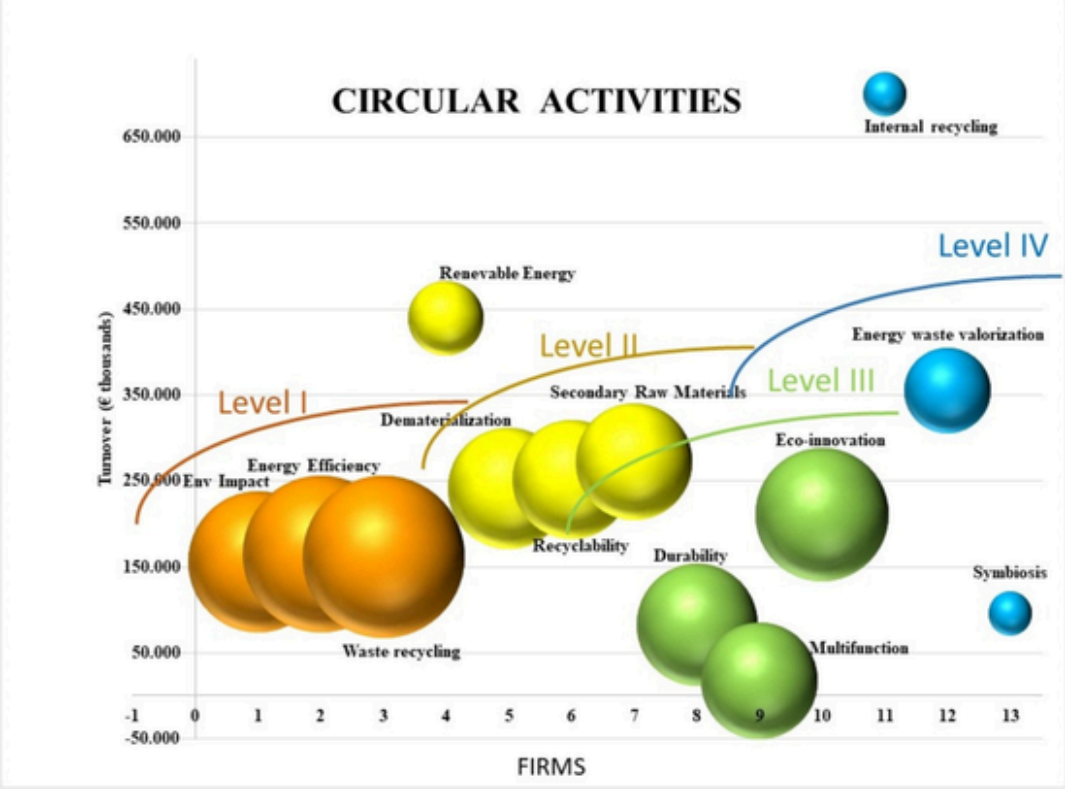
The level of adoption of the CE-related activities by firms is graphically summarised in Fig. 3.

The nine activities most frequently introduced at the regional level (between 42% and 82% of the sample) are implemented simultaneously by 15% of them. If we consider firms that undertake at least

Table 8
Percentage of firms that perform the CE-related activities classified into four levels and their average turnovers.

	CE-related activities	Average annual incomes (€ thousands)	No. firms	%
Group I REC	1. Environmental Impact	155,785.71	32	61.5%
	2. Energy Efficiency	165,195.80	40	76.9%
	3. Industrial waste recycling	161,530.62	43	82.7%
Group II DES	4. Renewable Energy	439,150.34	9	17.3%
	5. Dematerialisation	240,921.50	24	46.2%
	6. Recyclability	250,999.10	23	44.2%
	7. Secondary Raw Materials	271,989.50	22	42.3%
Group III VALW	8. Eco-design-Durability	82,595.80	24	46.2%
	9. Eco-design-Multifunction	16,979.20	22	42.3%
	10. Eco-innovation	211,264.50	29	55.8%
Group IV SIM	3a. Internal Recycling	700,000.00	3	5.8%
	11. Energy Waste Valorisation	355,183.52	12	23.1%
	12. Symbiosis	95,623.40	3	5.8%
Total		135,933.08	52	

Fig. 3



Graphical analysis of the adoption by firms of CE-related activities classified into four levels.

six of these nine activities, the percentage is 46.2%, while if five activities are considered, the percentage of firms rises to 55.8%.

4.3. Discussion and implications for a cleaner production from a CE perspective

Based on the main results achieved through the qualitative analysis of a regional study, we can argue that introduction of the CE in businesses remains in an early stage, and its measurement for the whole firm requires further investigation.

Environmental improvement towards circular business models is associated with change since it requires transformations in different areas of firms. Sustainability, moreover, requires coordinated change because the introduction of changes in a single business area is not enough (Del Río González, 2009). Indeed, partial measurement is not sufficient to understand the CE adoption by businesses; a greater transformation is required, affecting the entire organisation. Thus, given the increasing institutional pressure for the implementation of the CE (Zeng et al., 2017) and the pressure of stakeholder for reporting (Stewart and Niero, 2018), firms can analyse their level of adoption of the CE through the measurement of different activities related to the EC already being implemented. This approach to the measurement of the corporate CE, in line with Aranda-Usón et al. (2019), has been applied to a territory to analyse the main initiatives that could be planned by the regional government to encourage the CE among businesses (Scarpellini et al., 2019).

The results of this study indicate that CE-related activities are being adopted by companies progressively, from a small number to a greater number of simultaneous activities. This progressive adoption of the CE by businesses is not clearly related to the closing level of the material loops in terms of the CE. The activities that are usually introduced first by businesses are those with the lowest index of circularity. In facts, waste recycling and treatment are generally addressed first in the analysed region. Recycling has benefited from a large number of technological eco-innovations achieving greater efficiency, and this fact, along with sectoral regulation, has motivated companies to implement these activities (Scarpellini et al., 2016). Nevertheless, internal waste recycling in-house is not being implemented by companies mainly due to the regional regulations that limit such activities and promote the external management of waste through accredited and specialised firms (Portillo-Tarragona et al., 2017). Based on these results, it must be considered that the progressive approach to environmental strategy provides a continuum of possible behaviours -- based on a similar structure -- from passive or reactive to environmentally advanced or proactive strategies (Garcés-Ayerbe et al., 2016).

From another perspective, the opinions of experts and the data obtained from the companies surveyed are better aligned regarding the intermediate groups of activities, but the experts' opinions differ in certain respects from the results of the questionnaires collected from businesses about the CE-related activities that they consider relevant in the region. Most of the experts advocate the introduction of the circular model specifically to increase the level of the material loops closing, while the companies are introducing CE-related activities based on the volume of and return on the investment and are influenced by regulations and the market.

In summary, we observe that companies have widely implemented the activities in group I, which are considered first steps towards a more circular model. However, the regional experts interviewed do not identify the activities in group I as relevant, precisely because, in their opinions, businesses have already introduced them; these activities therefore bear less relation to a CE in terms of the closing of material loops. In many cases, companies have implemented the activities in group I to comply with regulations, due to the maturing of technologies or because the investments were profitable. Thus, as a result of this study to be discussed more deeply in future research, it can be argued that only firms with change processes of integrating a wide range

of CE-related activities, industrial symbiosis or/and collaborative solutions can achieve the most advanced levels of a CE.

It is undoubtedly that factors such as the sectors in which companies operate, the production processes that they must implement and the volume of investment required influence the process of adoption of the CE by firms (Aranda-Usón et al., 2019; Scarpellini et al., 2018). However, spatial factors and legal frameworks across local, regional and national levels add an additional layer of complexity to introducing the CE into businesses. From a regional perspective, it is important, therefore, to encourage the engagement of companies with the CE and to alleviate the difficulty in making these investments (Katz Gerro and López Sintas, 2019). In addition, the measurement of specific impacts of the business CE on the territory allows for focusing on the general drivers of the CE identified by Ranta et al. (2018) from each institutional environment, regulatory measures, normative indicators and institutional support at the territorial level to influence CE development (Aranda-Usón et al., 2018).

In summary, there is no doubt that the implementation of standardised metrics for measuring the environmental impact of CE-related activities and their impacts on linear models is required, in line with what was recommended by Lacy and Hayward (2011). However, the results obtained in this study suggest that existing sources of information can be used as a first approach to measuring the level of circularity adopted by a firm as a whole, at least until more specific metrics can be applied. Taking into account that the introduction of the CE at the micro-level is in the initial stage, the CE metrics have to be defined from different perspectives depending on the scope of the analysis, such as regional or sectoral. The metrics proposed in this study can offer selected insight into a company's sustainability work since they outline key topics of the year, filtered by the company's communication team and according to stakeholders' concerns (Ortas et al., 2019; Stewart and Niero, 2018). and corporate social responsibility (Zubeltzu-Jaka et al., 2018). While metrics and international standards are being developed for the CE, companies can measure their progressive approaches to the circular model through existing internal indicators and their environmental accounting and reporting practices, facilitating the internal measurement of circularity, which companies can perform to improve their cleaner production practices.

5. Conclusions

In this paper, a qualitative analysis based on a regional study was performed to measure the level of adoption of different CE-related activities by businesses and their engagement in the CE from a regional perspective. To this end, the main CE-related activities that can currently be implemented by companies have been categorised in this study through interviews with representatives of main stakeholders to define the relevance of the CE for businesses in the region.

As a general remark, we affirm that the level of adoption of the CE by businesses can be measured using a set of indicators able to define the volume of the CE-related activities performed by businesses that are considered relevant in a given territory. A certain incremental tendency can be appreciated through analysis of the specific activities that have been introduced at the micro-level in terms of the CE. However, we cannot affirm that the CE is being adopted by businesses with the principal aim of closing the material loops.

This approach to the CE from the micro-level allows us to elucidate the progressive process of adoption of the CE undertaken by businesses, influenced by different factors intrinsic to the regional contexts in which firms are located. At the first level of the CE - for those activities mainly related to recycling or energy and resource efficiency, renewables and eco-design - the CE introduction in firms is influenced by the specific regulations in the region and institutional planning (Scarpellini and Romeo, 1999). In this specific study, it has been emphasised that regulations regarding renewables and waste treatment have limited the introduction of some of the key activities for the deployment of the CE frequently addressed in other European regions. In addition, the most advanced levels of circularity are not considered by the firms located in the region. Subsequently, the implementation of new activities by firms would be conditioned on the volume of investment, the degree of uncertainty (legal and/or financial), and the public initiatives undertaken by administrations to promote new collaborative actions between companies in the territory to promote a greater degree of circularity. We conclude that, to improve institutional support for the CE and allow it to fulfil its potential as a sustainable growth model, diversified institutional support for reducing the products manufactured and materials used, as well as increasing reuse, is needed.

The main contribution of this paper o the academic literature is the measurement of the CE adoption by businesses in the area of the environmental management accounting, providing information about the progressive process of change and pointing out how firms could evolve to more advanced stages of a CE. This study enhances our knowledge about the scarce introduction of the CE among businesses and offers empirical evidence for the great difficulty in measuring internal processes that depend on different factors and often differ between companies. The proposed measurement represents a first approach to the stakeholders' theoretical framework applied to the CE, i.e., that of a subject still underexplored in the literature.

For policy makers, the availability of specific information about the level of adoption of the CE by businesses in a territory facilitates the development of environmental regional plans to promote the CE through specific actions depending on the level of adoption of the CE by businesses located in the region. This perspective can reduce the time required to introduce the CE through environmental planning to foster the most advanced stage of cleaner production based on the CE principles in the regional context.

This study has also important implications for management because the different CE-related activities can be used as a tool for the environmental management accounting to achieve competitive advantages and to change those processes to integrate progressively the CE-related practices. The measurement in a common framework of the proposed indicators-that are being measured at present by most of the firms-facilitates the decision-making to adopt a more circular business model or to introduce new CE-related activities to achieve a more advanced stage of circularity. In addition, this integrated measurement provides more detailed information for the social corporate responsibility and the sustainability reporting in terms of CE and facilitates to practitioners the estimation of the firms' impacts in response to the institutional initiatives that promote the CE in the territory. Thus, the measurement of this process at a territorial level is a complementary knowledge for both, the managers responsible for the environmental accounting processes for designing and developing environmental strategy, and for policy-makers to evaluate their environmental planning actions.

This study is not exempt from limitations, mainly due to the difficulty of obtaining internal data from the firms and the geographic limitations of this regional study. The evolution of the CE in a broader and ongoing organisational framework requires further investigation and must be thoroughly discussed. The individual business interplaying with the regional government and its institutional inference have not been specifically addressed in this study. A future line of inquiry should investigate how the different levels of adoption of the CE by businesses can be scaled up to the regional level.

Given its potential to provide information about corporate finance, environmental strategy, environmental management accounting, organisational issues, or the relations with stakeholders, now the CE literature at the micro level could be considered from both theoretical and applied environmental management angles and set different approaches for future research in the interrelation theoretical areas that the CE encompasses for cleaner production and sustainability.

Author contributions

All authors share equal contribution to this paper. All authors participated equally to the research design, development of the theoreti-

cal framework, methodological choices and the analysis. All authors wrote the paper and revised the manuscript for intellectual content and read and approved the final manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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2.4 Financial resources for the circular economy: A perspective from businesses (Artículo 4)

ARTICULO 3: Aranda-Usón, A., Portillo-Tarragona, P., Marín-Vinuesa, L. M., & Scarpellini, S. (2019). Financial resources for the circular economy : A Perspective from Businesses. Sustainability, 11(888), 1–23. https://doi.org/10.3390/su11030888

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JCR SOCIAL – Environmental Studies	2,592	44/116	Q2
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Financial Resources for the Circular Economy: A Perspective from Businesses

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Abstract: In recent years, a number of case studies of the circular economy in business have been analysed by academics. However, some areas of research are little explored at the micro level, such as the study of the characteristics of the financial resources applied to investments to introduce circular activities in businesses. Therefore, the main objective of this study is to define the resources applied to circular activities by firms. To describe the influence of financial resources on achieving a more advanced circular economy in business is also an objective of this paper. Using a sample of Spanish companies, we applied a partial least square structural equation model (PLS-SEM) to enhance the knowledge about financial resource management in the framework of the resource-based view. We find that availability of funds, quality of the firm's own financial resources and public subsidies have a positive effect in stimulating the implementation of circular economy initiatives in businesses.

Keywords: Financial resources management; circular economy; sustainability; resource-based view; environmental management accounting; corporate finance

1. Introduction

In this decade, the circular economy (CE) has been promoted as an approach to sustainable development that does not compromise economic growth [1]. The number of academic studies on the CE are increasing and different authors have reviewed its different definitions and approaches [2–7]. The introduction of the CE in businesses has also been analysed [8] due to the increasing interest of companies toward CE [9,10]. However, knowledge about how companies are adopting the principles of CE is still under investigation in the current literature [10].

Although there is a lack of studies specifically addressing matters of the CE at the micro level, scholars have investigated other factors that influence companies' commitment to the environment. Some examples are eco-innovation processes [11], eco-design [12,13], compatibility with existing production processes, capital life-cycle or the high initial direct costs of investment, and the exploitation of renewables [14]. Studies of eco-innovation are related to the CE since the introduction of environmental aspects in the design of products allows sustainability to be integrated in the production of goods [15]. Eco-design facilitates the CE in businesses since it contributes to closing the production loops by separating components and by preventing their obsolescence. Additionally, eco-design facilitates recycling and the reintegration of products into the economic system.

However, the study of specific internal resources and capabilities of companies related to the CE is at an early stage. In fact, to the best of our knowledge, a broad investigation remains open

regarding the definition and measurement of different characteristics of financial resources for the CE, although financial attractiveness can be considered today as a relevant aspect for the circular business model [16].

A number of the studies conducted within the resource-based view (RBV) framework analyse resources or capabilities related to eco-innovation [17] without offering total clarity concerning those resources required to finance the introduction of the CE at the micro level. In particular, identifying resources that are specifically applied to CE investments is a new line of enquiry. Financial resources applied to some of the different aspects of the CE, such as renewables, eco-innovation or to more general investments for environmental improvements have been addressed in the literature [18]; however, the combined effects of the characteristics of financial resources have not been considered with CE investments in the same analytical framework.

Therefore, the main objective of this study is to define and measure different characteristics of financial resources applied to the CE by firms. In summary, this study goes beyond previous research approaches related to the CE to extend knowledge by proposing connections with financial resource literature in the framework of the RBV. The analysis builds on and extends the research field on the CE by addressing both theoretical and methodological issues related to the definition and measurement of financial resources applied to CE activities by businesses.

To this end, a model of the cause-and-effect relationship between the CE scope achieved by businesses and the level of investment has been designed using partial least squares structural equation modelling (PLS-SEM). The model has been tested in a sample of companies in Spain that demonstrate special interest in eco-innovation, eco-design and some of the circular activities. Data was collected through the active collaboration of private businesses, which is required for analysing the financial resources that are needed to introduce the CE in firms.

This paper is organized as follows: a literature review is presented in the next section, before a description of the method and the sample. Following the methodology, the results are summarised and discussed within the RBV framework to outline main conclusions and potential avenues for future research.

2. Background

Different studies have been developed relating to the CE due to its relevance to the search for solutions to improve resource efficiency, materials intensity and other sustainability issues throughout the value chain [19]. To date, the debate about the specificity of resources has focused more on resources and capabilities for environmental proactivity or eco-innovation. Given the high difficulty posed by the CE, few authors have explored this line of research, probably due to the multifaceted aspects involved in the CE. Nevertheless, the measurement of the CE and the theoretical frameworks to define related resources are still under investigation due to the fact that CE implementation in businesses is still at an incipient stage.

It is not easy to opt for a theoretical approach when analyzing the environmental performance of companies in terms of the CE, since this model includes actions that affect all the functional areas of the companies. Thus, the close relationship that the CE has with eco-innovation is taken into consideration. At the micro level, proactive environmental strategies to enhance eco-innovative attitudes among companies [20,21] and eco-innovation [11] have been widely studied. Additionally, internal factors that influence eco-innovation have also been analysed in the literature [22–25]. Resources and capabilities of firms are demonstrated to be relevant for eco-innovative businesses within the theoretical framework of the RBV [26–28] and the natural resource-based view [29]. When considered in the study of corporate finance, the RBV is applied to define resources that a firm is able to control to eco-innovate [17]. The RBV theory has also been combined with institutional or contingency perspectives in order to account for external pressures that may affect the environmental strategies adopted by firms and to determine the specific advantages in the execution of these strategies [30].

In this study RBV is considered as an adequate theoretical framework to understand whether specific resources applied to the CE by businesses are relevant for closing production loops without affecting the level of competitiveness. In particular, the main goals of this study are to analyse the financial resources applied to the CE activities in the framework of the RBV and to enhance the knowledge about the financial resources that are needed when the CE is adopted by businesses. The level of CE achieved by companies is measured through a wide number of investments and activities carried out by businesses. Furthermore, the characteristics of the applied resources are also explored to help industries to develop specific resources in order to increase their scope in terms of the CE.

2.1. Financial Resources and the Circular Economy

While the benefits of the CE are increasingly recognised, there are still many barriers hindering the transition to a circular model in businesses. Some authors indicate that the inadequate financial scheme, the lack of financial resources [31], and the lack of support from public institutions [16,32,33] cause the slower adoption of the CE. Insufficient investment and the risks associated with circular business are considered to be obstacles to achieving the transition towards a CE, particularly for small and medium-sized enterprises (SMEs) [34].

The risk for organizations to include the CE in their actual practices [10] is mainly due to new investments in recycling, recovery infrastructure and eco-technologies for closing the loops. Insufficient investments in these activities and infrastructure, as well as an insufficient level of funds applied to eco-innovation, are considered barriers to the CE. It can be considered as accepted that in order to address the risks associated with circular business, it is necessary to encourage learning and innovation, initiate business strategies and facilitate cross-sector collaborations [35].

A study of barriers to promoting clean technology in Chinese SMEs reveals that the exterior barriers of policy and financing are more relevant than the internal technical and managerial barriers [36]. Therefore, the availability of funding, especially for investments in technology, is critical for firms to implement CE practices. Shahbazi et al. [37] affirm that limited financial capability for environmental investments is a primary management issue. Sue et al. [36] show that large financial resources need to be invested in CE pilot projects. In particular, the new perspective on selling services rather than products implies that businesses will not receive payment at the beginning of the product's life cycle, such that the timing of cash flow is even more relevant in these investments [38]. Therefore, there are no doubts that circular business models require adapted financial mechanisms.

An example of advanced collaboration within the CE is industrial symbiosis [39,40]. Ghisellini et al. [41] demonstrate that the reasons for companies to be involved in these advanced solutions of the CE are to recover the costs involved with environmental investments. The tax cuts, refund policies on resource use and financial subsidies positively stimulate the development of industrial symbiosis. Aid et al. [42] point out that problems in financing synergy partnerships are a limitation to the development of eco-industrial parks and they discuss how taxes and government subsidies allow viable economies of scale. On a similar theme, Velenturf [43] considers that collaborative processes fomented through the CE involve stakeholders for co-producing or co-deciding, and also for financing projects.

Masi et al. [44] highlight the importance of financial support through subsidies and other incentives in the recycling industry, in which the investment supports for technology development are believed to be vital [45]. Different studies have also emphasised public subsidies as an element that facilitates research, development and innovation activities [46]. Regarding the environmental sphere, Tirguero et al. [47] and Ghisetti and Rennings [48] point out the positive effect of public subsidies for adopting environmental innovation in companies. Moktadir et al. [49] demonstrate that small companies need more support from government for the adoption of sustainable manufacturing practices because they do not have sufficient capital.

From the cited authors, economic instruments—including fiscal and financial incentives, direct funding, and public procurement—have to be considered as relevant resources to foment the CE [50]. However, the incipient stage of adoption of a CE by businesses does not allow an in-depth analysis of literature around specific financial resources applied to the circular processes in the framework of the RBV. It has to be taken into account that the CE is a complex model that includes different environmental issues and concerns different areas of investments, such as those devoted to the environmental improvements of the company, eco-innovation or energy saving, and renewables. From an analysis of the literature regarding the CE, it could be assumed that all these areas represent an adequate endowment of resources and capabilities of the companies to invest in new activities for closing loops, and that a higher level of related activities carried out by businesses would suppose greater environmental performance in terms of the CE. However, it should be noted that most studies available in this area refer to resources and internal capabilities of companies that are not specifically related to the CE [17,51–53]. Accordingly, in this study, the financial resources are defined and measured when they are directly related to different activities of the CE: environmental improvements, eco-innovation, eco-design for circularity and resource saving. Therefore, the analysis of the background has been enhanced in our study to also include previous literature about investments to improve the environmental performance of businesses, the financial aspects of investments in energy saving and renewables and the financial resources applied to more general aspects of environmental innovation.

The insufficient investments and the risks associated with the improvement of the environmental performance in businesses have been traditionally palliated through direct public funding, such as grants for R&D, piloting activities, research infrastructure, innovation vouchers, supporting innovation incubation, etc. [34]. Likewise, tax reduction for recycled products has been proposed to increase their consumption and to promote the CE [34]. Few authors have delved into the analysis of these specific factors [54] given the great difficulty of differentiating the specific resources and capabilities of companies applied to the environmental investments by firms. Some authors focus their interest specifically on financial resources [55–57], access to capital, either through credit institutions or venture capital, expansion of capital and own funds, or the availability of public funds [58].

In the eco-innovation field, the influence of different parameters inherent to financial resources applied to eco-innovative investments has been considered in more dimensions [47,59–62]. Volume, availability, qualitative aspects of financing and the allocation of public subsidies to promote these investments have been analysed [18]. However, the in-depth study of the resources and capabilities that enable environmental performance continues to be a subject of debate with regard to financial resources and their application to eco-innovation.

In previous studies, other aspects related to financing, such as the level and structure of company debt, have been considered as explanatory variables of a company's eco-innovation behaviour through their relationship with financial performance [62–66]. It has also been demonstrated that the associated uncertainty implies a higher level of collateral for the granting of loans related to high risk investments [67,68] and reduces the flow of funds towards this type of investment [69]. Thus, the results obtained in the eco-innovation field were taken into account in this study to define how to measure the quantity of funds allocated to CE activities by companies. The availability of financial resources and their potential restrictions are also included into the analysis as they could affect the investments on CE [70,71].

From another perspective, renewables are considered as a pillar of the CE. The aim of increasing the contribution of renewable sources to the total energy supply is of worldwide importance to mitigate the negative energy effects of climate change [72]. However, a large amount of investment is needed for the energy transition and a significant lack of investment has been pointed out in the renewable energy sector in different geographic areas [73,74]. The financing gap for renewables when businesses are involved in the CE process could be framed within the availability and the cost of capital (and risk) since they influence the attractiveness of projects to investors. In fact, renewable energy projects are typically financed with a mix of equity and debt [73].

Financial constraints are a pertinent feature of the energy industry. Ekholm et al. [74] demonstrate that energy projects are typically capital-intensive, large, lumpy and with long payback periods. If insufficient capital is mobilised towards these projects, under-investment will lead to adverse consequences, including from a CE perspective. Specific funds have been created in various contexts in response to under-investment in climate mitigation [75]. Additionally, it has to be taken into account that most electricity market investment has traditionally come through a utility model, based on low levels of risk and secure returns [76]. It is questionable whether this model would work for renewables that have to be implemented in a CE because such investments require more diverse methods of financing. The availability of private resources increases under the established public–private partnership agreements and opens new financing channels that can be available in a high growth of renewable energy sector [77].

Safarzyńska and Van den Bergh [78] state that an overly rapid transition to renewable energy can pose a serious burden on the financial system because investments in renewable energy increase the price of electricity. The need for subsidies is also pointed out for renewables by Frisari and Stadelmann [79], who consider that the high cost and perceived risks represent significant barriers to the deployment of stable and clean energy in developing countries, and that public financing to improve projects' financial profiles is required.

In this context, financial resources are needed to perform a circular business model [80]; however, the investigation of the different characteristics of financial resources for the CE remains open. Thus, in this study specific variables have been developed and tested in this study to measure and define the characteristics of financial resources applied to the CE by companies. In summary, Table 1 shows how financial resources have been analysed in the general framework of environmental performance, business eco-innovation and sustainable energy

Table 1. Definition of different characteristics of financial resources applied to the circular economy (CE) and authors that have used similar variables.

FINANCIAL RESOURCES	Authors
"Quality" of financial resources for the Circular Economy (CE)	
Collateral (guarantees) required for the CE	[18,67,69,73,81]
Costs of the external funds for the CE	[18,65,71,74,76,82–84]
"Availability" of financial resources for the CE	
Capital availability as a restriction	[31,37]
Uncertainty about the cash flows derived from investments in the CE	[42,83]
Source of financial resources for the CE	
Investments financed with the company's own funds. ("equity funds")	[77,85–90]
Incentives and public funds, etc.	[17,18,47,48,77,79,91–97]
Investments in energy valorisation and renewables	
Financial aspects of investments in energy valorisation and renewables	[35,73,74,76,77]
Investments in eco-innovation	
Investments in innovative solutions to reduce the company's environmental impact.	[17,18,98]
Investments in environmental R&D (internal or external) for eco-innovation.	[17,47,50,59–62,99,100]

Studies on barriers and incentives for the CE are also included since they consider financial resources, even in terms other than those covered by our study.

2.2. Circular Economy Measurement

In a CE, materials that can be re-circulated are injected back into the economy as new raw materials, increasing the security of supply. These "secondary raw materials" can be traded and shipped just like primary raw materials from traditional extractive resources [101]. Materials from products at the end of their lifecycle are recovered through dismantling and recycling to reduce environmental impacts and production costs. Recycling is therefore a necessary precondition for a CE that includes eco-design for recyclability, reuse and other environmental management practices, such as resource efficiency [13].

In order to elaborate on comparative assessments of CE performance across the European Union (EU), data from Eurostat, the Resource Efficiency Scoreboard and the Raw Materials Scoreboard are being used for tracking progress in terms of circularity. However, these metrics are not adequate to measure the CE in firms because they are mainly applied to measure materials and resource flows at the territorial level but not internally in a company. Thus, it is important to have a set of reliable indicators specifically designed to be applied to businesses. To this end, in this study, the main activities carried out within the framework of the CE by businesses are considered. Repairing, reusing, refurbishing, reconditioning and recycling [102] are also taken into consideration because they are related to the CE.

Academics mostly address the measurement of the CE from the perspectives of resource scarcity if the research topic is energy. Criticality of materials or resource productivity is measured from the perspective of the reduction of solid waste, and the environmental impact is taken into account if the goal is to reduce emissions or pollution [103]. Bio-based and recycled products made from renewable biological resources and/or totally recycled materials are also considered as crucial for a CE. Moreover, it has been stated that eco-innovation plays a relevant role in transforming a linear system into a circular one [34].

In order to measure the CE, the relationship between the CE and indicators applied to eco-innovation measurement has been pointed out by Smol et al. [100]. From these considerations, waste recovery, actions related to energy efficiency and renewables, and eco-design and eco-innovation have been considered as basic activities when the CE is measured.

2.3. Research Questions

To the best of our knowledge, there is a gap in the literature as the relationship between the level of investment and firms' activities within the circular model has not been studied in detail. Within the framework of the RBV, certain resources and capabilities are particularly relevant for companies to improve their competitive advantage through eco-innovation.

In summary, the RBV is applied in this study to expand the knowledge in the corporate finance field to better understand whether the amount of financial resources drives better environmental performance in terms of the CE in businesses. The definition and description of specific financial resources applied to CE is also a goal of this study and the measurement of the level of CE achieved by companies allows us to enhance the knowledge about the measurement of the circular scope at the micro level.

On this basis and following the analysis of the literature about financial resources that can be applied to the CE, the research questions proposed in this study are as follows:

R1: Does a higher level of investment mean a higher level of CE in businesses?

R2: What characteristics of financial resources are related to the level of investment in the CE?

R3: Are financing decisions about the nature of resources related to the level of investment in the CE?

R4: Which activities for environmental improvement are influencing the circular scope of companies?

This study is transversal as it falls between the bodies of the measurement of financial resources for environmental investments and the CE activities carried out at the micro level, excluding analyses at the meso and macro levels [104].

3. Method and Sample

3.1. Sample and Data Collection

The analysis was performed through surveys that were sent to companies that were collaborating with an R&D project in north-eastern Spain. Companies were selected with more than 50 employees because the size is a factor that facilitates eco-innovative processes [105–108] and it was considered as a relevant characteristic of firms for the transition from a linear model to a circular model. Additionally, companies were selected if they operate in sectors with potential engagement with the CE. For this study, those sectors related to technologies included in the "Best Available Techniques", the so called "BREFs", were considered: industrial, transport and logistics, waste, extractive industry, manufacturing industry, electricity, gas, steam and air conditioning supply; water supply, sewerage, waste management, transport and storage. In these sectors the introduction of CE principles is both, necessary and technologically feasible [109]. Finally, 87 valid answers were obtained from a population of approximately 1000 companies that were identified with their corresponding value added tax identification number (VAT number). Table 2 summarizes the profile of the sample.

Table 2. Profile of sample.

	Total Assets (thousand euros)	Total Turnover (thousand euros)	Number of Employees	Return on Assets
Means	903,181.3	298,140.3	558.1	0.063
Deviation	5,426,286	1,084,284	1700.53	0.125
Minimum	1362.613	3952.4	50	−0.39
Maximum	48,300,000	8,597,300	14,106	0.56

The sample is integrated by medium businesses (66.67% have less than 250 employees), manufacturing firms (39.08%) and firms that are operating in the energy sector (26.44%).

3.2. Measurement and Variables

Specific variables were designed to measure the level of investments and the characteristics of the financial resources applied to CE-related activities. Variables used in other studies were taken as a starting point and specific variables were also developed for this study. Table 3 provides the items of the construct elaborated from the surveyed companies for the measurement of investments related to CE activities. Company size was considered as a control variable [110].

Table 3. Constructs, items and selected variables used to measure the financial resources applied by businesses.

Construct/Items	Description
Measurement of Investment in Activities Related to the CE	
Construct: FR	**Financial Resources**
FR-Q	*Construct "FR-Q":* **Financial Resources – Quality**
FR1	Level of collateral (guarantees) required for the company to finance eco-design/eco-innovation/environmental improvements compared to that required for other investments
FR2	Level of costs of external funds for eco-design/eco-innovation/environmental improvements higher than those necessary for the company's other investments
FR-A	*Construct "FR-A":* **Financial Resources – Availability**
FR3	Level to which the capital availability of the company's financial resources determines the investments
FR4	Level to which uncertainty about the cash flows derived from the investments in eco-design/eco-innovation/environmental improvements hamper the decision-making process

Table 3. *Cont.*

Construct/Items	Description
Measurement of Investment in Activities Related to the CE	
Construct: SF	**Source of Financing**
SF1	% of investments in environmental R&D, eco-design or similar that are financed with the company's own funds ("equity funds")
Construct: FR	**Financial Resources**
SF2	% of environmental R&D investments, eco-design or similar that are financed through public funds ("public grants"— subsidies, tax deductions, incentives, bonuses, etc.)
SF3	% of environmental R&D investments that are financed through foreign funds ("foreign funds")
Construct: ICA	**Investment in Activities Related to the CE**
CER	*Construct "CER":* **Energy Valorisation and Renewables (Circular Investments)**
ICA1	% of total revenues invested in energy valorisation of waste
ICA2	% of total revenues invested in renewables
CECOi	*Construct "CECOi":* **Eco-Innovation**
ICA3	% of the company's total revenues invested in innovative equipment/machines to reduce the company's environmental impact
ICA4	% of the company's total revenues invested in environmental R&D (internal or external) for eco-innovating
Construct: S	**Size of Companies**
S1	Total assets (thousand euros)
S2	Total turnover (thousand euros)
S3	Total employees (number of employees)

Thus, the possibility to extend a system of measuring eco-innovations and combine it with CE principles offered a set of transparent and accessible indicators that have already been tested and represents a simple and quick instrument for assessing the level of CE eco-innovation in a group of industries [100]. To define the scope of CE thought the activities performed by the firms, the variables described in Table 4 were selected.

Table 4. Constructs, items and selected variables used to measure the scope in terms of CE achieved by businesses.

Construct/Items	Description
Measurement of Circular Scope	
Construct CS	**Circular Scope**
CW	*Construct "CW":* **Waste Recovery**
CW1	% of recycling waste within the company itself (treatment to be recycled)
CW2	% of waste recovery within the company and reuse
DR	*Construct "DR":* **Dematerialization and Recycled Materials**
DR1	% of resource that has been replaced by other fully recycled materials to manufacture products or to provide services
DR2	% of the products' design or services that have been modified to reduce the resource intensity
CSE	*Construct "CSE":* **Circular Eco-Design**
CSE1	% of the products' design or services that has been modified to increase their functions (multifunction)
CSE2	% of the products' design or services that has been modified to extend their durability
CSE3	% of the products' design or services that has been modified to increase their recyclability (waste prevention)
SR	*Construct "SR":* **Resource Saving and Efficiency**
SR1	% of equipment or facilities that has been replaced and/or improved to reduce energy consumption
SR2	% of processes or operating procedures that has been replaced and/or improved to reduce energy consumption or to exploit renewables
SR3	% of components of the product or service that has been replaced by innovative components to comply with environmental regulations

In summary, variables were designed to measure the savings in emissions and resources, the replacement of raw materials and components and the investments made to decrease the environmental impact of products and companies, eco-design for the CE, waste valorisation and other related variables.

3.3. Statistical Analysis

To test the research questions, we used PLS-SEM. Our objectives were to predict the CE level of activity carried out by a company in the framework of the RBV to identify the key drivers that explain the specific characteristics of those funds invested in CE-related activities to make a firm more circular. PLS is recommended when the research objective has predictive purposes [111–114] and explanatory purposes [115]. Moreover, the use of PLS-SEM is also recommended when the research is trying to identify the key target constructs [116]. The application of a multiple indicators and multiple causes (MIMIC) approach in CB-SEM could mean constraints on the model that often contradict the theoretical assumptions. This conceptualisation and these conditions have been found in our model. We applied this statistical approach since it enabled us to estimate a complex model with many constructs, indicator variables and structural paths without imposing restrictions on distributional assumptions and size on data [117].

The PLS-SEM method is currently being subjected to debate about its pros and cons. The main criticisms of this methodology have been summarised by Rönkkö and Evermann [118] and Rönkkö et al. [119]. These authors argue that the use of PLS weights and many rules of thumb that are commonly employed with PLS are unjustifiable. In responses to the criticisms, different improvements and extensions to the method have been introduced by some authors [120,121]. Hair et al. 2018 [117] and Petter [122] recently demonstrate the value of PLS as an SEM technique. Currently, this method is widely applied by academics in the environmental innovation field [123–125].

PLS can be used with small sample sizes [117]; however, the nature of the population also determines the situations in which small sample sizes are acceptable [117,126]. Kock and Hadaya [127] demonstrate that the power of PLS-SEM is consistent with what one would expect from ordinary least

squares regression and probably from other methods with similar mathematical underpinnings. Thus, in this study, the recommendations of Kock and Hadaya [127] are also taken into account to evaluate the minimum sample size estimation that is required for PLS. The method known as the "minimum R-squared method", proposed by Hair et al. [128], that builds on Cohen's [129] power tables for least squares regression, has been applied in our study. Taking into account the values reached in our model for three elements—the maximum number of arrows pointing at a latent variable, the significance level and the minimum R2 in the model—we confirm that the data available in this research are sufficient to perform PLS properly.

The empirical study was carried out in two phases. In the first phase, an exploratory factor analysis was performed to validate the composite variables obtained from the indicators (i.e., the measurement scales). In the second phase, both the measurement model and the structural model were assessed. To this end, the SmartPLS 3.0 software (SmartPLS GmbH, Bönningstedt, Germany) was used as it is less sensitive to the violation of assumptions of data normality [130,131]. Moreover, we assessed the predictive validity of the structural model through the PLSpredict technique [112].

4. Main Results and Discussion

As a main result of this study, it was found that the level of investments carried out by companies was related to their scope of CE. To describe the activities carried out by businesses, it was observed that the level of innovative component replacement to comply with environmental regulations ranged from 1 to 10% of the incomes of the surveyed companies. Likewise, the respondents indicated a level investment in environmental R&D, eco-innovation, eco-design or similar that ranged between 1 and 10% of their revenues. In terms of investments in new equipment, appliances and machinery to reduce the environmental impact of the company as a whole, the average levels ranged from 6 to 10%. Average values for investments in waste valorisation and renewables ranged from 1 to 10% of the total revenues.

From another perspective, investments in eco-innovation, eco-design or similar that were financed with own funds, public incentives (subsidies, tax deductions, bonuses, etc.) and foreign funds had an average score that ranged from 6 to 10%, 1% to 5% and from 1 to 5% (and less than 1%), respectively. In Table 5, it can be observed that a high percentage of companies (26.44%) had financed more than 20% of these investments (environmental R&D investments, eco-design or similar) with their own funds, while 5.75% of companies had done so with public subsidies and 9.20% of companies with foreign funds.

Table 5. Financial resources mostly used to finance environmental investments by companies.

	More than 20% of own fund	More than 20% of public subsidies	More than 20% of foreign funds
Percentage of companies	26.44%	5.75%	9.20%

In this study, we did not differentiate the nature of these funds since the objective was to know whether companies received non-local funds or not, regardless of their nature. However, it was observed that 42.5% of the companies had foreign capital to finance their business activities. In more than 90% of these companies, the participation of foreign capital exceeded 20% of the capital. However, only 9.20% of the companies used more than 20% of foreign funds to finance their investments in environmental R&D, eco-design or similar.

The origin of subsidies and the purposes of this type of funds are summarised in Table 6.

Table 6. Origin and purpose of the public subsidies mostly used to finance environmental investments by companies.

Origin of subsidies	*% of companies with public subsidies from different financing agents*	**Purpose of subsidies**	*% of companies with public subsidies for different purposes*
Local Administration	**2.90%**	Employment	**14.49%**
Regional Administration	**36.23%**	R&D and innovation	**23.18%**
National Government	**39.13%**	Foreign trade	**11.59%**
European Union	**2.90%**	Environmental issues	**21.74%**
Other	**18.84%**	Other	**18.84%**

Regarding the scope of the CE achieved by the surveyed companies, the percentage of resources that were substituted ranged from 6 to 10%. The percentage of modified products to reduce resource intensity ranged from 1% to 5%. Internal waste recycling undertaken by the companies also ranged from 1 to 5% of the total volume of waste. Eco-design performed to improve the multifunctioning of products, their durability and recyclability of the products/services had an average level from 6 to 10% of the total production. In terms of resource saving, 10 to 20% of improved equipment or facilities were installed to reduce energy consumption. The percentage of improvement processes to reduce energy consumption or to exploit renewable sources ranged from 1 to 10%.

The characteristics of the financial resources applied to activities related to the CE had average scores of between 2 and 3 on a six-point scale that was used for the measurement of these variables in the questionnaire (0–"in no measure" to 5–"in large measure"). The respondents' perceptions about the extent to which the collateral (guarantees) and the cost of external financing to support eco-innovation activities were higher than for other activities reached values of 2.1 and 1.8, respectively, suggesting that these guarantees influenced eco-innovation activities. The availability of financial resources and uncertainty about the cash flows supporting the implementation of eco-innovation also greatly influenced the development of eco-innovation (the average scores achieved were 3.0 and 2.7, respectively).

4.1. Assessment of the Structural Model

As a preliminary stage to the assessment of the structural model, we carried out an exploratory factorial analysis (EFA) to test the unidimensional factors comprising the measurement scales. Results from the EFA showed that for the scales of financial resource quality (FR-Q), financial resource availability (FR-A), source of financing (SF), energy valorisation of waste and renewables circular investments (CER), eco-innovation (CECOi), waste recovery (CW), dematerialization and recycled materials (DR), circular eco-design (CSE), resource saving and efficiency (SR) and size of companies (S) were all formed by a single factor with a high explained variance: FR-Q = 82.07% (Kaiser-Meyer-Olkin (KMO) = 0.5), FR-A = 60.18% (KMO = 0.5), SF = 88.8% (KMO = 0.52), CER = 63.53% (KMO = 0.5), CECOi = 68.02% (KMO = 0.5), CW = 81.5% (KMO = 0.5), DR = 57.62% (KMO = 0.5), CSE = 61.4% (KMO = 0.56), SR = 57.3% (KMO = 0.5), and S = 68.74% (KMO = 0.51). For all scales, the KMO index provided good results, and the Bartlett's sphericity tests reflected a significance level of less than 0.001. These results show the appropriateness of the exploratory factor analysis performed.

In a second stage, the structural model was assessed. Figure 1 shows the results of PLS analysis. First, variables were combined as weighted sums (composites). In this way, aggregate measures were generating as they can be expected to be more reliable than any other indicator. Consequently, we used them as proxies for the following constructs: FR-Q, FR-A, SF, CER, CECOi, CW, DR, CSE, SR and S. The quality of this measurement model was assessed by analyzing the construct's reliability, the convergent validity criterion and the discriminant validity. Then, the cause–effect relationship between the variables was analysed. The effects from the exogenous variables on the endogenous

variables and the statistical significance of the relationships between the variables are shown in Figure 1. Below, we detail and explain the results of the analysis, differentiating both the assessment of the measurement model and the assessment of the structural model.

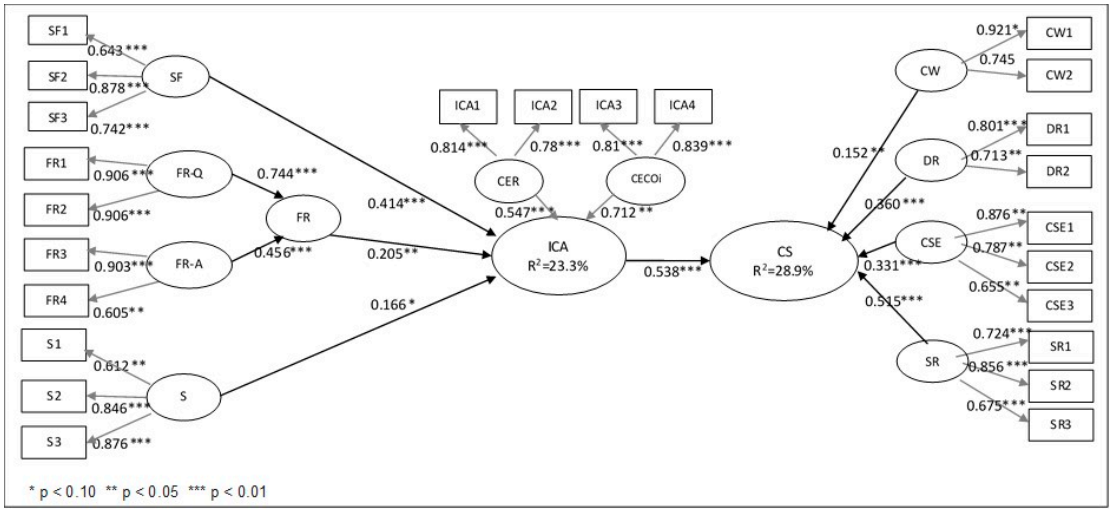

Figure 1. Structural model results.

With regard to the assessment of the measurement model, Table 7 shows the variables' standardized loadings. For all of the variables, standardized loadings were greater than 0.7 and were thus found to be significant. These results ensured the adequacy of the selected indicators. The consistency of the indicators that formed each factor was ensured by examining the composite reliability index. In all cases this index achieved very high values, being higher than 0.7, and in some cases near to or higher than 0.8 (Table 8).

The convergent validity criterion was met; in other words, all constructs had an average variance extracted (AVE) higher than 0.5 (Table 8). The minimum value recommended is 0.5 [132], which means that over 50% of the construct variance was due to its indicators. Discriminant validity was tested by examining two criteria. First, the matrix of loadings and cross-loadings was examined. The model loadings were larger than the cross loadings (see Table 7), then the criterion was fulfilled. The second criterion was also met, as the square root of the AVE of each construct was larger than the correlations among constructs (see Table 8).

Regarding the assessment of the structural model, Figure 1 and Table 9 show the overall model results, namely, the explained variance (R2) of the dependent variables, the path coefficients, and the significance of the paths. The significance of the path coefficients was tested using a bootstrap resampling procedure with 5000 iterations [133].

Table 7. Outer model loadings and cross-loadings.

	CER	CECOi	FR-Q	FR-A	SF	CW	DR	CSE	SR	S
ICA1	0.814	0.214	0.129	0.166	0.169	0.134	0.175	−0.075	0.284	0.185
ICA2	0.78	0.174	0.289	−0.002	0.104	−0.088	0.168	0.032	0.262	0.332
ICA3	0.178	0.81	0.084	−0.138	0.184	0.104	0.491	0.244	0.545	−0.041
ICA4	0.223	0.839	0.187	−0.017	0.499	0.164	0.353	0.072	0.379	0.058
FR1	0.223	0.152	0.906	0.317	−0.23	−0.147	0.179	0.06	0.025	0.043
FR2	0.245	0.149	0.906	0.319	0.064	−0.09	0.121	0.025	0.067	0.104
FR3	0.033	−0.046	0.367	0.903	0.037	0.004	0.286	0.102	0.062	0.13
FR4	0.182	−0.123	0.119	0.605	−0.084	−0.071	−0.042	−0.29	−0.115	0.193
SF1	−0.01	0.356	−0.162	−0.059	0.643	0.175	0.145	0.051	0.208	−0.167
SF2	0.215	0.33	−0.065	0.006	0.878	0.244	0.238	0.063	0.41	0.061
SF3	0.127	0.186	0.051	0.042	0.742	0.15	0.107	0.145	0.417	0.037
CW1	0.082	0.158	−0.14	−0.041	0.28	0.921	0.142	0.073	0.211	−0.059
CW2	−0.061	0.109	−0.064	0.006	0.166	0.745	0.133	−0.078	0.104	−0.107
DR1	0.245	0.519	0.046	0.181	0.243	0.1	0.801	0.047	0.675	0.332
DR2	0.069	0.232	0.22	0.142	0.123	0.15	0.713	0.544	0.242	−0.08
CSE1	−0.08	0.131	−0.03	−0.02	0.07	0.093	0.372	0.876	0.237	−0.172
CSE2	−0.066	0.052	0.083	0.025	−0.036	−0.08	0.192	0.787	0.108	−0.092
CSE3	0.079	0.239	0.08	−0.1	0.207	−0.001	0.244	0.655	0.291	−0.021
SR1	0.048	0.319	−0.026	−0.118	0.446	0.188	0.21	0.399	0.724	−0.197
SR2	0.46	0.407	0.087	−0.076	0.422	0.169	0.371	0.214	0.856	0.122
SR3	0.245	0.519	0.046	0.181	0.243	0.1	0.801	0.047	0.675	0.332
S1	0.278	−0.049	−0.046	−0.04	−0.031	−0.058	0.028	−0.061	0.12	0.612
S2	0.2	0.008	0.114	0.176	−0.037	−0.075	0.282	−0.083	0.174	0.846
S3	0.273	0.049	0.104	0.258	0.005	−0.076	0.142	−0.141	0.044	0.876

Table 8. Construct reliability, convergent validity and discriminant validity.

	CER	CECOi	FR-Q	FR-A	SF	CW	DR	CSE	SR	S	Composite Reliability	AVE
CER	0.797										0.777	0.635
CECOi	0.244	0.825									0.809	0.680
FR-Q	0.258	0.167	0.906								0.902	0.821
FR-A	0.107	−0.091	0.351	0.768							0.735	0.590
SF	0.173	0.421	0.091	0.007	0.715						0.748	0.512
CW	0.034	0.164	0.131	0.028	0.278	0.838					0.823	0.702
DR	0.215	0.508	0.166	0.214	0.247	0.162	0.759				0.730	0.576
CSE	−0.03	0.188	0.047	0.044	0.112	0.021	0.362	0.778			0.819	0.605
SR	0.343	0.556	0.05	0.001	0.488	0.201	0.625	0.283	0.755		0.798	0.571
S	0.321	0.013	0.081	0.19	0.021	0.089	0.187	0.129	0.128	0.787	0.827	0.619

Table 9. Structural model results.

Relations	Path Coefficients	t-value	Percentile Bootstrap 95% Confidence Level	
			Lower	Upper
CW => CS	0.152 **	2.043	0.027	0.310
DR => CS	0.360 ***	9.420	0.302	0.460
CSE => CS	0.331 ***	3.227	0.109	0.476
SR => CS	0.515 ***	9.696	0.430	0.620
ICA => CS	0.538 ***	7.789	0.383	0.658
CER => ICA	0.547 ***	6.002	0.363	0.727
CECOi => ICA	0.712 ***	8.487	0.579	0.918
SF => ICA	0.414 ***	4.202	0.196	0.591
FR => ICA	0.205 **	2.081	0.004	0.362
FR-Q => FR	0.744 ***	12.347	0.654	0.906
FR-A => FR	0.456 ***	8.097	0.353	0.548
S => ICA	0.165 *	1.796	0.019	0.342
Variances explained R2	$R2_{ICA}$ = 23.3%, $R2_{CS}$ = 28.9%			
Stone-Geisser's Q2	$Q2_{ICA}$ = 0.168, $Q2_{CS}$ = 0.269			

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Empirical support was found for all of the cause–effect relationships proposed in the research questions (Figure 1 and Table 9). Specifically, the construct we term investment in activities related to CE was positively related with the circular scope of businesses. These results suggest empirical support for the first research question (R1). Likewise, investment in activities related to CE, explained by energy valorisation of waste, renewable energy investments and eco-innovation, was positively related with the characteristics of the financial resources applied to the activities, including their quality and availability, the source of financing and the company's size. These results allowed us to respond to the second research question (R2) and suggest that all characteristics of financial resources were related to the level of investment in the CE. In particular, the construct named financial resources quality (FR-Q) explained 67% of the variance of the construct FR (Table 10).

Table 10. Effects on endogenous variables.

Relations	Direct Effects	Correlation	Variance Explained
SF => ICA	0.414	0.397	0.16
FR => ICA	0.205	0.192	0.04
S => ICA	0.165	0.186	0.03
FR-Q => FR	0.744	0.904	0.67
FR-A => FR	0.456	0.717	0.33
CW => CS	0.152	0.321	0.05
DR => CS	0.360	0.829	0.30
CSE => CS	0.331	0.612	0.20
SR => CS	0.515	0.868	0.45
ICA => CS	0.538	0.538	0.29
CER => ICA	0.547	0.722	0.39
CECOi => ICA	0.712	0.825	0.59
Variances explained R2	$R2_{ICA}$ = 23.3%, $R2_{CS}$ = 28.9%		

The results also allow us answer research question R3 in the affirmative, since the construct named source of financing was related to level of investment in the CE, especially the decision about financing through public subsidies (0.88). As shown in Table 10, the construct named financing resource contributed the highest percentage (16%) to the explained variance of the investment in activities related to CE.

Regarding research question R4, Table 8 shows that empirical support was also found for the positive relationship of the circular scope of businesses, summarised with the activities related to waste recovery, dematerialisation and recycled materials, circular eco-design and resource saving and efficiency. The construct named resource saving and efficiency contributed the highest percentage (45%) to the explained variance of the circular scope (Table 9). Empirical support was not found for the relationship between the size of company and the investment in activities related to CE.

The variance of the dependent variables was high: 23.3% and 28.9% for the investment in activities related to the CE and the circular scope, respectively (see Figure 1 and Table 8). The model was highly predictive of the investment in activities related to the CE and the circular scope. The values of Stone Geisser's cross-validated redundancy (Q2 = 0.16 for the investment in activities related to CE, and Q2 = 0.26 for the circular scope) confirmed the structural model's predictive relevance (Q2 > 0). The approach and recommendations of Shmueli et al. [112] were applied for assessing the predictive validity of the model. For this one, we used PLSpredict and carried out the benchmark procedures developed by the SmartPLS team [134]. Table 11 shows Q2 values, which compared the prediction errors of PLS results against simple mean predictions. All Q2 values (Q2 > 0) confirmed that the prediction error of the PLS results was smaller than the prediction error of simply using the mean values. Moreover, the differences between PLS and LM results (named differences PLS-LM) were very small for all indices: Q2, mean absolute error (MAE) and the root-mean-square error (RMSE). The Q2 differences were less than 0.06 in all cases, and the MAE differences and RMSE differences were around 0.03 and lower. Thus, the predictive validity of the model was confirmed.

Table 11. Partial least square (PLS) prediction assessment.

Indicator Prediction Summary									
	PLS			LM			Differences PLS-LM		
	RMSE	MAE	Q2	RMSE	MAE	Q2	RMSE	MAE	Q2
CW	1.006	0.609	0.01	1.03	0.618	0.037	−0.024	−0.009	−0.027
DR	0.956	0.713	0.107	0.975	0.725	0.073	−0.019	−0.012	0.034
CSE	1.015	0.757	0.004	1.041	0.783	0.054	−0.026	−0.026	−0.050
SR	0.918	0.699	0.182	0.913	0.690	0.19	0.005	0.009	−0.008
CER	0.972	0.685	0.076	0.966	0.682	0.086	0.006	0.003	0.001
CECOi	0.952	0.687	0.116	0.947	0.677	0.125	0.005	0.01	−0.009
Construct prediction summary									
CS	Q2 CS = 0.145								
ICA	Q2 ICA = 0.184								

4.2. Discussion and Implications on CE

In this paper, we have addressed certain characteristics of financial resources that can influence the circular activities developed by firms in the RBV framework to explain the relevance of specific resources of businesses in the transition towards the circular model. Based on the literature reviewed in this paper, which takes a theoretical approach to firms' financial resources, we have made progress in the knowledge of the management of the endogenous factors that are applied by businesses in the processes of the CE.

From the obtained results, we can affirm that the level of investment is related to the scope of CE achieved by companies (R1). These results allow us to make inferences in a line of inquiry that is, thus far, little explored due to the initial stage of the CE activities implemented by the companies. To the best of our knowledge, similar studies do not currently exist that could be discussed.

The availability of funds and, in particular, the quality of financial resources, are also related to the level of investment in the CE. The availability of resources, especially at an adequate cost, are shown as relevant factors in the development of diverse circular activities carried out by companies. In particular, the quality of resources should be noted as the level of collateral (guarantees) required for a company to finance activities in the framework of CE was higher than the level required for other investments. A similar observation was made with respect to the higher level of costs of the external funds required for these activities (R2). Thus, the obtained results endorse and expand the studies that identify the quantity and availability of financial resources as one of the barriers to the CE [31,37,44].

Another line of research concerns the relevance of the financing decisions on the nature of resources (R3). The results obtained in this study bear out the role of public funds and subsidies as drivers to the promotion of the CE [44,45]. The lack of financial resources is also considered as a barrier for eco-innovation [68]. Likewise, the availability of public funds (subsidies) to finance environmental R&D investments also affects the level of CE activities implemented by firms. These results are in line with the conclusions gathered in studies focused on eco-innovation [18]. Public incentives and the availability of financial resources and their quality influence a higher level of eco-innovation.

In the same line of enquiry, Cecere et al. [68] identify access to public funds and tax incentives as elements that propel the development of eco-innovation. In the CE, Ormazabal et al. [31] state that a lack of financial resources is a barrier that limits the implementation of the CE in companies and highlight the need to have public institutional support for Spanish SMEs that require different strategies, namely, financial stimulation and technological modernization, both of which are connected to the lack of financial resources. More specifically, for eco-innovation, Scarpellini at al. [18] demonstrate with a specific analysis of this sample that the availability and quality of financial resources and public incentives lead to a higher level of eco-innovation in order to define and measure different financial resources within the RBV framework.

The results of this study also suggest that access to public funds and fiscal incentives may accelerate the development of eco-innovations, and that their effectiveness interacts, in particular, with firms' availability of external financing, in line with Cecere et al. [68]. Empirical results regarding the effectiveness of subsidies (and tax incentives) to promote eco-innovation are not absolutely conclusive [135,136], although some authors show that public subsidies drive the development of eco-innovations [92,137–140]. From our analysis, the relationship between the CE and indicators applied for eco-innovation measurement pointed out by Smol et al. [100] is endorsed.

5. Conclusions

The different characteristics of financial resources applied to circular activities by firms have been analysed in this study to enhance the knowledge about the influence of businesses' financial resources to achieve a more advanced level of CE. Public subsidies and the availability and quality of finance applied by firms to circular activities have been measured using a novel approach in the framework of the RBV. These characteristics of financial resources influence the activity's development and determine the choice of resources to finance the investments. The importance of public financial incentives has also been demonstrated, as it allows a reduction in risk exposure, the financial feasibility and the provision of profitability of the CE investment projects.

Although it cannot be conclusively demonstrated that the CE requires exclusive resources, we observed that some resources that are applied by businesses to investments related to the CE, such as the improvement of the environmental performance, eco-innovation, eco-design, resource valorisation, energy efficiency or renewables, can be differentiated from those applied to other processes by companies.

In summary, this paper represents an expansion of the previous literature by increasing the knowledge about financial resources as one of the barriers to the CE. Additionally, the relevance of the financing decisions to the nature of financial resources has also been analysed, which is a novelty in this field. The results obtained in this study bear out the role of public funds and subsidies as drivers for the promotion of the CE, and can be applied by public administrations to promote circular businesses.

The measurement of different activities carried out by firms that are related to the circular model provides a preliminary outlook for progress towards the CE in businesses. Activities that are influencing the circular scope of companies have been defined. These results launch a double line of enquiry about the measurement of the circular scope of businesses, from one side, and the specific investments that must be applied to the CE as unique and inimitable resources of each company in the framework of the RBV, from another side.

In the academic field, this study offers innovative results in the corporate finance framework for the management of financial resources. In the environmental management accounting field, this study offers specific knowledge for measuring CE activities and processes. For practitioners, the obtained results provide a set of indicators for CE measurement at the industry level, allowing companies a means of transparency and reporting on their activity, corporate social responsibility related to the CE, and environmental performance in closing the production loops.

A limitation of this study is related to the measurement of the degree of circularity, which only accounts for some of the activities carried out by businesses. The use of other indicators that also reflect materials embodied in trade could provide an additional perspective. However, this study does not provide a detailed analysis of the relationship between financial resources and financial performance. The role of venture capital operations or business-angels' funds and the role they can play in the development of investments in the CE are also not addressed in this paper since this would require more in-depth analysis taking into account a larger set of indicators.

Furthermore, it is important to also investigate trends in progress made over a longer period in order to obtain longitudinal data relating to current development trends in the CE. Reliable and relevant data are essential in order to monitor progress towards a circular economy and to analyse the role of eco-innovation in this process.

The obtained results are relevant for the internal measurement processes related to the CE.

One of the challenges for academics is to bring the discussion around the CE to the firm level. In our case, the contribution to the debate about what resources are being applied by businesses to close the loops to be more competitive in this new business model has been focused on those financial resources that are needed to invest in circular innovative solutions.

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2.5 Dynamic capabilities and the environmental accounting for the circular economy in businesses (Artículo 5)

ARTICULO 4: Scarpellini, S. Marín-Vinuesa, L.M., Aranda-Usón, A., Portillo-Tarragona, P. (2019) *on-line*. Dynamic capabilities and environmental accounting for the circular economy in businesses. Sustainability Accounting, Management and Policy Journal. in press doi https://doi.org/10.1108/SAMPJ-04-2019-0150 - IN PRESS

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Dear Dr Sabrina Scarpellini, Dr Luz María Marín-Vinuesa, Dr Jose Alfonso Aranda Uson and Prof María Pilar Portillo Tarragona,

This letter is to confirm that your paper "Dynamic capabilities and environmental accounting for the circular economy in businesses" has been accepted and is scheduled to be published in the *Sustainability Accounting, Management and Policy Journal*. Your article was accepted for publication on 18th November 2019, and is scheduled to publish online on 15th January 2020.

I would like to thank you for your contribution to the journal, on behalf of Emerald Publishing and the editorial team of *Sustainability Accounting, Management and Policy Journal*.

Best regards,
Jenny Chester

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Dynamic capabilities and environmental accounting for the circular economy in businesses

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ABSTRACT

The circular economy (CE) is becoming a common theme in the literature on sustainability. However, the impact of the environmental capabilities of firms on the introduction of a CE at the micro-level is still under investigation. In this context, this study uses the dynamic capabilities theoretical approach to analyze the different environmental capabilities that firms apply to introduce the CE. Environmental management systems, corporate social responsibility, reporting and accountability, and other environmental accounting practices are studied in the same framework of analysis as a set of environmental capabilities that influence the circular scope (CS) of firms. We also examine the influence of stakeholders on the level of CE achieved by firms. The results are obtained using least squares structural equation modeling (PLS-SEM), which has been tested in a sample of Spanish companies. This study also addresses methodological issues in CE research by applying a novel approach to measurement.

1. Introduction

In recent decades, managers' awareness of environmental issues—such as climate change, greenhouse gas emissions, waste disposal, landfill site utilization, land and water pollution, resource consumption, and the recycling of materials—has increased. In this context, the term circular economy (CE) is used by governments, researchers, and businesses alike to describe an approach to sustainable development that does not constrain economic growth (Pratt et al., 2016). A CE involves the transformation of a linear economic model into a circular one to reduce dependence on raw materials and energy and to mitigate the environmental impact of production and consumption.

In summary, the main objectives of a CE are the reduction of the flow of materials, the achievement of energy efficiency, and the continual renewal of natural and social capital through multiple phases (Yuan et al., 2006). In a CE, fewer materials are required to produce a constant level of products, either because of a reduction in the amount of

resources used or because raw materials are replaced with recycled ones (Figge et al., 2017).

Several initiatives for businesses have been launched by Governments in different geographic areas, In the European Union (EU), the communication 'Towards a circular economy: A zero waste programme for Europe' and its annex (European Commission, 2014) laid foundations for the promotion of CE in the EU's member states. Among the EU's ongoing initiatives are those concerning plastics (European Commission, 2018a), energy extraction from waste (European Commission, 2017) and critical raw materials (European Commission, 2018b), in addition to those concerning renewable energy, eco-design and energy efficiency (European Commission, 2015). China led the way in enacting the Circular Economy Act (Republic of China, 2008), which was the first time that the promotion of CE was elevated to the status of law (Ghisellini et al., 2018; Mathews and Tan, 2011, 2016; Wang and Li, 2006; Zhijun and Nailing, 2007). Similarly, other countries are using the principles of CE among businesses (Aranda-Usón et al., 2018). Even so, most companies have a long way to go before they can be considered as fully engaged in a circular business model (Witjes and Lozano, 2016).

Research into the CE is also gaining ground in the academic, particularly at the macro-level (Ghisellini et al., 2016; Kirchherr et al., 2017; Korhonen et al., 2018; Merli et al., 2018; Pomponi and Moncaster, 2017; Prieto-Sandoval et al., 2018; Urbinati et al., 2017). At the micro level, scholars are studying the role of firms in the development of the CE (Aranda-Usón et al., 2019; Katz Gerro and López Sintas, 2019; Lewandowski, 2016), but knowledge about how businesses understand and introduce the CE model is still limited, and the study of internal factors—such as resources and capabilities related to the CE in businesses—is in an early stage.

Studies conducted at the micro-level have analyzed certain resources that are being applied by firms to achieve a CE (Aranda-Usón et al., 2019; Katz Gerro and López Sintas, 2019). The financial resources applied by firms to the different activities that contribute to a CE were recently considered by Aranda-Usón et al. (2019) within the resource-based view (RBV), and different approaches to the capabilities applied to CE-related activities in businesses—founded on the theoretical framework of dynamic capabilities—were carried out by Katz-Gerro and López Sintas (2018) or by Garcés-Ayerbe et al. (2019) who analyse barriers and drivers to introduce the CE in European businesses. Although these researchers seem to agree on the relevance of a firm's resources and capabilities to the CE, no specific studies yet exist that explore ways of defining and measuring environmental practices and capabilities for the CE.

If we study the capabilities that may be applicable to the CE, informal environmental management systems (EMSs) such as certification standards (ISO 14001, EMAS, ISO 50001, ISO 14006), have to be considered as important managerial competences, in addition to those indicated by Katz-Gerro and López Sintas (2018). Furthermore, in order to extend the concept of eco-innovation that is identified as part of a transition toward the CE (Kiefer et al., 2018), we consider that standardised processes and controls could contribute to the introduction of a CE as they do in the case of eco-innovation (Daddi et al., 2016; Park et al., 2017; Portillo-Tarragona et al., 2018; Rehfeld et al., 2007).

From the perspective of dynamic capabilities, reporting activities are also included in the analysis because investors' access to non-financial information is a milestone on the roadmap to resource efficiency. Environmental reporting to stakeholders and financial

markets are relevant in the context of the CE (Verbeke and Buysse, 2003). Likewise, environmental accounting and environmental management accounting (EMA) need to be included in the analysis, because the circular model implies changes made in the management and accounting practices of companies in order to manage natural resources for cleaner production (Burritt et al., 2019).

Accounting has been identified by Burritt and Schaltegger (2001) as a tool for corporate environmental management, and EMA has been related to different environmental fields (Burritt et al., 2019). Thus, environmental accounting practices are sure to be relevant in management operational planning and decision-making processes within businesses aimed at achieving a circular model, and in particular in those applications related to such aspects of the CE as material flow and waste. Therefore, in this study we investigate the relationship between certain practices of environmental accounting and the CE-related activities that are being introduced by firms (Hong et al., 2018; Pieroni et al., 2019).

From another perspective, the influence of stakeholders in firms' adoption of the CE there have been studied (Lieder and Rashid, 2016; Ranta et al., 2018; Stewart and Niero, 2018). However, to the best of our knowledge, the broad topic of stakeholder pressure and its relation with the environmental capabilities (capabilities applied to the environmental activities of firms) that firms have to manage in order to introduce the CE in their processes, particularly if a circular business model is adopted, remains open.

On these bases, the main objective of this study is to define and measure in a broader framework the environmental capabilities that firms apply to introduce the CE. This study goes beyond previous research to extend our knowledge of the adoption of the CE at the micro-level by using a transversal approach, since the topic bridges the fields of environmental accounting and the CE while addressing both theoretical and methodological issues.

To this end, a model of the cause-and-effect relationship between firms' circular scope and their level of environmental capabilities and stakeholder pressure has been designed using partial least squares structural equation modeling (PLS-SEM), which was tested in a sample of Spanish companies.

The remainder of the article is structured as follows. Following a review of the literature, the methodology of the study is described. The results are summarized and discussed within the dynamic capabilities framework to outline the main conclusions and potential avenues for future research.

2. Background

2.1 Circular scope and environmental capabilities

The CE is becoming a topic of increasing interest among scholars in the social sciences because it is a relevant instrument in the search for solutions to problems regarding resource efficiency and the sustainable consumption of materials across all stages of the value chain (Yuan et al., 2006). Researchers also show a burgeoning interest in the introduction and measurement of the CE in firms (Aranda-Usón et al., 2019; Lewandowski, 2016; Pauliuk, 2018), although the adoption of this model by private firms remains poorly understood (Stewart and Niero, 2018).

To date, the literature has mainly focused on factors that affect the commitment of private firms to the CE, on existing barriers and incentives (Ormazabal et al., 2016, 2018), and

on the adoption of the circular business model (Bocken et al., 2014, 2016; Mentink, 2014; Witjes and Lozano, 2016). In summary, the circular business model aims to reduce companies' dependence on raw materials and to promote the transition from fossil fuels to renewables and the adoption of sustainable production in the value chain (Linder and Williander, 2017; Zamfir et al., 2017).

In order to measure the introduction of the circular business model and the CE at the micro-level, particular indicators have been applied to products (Linder et al., 2017; De los Rios and Charnley, 2017; Di Maio and Rem, 2015) and consumers (Borrello et al., 2017). However, only a few studies have looked at measuring the level of CE achieved by a company as a whole (Aranda-Usón et al., 2019; Pauliuk, 2018), and there is still no consensus on how to measure the different CE principles introduced by firms. In particular, the definition and measurement of the capabilities that firms are required to have to introduce the CE remain under investigation.

Resources and capabilities have been demonstrated to be relevant to success in environmental strategy within the theoretical framework of an RBV of the firm (Barney, 1991, 2001) and its extension to dynamic capabilities (Teece et al., 1997). In recent years, the dynamic capabilities–based perspective has provided a theoretical basis for analyzing the competitive advantage resulting from a firm's environmental improvements (Aragón-Correa and Rubio-López, 2007; Boiral, 2007; Essid and Berland, 2018; Iñigo and Albareda, 2016; Kabongo and Boiral, 2017; Katz Gerro and López Sintas, 2019). Under the dynamic capabilities framework, the competitive advantage lies in the firm's capacity to integrate, build, and reconfigure business competences to better adapt to the changing business environment (Eisenhardt and Martin, 2000; Teece et al., 1997; Zollo and Winter, 2003).

Zollo and Winter (2003) define dynamic capability as the learned and stable pattern of collective activity through which an organization systematically generates and modifies its operating routines in pursuit of improved effectiveness. Teece (2007) points out that in the dynamic capabilities framework, success in management innovation can be achieved by a firm in creating, extending, and modifying its resource base. A number of studies conducted within the dynamic capabilities perspective have analyzed the antecedent organizational routines by which managers alter their deployment of resources to generate new value-creation strategies (Ambrosini et al., 2009; Eisenhardt and Martin, 2000; Scott, 2013; Teece, 2007; Wu et al., 2012). Thus, from the perspective of a CE, dynamic capabilities are considered well suited to the study of circular patterns in firms (Katz Gerro and López Sintas, 2019), because this theoretical approach can capture proactive environmental strategies related to the sustainability of competitive advantage in dynamic environments.

According to Katz- Gerro and López Sintas (2018), interdependence among CE activities should produce better environmental and financial performance. The implementation of the 3R's (reduction, reuse, and recycling) within firms is also understood as a dynamic capability that includes interrelated CE practices to achieve a common goal (Zeng et al., 2017). Consequently, a firm's development of CE-related activities must follow a certain trajectory of competence and activity development.

In addition, some authors highlight the importance of developing dynamic capabilities to support proactive environmental strategies through adopting informal EMSs (Aragón-Correa and Sharma, 2003; Russo, 2009; Zhu et al., 2013). In fact, path-dependent

learning, such as that exemplified in ISO 14001 and related EMSs, comprises an important aspect of the dynamic capabilities (Zhu et al., 2013) that are deployed when environmental management tools are adopted.

Despite the fact that EMSs vary in their ability to mitigate environmental impacts, they can be considered as complementary competencies that may support the CE-related activities of firms. Scholars have demonstrated that EMSs improve environmental performance (Aravind and Christmann, 2011; Boiral et al., 2018), and they have been highlighted as potential conduits for the development of firms' environmental capabilities for eco-innovation (Amores-Salvadó et al., 2015). However, the impact of EMSs on the CE in businesses has not, to date, been empirically investigated. Thus, following this analysis of the literature, the first research question proposed in this study is:

- *(RQ1) Is the adoption of EMSs related to the circular scope of firms?*

In summary, in this study, the circular scope (CS) is considered to be the level of adoption of CE-related practices by businesses and is used in order to define the different activities (their number and range) that firms have introduced to close the loops in terms of a CE. In a CE framework, firms are currently expected to integrate environmental responsibility at all levels of their operations; to find sustainable solutions for reducing the consumption of natural resources; to manage environmental risks ensuring reduction in waste, pollution, and emissions; and to maximize the efficiency and productivity of all assets and resources, including improvements in the management of water, energy, and materials (Katsoulakos and Katsoulacos, 2007). The extent to which these practices are introduced in businesses—which in this study is briefly defined as circular scope, or CS—can lead to different levels of loops closure in terms of a CE, and its measurement in still under investigation.

2.2 Environmental accounting and management for a circular economy

The CE has emerged as a solution to the wide-ranging challenges presented by economic growth and sustainability (Franco, 2017) and it implies that firms must define and measure the investments they make and the activities they carry out to close loops. Thus, when a circular business model is adopted, environmental accounting practices become more relevant within firms.

There are a variety of concepts involved in environmental accounting. Tanc and Gokoglan (2015) offer an exhaustive definition of this concept and its genesis in the literature. They discuss it as a combination of accounting practices used in studying mutual relations between accountants and ecology, awareness of environmental cost information, and settled environmental costs distribution to the appropriate products and processes.

Although some aspects of the adoption of environmental accounting processes by companies have been studied (Wilmshurst and Frost, 2001), little is known thus far about how information relating to the CE principles introduced by businesses should be accounted, gathered, analyzed, and internally reported. The paradigm shifts from providing financial information to reporting social and environmental concerns is a missing link in our knowledge of sustainable practices and strategy development (Collins et al., 2011), particularly when circular business models are adopted by firms.

The accounting data inherent to the CE that could potentially be separated and reported may arise from environmental issues depending on the nature of the business, such as

tangible and intangible assets related to the application of environmental laws and regulations. Investments and expenses related to participation in carbon trading schemes; assets and provisions related to soil, groundwater or air pollution, the use of hazardous substances, or the disposal of waste; and fines or penalties incurred are also issues that have to be reported. In facts, financial flows related to climate change risks and potential flood risks are relevant data for firms in a circular model. In particular, the decision-making process about investments to improve the environmental performance are influenced by environmental pressures, the increasing energy costs, or other activities such as estimating impacts on the risk management policy of the company or determining appropriate financial provisions for liabilities, pollution, environmental contamination, and the restoration of wildlife habitats are becoming more relevant.

In such a context, we can assume that a CE-related accountancy might involve, principally, a reappraisal of the identification and measurement of the relevant costs of processes and products. Such accounting may include life-cycle management (Qian et al., 2011), environmental cost accounting, environmental liabilities, environmental investment appraisal, life-cycle assessment (LCA), and life-cycle costing. In particular, the "3R" principles of a CE (Jawahir and Bradley, 2016; Liu and Bai, 2014) have been combined with Material Flow Cost Accounting (MFCA) as a method of EMA (Zhou et al., 2017) that has been introduced by firms for eco-innovation.

Albelda (2011) has demonstrated that management accounting is a facilitator of environmental management and there is no doubt that the application of specific costing methods and the calculation of the value of flows will provide valuable information for environmental management and for the decision-making process regarding circular business models (Yang et al., 2019) There is, however, little evidence to demonstrate the role of EMA in improving sustainability in all types of businesses and, in particular, in addressing CE-related issues. To the best of our knowledge, no specific studies analyze the level to which companies have introduced EMA in a CE framework—to, for instance, post entries related to environmental activities and investments and specific information about sustainability in a circular model.

In a wider context, the managerial environmental capabilities related to top managers' environmental commitment have been analyzed for eco-innovation (Chang and Chen, 2013; Del Río et al., 2012, 2016). Thus, a joint environmental management competence, which includes the availability of human resources for the CE and EMA, needs to be explored. Therefore, a second research question is considered in this study:

- *(RQ2) Are environmental accounting and management capabilities related to the circular economic scope of firms?*

2.3 Reporting and accountability in a circular model

Reporting practices that include both financial and non-financial key environmental performance indicators are expected to be relevant to redirecting businesses toward a CE. At present, the level of information on environmental matters provided by firms is a topic of interest in the literature on sustainability. Research has focused on analyzing the inclusion of environmental data in annual accounts using social and environmental standards (Mathews, 2008), disclosure practices and accountability in green sectors (Burritt and Schaltegger, 2010; Llena et al., 2007; Walton, 2000), and cleaner production (Marco-Fondevila et al., 2018). In this context, the reporting of environmental

information and its quality are interesting topics to the CE research community, although very few authors have addressed these issues (Stewart and Niero, 2018).

Yearly, an increasing number of large companies release CSR reports, which are provided to their external stakeholders. In particular, regarding companies' approaches to the CE, CSR reports have been used by scholars as a data source with which to investigate CE-related activities (Sihvonen and Partanen, 2017; Stewart and Niero, 2018). In CE studies, CSR has generally been framed in terms of the "triple bottom line" of sustainability (Merli et al., 2018). While studies focusing on eco-innovation have demonstrated the relation between eco-innovative activities and environmental disclosure policies (Correa et al., 2013; Marco et al., 2019; Ruiz-Romero et al., 2013), the relation between CSR and the introduction of a CE in businesses has not been specifically addressed.

Departing from these premises, this study aims to explore the link between the CS achieved by firms and their CSR practices, because this investigation might yield different results from those found in studies of companies carrying out eco-innovation. Therefore, the following research question is considered:

- *(RQ3) Is the level of CSR and accountability of firms related to their circular scope?*

2.4 Circular economy and stakeholders

There is a general understanding that both CE and sustainable business practices require a systematic perspective on the role of businesses in the wider system of stakeholders and the environment (Murray et al., 2017; Pauliuk, 2018). The environmental behavior of a company in a CE context is influenced not only by internal factors but also by its external context (Liu and Bai, 2014). Research has demonstrated that stakeholder pressure positively affects environmental proactivity and the adoption of a circular business model (Witjes and Lozano, 2016) to generate value according to the firms' internal activities (Urbinati et al., 2017). Thus, to define a comprehensive set of CE-related indicators, the needs of all stakeholders should be satisfied (Banaite and Tamosiuniene, 2016).

The role of stakeholders is an issue that intersects with the introduction of a CE at the micro-level, due to benefits such as cost savings, investments in innovation, improved customer relationships, and the resilience of organizations (Pauliuk, 2018). However, to the best of our knowledge, no specific empirical studies have yet focused on stakeholder pressure and the circular scope of businesses, and one of the objectives of this study is to begin to fill this gap. To that end, the fourth research question is proposed:

- *(RQ4) Is the level of stakeholder' pressure related to the circular scope of firms?*

To answer these four research questions, the methodology described in the following section was designed.

3. Methodology and sample description

3.1 Sample and data collection

To achieve the objectives of this research study, we empirically analyzed surveys obtained through the active cooperation of a sample Spanish firms with more than 50 employees. Size was considered a relevant characteristic of firms in the transition from a

linear model to a circular one because it is a factor that facilitates eco-innovative processes (Aboelmaged, 2018; Triguero et al., 2015; Wagner, 2007; Zhang and Walton, 2017).

The population from which the sample of firms was selected was defined through an R&D project[1] and a specific campaign promoting eco-innovation, eco-design, and the CE in the Northeast Spanish regions of Aragon, Catalonia, Navarre, and the Basque Country, that is an area with high eco-innovation rates which offers earlier results about eco-innovative firms at regional level (Scarpellini et al., 2019). Aiming at focusing the research on cases where proactive environmental strategy can be considered a truly competitive advantage, in line with the dynamic capabilities theoretical framework, the sample was shortened to those companies operating in sectors with the greatest potential for eco-innovation, eco-design, or the CE. Thus, surveyed firms were selected if they were operating in industries related to the technologies referred to in the documents as "BREFs" of "Best Available Techniques"[2]. These industries include industrial transport and logistics; waste; the extractive industry; the manufacturing industry; electricity, gas, steam, and air conditioning supply; water supply; sewerage; waste management; transport; and storage. Although this selection criterion may exclude some companies that are adopting a circular business model, it is believed that, following Ding (2014), this criterion selects the vast majority of firms that are eco-innovating. Moreover, we consider that the majority of firms that are introducing CE-related activities are included in these industries, in line with Aranda-Usón et al. (2019) who consider these sectors provide the technological conditions for the introduction of the CE at micro level. The objective was to count on companies with proven proactivity in these practices and investments. and the eco-innovative nature of firms and theirs interest on the CE were determined through their active participation in the collaborative project.

The sample was obtained through refining a list of 2,232 companies elaborated from the SABI database[3] that provide main economic and financial figures of Iberian companies. In 2015, a total of 996 questionnaires were e-mailed to these companies with detailed contact information. Finally, 110 surveys were obtained, and 87 of them were considered complete observations for this study, representing a final sample of 8.8%. The main data collection instrument used was a questionnaire (Figure 2), that was e-mailed to the firms' managers who answered through an on-line platform in order to collect the primary data. It should be highlighted that the main objective of this study required the collection of internal data from potential CE-interested companies that are carrying out eco-innovation, eco-design, or related investments in order to assess the internal resources of businesses.

The focal respondents were managers in charge of these investments or, failing that, the firms' managers because their linkage with eco-innovation implementation has been demonstrated by Marín-Vinuesa et al. (2018) and by Rivera-Torres et al. (2015) who empirically demonstrate the impact of the environmental concerns on internal organization. Thus, managers were considered as adequate to collect information about

[1] Further information about the project and the selected firms at: https://socioene.unizar.es/proyectos/recoinno/empresas.html (assessed on July 2019)

[2] See http://www.prtr-es.es/documentos/documentos-mejores-tecnicas-disponibles (accessed June 2016).

[3] SABI Balance Sheet Analysis System (SABI) [online database]. 2016. Madrid.

the investments of companies and their perception due to their knowledge, experience and expertise (Oduro and Haylemariam, 2019).

The companies that filled out the questionnaire were identified by their value added tax (VAT ID) numbers in order to obtain financial data. Consequently, the research included qualitative data (obtained from managers) and quantitative data (those collected from the SABI database). The collaboration with identified firms for the empirical analysis means a smaller number of valid observations, but the identification of the companies in the sample allows us to integrate the economic–financial data of the companies with their position regarding the CE and the specific resources allocated.

3.2 Measurement and variables

In order to answer to the research questions formulated in this study, three groups of CE-related activities and competencies are analyzed: EMS, environmental capabilities and accounting, CSR and accountability. In addition, the financial performance of the companies and stakeholder pressure were measured as well.

The variables were selected or designed to measure the relationship between the CS achieved by firms and its relationship with the above described environmental capabilities of firms. To select these variables, methods used in other studies were taken as a starting point and specific variables were elaborated for this study. Tables 1, 2, and 3 provide the scale items of the constructs obtained for the analysis.

As already observed in the literature review, methods for designing specific CE indicators are being developed, but a gap remains regarding CE indicators at the organizational level (Pauliuk, 2018). A dashboard of quantitative indicators for the implementation of a CE in organizations has been proposed by Pauliuk (2018) through MFCA and LCA, which have been identified by other authors, too, as methods for assessing environmental strategy in organizations (Daddi et al., 2017; Haas et al., 2015; Huysman et al., 2017; Pratt et al., 2016). In a similar line of research, Zhou et al. (2017) have applied a composite index based on MFCA to the analysis of CE performance in firms. However, the application of these proposals is limited to businesses that have introduced these tools and that operate mainly in the manufacturing and industrial sectors. Thus, this study applies the set of indicators recently proposed by Aranda-Usón et al. (2019) for measuring the CS of a firm at an organization level (Table 1).

Table 1. Constructs, items, and selected variables to measure the circular scope of businesses (Aranda-Usón et al., 2019)**.**

Environmental activities related to the CE: **CIRCULAR SCOPE (CS)**		
Construct/Items	Construct/Items description	Variable description
Construct: CW	Waste recovery (CW)	
CW1	% of recycling waste within the company itself (treated to be recycled)	*Likert scale from 0 to 5*
CW2	% of waste recovery and reuse within the company	*Likert scale from 0 to 5*
Construct: DR	Dematerialization and recycled materials (DR)	
DR1	% of resources replaced by other fully recycled materials to manufacture products or provide services	*Likert scale from 0 to 5*

DR2	% of products' design or services modified to reduce resource intensity	*Likert scale from 0 to 5*
Construct: CSE	Circular eco-design (CSE)	
CSE1	% of products' design or services modified to increase function (multifunction)	*Likert scale from 0 to 5*
CSE2	% of products' design or services modified to extend life	*Likert scale from 0 to 5*
CSE3	% of products' design or services modified to increase recyclability (waste prevention)	*Likert scale from 0 to 5*
Construct: SR	Resource saving and efficiency (SR)	
SR1	% of equipment or facilities replaced and/or improved to reduce energy consumption	*Likert scale from 0 to 5*
SR2	% of processes and operating procedures replaced or improved to reduce energy consumption or exploit renewables	*Likert scale from 0 to 5*
SR3	% of components of products or services replaced with innovative components to comply with environmental regulations	*Likert scale from 0 to 5*

The construct called "environmental capabilities for the circular economy," to measure the firm competences deployed for CE-related activities, includes qualitative data about environmental reporting derived from managers' responses about their standards and procedures. Taking into account the capabilities that may be applicable to the CE, this construct measures formal and informal EMSs through the certification standards that the firms hold, such as ISO 14001, EMAS, ISO 50001, and ISO 14006 (Table 2). These responses include the type and volume of environmental information reported about the adoption of the EMS.

From another perspective, certain environmental items may require special treatment, due to their negative impact with regard to the introduction of a circular business model. To this end, the advantages of the EMA system pointed out by Cullen and Whelan (2006) are considered, such as the identification, classification, and allocation of costs for the reduction of the negative impact and decision-making (Adams, 2002; Bartolomeo et al., 2000; Gibson and Martin, 2004). This study also proposes a general variable for measuring the extent to which companies post entries related to environmental activities and investments and specific information about sustainability. These variables were developed in line with those applied by Marco et al. (2019) to the eco-innovation carried out by these firms. The human resources available for environmental management is also considered, and it is measured in accordance with the procedures used by Scarpellini et al. (2017).

Finally, in a CE model in which environmental issues have a material impact, specific disclosures may be necessary (Table 2). A third variable integrates the construct to measure the dissemination of good corporate governance rules, because this assures the firm's capability of reconfiguring internal and external competences to address the new environments required by the CE. Thus, the qualitative data regarding managers' perceptions of environmental disclosure were gathered in order to measure the relevance and importance of environmental proactivity (Luque-Vílchez et al., 2019) and of environmental reporting to managers, based on their policies regarding transparency and accountability (Marco et al., 2019).

Table 2. Constructs, items, and selected variables to measure environmental capabilities for the CE.

ENVIRONMENTAL CAPABILITIES FOR THE CIRCULAR ECONOMY (CE)		
Construct/Items	Construct/Items description	Variable description
Construct: EMS	Environmental management systems (EMS)	
EMS1	Level to which the company implements the ISO 14001 standards	*Likert scale from 0 to 5*
EMS2	Level to which the company implements the EMAS standards	*Likert scale from 0 to 5*
EMS3	Level to which the company implements the ISO 50000 standards	*Likert scale from 0 to 5*
EMS4	Level to which the company implements the ISO 14006 standards	*Likert scale from 0 to 5*
Construct: EA	Environmental capabilities and accounting (EA)	
EA1	Level to which the company posts entries related to environmental activities and investments and specific information about sustainability	*Likert scale from 0 to 5*
EA2	Number of employees in the environmental management department or similar	*Likert scale from 0 to 5*
EA3	Level to which the company applies and disseminates its good corporate governance rules	*Likert scale from 0 to 5*
Construct: CSR	CSR and accountability (CSR)	
CSR1	Level to which the company adheres to the CSR model compared to other companies in the sector	*Likert scale from 0 to 5*
CSR2	Level to which the company voluntarily reports on its activity related to sustainability in open access platforms (web, reports, press)	*Likert scale from 0 to 5*
CSR3	Level to which the company provide specific sustainability reports of environmental impacts addressed to stakeholders	*Likert scale from 0 to 5*
CSR4	Level to which the company has a specific and public policy on reporting and accountability	*Likert scale from 0 to 5*

In two separate constructs, other variables were introduced to measure managers' perceptions regarding stakeholders' pressure, and the financial performance of firms was measured using a construct from three indicators (Hamann et al., 2013): return on equity (ROE), return on sales (ROS), and return on assets (ROA) (Table 3).

On the other hand, the variables organizational size and industry sector were included as control variables in the statistical analysis. The organizational size (S) was measured using a construct from three indicators (Table 3): number of employees, total revenues and total assets (Aboelmaged, 2018; Triguero et al., 2015; Wagner, 2007; Zhang and Walton, 2017). The industry sector to which the firm belongs was measured using two

dichotomous variables in line with Aranda-Usón et al. (2019) and Ding (2014): - manufacturing industry (MI) variable that takes the value 1 if the firm is from the manufacturing and 0 otherwise; and - transport and storage industry (TI) variable that takes the value 1 if the firm is from this industry and 0 otherwise. In this way, we examine outcome considering three different sectors, the manufacturing, the transport and storage, and the other industries. We select these variables considering the sample distribution regarding industry sector, the largest percentage of the firms in the sample (59.77%) was made up of firms belong to the manufacturing industry, followed by those industries involved in transport and storage (24.14%), and other industries (16.1%) which include power, gas, steam and air-conditioning supply, water-supply, drainage, waste management and decontamination, and mining.

Table 3. Constructs, items, and selected variables to measure stakeholder pressure and the financial performance of the firms contained in the sample.

Construct: ST	Stakeholders (ST)	Variable description
ST1	Degree to which the company must reduce its environmental impact to comply with regulations in the short term	*Likert scale from 0 to 5*
ST2	Level of social pressure on the company to reduce its environmental impact	*Likert scale from 0 to 5*
Variable	Financial performance (FP)	Variable description
FP1	Return on equity	*Min = -5.508; Max = 0.779*
FP2	Return on sales	*Min = -0.751; Max = 5.000*
FP3	Return on assets	*Min = -1.502; Max = 0.491*

3.3 Statistical analysis

Given the objectives of this study, we used SEM based on the partial least squares (PLS) approach for measurement, validation, and testing of the structural model. We used SmartPLS version 3.0 (Ringle et al., 2015), because the PLS approach enabled us to estimate a complex model with many latent variables, indicator variables, and structural paths. The variance-based PLS method is preferable to the covariance-based alternative when the construct modeling is established as a composite model of multiple indicators and multiple causes (MIMIC) and the conceptualization of the measurement model is reflective (Sarstedt et al., 2016). The application of a MIMIC approach in CB-SEM could place constraints on the model that would contradict the theoretical assumptions. PLS analysis was deemed suitable for this study because one segment of the study is measured using a single item (Hair et al., 2018).

This study applies the ten times rule proposed by Hair et al. (2011) for determining appropriate sample size when using PLS. The rule of thumb is that the sample size should be greater than ten times the maximum number of inner or outer links pointing at any latent variable in the model (Goodhue et al., 2018). In our proposed model, the highest number of paths leading to a dependent variable is three, while the number of indicators on the latent variable is five. Thus, according to this rule, the minimum required sample

size would be 50. The 87 responses in the data set are thus sufficient to perform PLS properly.

To determine whether or not common method bias threatens the interpretation of our results, two criteria were examined (Podsakoff and Organ, 1986). First, Harman's one-factor test was used: when all indicators are entered into a principal components factor analysis, no single factor accounts for the threshold of 50% variance, indicating no substantial common method bias. Second, when the matrix of bivariate correlations between constructs was examined, the correlations were not high ($r < 0.9$), meaning the criterion was fulfilled (Bagozzi and Yi, 1988). These results suggest that common method bias is not a serious threat in our study.

The empirical analysis was carried out in two phases. In the first phase, the measurement model was estimated. In the second phase, the structural relationships outlined in the structural model were assessed.

4. Main results and discussion

4.1. Measurement model

The measures from the dataset were tested by assessing the unidimensionality and reliability of the multi-item constructs. First, an exploratory factor analysis (EFA) was performed using principal components analysis, followed by varimax rotation for factor extraction. To test the appropriateness of the data for the EFA, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's sphericity test were used. The results of the EFA showed that the multi-items constructs—environmental management systems (EMS), environmental capabilities and accounting (EA), CSR and accountability (CSR), waste recovery (CW), dematerialization and recycled materials (DR), circular eco-design (CSE), resource saving and efficiency (SR), stakeholders (ST), financial performance (FP), and size organizational (S)—were all formed by a single factor with a high explained variance: EMS = 48.8% (KMO = 0.68), EA = 51.1% (KMO = 0.56), CSR = 60.5% (KMO = 0.77), CW = 81.5% (KMO = 0.5), DR = 57.6 (KMO = 0.5), CSE = 61.4% (KMO = 0.56), SR = 57.3% (KMO = 0.5), ST = 67.9% (KMO = 0.5), FP = 59% (KMO = 0.55), S = 79% (KMO = 0.53). For all scales, the KMO index provided good results, and Bartlett's sphericity tests reflected a significance level of less than 0.001. These results show the appropriateness of the EFA analysis performed.

Next, we verified the reliability and validity of the measurement model. Convergent validity was assessed through the average variance extracted (AVE), composite reliability (CR), and variables' standardized loadings (Table 4). All constructs had an AVE that exceeded the recommended value of 0.5 (Bagozzi and Yi, 1988). This means that over 50% of the construct variance was due to its indicators. The consistency of the indicators that formed each factor was also ensured by examining the CR index. In all cases, this index achieved very high values—all higher than 0.7 and, in some cases, near 0.8 or higher. Moreover, for all variables, standardized outer loadings were close to 0.7 or higher and were thus found to be significant. These results confirm the adequate convergent validity of the model for the selected indicators.

Table 4. Validity and reliability for constructs

	Outer Loadings	AVE	CR

Environmental management systems (EMS)		0.491	0.762
EMS1	0.666		
EMS2	0.671		
EMS3	0.737		
EMS4	0.703		
Environmental capabilities and accounting (EA)		0.511	0.755
EA1	0.742		
EA2	0.801		
EA3	0.637		
CSR and accountability (CSR)		0.604	0.859
CSR1	0.688		
CSR2	0.830		
CSR3	0.843		
CSR4	0.740		
Waste recovery (CW)		0.701	0.822
CW1	0.926		
CW2	0.737		
Dematerialization and recycled materials (DR)		0.576	0.731
DR1	0.769		
DR2	0.749		
Circular eco-design (CSE)		0.607	0.820
CSE1	0.881		
CSE2	0.799		
CSE3	0.638		
Resource saving and efficiency (SR)		0.572	0.798
SR1	0.739		
SR2	0.857		
SR3	0.660		
Stakeholders (ST)		0.679	0.809
ST1	0.826		
ST2	0.822		
Financial performance (FP)		0.573	0.801
FP1	0.769		
FP2	0.765		
FP3	0.737		

To verify the discriminant validity of the model, we confirmed that the square root of the AVE of each construct was larger than the correlations among constructs (see Table 5). Later, the matrix of loadings and cross loadings was examined to confirm that the model loadings were larger than the cross loadings (Table 6). However, some cross loadings attain values higher than 0.4 for the other constructs (CSR1/ST: 0.41; SR3/DR: 0.77; DR2/CSE: 0.54; and DR1/SR: 0.66).

To further explore this issue, the heterotrait-monotrait (HTMT) criterion was examined to confirm that all values of correlations between the constructs are below 0.85 (Table 5). The HTMT ratio of correlations has been established as a criterion superior to other ones

(the Fornell-Larcker criterion and the examination of cross loadings) for measuring the discriminant validity (Henseler et al., 2016). Given that the HTMT ratio criterion was met in our analysis and that the standardized outer loadings were higher than 0.7 in all cases, we conclude that the measurement model showed adequate convergent validity and discriminant validity.

Despite the fact that the discriminant validity criterion was met, the information provided by the respondents about the resources/products managed for the dematerialization and the use of recycled materials.

Table 5. Discriminant validity

Construct	CSR	EA	EMS	CW	DR	CSE	SR	ST	FP
CSR and accountability (CSR)	0.777	0.661	0.471	0.222	0.21	0.199	0.223	0.68	0.314
Environmental capabilities and accounting (EA)	0.405***	0.714	0.563	0.193	0.357	0.294	0.351	0.542	0.556
Environmental management systems (EMS)	0.325***	0.31***	0.706	0.173	0.152	0.199	0.292	0.391	0.398
Waste recovery (CW)	0.156 ns	0.014 ns	0.021 ns	0.837	0.247	0.179	0.277	0.26	0.231
Dematerialization and recycled materials (DR)	0.134 ns	0.138 ns	0.117 ns	0.164 ns	0.759	0.761	0.797	0.374	0.225
Circular eco-design (CSE)	0.098 ns	0.003 ns	0.031 ns	0.021 ns	0.381***	0.779	0.271	0.19	0.13
Resource saving and efficiency (SR)	0.140 ns	0.135 ns	0.076 ns	0.203 ns	0.599**	0.285ns	0.756	0.284	0.277
Stakeholders (ST)	0.435***	0.254**	0.215**	0.153 ns	0.206 ns	0.06 ns	0.138 ns	0.824	0.359
Financial performance (FP)	0.223**	0.363***	0.243***	0.046 ns	0.081 ns	0.017 ns	0.196 ns	0.224**	0.757

Values below the diagonal are correlations between factors (*** $p < 0.01$; ** $p < 0.05$; ns = not significant). Values above the diagonal: ratio HTMT 0.85 criterion.

Table 6. Cross loadings

Construct	EMS	EA	CSR	CW	DR	CSE	SR	ST	FP
EMS1	**0.666**	0.198	0.137	0.064	0.093	0.007	-0.092	0.097	0.049
EMS2	**0.671**	0.164	0.249	0.002	0.103	0.049	0.129	0.185	0.161
EMS3	**0.737**	0.262	0.218	0.069	0.019	-0.063	0.004	0.114	0.135
EMS4	**0.703**	0.205	0.251	-0.067	0.107	-0.063	0.133	0.173	0.242
EA1	0.266	**0.742**	0.238	-0.034	0.254	0.117	0.15	0.258	0.169
EA2	0.293	**0.801**	0.302	-0.014	0.056	-0.149	0.088	0.244	0.362
EA3	0.079	**0.637**	0.340	0.023	-0.028	0.069	0.047	0.011	0.103
CSR1	0.288	0.322	**0.687**	0.073	0.017	-0.011	0.045	0.415	0.146
CSR2	0.283	0.278	**0.830**	0.126	0.21	0.132	0.200	0.350	0.117
CSR3	0.314	0.338	**0.843**	0.173	0.096	0.108	0.187	0.323	0.099

CSR4	0.104	0.326	**0.74**	0.103	0.083	0.062	-0.027	0.263	0.079
CW1	0.047	0.009	0.146	**0.926**	0.147	0.073	0.214	0.161	-0.031
CW2	-0.034	0.05	0.110	**0.737**	0.129	-0.081	0.103	0.08	0.051
DR1	0.154	0.177	0.132	0.099	**0.769**	0.044	0.66	0.216	0.137
DR2	0.022	0.03	0.071	0.151	**0.749**	0.544	0.243	0.094	0.069
CSE1	-0.100	0.018	-0.015	0.094	0.393	**0.881**	0.242	0.043	0.079
CSE2	0.004	0.014	-0.014	-0.077	0.210	**0.799**	0.115	-0.029	-0.046
CSE3	0.048	0.043	0.271	0.000	0.254	**0.638**	0.294	0.118	-0.056
SR1	-0.049	0.064	-0.003	0.189	0.214	0.399	**0.739**	-0.022	0.024
SR2	0.063	0.184	0.181	0.171	0.365	0.208	**0.857**	0.113	0.126
SR3	0.154	0.177	0.132	0.099	0.769	0.044	**0.66**	0.216	0.137
ST1	0.157	0.184	0.389	0.071	0.185	0.096	0.12	**0.826**	0.052
ST2	0.197	0.235	0.327	0.182	0.155	0.002	0.107	**0.822**	0.091
FP1	0.231	0.310	0.144	-0.001	0.106	0.007	0.151	0.087	**0.769**
FP2	0.034	0.117	0.177	-0.089	0.088	0.026	0.135	0.124	**0.765**
FP3	0.220	0.325	0.185	-0.038	0.005	-0.052	0.152	0.270	**0.737**

We applied the second-order construct type II or higher component model (HCM) type reflective-formative measurement model (Ringle et al., 2015). To analyze the relationships between the first-order and second-order constructs, the following steps were carried out. First, an EFA analysis was performed using principal components analysis; both environmental capabilities for the CE (ECA) and circular scope (CS) were found to be higher-order constructs, with second factors represented by three (in the case of ECA) and four (in the case of CS) first-order factors. Second, we analyzed the validity of the higher-order constructs (known as hierarchical component models, or HCMs) with PLS-SEM to demonstrate that the relationship between each second-order factor and its first-order factors was one of statistical significance (Hair et al., 2011). Next, a bootstrapping procedure with 5,000 iterations was performed to examine the statistical significance of the relationships between the constructs. Table 7 shows the statistical significance of weights ($p < 0.01$ and $p < 0.05$) of the first-order constructs on the specified second-order constructs. Subsequently, we confirmed the environmental capabilities for the CE (ECA) as an HCM with a second-order factor represented by three first-order factors: EMS for the CE (EMS), environmental capabilities and accounting (EA), and CSR and accountability (CSR). Similarly, the second-order factor of CS is represented by four first-order factors: waste recovery (CW), dematerialization and recycled materials (DR), circular eco-design (CSE), and resource saving and efficiency (SR).

Moreover, we assessed the formative measurement model for collinearity between indicators using variance inflation factor (VIF) values. The tolerance represents the amount of variance of the formative indicator not explained by the other indicators in the same factor. In our analysis, all VIF values are lower than 3.3 (Rohdin et al., 2007).

Table 7. Higher-order constructs

Second-order constructs	First-order constructs	VIF	Weight	T-value
Environmental capabilities for CE (ECA)	EMS	1.175	0.365	6.144***
	EA	1.265	0.338	8.002***

	CSR	1.444	0.603	9.269***
Circular scope (CS)	CW	1.057	0.158	2.039 **
	DR	1.384	0.357	8.552***
	CSE	1.284	0.380	3.417***
	SR	1.179	0.485	6.340***

Note: *** $p < 0.01$; ** $p < 0.05$

4.2. Assessment of structural model

Having tested the dimensional structural of the variables, PLS-SEM was used to test whether there were cause-and-effect relationships between environmental capabilities for the CE and CS achieved by firms, along with the mediating effect of stakeholders and financial performance. This model was formulated to answer the research questions (RQ1, RQ2, RQ3, and RQ4).

Bootstrapping (5,000 resamples) was used to assess the significance of the path coefficients (Hair et al., 2011). Table 8 shows that the construct called "environmental capabilities for the CE" is positively related to the level of CS (the path coefficient is positive and significant at 0.05 level of significance). Likewise, there is a positive relationship between environmental capabilities for the CE and financial performance ($p < 0.01$). These results offer empirical support for the positive relationships between CS and the variables EMS, environmental accounting practices, and other management capabilities to answer research questions RQ1, RQ2, and RQ3. Figure 1 shows the model results of the overall relation, namely, R2 in the dependent variables and path coefficients.

Moreover, the results verified the mediating effect of environmental capabilities on the stakeholders–CS link by confirming that all criteria discussed by Baron and Kenny (1986) are met. We tested the mediating relationships by (1) establishing the positive relationship between ST and CS; (ii) establishing the positive relationship between ST and ECA; (iii) establishing the positive relationship between ECA and CS; and (iv) establishing that the positive relationship between ST and CS becomes weaker or insignificant once ECA (environmental capabilities for the CE) is included in the model as a mediation variable. The results of these tests, presented in Table 8, support these four conditions. First, the independent variable ST has a significant effect on the CS variable (0.189, $p < 0.05$) in a model that excludes environmental capabilities for the CE (ECA); second, the variable ST has a significant positive effect on the ECA variable (0.43, $p < 0.01$); third, the variable ECA has a significant positive effect on the CS variable (0.17, $p < 0.05$); and fourth, the relationship between ST and CS becomes statistically insignificant (at 0.5 level of signification) once the ECA variable is included in the model as a mediation variable (0.14, $p = 0.235$). We also conducted three tests to examine the mediating effect: the Sobel test, the Aroian test, and the Goodman test.

The results of these tests offer empirical support for the mediation relation (Sobel test statistic: 2.73, $p = 0.038$; Aroian test statistic: 2.038, $p = 0.041$; Goodman test statistic: 2.11, $p = 0.034$). Once the conditions recommended by Baron and Kenny (1986) have been met, examining indirect effects is more effective in testing for mediation (Preacher and Hayes, 2004). As shown in Table 8, the path coefficient that measures the indirect effect of stakeholders on CS through environmental capabilities for the CE is positive and

significant (0.067, $p < 0.05$); since the direct effect was not significant, the findings reveal that environmental capabilities for the CE mediate the influence of stakeholders on CS.

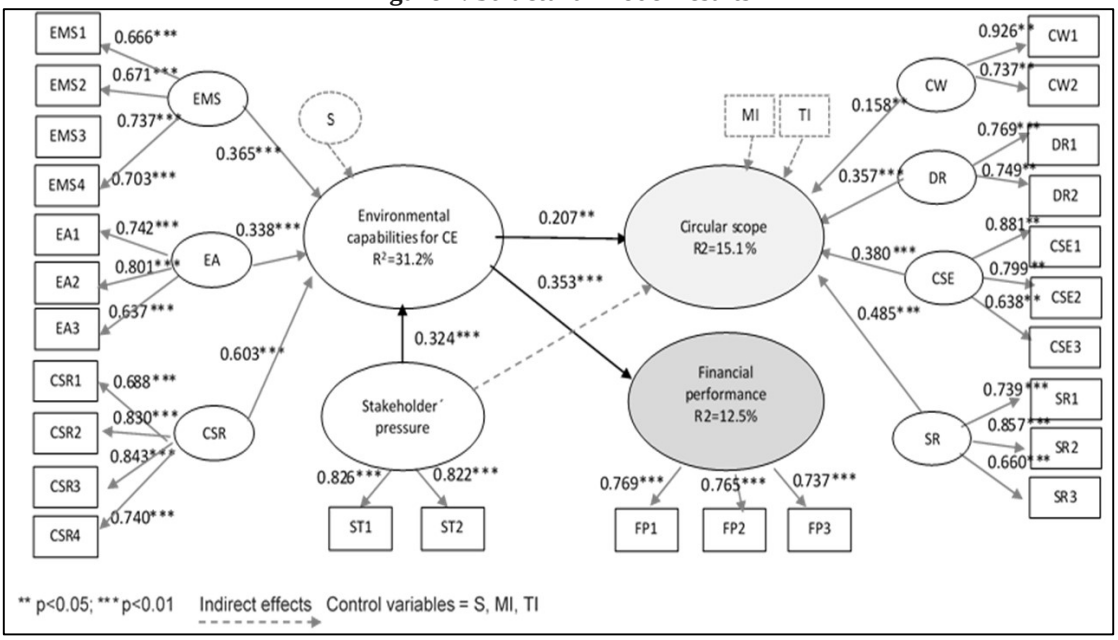
Table 8. Results of structural model

Relations	Path coefficients	t-value	Percentile bootstrap 95% confidence level	
			Lower	Upper
Direct effects				
ECA => CS	0.193	2.356**	0.029	0.344
ECA => FP	0.353	3.069***	0.101	0.549
ST => ECA	0.432	4.939***	0.239	0.585
Indirect effects				
ST => ECA => CS	0.084	2.025**	0.014	0.174
ST => ECA => FP	0.153	2.306**	0.039	0.295
Variances explained R2	R2 ECA = 0.186, R2 CS = 0.087, R2 FP = 0.124			
Stone-Geisser's Q2	Q2 ECA = 0.172, Q2 CS = 0.034, Q2 FP = 0.083			

Note: *** $p < 0.01$; ** $p < 0.05$; ns = not significant

These results provide empirical support for the positive relationship between stakeholder pressure and circular scope, thus offering an answer to RQ4. The rest of positive and significant path coefficients indicate that the firm size (0.370, $p<0.001$) and industry sector (0.404, $p<0.001$) are related with the environmental capabilities for the CE, and the circular scope, respectively. Then, in line with previous studies both firm size and industry sector are relevant characteristic of firms in the transition from a linear model to a circular one because it is a factor that facilitates eco-innovative processes.

Figure 1. Structural model results



4.3 Discussion

In this paper, we have addressed the different aspects of the environmental capabilities of firms that might influence the extent to which the CE-related practices are introduced in businesses—which in this study is briefly defined as circular scope or CS—. Based on the literature reviewed in this paper, we propose a construct to measure dynamic capabilities for the CE that integrates different competences of firms that have not before been discussed in the same framework of analysis, in response to Katz-Gerro and López Sintas (2018), who point out the necessity of qualitative research to study dynamic capabilities through firms.

To this end, we take the dynamic capabilities theoretical approach, which has to date been scarcely been employed for the CE. The dynamic capabilities analysis has been adopted by an increasing number of studies on eco-innovation (Gabler et al., 2015; Kiefer et al., 2018; Portillo-Tarragona et al., 2018) and in environmental strategy (Daddi et al., 2018; Garcés-Ayerbe and Cañón-de-Francia, 2017), but only a few authors have focused their CE-related analysis on this theoretical framework (Katz Gerro and López Sintas, 2019), probably due to the difficulty of obtaining specific information about the circular practices carried out by businesses. In this study, we measured some of the competencies that are applied to CE-related practices by firms of different sectors and sizes. Thus, the approach taken by Katz-Gerro and López S intas (2018), which is applied only to SMEs, was extended because our sample also included larger companies and different environmental capabilities.

As a general remark, the importance of dynamic capabilities indicated by other authors (Eisenhardt and Martin, 2000; Gabler et al., 2015; Teece et al., 1997) was also corroborated in this study, as was the relevance of managerial proactivity for eco-innovation projects (Chang, 2013; Del Río et al., 2016) and the relevance of the ability to implement advanced environmental management systems (Demirel and Kesidou, 2011; Horbach, 2008; Wagner, 2007).

In detail, the obtained results suggest positive relationships between the CS of businesses and their environmental capabilities for the CE, which, in this study, are measured through different variables focused on the EMSs adopted by firms, their environmental accounting practices, and their levels of CSR and accountability. To the best of our knowledge, no similar studies exist that could allow us to discuss the obtained results. However, some of the studies carried out to date and mentioned in the background allow us to partially address the discussion of the results for each research question.

Based on the dynamic capabilities theoretical arguments, in the context of RQ1, our study analyzed formal EMSs to demonstrate their positive impact on the level of a CE achieved by firms. This positive relationship confirms that EMSs are standardized processes that contribute to the introduction of a CE, just like they do in the case of eco-innovation (Amores-Salvadó et al., 2015). These results reinforce those of previous studies that demonstrate the positive influence of EMSs as specific environmental capabilities for eco-innovation—in line with Amores-Salvadó et al. (2015)—but they also open a new line of inquiry for the literature on the CE. Even though this result may seem intuitive, our analysis contributes to the specific knowledge about the impact of EMSs on the CE in businesses because this has not, to date, been empirically investigated. In addition, we are able to offer new insights into arguments that consider that EMSs could also restrict firms by making them focus on exploiting present production systems rather than exploring new systems based on radical innovations (Könnölä and Unruh, 2007).

In the context of accounting and other managerial environmental competences applied by firms to introduce the CE, the approach to the study of EMA under the theoretical framework of dynamic capabilities is quite original. This approach constitutes this study's innovation, because RQ2 allows us to explore the positive relationship between the CS of businesses and different variables designed to measure those endogenous EMA methods that firms apply to carry out CE-related activities. In this study, the EMA is measured through an enhanced construct. In previous studies, EMA has been associated with waste and recycling management (Qian et al., 2011); physical flows of energy, water, and materials (including wastes); monetary information on environment-related costs, earnings, and savings; and also indirect environmental information in overheads.

To date, little research has examined how to manage waste and material recycling through the EMA, but it can be expected that CE-related activities' introduction in businesses will involve changes in their environmental information systems and entail specific modification of the mechanisms of eco-control and sustainability control as defined by Qian et al. (2018). Thus, our study reinforces the idea that the use of EMA tools can be associated with CE management in businesses and the disclosure quality, expanding carbon emissions management studies (Qian et al., 2018).

The EMA-related capabilities measured in this paper include the availability of human resources for environmental management activities, which is also positively related to the CS of firms, confirming the result obtained for eco-innovation (Scarpellini et al., 2017). This result is also partially connected with pro-environmental managers' personal values, which were analyzed by Luque-Vílchez et al. (2019) to ensure the quality of environmental disclosure. From another perspective, the attitude of management toward the environment and CSR has been considered of interest (Cameron, 2011; Cheng et al., 2013; Groves and LaRocca, 2011; Pless and Maak, 2011; Del Río et al., 2016) because it allows an organization to align itself with changes in its natural and business environments and to combine external information with the organization's internal knowledge (De Marchi, 2012).

In this line of inquiry, the level of CSR and the reporting of environmental information and its quality are also identified in this study as relevant factors in the introduction of the CE in the micro-field (RQ3). In particular, these achievements represent a contribution to the CE research community and supports and enhances the conclusions reached by Stewart and Niero (2018). It should be noted that the level of accountability of the surveyed forms is higher when their CS increases, in line with the results obtained for eco-innovation (Marco et al., 2019) and other green sectors (Marco-Fondevila et al., 2018).

The results achieved here also make a novel contribution to our understanding of the relationship between the CE and stakeholder pressure, which has a mediating effect on the CS of firms, adding new insights to recent studies on this topic at the micro-level. Stakeholder pressure has been demonstrated, through case studies, to positively affect the adoption of the CE by firms (Witjes and Lozano, 2016), but this effect is mediated when a more general analysis of the CS of firms is performed in a larger sample of businesses that have not necessarily adopted the circular business model (RQ4). In line with Zubeltzu-Jaka et al. (2018), CSR elements are necessary and fundamental to the establishment of a business model that satisfies the needs of the highest possible number of stakeholders (including shareholders), with the objective of increasing, in the long term, the value of the company for those same stakeholders. This statement can also be

considered as summarizing the results obtained in our study regarding the relationship between the CS and the stakeholders.

Finally, regarding the relationship between the different CE-related activities, we cannot demonstrate that there is interdependence between specific activities and certain capabilities, but we can point out that the CS is related to the capabilities studied, partially confirming arguments about the interrelations indicated by others authors (Katz Gerro and López Sintas, 2019).

5. Conclusions

In this paper, a quantitative study of the specific endogenous capabilities that businesses apply when introducing the CE is conducted within the framework of the dynamic capabilities perspective. Our main purpose is to enhance previous research on the CE at the micro-level by exploring whether the adoption of different CE-related practices is reinforced through four specific capabilities of businesses: the adoption of EMS, their environmental accounting practices and the human resources involved in environmental management, the CSR and the level of accountability, or the stakeholder pressure on the firms. The applied research approach is not innovative in itself, but the measurement of the CE-related activities and different competences of firms using the same framework of analysis constitutes a contribution of this study. In addition, the dynamic capabilities theoretical approach has rarely been adopted in the academic CE literature to date.

A central finding of this study is that CE-related activities introduced by businesses are influenced by the analyzed capabilities that also improve the environmental and financial performance of firms in a CE framework. In addition, we show the mediating role of stakeholders in introducing the CE in businesses, which is a little explored line of inquiry, since this relationship has not been widely analyzed for the CE.

The measurement of the level of CE of an organization is a topic of interest at present because the specific indicators that can be applied to firms are still under development. Our study defines the CS of businesses through measuring activities and investments that are being developed by firms at present and that are considered as relevant in terms of the CE. This allows for partially implementing a circular business model, and the measurement of the CE-related activities can be applied to a large number of firms, regardless of their size or the industry in which they operate. The new insights proposed in this study facilitate the measurement of the introduction of the CE and make inferences regarding a research area that has been, thus far, little explored.

In addition, the obtained results can help overcome the limitations of conventional accounting approaches and incorporates a much broader scale of environmental information that can be applied to CE practices. In this regard, this study contributes to bridging the gap between academic research focused on environmental accounting and that investigating the introduction of the CE in businesses.

For business scholars we provide empirical support to show that the adoption of CE-related activities by firms behaves similarly to eco-innovation. Following the research approach initiated by other authors in the micro-field, we offer new insights that can help future business researchers study the endogenous resources and capabilities of firms for the deployment of the CE. One challenge facing academics is to bring the discussion around the CE into conversation with research into sustainability accounting to develop a still-incipient debate, in which we have intervened through this study. New

investigations are needed, however, in particular on the financial performance of firms who introduce the CE in their business strategy framework.

We offer insights to practitioners who wish to understand how to manage the specific competences that integrate the capabilities applied to the CE. The environmental management activities and the availability of specialized human resources have been shown to be relevant for the implementation of a circular business model. Thus, the results obtained can be applied to decision-making processes regarding investments in eco-innovation, eco-design, and the improvement of the CS of firms that will need specific capabilities of businesses. Practitioners gain insights for integrating capabilities related to CE (indicators, what to report, what capabilities, measurement techniques). Managers should seek efforts to strategically bundle EMA and accountability practices in their CE-related activities. Findings, therefore, highlight the need for firms to prioritize the sustainability accounting implementation that lead to higher levels of CS. In summary, this methodological approach provides metrics that allow firms, included SMEs, to measure and report on CE-related activities, and these metrics can be partially applied depending on those practices that have been introduced in each firm.

For policymakers, a better understanding of the introduction of the CE in businesses will contribute to the design of policies that can enhance the CE's deployment in a territory, for example, by providing tools and measures to help companies close material loops, control their efficiency, and invest in new technologies to adopt new, CE-related activities. The proposed methodologies could be used to promote the CE in other geographic areas and to influence the setting up of regional priorities depending on the CE-related practices adopted by the firms located in the territory.

The main limitations of this study are related to the measurement of the degree of circularity—which accounts for only some of the activities carried out by businesses—and the characteristics of the sample. The use of a higher number of firms in different regional contexts could provide an additional perspective on the issues considered in this study. Another limitation of this study is the scarce amplitude of the variable construct applied to the measurement of the EMA and the other CE-related activities.

Furthermore, it is important to also investigate trends over a longer period, in order to obtain longitudinal data relating to the current development of specific dynamic capabilities applied to the CE by businesses. Despite the fact that the discriminant validity criterion was met, the authors recognize that the objective minimum value of the cross loads was not achieved for three variables, which is a limitation to analyzing in depth the information provided by the respondents about the resources/products managed for the dematerialization and the use of recycled materials.

Future research should try to overcome these limitations and reach a better understanding of the dynamic capabilities specifically needed for the adoption of the CE, which requires changes in the business model and in the EMA due to the monitoring and measurement of flows of raw materials and resources, especially as the progressive introduction of increasingly far-reaching collaborative models is expected.

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ANNEX

Figure 2. Main questions of the survey

SECTOR: _____ **NACE Code:** _____

N. of Employees: ☐ less than 10 ☐ between 10 and 50 ☐ between 51 and 249 ☐ More than 250. **%of women:** _____%

Legal name*: _____ **VAT number:** _____

Contact person*: _____ **E-mail*:** _____

*Please, check disclosure rules.

ECO-DESIGN AND ECO-INNOVATION IN BUSINESSES

Read carefully the following questions and select one of the values, taking into account that "0" means that the measures described have NOT been executed in the company and "NA" means that you do not know or do not answer). Throughout the last THREE YEARS in your company:

ECO-INNOVATION, ECO-DESIGN AND CIRCULAR ECONOMY	0%	From 1 to 5 %	From 6 to 10 %	From 11 to 20 %	From 21 to 30 %	More than 30 %	NA
SR3 % of components of products or services replaced with innovative components to comply with environmental regulations	☐	☐	☐	☐	☐	☐	☐
DR1 % of resources replaced by other fully recycled materials to manufacture products or provide services	☐	☐	☐	☐	☐	☐	☐
DR2 % of products' design or services modified to reduce resource intensity (dematerialization)	☐	☐	☐	☐	☐	☐	☐
CSE1 % of products' design or services modified to increase function (multifunction)	☐	☐	☐	☐	☐	☐	☐
CSE2 % of products' design or services modified to extend life	☐	☐	☐	☐	☐	☐	☐
CSE3 % of products' design or services modified to increase recyclability (waste prevention)	☐	☐	☐	☐	☐	☐	☐
RESOURCE EFFICIENCY AND RENEWABLES	**0%**	**From 1 to 10 %**	**From 11 to 20 %**	**From 21 to 30 %**	**From 31 to 40 %**	**More than 40 %**	**NA**
SR1 % of equipment or facilities replaced and/or improved to reduce energy consumption	☐	☐	☐	☐	☐	☐	☐
SR3 % of processes and operating procedures replaced or improved to reduce energy consumption or exploit renewables	☐	☐	☐	☐	☐	☐	☐

INTRODUCTION IN FIRMS

Please indicate if your company performs some of the following environmental accounting practices and/or management systems and they relevance (0= not relevant; 5=very relevant; "NA" = do not know or do not answer)

EMS1	ISO 14001 standards	0	1	2	3	4	5	NS
EMS2	EMAS standards	0	1	2	3	4	5	NS
EMS3	ISO 50000 standards	0	1	2	3	4	5	NS
EMS4	ISO 14006 standards	0	1	2	3	4	5	NS
EA1	The expenses to reduce the emissions are separately recorded as specific costs	0	1	2	3	4	5	NS
EA2	Good corporate governance rules are applied and disseminated	0	1	2	3	4	5	NS
CSR1	The company adheres to the CSR model compared to other companies in the sector	0	1	2	3	4	5	NS
CSR2	The activity related to sustainability is voluntarily reported on in open access platforms (web, reports, press)	0	1	2	3	4	5	NS
CSR3	Environmental impacts are sustainability are reported to stakeholders.	0	1	2	3	4	5	NS
CSR4	The company has a specific and public policy on reporting and accountability	0	1	2	3	4	5	NS

Please, specify the percentage and place of the following waste and activities and their relevance for a CE:

CW1	Place of recycling waste (treated to be recycled)	% within the company: ____%	0	1	2	3	4	5	NS
CW2	Place of recovering waste and reuse	% within the company: ____%	0	1	2	3	4	5	NS

Please indicate your opinion about the following factors and their relevance (0= not relevant; 5=very relevant; "NA" = do not know or do not answer)

ST1	The company must reduce its environmental impact to comply with regulation in the short term	0	1	2	3	4	5	NS
ST2	Level of social pressure on the company to reduce its environmental impact	0	1	2	3	4	5	NS

3 Parte tercera. Conclusiones

3.1 Consideraciones finales

En esta tesis se ha abordado la relación entre la adopción de la EC por parte de las empresas y los recursos y capacidades de aplicación al cierre de círculos que las caracterizan, tales como sus recursos financieros y las capacidades de contabilidad medioambiental, siendo esta una línea de investigación de actualidad en el ámbito de la economía financiera y contabilidad.

A nivel micro, la EC representa uno de los puntos de conjunción entre el medioambiente y la empresa, como expresión del equilibrio contemplado por la *triple bottom line* que amplía la información contable y financiera tradicional proporcionada por las compañías a la divulgación de indicadores ecológicos y sociales. Es en este escenario donde la EC va a tener un papel relevante en los modelos de negocio, al implicar el respeto de los recursos naturales y un desarrollo humano equilibrado entre los ejes de la sostenibilidad, y nos hace vislumbrar un cambio tecnológico y de gobernanza profundo sometido a la influencia de diferentes factores como la presión ambiental, la creación de valor (compartido) y la demografía.

Desde el punto de vista teórico, esta tesis amplia la investigación previa a nivel micro, aún escasa, para contribuir al conocimiento sobre la adopción de la EC empresarial, ya que se ha abordado la investigación en el ámbito de la contabilidad medioambiental y de la EC en un mismo marco de análisis y desde un enfoque transversal.

Al amparo del marco teórico de la RBV y su evolución de *Dynamic Capabilities*, en esta tesis se considera aceptado que la ventaja competitiva de una empresa radica en un conjunto de recursos que la caracteriza que son gestionados a través de sus capacidades estratégicas. El estudio de las implicaciones contables que la EC plantea en las empresas es bastante original en el marco teórico de la RBV y de las *Dynamic Capabilities*, debido al nivel incipiente de la investigación, marcándose así a través de esta tesis el inicio de líneas de investigación de creciente interés en la actualidad y en el futuro próximo.

A partir de las consideraciones introductorias expuestas en esta tesis (Parte primera), queda patente la importancia de avanzar en el conocimiento en este ámbito para realizar una aportación a la conceptualización del conjunto único de recursos y capacidades específicas que caracteriza a empresas con altos índices de adopción de EC, siendo un tema de interés no solo para los académicos, sino también para los *practitioners* en la aplicación de soluciones avanzadas de ecología industrial sin menoscabo de la rentabilidad económica.

El análisis a nivel micro, pone de manifiesto aquellas actividades más relevantes para la implantación de la EC en empresas, como son el eco-diseño de productos para que sus

componentes y materiales puedan reutilizarse múltiples veces; la promoción de modelos de negocio circulares para la valorización de todos los componentes y materiales; o la implementación de soluciones de logística inversa con el objetivo final de reintroducir estos materiales y recursos en la cadena de suministro. Entre las iniciativas relevantes facilitar la adopción de la EC empresarial se contempla la introducción de modelos colaborativos de simbiosis industrial; la adopción de normas voluntarias, especialmente en relación con la gestión y la valorización de materiales; y, la promoción de estándares de diseño ecológico y fabricación que estimulen el cierre de círculos de materiales.

En síntesis, la medición integrada del alcance de la EC que en esta tesis se ha definido como "circular scope", permite ampliar el conocimiento acerca de la adopción interna de la EC, tema hasta ahora inexplorado en la investigación de la EC a nivel micro, y proporciona indicadores inéditos para la actividad de *reporting* en el marco de la RSC en empresas. Asimismo, en esta tesis se ha profundizado en un ámbito aún inexplorado hasta la fecha en la literatura de finanzas corporativas como es el de los recursos financieros específicos empleados para las inversiones en EC, analizando diferentes características de los mismos, con la finalidad de conceptualizar su aplicación a través de las capacidades específicas de contabilidad medioambiental.

Para alcanzar los objetivos de investigación planteados se ha aplicado un doble enfoque metodológico, cualitativo y cuantitativo, y se ha recabado información a nivel territorial desde distintos grupos de interés, supliendo así una de las limitaciones existentes en este ámbito de estudio, derivadas de la escasez de fuentes de información al tratarse de datos sensibles que tienen que ser proporcionados por las propias organizaciones.

Este enfoque metodológico ha permitido obtener un hallazgo central de esta tesis, al quedar demostrado que las actividades de EC introducidas por las empresas están influenciadas por las capacidades analizadas que también mejoran el desempeño ambiental y financiero de las empresas en un marco de EC. Como resultado complementario, se introduce el papel mediador de *stakeholders* en la adopción de la EC por parte de las empresas, que es una línea de investigación aún poco explorada en este ámbito. Además, cabe destacar que queda patente la relación entre la introducción de las actividades de EC en las empresas y la implementación decisiva de una serie de medidas clave a nivel territorial.

A modo de conclusión, como resultado de esta tesis se desprende que la adopción del modelo circular supone la implicación de los sistemas contables y de gestión ambiental y de nuevos indicadores de control de gestión, la introducción de cambios en la estructura de costes y de herramientas de *Life Cycle Costing* y de *Material Flow Cost Accounting*, la aplicación de

modelos colaborativos, la mejora de las prácticas de *reporting* incluyéndose la medición integrada de los índices de circularidad no solo de productos, sino también de la empresa en su conjunto.

3.2 Implicaciones de la tesis

En síntesis, en el marco del paradigma de la sostenibilidad, la implantación de una EC implica la transformación del modelo económico lineal en otro circular para reducir la dependencia de las materias primas y la energía y para reducir el impacto ambiental de la producción y el consumo. La medición del nivel de EC de una organización es un tema de interés en la actualidad porque los indicadores específicos que se pueden aplicar a las empresas todavía están en desarrollo. Así, comprender cómo gestionar las capacidades específicas de tipo medioambientales que integran las capacidades aplicadas a la EC permitirá a las empresas mejorar sus memorias de sostenibilidad y de RSC. Además, otras implicaciones sociales de este estudio se relacionan con la mejora de las relaciones con los consumidores y las partes interesadas y con la práctica de la responsabilidad social corporativa.

Ante estas consideraciones, en esta tesis, se define el alcance circular de las empresas a través de la medición de actividades e inversiones que están desarrollando las empresas en la actualidad y que se consideran relevantes en términos de la EC. Esto permite implementar parcialmente un modelo de negocio circular, y la medición de las actividades relacionadas con la EC se puede aplicar a un gran número de empresas, independientemente de su tamaño o la industria en la que operan. Las nuevas ideas propuestas en esta tesis facilitan la medición de la introducción de la EC y hacen inferencias con respecto a un área de investigación que, hasta ahora, ha sido poco explorada.

En ámbito académico, esta tesis representa una aportación para la literatura al ampliar el conocimiento sobre las características de los recursos financieros quedando demostrada empíricamente su relación con el nivel de EC de las empresas. En línea con el enfoque iniciado por otros autores en EC a nivel micro, los resultados alcanzados en esta tesis abren camino en la investigación de los recursos endógenos y las capacidades de las empresas para el despliegue de la EC. Uno de los desafíos al que se enfrentan los investigadores es llevar la discusión en materia de EC hacia el campo de la economía financiera y la contabilidad para desarrollar un debate, aún incipiente, en el que esta tesis contribuye.

Los resultados alcanzados a través de esta tesis contribuyen a superar las limitaciones de los enfoques contables convencionales al incorporar una escala mucho más amplia de información medioambiental derivada de la introducción de la EC en las empresas.

Otras aportaciones obtenidas a través de la investigación llevada a cabo están relacionadas con los aspectos metodológicos de medición del nivel de adopción de la EC en las empresas y de su relación con los impactos a nivel territorial. Así, estos resultados resultan de utilidad tanto a los académicos, para la conceptualización y medición de la EC a nivel micro, como para los profesionales, para el desarrollo de indicadores integrados de aplicación a las actividades que las empresas llevan a cabo en el marco de la EC. Las actividades consideradas en esta tesis proporcionan una base para la medición interna en las propias empresas del nivel de cierre de círculos alcanzado en su conjunto y permiten dimensionar su impacto en términos de volumen de negocio, inversiones, empleos y otros indicadores de carácter socioeconómico de aplicación a la actividad de *reporting*.

Los resultados obtenidos proporcionan información y herramienta para los profesionales que desean comprender cómo gestionar las capacidades de las empresas para su aplicación a un modelo de negocio circular. La gestión medioambiental y las prácticas relacionadas con la EMA, así como la disponibilidad de recursos humanos especializados han demostrado su relevancia para la implementación de un modelo de EC. Por consiguiente, los resultados obtenidos en esta tesis pueden ser aplicados a los procesos de toma de decisiones para incrementar el alcance de la EC en las empresas de distintos sectores y procesos. En resumen, el enfoque metodológico desarrollado en esta tesis proporciona métricas que permiten a las empresas, incluidas las PYMES, medir e informar sobre las actividades relacionadas con la EC.

Los resultados ponen de relieve la necesidad de que las empresas prioricen la implementación de prácticas de contabilidad en el marco de la sostenibilidad que conduzca a niveles más altos de EC.

Para las administraciones públicas, los resultados aquí expuestos permiten una mejor comprensión de la introducción de la EC en las empresas que puede ser de aplicación para el diseño de políticas públicas para el fomento de la EC en un territorio. Las metodologías cuantitativas y cualitativas implementadas de medición a nivel territorial pueden aplicarse a otras áreas geográficas y contribuir a la definición de prioridades regionales en función de las actividades y el alcance de EC en las empresas que operan en el territorio. Otro resultado relevante para las políticas regionales es la confirmación en esta tesis de la función que ejercen las ayudas públicas como incentivos para la promoción de la EC.

Como reflexión final, ante el incipiente nivel de adopción de EC por parte de las empresas, como primeras medidas, las administraciones deberían definir los incentivos de forma específica en función del nivel de reciclaje interno y el grado de recuperación de residuos en territorio, siendo estas actividades escasamente implantadas en las empresas en un marco de EC.

3.3 Limitaciones y Perspectivas

La investigación llevada a cabo en esta tesis no está exenta de limitaciones y queda incompleta, ya que no permite realizar una comparación entre las empresas más proactivas en eco-innovación, eco-diseño y EC y las empresas que no hayan introducido aún actividades relacionadas con la EC. Con una muestra diferenciada de empresas, tanto pro-activas como no, podrían alcanzarse resultados más amplios en la definición de los recursos y las capacidades aplicadas por las empresas al cierre de círculos en aras de la EC.

Las principales limitaciones del trabajo empírico responden sobre todo al tamaño de la muestra de empresas, al número de actividades de EC analizadas y al hecho de que el caso de estudio abarca una sola región europea. Por lo anterior, las futuras líneas de investigación irían a paliar estas limitaciones y podrían proporcionar mayor conocimiento en la relación entre la adopción de la EC en las empresas y el relativo impacto a nivel territorial.

La limitación de esta tesis relacionada con la medición del alcance de la EC en las empresas ("circular scope") deriva del hecho de que no se miden todas las actividades que realizan las empresas que integran un modelo circular. Más concretamente, actividades de tipo colaborativo se analizan solo parcialmente en el constructo empleado para la medición del alcance de la EC en empresas. El uso de otros indicadores que también reflejasen los materiales incorporados en la fase de distribución y comercialización también podrían proporcionar una perspectiva adicional.

En lo que concierne a los recursos financieros aplicados a la EC, cabe mencionar que esta tesis no proporciona un análisis detallado de la relación entre estos recursos y el desempeño financiero de la empresa. Además, las operaciones de capital riesgo, la participación de fondos de *business angels* o el papel que pueden desempeñar en las inversiones en EC otros recursos alternativos tampoco se abordan en esta tesis, ya que a tal fin se requeriría un análisis específico aplicándose un conjunto más amplio de indicadores. Finalmente, se destaca la limitación derivada del reducido número de variables empleado para la medición de las capacidades de contabilidad medioambiental que podrían ser ampliadas a través de estudios específicos.

Futuros trabajos de investigación deberían tratar de paliar estas limitaciones para alcanzar una mejor comprensión de las capacidades dinámicas específicamente necesarias para la adopción de la EC en empresas de diferentes sectores, tamaños y que operen en otros entornos. Los cambios a nivel contable derivados de la introducción de la EC en empresas es una de las cuestiones aún sin resolver que abre esta tesis, sobre todo a nivel meso y para modelos de simbiosis industrial y para el despliegue de la EC a lo largo de toda la cadena de valor.

Uno de los desafíos para los académicos es llevar la discusión sobre la EC empresarial al ámbito de la economía financiera y la contabilidad, en particular, en lo que concierne al perfeccionamiento de las prácticas contables y de EMA en modelos de negocio circulares en los que primarán esquemas colaborativos cada vez de mayor alcance.

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