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'Circular patents' and dynamic capabilities: new insights for patenting in a circular economy

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ABSTRACT

In recent years, the introduction of the circular economy concept in business has been studied by academics because it entails the definition and measurement of the resources and capabilities necessary for firms to invest in innovation and adopt a circular model. In this context, this study investigates the intangible assets related to the circular economy, defined as 'circular patents', that are classified and measured to be bundled into the innovation capabilities of a firm. The impact of a business's capabilities on its level of circular patent activism is empirically analysed in this study in a theoretical framework of dynamic capabilities. To this end, a model of the cause-and-effect relationship between the circular patents held by firms and their capabilities is designed using partial least squares structural equation modelling (PLS-SEM) and is tested using a sample of 120,406 patents in 2,216 Spanish companies. In this analysis, patents that can foster the sharing economy and the circular economy in *sensu latu* are also considered circular patents, in addition to waste patents and other green patents, offering an enhanced measurement of the intangible assets related to the circular economy.

Based on these results, this study provides new insight of how accounting can enable or constrain the transition to a circular economy business model through the measurement and valuation of related intangible assets and the specific business' capabilities in an environmental management framework.

'Circular patents' and dynamic capabilities: new insights for patenting in a circular economy

Introduction

The increasing focus of academics and practitioners on the greenness of the economy underscores the relevance of environmental innovations at the micro level to achieve a circular economy (CE). Currently, the CE is a model promoted by governments and institutions that requires radical and systemic eco-innovation to transform linear production and consumption patterns into circular flows of materials and resources.

This model requires companies to develop a research and development (R&D) process that can lead to patents and facilitate the development of new innovative technologies as registered and codified knowledge (Rodriguez and Wiengarten 2017). Despite patents can also be obtained for purposes other than market or technological needs of the company, patent registration it has been related to environmental R&D investment, internal R&D or eco-innovation (Aragón Correa and Leyva de la Hiz, 2016; Doran and Ryan, 2012; Peiró et al., 2011).

Patenting is claimed by innovators (Halila and Rundquist, 2011) as an important factor in innovation success, and green patents have been identified as key assets for protecting companies' technologies and generating competitive advantage (Higgins 2003; Marín-Vinuesa et al. 2020). Rodriguez and Wiengarten (2017) also suggest that patents are internal resources that enhance eco-innovation.

Thus, investigating how green patents can foster the adoption of the CE by companies is relevant and provides objective data to analyse the environmental innovation output. However, the best way of deploying these intangible resources to introduce the CE in companies is still unknown and this study partially fill this gap.

From a CE context, we could consider a priori that most of the eco-innovations and green patents offer clear improvements to achieve closing of the material loops (Scarpellini et al. 2020). Patents related to waste management and recycling and their subsequent use as secondary raw materials are closely related to the CE model (Vuţă et al. 2018; Aldieri et al. 2019; Momete 2020). Furthermore, other patents outside those related to waste technologies could also be linked to the development of the CE, insofar as they favour its objectives, as is the case of the sharing economy (David, Chalon, and Yin 2016).

The previous research on green patents has built upon the Resource-Based View (RBV) to argue that innovation resources enable environmentally innovative companies to distinguish themselves from non-environmentally innovative ones (Rodriguez and Wiengarten 2017; Marín-Vinuesa et al. 2020), also in a CE framework (Aranda-Usón et al. 2019). More recently, different dynamic capabilities have been analysed for their positive effect on green innovation (Ahmad et al. 2022; Yin and Wang 2021), and to enhance companies' ability to gain competitive advantages for the CE (Marrucci et al. 2021; Herrero-Luna, Ferrer-Serrano, and Pilar Latorre-Martínez 2022).

However, detailed analyses of the specific capabilities that apply to the CE-related innovation process are still in an incipient stage (Marín-Vinuesa, Portillo-Tarragona, and Scarpellini 2021), and this research focuses on the specific innovation capabilities applied to circular patents. In addition, the definition of an enhanced category of patents related to the CE in sensu lato, here defined as 'circular patents', is another objective of this study to measure these quantifiable, standardised, and comparable intangible assets that companies can apply to circular processes. It is important to fill this gap in knowledge of environmental management, providing a much-needed understanding of the development of intangible resources to undertake patented innovations to close material loops.

Given these premises, the main purpose of our research is to explore companies' capabilities applied to circular patents using a dynamic capabilities theoretical framework to enhance the results of prior studies, and providing new metrics for decision-making regarding investments in patenting. In facts, the antecedents to the capabilities related to the CE may differ from those related to traditional innovation and may be more specific than those applied to eco-innovation. To explore these lines of enquiry, we propose three research questions focused on contribute to the specific measurement of 'circular patents', as well as to analyse capabilities applied to the innovation in the framework of a CE that differ from the eco-innovation capabilities, and finally their impacts on patenting.

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

Theoretical Background

Patents in a circular economy

In an incipient and restrictive approach, patents related to recycling and secondary raw materials have been used as proxy indicators for monitoring the CE (European Commission 2018; Corona et al. 2019; Marín-Vinuesa, Portillo-Tarragona, and Scarpellini 2021). Previous studies have analysed patent data to explore the activities related to waste recovery (Aldieri et al. 2019) and the R&D results for closing a material loop (Vuţă et al. 2018). In fact, the reduction of waste through recycling and reuse as secondary raw materials is a specific goal of the CE (Momete 2020).

The underlying contribution of waste patents to social welfare is clear (Ribeiro and Shapira 2020). These patents can undoubtedly be classified as circular patents. However, within the category of green patents, some families of patents could have different levels of application in terms of the CE, and some innovations applicable to the circular model could be excluded from the current classification of green patents.

In that regard, we refer to those innovations related to the sharing economy and information and communication technologies that are facilitating the CE through platforms for sharing the use of assets rather than relying on ownership of those assets. In summary, from the analysis of the literature, we can affirm that the definition and measurement of circular patents is a line of inquiry that is still under development. In fact, to the best of our knowledge, no specific empirical studies have focused on measuring companies' patents related to the CE, and the objectives of this study is to begin to fill this gap. To that end, we propose the first research question, which is as follows:

RQ1) How can CE-related patents be measured?

Through this research objective, circular patents are defined and measured so that they can be bundled into the companies' innovation capabilities in the second step of this study.

Companies' capabilities related to the circular economy and patents

The previous studies on green patents have built upon the RBV to argue that innovation resources allow environmentally innovative companies to distinguish themselves from non-environmentally innovative ones (Rodriguez and Wiengarten 2017; Marín-Vinuesa et al. 2020). The companies' resources and capabilities are found to be relevant to a successful environmental strategy within the theoretical framework of the RBV (Barney 1991) and its extension to dynamic capabilities (Teece, Pisano, and Shuen 1997).

These capabilities include the mobilisation of resources to address new needs and opportunities and to quickly implement a new business model or other changes. The related studies have also enhanced the understanding of how some companies with high-level capabilities overcome resource deficiencies and perform better than those companies with similar resources.

In a CE, a company has to pursue economic, environmental, and social objectives along the value chain in a collaborative scheme to innovate towards a CE. This process poses a challenge for companies to organise their dynamic capabilities to adapt and anticipate the new complexities required by the CE (Khan, Daddi, and Iraldo 2020; Scarpellini et al. 2020). Thus, we could suppose that capabilities related to the CE and, specifically to the circular patents, may be based on previous companies' capabilities developed for eco-innovation processes such as: a) organisational and technical capabilities; b) collaborative R&D capabilities; c) Innovation persistence; d) the innovation diversity; the patent scope; and the collaborative innovation.

Recently, Marín-Vinuesa et al. (2021) highligted the importance of technological and organisational capabilities in patenting in the area of recovery and recycling, and the relevance of these capabilities for closing the material loops has been also analysed in previous studies (Gitelman et al., 2019).

Rodriguez and Wiengarten (2017) demonstrate that the internal knowledge created through R&D collaborations with public research institutions can be bundled into process innovation capabilities. Horbach (2008) shows that the probability of being innovative increases if a company engaged in innovation activities in the past; thus, companies with higher and continuous R&D efforts and persistence in patenting are prone to introduce any type of environmental innovation because they take advantage of the knowledge that has already been mobilised (Chassagnon and Haned 2015). Halila and Rundquist (2011) observe that most innovators agree that the existence of the research behind an innovation is a success factor in itself. Taking into account these considerations, our research incorporates the patents' complementarity as an innovation capability, and it is measured through conventional, green, and circular patents.

Another characteristic of patents is their scope. The number of different technological fields of patents is considered one of the company's capabilities related to patenting because it indicates a higher level of assets. A broader scope of patents helps to reduce a company's asset specificity, and increases their exploitation. This characteristic of patents is also related to the development of general purpose technologies, and some authors argue that expanding the knowledge base behind an invention increases its impact in diverse industrial contexts (Ardito, Petruzzelli, and Ghisetti 2019), and could impulse the collaborative patenting increasing the number of inventors.

An overview of the previous studies focused on capabilities related to patents (innovation), green patents (eco-innovation), and general sustainability innovation systems are classified in Table 1.

	Patents (innovation)	Green patents (eco-innovation)	CE or sustainable innovation systems
Dynamic capabilities (general focus)	(Dixon, Meyer, and Day 2014; Chassagnon and Haned 2015; Battagello, Cricelli, and Grimaldi 2019)	(Daddi et al. 2018; Scarpellini et al. 2020; Kiefer, del Río, and Carrillo-Hermosilla 2021)	(Battagello, Cricelli, and Grimaldi 2019; Katz Gerro and López Sintas 2019; Khan, Daddi, and Iraldo 2020; Suchek et al. 2021)
Organisational and technical capabilities	(Huang and Cheng 2015; Ding 2014; Wang, Jiang, and Wakuta 2022)	(Iñigo and Albareda 2016; Rodriguez and Wiengarten 2017; Halila and Rundquist 2011; Pacheco et al. 2018)	(Bae 2017; Iñigo and Albareda 2016; Mousavi, Bossink, and van Vliet 2018; Sánchez-Alegría, Lizarraga-Dalloa, and Marín-Vinuesa 2021;

			Gitelman et al. 2019; Cainelli, D'Amato, and Mazzanti 2020; Kristoffersen et al. 2021; Sehnem et al. 2022; Kapp 1965)
Collaboration with R&D institutes	(Huang and Cheng 2015; García-Muiña and González-Sánchez 2017; Motohashi and Muramatsu 2012)	(Iñigo and Albareda 2016; Pacheco et al. 2018; Sun et al. 2008)	(Iñigo and Albareda 2016; Marín-Vinuesa, Portillo-Tarragona, and Scarpellini 2021)
Innovation persistence	(Chassagnon and Haned 2015; Halila and Rundquist 2011)	(Sun et al. 2008; Przychodzen, Leyva-de la Hiz, and Przychodzen 2019; Halila and Rundquist 2011; Pacheco et al. 2018)	(Calik and Bardudeen 2016)
Patents complementarity	(Altuntas, Dereli, and Kusiak 2015)	(Pacheco et al. 2018; Sun et al. 2008; Aragon-Correa and Leyva-de la Hiz 2016; Przychodzen, Leyva-de la Hiz, and Przychodzen 2019)	(Altuntas, Dereli, and Kusiak 2015)
Patent scope	(Altuntas, Dereli, and Kusiak 2015)	(Albino et al. 2014; Ardito, Petruzzelli, and Ghisetti 2019)	(Marín-Vinuesa, Portillo-Tarragona, and Scarpellini 2021)
Collaborative patents (several inventors)	(Ardito, Petruzzelli, and Ghisetti 2019)	(Sun et al. 2008; Ardito, Petruzzelli, and Ghisetti 2019)	(Marín-Vinuesa, Portillo-Tarragona, and Scarpellini 2021)

Table 1. Classification of revised studies for analysing circular patents and the related capabilities

From the analysis of Table 1, we observe that the capabilities related to 'circular patents' differ from the antecedents to traditional innovativeness and, furthermore, could be more specific than those applied to eco-innovation. Consequently, defining the specific capabilities that companies need when patenting CE-related technologies is a novel line of inquiry. Thus, departing from these premises and from the previous literature, we present the following research questions:

RQ2) Which capabilities of companies are related to circular patents? And (RQ2b) which circular capabilities differ from capabilities applied to eco-innovation?

Based on this questions, we also attempt to enhance the empirical knowledge on this topic by studying the relationship between the 'circular patents' owned by companies and their dynamic capabilities. Thus, we propose a third research question, as follows:

RQ3) What are the impacts of companies’ capabilities on their ‘circular patent’ level?

To achieve these main research objectives and address the corresponding gaps in the literature, we designed the methodology described in the following section and tested it using a sample of Spanish companies.

Method and Sample

Measurement of circular patents

To achieve the study´s objectives, the empirical analysis is based on an original dataset of 2,216 companies located in north-eastern Spain, which is a geographic area with high eco-innovation rates and high R&D potential at the regional level (Scarpellini, Portillo-Tarragona, and Marin-Vinuesa 2019; Scarpellini et al. 2020).

The sample was obtained from the SABI database[1] and includes companies with more than 50 employees operating in the sectors with the greatest potential for environmental investments and eco-innovation, such as those related to the technologies referred to in the ‘BREFs’ document (i.e., the ‘Best Available Techniques Reference’[2]), because these characteristics facilitate a shift to a CE (Smol, Kulczycka, and Avdiushchenko 2017). They specifically belong to transport, logistics and waste, the Spanish codes NACE (Nomenclature of Economic Activities or in Spanish; clasificación nacional de actividades económicas, CNAE 09) mining (05-09), manufacturing industry (10-33), supply of electricity, gas, steam and air conditioning (35), water supply, sanitation, waste management and decontamination (36-39), transport and storage (49-53). The reason why we chose to focus on companies with more than 50 employees was

[1] Balance Sheet Analysis System (SABI) [online database]. 2014. Madrid
[2]See https://eippcb.jrc.ec.europa.eu/reference/ (accessed June 2022).

due to that small and micro-companies could have, in principle, a lower potential for implementing or patenting eco-innovation or 'circular patents' than medium and large companies (Scarpellini, Portillo-Tarragona, and Marin-Vinuesa 2019).

The sample comprises total of 694 companies that hold 120,406 patents registered at the national (Spanish Patent and Traddemark Office-SPTO – in spanish oficina Española de patentes y marcas OEPM-) or international level (European Patent Office –EPO-) that are analysed and classified using the International Patents Classification (IPC).

To answer to the first research question (RQ1), we use the IPC codes to identify the companies that hold circular patents, those companies that have only conventional patents, companies that hold both types of patents, and those that have never patented. To delimitate green patents, we apply the Green Inventory created by the IPC Committee of Experts of the World Intellectual Property Organization (WIPO). The WIPO green inventory enables the search for patent information related to so-called 'environmentally sound technologies', as defined by the United Nations Framework Convention on Climate Change (UNFCCC). This inventory includes all IPC classes that are associated with environmentally friendly technologies in a variety of fields. In particular, it includes the six technological fields of alternative energy production, transportation, energy conservation, agriculture/forestry, and administrative/regulatory work, as well as design aspects and nuclear power generation (Cecere et al. 2014). Patents related to waste management are also considered green patents, but they are considered separately in our study.

Finally, we define a third group of 'other circular patents' that are related to the sharing economy or to information and communication technologies or to other innovations related to the circular model not included in the green patents. Patented innovations in the field of new information technologies can be related to the CE if they favour cooperation and convergence in a circular model between previously disconnected ecosystems (Narayan and Tidström 2020; Aaldering, Leker, and Song 2019).

In Figure 1, the three groups of patents that integrate 'circular patents' are detailed, which are as follows: 'waste patents', green patents (excluding 'waste patents'), and 'other circular patents' related to the CE.

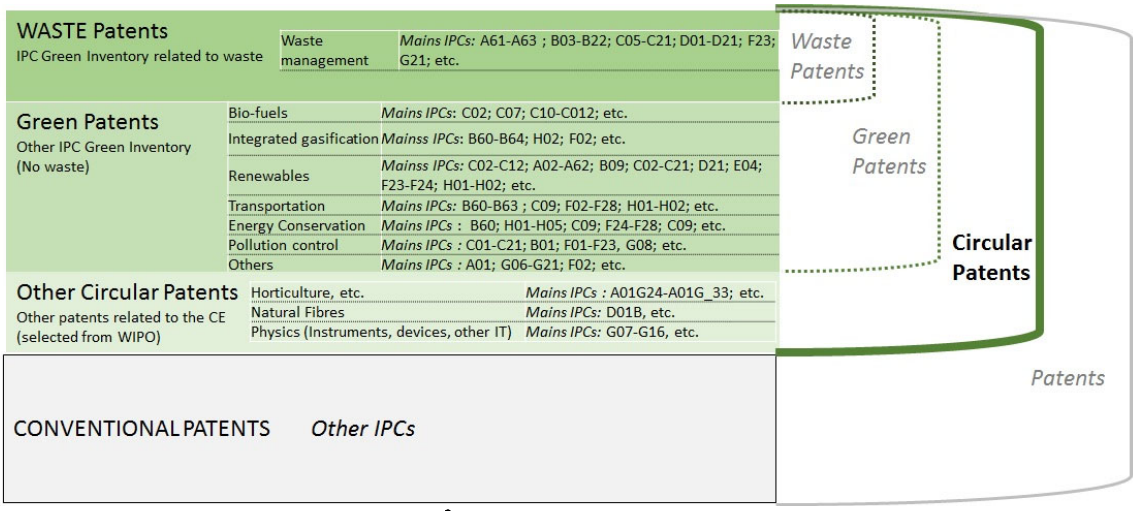

Figure 1. Classification of circular patents[3] and the main IPCs included in each group of patents.

The classification summarised in Figure 1 is applied to the sample as shown in Figure 2.

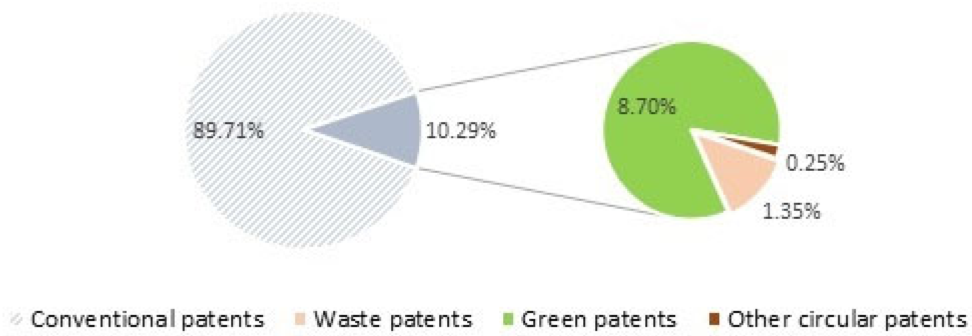

Figure 2. Classification of patents held by the companies of the sample

[3] See https://www.wipo.int/classifications/ipc/en/green_inventory/index.html and https://www.wipo.int/classifications/ipc/ipcpub/ (accessed on July 2020).

Figure 3 shows that significant numbers of circular patents relative to conventional patents were registered in all the analysed periods, and 7.83% of the circular patents were registered in the first period (before 1986), before Spain entered the EU and the EU Patent Law of 1973 was transposed to Spanish legislation. Periods 2, 3, and 4 include patents registered in 1986-1991, 1992-2000, and 2001-2010, respectively, in concordance with legislation changes introduced to the EU Patent Law. Consequently, the number of registrations shows a more pronounced change in trend in these periods, has dipped from a high in 1986-1991, and they starting to increase again now after 2011, when the green patent classification of the IPC Green Inventory of the UNFCCC was applied. In figure 3 the growing evolution of the percentage of registered circular patents be broken down more granularly for the period from 2011.

Figure 3. Evolution of the percentage of registered circular patents

Patents owned by companies and R&D institutes are also analysed, following Sun et al. (2008). Figure 4 summarises the average percentages of circular and conventional patents developed in collaboration.

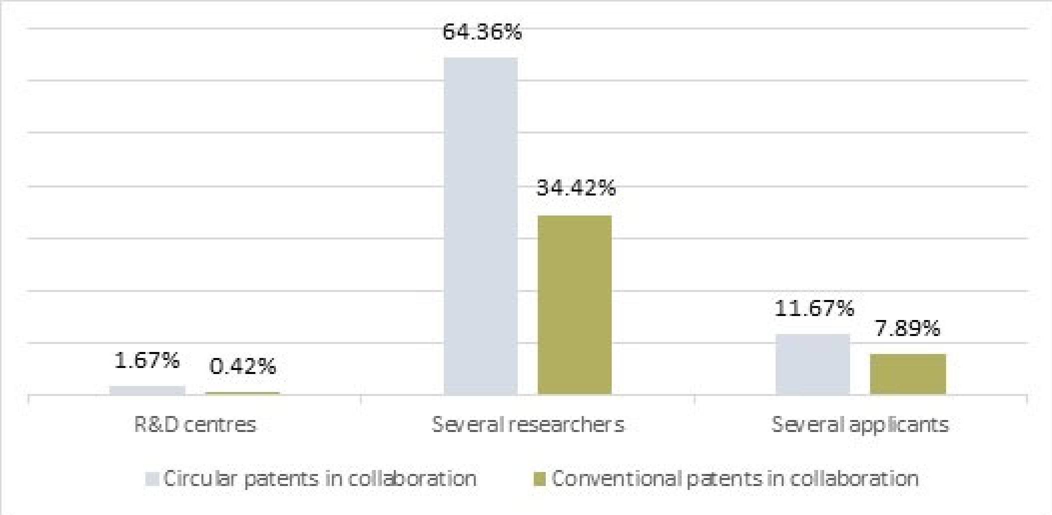

Figure 4. Analysis of collaborative patents

The numbers of patents registered in different IPCs (Kim and Lee 2015) and the numbers of conventional patents differentiated by circular patents are introduced to the analyses of companies’ capabilities to innovate in line with other authors (Sun et al. 2008; Ding 2014; Marín-Vinuesa et al. 2020).

In summary, this study where various categories of patents for emerging technologies and eco-innovations related to the CE were examined is contributing to the first research objective, called defining ‘circular patents’, by shed light on a new analytical framework and a classification of patents as strategic intangible assets for environmental management accounting to measure a company’s alignment with the CE.

Sample description

A total of 2,216 companies comprise the sample for the empirical analysis, and 694 of them (31.32%) hold patents; 271 companies (39.05%) hold national patents registered only in the Spanish office; and 282 companies (40.63%) hold some patents registered in the national or European offices. Descriptive statistics of the sample (n= 694) are provided in Table 2.

	Total		Companies with circular patents		Companies with conventional patents			
	%	n	%	n	%	n		
Legal status								
Cooperative	3.3	23	5.4	16	1.8	7		
Public Limited	66.3	460	63.7	188	68.2	272		
Limited Partnership	0.7	5	1.4	4	0.3	1	Pearson	p-value
Limited Company	29.7	206	29.5	87	29.8	119	10.278	0.016
Observations	**694 (100%)**		**295 (42.51%)**		**399 (57.49%)**			
Sector	%	n	%	n	%	n		
Mining	0.3	2	0.34	1	0.3	1.00		
Manufacturing	90.8	630	88.47	261	92.5	369.00		
Energy	5.3	37	7.80	23	3.5	14.00		
Water and waste	1.4	10	3.05	9	0.3	1.00	Pearson	p-value
Transport and storage	2.2	15	0.34	1	3.5	14.00	23.309	0.000
Observations	**694 (100%)**		**295 (42.51%)**		**399 (57.49%)**			
Regions	%	n	%	n	%	n		
Aragon	12.7	88	7.12	21	16.8	67		
Navarre	8.9	62	9.83	29	8.3	33	Pearson	p-value
Basque Country	22.2	154	20.68	61	23.3	93	16.990	0.001
Catalonia	56.2	390	62.37	184	51.6	206		
Observations	**694 (100%)**		**295 (42.51%)**		**399 (57.49%)**			
Size	median	n	median	n	median	n	Anova F (p-value)	
Employees	329	676	476.4	283	223.0	393	20.330	0.000
Assets	243,448.90	683	471,062.02	288	77,493.02	395	6.7	0.009
Revenues	149234.3	679	243,327.77	285	81,171.70	394	15.07	0.000

Table 2. Descriptive statistics of the sample

The percentage of companies that hold circular patents varies according to their legal statuses, locations, and sectors. For these variables, the differences between companies with and without circular patents are statistically significant according to Pearson's $\chi2$ test.

Method

To test the research questions, we construct a PLS-SEM. This analysis allows us to test the cause-and-effect relationship between companies' capabilities and their levels of circular patents by assessing the significance of the path coefficients and evaluating the measurement model for the level of circular patents. The statistical analyses are performed using SmartPLS 3.0 statistical software (Ringle, Wende, and Decker 2015).

To measure the companies' circular patents (CP), we use a construct generated from the three groups of patents, as follows: the number of 'waste patents' (CP-WP), the number of green patents excluding 'waste patents' (CP-GP), and the number of 'other circular patents' (CP-OP).

Main Results and Discussion

Dynamic capabilities and the 'circular patents'

To answer RQ2 and RQ2b, an ANOVA analysis is conducted to determine the relationships between the circular patents held by companies and the variables that integrate their dynamic capabilities. To this end, we group companies into those that have circular patents and those that do not. Table 3 summarises the results of this analysis. The differences in the mean values for companies with and without circular patents are statistically significant according to the ANOVA test for all the variables except R&D collaboration (RDC) and applicant intensity (APP).

We observe that the mean value of each independent variable is greater for companies with circular patents than for those without such patents (conventional patents). These results provide empirical evidence on the dynamic capabilities related to 'circular patents' level, responding so to the research question RQ2.

	Total		Companies with circular patents		Companies with conventional patents		Differences in means test	
	Mean	Std.Err.	Mean	Std.Err.	Mean	Std.Err.	Anova F	p-value
Inventor intensity (INV)	0.235	0.341	0.340	0.020	0.160	0.015	53.660	0.000

R&D collaboration (RDC)	0.014	0.091	0.015	0.004	0.140	0.005	0.010	0.939
Applicant intensity (APP)	0.079	0.171	0.090	0.009	0.070	0.008	4.230	0.040
Patent scope (PSC)	0.743	0.257	0.820	0.011	0.690	0.014	47.260	0.000
Innovation persistence (INP)	0.182	0.298	0.240	0.011	0.100	0.017	36.990	0.000

Table 3. Test of differences in means for companies that hold circular patents and those that do not

Cause-and-effect relations between capabilities and circular patents

The PLS-SEM is conducted following a sequential process. First, the model measuring the level of circular patents is assessed by testing the reliability and validity of the measurement scale. Second, we test whether cause-and-effect relationships exist between the circular patent variables used to measure the dynamic capabilities, to answer to the third research question (RQ3).

To ensure the adequacy of the selected indicators, we examine the variables' standardised loadings. For all variables, the standardised loadings are greater than 0.7 and are significant (Figure 4). The circular patents construct has an extremely high composite reliability (0.85), higher than 0.7. Convergent validity is tested by calculating the average variance extracted, which determines whether the construct variance can be explained by the indicators selected. The minimum value recommended is 0.5 (Bagozzi and Yi 1988), which means that over 50 percent of the construct variance is due to the indicators. The value obtained (0.67) satisfies this criterion for the analysed construct. The size construct also has both extremely high values of composite reliability and average variance extracted (0.75 and 0.53, respectively). The variables' standardized loadings also have appropriate values (employees 0.94; assets 0.63; revenues 0.82).

Table 4 describes the variables in the path analysis. The Pearson correlations (Table 5) for each pair of independent variables indicate weak associations in most cases, with values ranging between 0.04 and 0.32. No correlation value is higher than 0.9, indicating the absence of multicollinearity between the variables (Hayduk 1987).

Variables	Mean	Std. Dev.	Minimum	Maximum
Waste patents (CP-WP)	2.340	10.729	0	126
Green patents (CP-GP)	15.086	66.163	0	767
Other circular patents (CP-OP)	0.434	2.631	0	34
Inventor intensity (INV)	0.235	0.341	0	1
Applicant intensity (APP)	0.079	0.171	0	1
Patent scope (PSC)	0.743	0.257	0	1
Innovation persistence (INP)	0.182	0.298	0	1
Diversity of patents (DVP)	proportion: value = 0 (0.7) value = 1 (0.3)			

Table 4. Description of the final variables of the path analysis

	1	2	3	4	5	6	7
1. INV	1						
2. APP	0.272	1					
3. PSC	0.175	0.053	1				
4. INP	0.229	0.115	0.355	1			
5. DVP	0.042	0.009	0.163	-0.073	1		
6. S	0.255	0.086	0.103	-0.045	0.105	1	
7. MS	-0.152	-0.095	-0.104	0.127	0.012	-0.103	1

Significance level: ** $p < 0.01$ * $p < 0.05$ (two-tailed). Observations n= 694

Table 5. Pearson correlations between the variables in the model

Bootstrapping with 5,000 resamples is used to assess the significance of the path coefficients (Hair, Ringle, and Sarstedt 2011). Figure 5 shows the overall model results, namely, the R2 value for the dependent variable and the path coefficients. The results indicate empirical support for the five cause-and-effect relations (Figure 5 and Table 6). Similar results are shown in the parameters estimated in a model that does not include the control variables (Model 2), i.e., the MS and S variables (Table 6).

Relation	Path Coefficient	t-value	Percentile Bootstrap 95% Confidence Level

				Lower	Upper
Inventor intensity (INV)	=>CP	0.106	2.16 **	0.011	0.171
Applicant intensity (APP)	=>CP	0.016	0.43 ns	-0.037	0.097
Patent scope (PSC)	=>CP	0.103	5.21***	0.050	0.111
Innovation persistence (INP)	=>CP	0.055	2.23 **	0.007	0.105
Diversity of patents (DVP)	=>CP	0.309	11.10***	0.252	0.363
Company size (S)	=>CP	0.049	0.741 ns	-0.031	0.226
Manufacturing Sector (MS)	=>CP	0.042	1.347 ns	-0.023	0.091
Variance explained R2		R2 CP = 0.164			
Stone-Geisser's Q2		Q2 P = 0.103			
Note: *** p < 0.01; ** p < 0.05; ns = not significant					

Relation Model 2 (*without control variables*)		**Path Coefficient**	**t-value**	**Percentile Bootstrap 95% Confidence Level**	
				Lower	**Upper**
Inventor intensity (INV)	=>CP	0.106	2.12 **	0.010	0.175
Applicant intensity (APP)	=>CP	0.015	0.41 ns	-0.042	0.098
Patent scope (PSC)	=>CP	0.080	5.07***	0.051	0.112
Innovation persistence (INP)	=>CP	0.061	2.40 **	0.013	0.110
Diversity of patents (DVP)	=>CP	0.314	11.52***	0.259	0.365
Variance explained R2		R2 CP = 0.122			
Stone-Geisser's Q2		Q2 P = 0.078			
Note: *** p < 0.01; ** p < 0.05; ns = not significant					

Table 6. Estimation results for the structural equation model

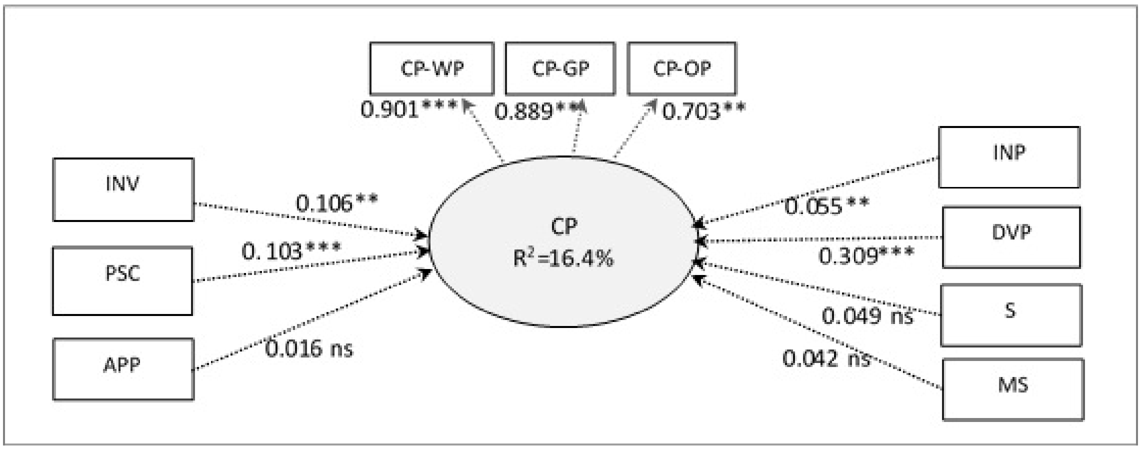

Figure 5. Structural model results

In summary, the results provide response to RQ3 as our construct for circular patents is positively related to the variables inventor intensity (INV), applicant intensity (APP), patent scope (PSC), innovation persistence (INP), and the diversity of patents (DVP). These variables explain 16.4% of the variance in the model. Stone-Geisser's crossvalidated redundancy Q2 (0.103) confirms the model's predictive relevance (i.e., Q2 > 0). These results show that the model predicts the level of circular patents of the companies of the sample.

Discussion

In the absence of a recognised method for assessing the level of a company in terms of the CE, we enhance the previous studies defining and measuring circular patents. To the best of our knowledge, no similar studies could allow us to discuss in detail the obtained results related to the circular patents classifications. However, some prior studies mentioned in the literature review related to dynamic capabilities applied to the CE (Scarpellini et al. 2020; Marín-Vinuesa, Portillo-Tarragona, and Scarpellini 2021; Marrucci et al. 2021) allow us to partially discuss the results for the second research question due to the incipient stage of the research. In particular, the third line of inquiry need further development to contribute to the incipient discussion about the long-term impacts of circular innovations (Kiefer, del Río, and Carrillo-Hermosilla 2021).

The classification of circular patents proposed in this study (RQ1) offers a first approach to the debate about how to determine the circular character of intangible assets to go beyond the concept of 'circular eco-innovation' provided by Scarpellini et al. (2020) and other attempts based on waste patents (Marín-Vinuesa, Portillo-Tarragona, and Scarpellini 2021).

In summary, this line of inquiry enhances the previous research focused on CE-related patents in the EU that has considered only the waste technologies and by-product innovations applied to improve the efficiency and the sustainability of processes (Asensio et al. 2020). Our research also infers an overlap between environmental and conventional innovations to contribute to the analysis of impact of patent complementary in the innovation process.

From the dynamic capabilities perspective, the previous studies have demonstrated the importance of specific internal resources and capabilities in generating eco-innovation (Ghisetti and Pontoni 2015; Portillo-Tarragona et al. 2018) and green patents (Aragon-Correa and Leyva-de la Hiz 2016; Marín-Vinuesa et al. 2020), but the influence of a company's capabilities on circular patents has not been empirically analysed for different patents categories and by using a enhanced classification. This study addresses this gap in the literature and offers measurements and tools to define circular patents and manage companies' dynamic capabilities specifically applied to circular inventions such as organisational capabilities, the relevance of R&D collaboration, the capabilities related to innovation persistence, complementarity or the patents' scope, as well as the collaborative aspects of the CE-related innovation measured through the number of inventors or applicants.

Although these researchers seem to agree on the relevance of companies' resources and capabilities to the CE, no specific previous studies explore ways of defining and measuring environmental practices and capabilities related to the circular model at the micro level (Marrucci et al. 2021). In this circular research, patents are considered as integral elements of companies' dynamic capabilities, considering that environmental concern is a strategic element that positively impacts competitiveness and contributes to sustainable development (Ahmad et al. 2022).

Following the capabilities analysed in this study (RQ2), the results point out that administrations and governments when defining R&D policies have to promote specifically circular innovation and patents in a CE scenario. As a general remark, using the insights achieved in this paper, policy-makers have a clear perspective on the capabilities of companies applied to waste patents as circular innovations. When promoting R&D and innovation for a CE, the micro level repercussions should also be taken into account to in the territory to mobilise resources through specific capabilities of companies without undermining their performance. In particular, the collaborative aspects intrinsic to the CE, could be considered as specific dynamic capabilities that differ to those capabilities applied to eco-innovation (RQ2b). These considerations integrate the previous contribution of other authors (Ponta, Puliga, and Manzini 2021) and corroborate that innovation in the CE depends on forming strategic alliances in line with (Suchek et al. 2021). Our results enhance the previous studies that highlighted the lack of meso-level indicators to measure the CE-related innovation (Kuzma et al. 2022) as specific capabilities (RQ2b).

For patent scope and persistence capabilities, the diversity of patents achieved in this research indicates that the company's ability to innovate is a fundamental aspect for circular patents. Other authors find that the growth in the percentage of green patents over time is lower than the growth in the total number of patents (Sun et al. 2008). Our study does not confirm this result and instead demonstrates that circular patents increase with a company's innovation persistence, as one of the dynamic capabilities that they use to manage intangible assets as resources for innovating. In addition, more research is required to clarify how companies may reinforce their capabilities for different patents and social impacts of the different groups of circular patents (Scarpellini 2022).

Conclusions

The achieved results are a first approach to the debate about the influence of the capabilities that companies apply to innovation in a CE context.

For academics, these contributions are relevant because they provide a much-needed understanding of the development of a company's intangible resources to undertake patented innovations in a CE model. In this analysis, patents that can foster the sharing economy and the CE in sensu latu are also considered circular patents, in addition to waste patents and other green patents, offering an enhanced measurement of the intangible assets related to the principles of decoupling, which are intrinsic to the CE, to decouple usage from ownership at the micro level.

Policy makers can encourage R&D collaborations between companies and public research institutions for the CE, supporting circular patents as an effective innovation policy for closing the material loop. Green patents, used as an approach to the development of eco-innovation, are now required to measure the innovation level in a CE context, thus, they must be integrated with the other patent families. Our study provides a first approach to this framework of analysis for a future international circular patent classification provided by policy makers that is broader than the one focusing on the waste patents adopted so far in the EU. A comprehensive understanding of the values being mobilised in the background helps to also inform the direction of the innovation policy.

For practitioners, we offer the definition and measurement of the companies' capabilities for improving resource allocation under a CE scheme. As such, companies may gain competitive advantages in a CE environment using their present capabilities in managing their accumulated experience associated with innovation practices and patenting, collaborating with R&D institutes, persistence in innovation activities, and managing the diversity of patents as strategic intangible assets. We recommend that managers deploy their dynamic capabilities to build meso-level EC-related processes, which, in turn, are the basis for developing collaborative circular patents. Practitioners can organise their resources to foster innovation and, thus, the number of patents.

We acknowledge that the use of patent data causes some limitations that suggest more interdisciplinary work on this topic owing to the systemic nature of the CE at the company level. Future studies must also consider the environmental divergence when an organisation's environmental innovations fall outside the regular domain of its industry. Investigations of the full text of patents and the availability of the geographical scope of patents when registered in different national offices can also enhance the results of future studies.

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References

Aaldering, Lukas Jan, Jens Leker, and Chie Hoon Song. 2019. "Competition or Collaboration? – Analysis of Technological Knowledge Ecosystem within the Field of Alternative Powertrain Systems: A Patent-Based Approach." *Journal of Cleaner Production* 212. Elsevier Ltd: 362–71. doi:10.1016/j.jclepro.2018.12.047.

Ahmad, Bashir, Imran Shafique, Ahmad Qammar, Mehmet Ercek, and Masood Nawaz Kalyar. 2022. "Prompting Green Product and Process Innovation: Examining the Effects of Green Transformational Leadership and Dynamic Capabilities." *Https://Doi.Org/10.1080/09537325.2022.2071692*, May. Routledge, 1–13. doi:10.1080/09537325.2022.2071692.

Albino, Vito, Lorenzo Ardito, Rosa Maria Dangelico, and Antonio Messeni Petruzzelli. 2014. "Understanding the Development Trends of Low-Carbon Energy Technologies: A Patent Analysis." *Applied Energy* 135 (1): 836–54. doi:10.1016/j.apenergy.2014.08.012.

Aldieri, Luigi, Fabio Carlucci, Andrea Cirà, Giuseppe Ioppolo, and Concetto Paolo Vinci. 2019. "Is Green Innovation an Opportunity or a Threat to Employment? An

Empirical Analysis of Three Main Industrialized Areas: The USA, Japan and Europe." *Journal of Cleaner Production* 214: 758–66. doi:10.1016/j.jclepro.2019.01.016.

Altuntas, Serkan, Turkay Dereli, and Andrew Kusiak. 2015. "Forecasting Technology Success Based on Patent Data." *Technological Forecasting and Social Change* 96. Elsevier Inc.: 202–14. doi:10.1016/j.techfore.2015.03.011.

Aragon-Correa, Juan Alberto, and Dante I. Leyva-de la Hiz. 2016. "The Influence of Technology Differences on Corporate Environmental Patents: A Resource-Based Versus an Institutional View of Green Innovations." *Business Strategy and the Environment* 25 (6): 421–34. doi:10.1002/bse.1885.

Aranda-Usón, Alfonso, Pilar Portillo-Tarragona, Luz María Marín-Vinuesa, and Sabina Scarpellini. 2019. "Financial Resources for the Circular Economy : A Perspective from Businesses." *Sustainability* 11 (888): 1–23. doi:10.3390/su11030888.

Ardito, Lorenzo, Antonio Messeni Petruzzelli, and Claudia Ghisetti. 2019. "The Impact of Public Research on the Technological Development of Industry in the Green Energy Field." *Technological Forecasting and Social Change* 144 (April). Elsevier: 25–35. doi:10.1016/j.techfore.2019.04.007.

Asensio, Eloy, César Medina, Moisés Frías, and María Isabel Sánchez de Rojas. 2020. "Fired Clay-Based Construction and Demolition Waste as Pozzolanic Addition in Cements. Design of New Eco-Efficient Cements." *Journal of Cleaner Production* 265. doi:10.1016/j.jclepro.2020.121610.

Bae, Hee Sung. 2017. "The Effect of Environmental Capabilities on Environmental Strategy and Environmental Performance of Korean Exporters for Green Supply Chain Management." *Asian Journal of Shipping and Logistics* 33 (3). Elsevier B.V.: 167–76. doi:10.1016/j.ajsl.2017.09.006.

Bagozzi, R.P, and Y Yi. 1988. "On the Evaluation of Structural Equation Models." *Journal of the Academy of Marketing Science* 16 (1): 74–94. doi:10.1007/BF02723327.

Barney, Jay B. 1991. "Firm Resources and Sustained Competitive Advantage." *Journal of Management* 17 (1): 99–120. doi:10.1177/014920639101700108.

Battagello, Franco Maria, Livio Cricelli, and Michele Grimaldi. 2019. "Prioritization of Strategic Intangible Assets in Make/Buy Decisions." *Sustainability* 11 (5): 1–25. doi:10.3390/su11051267.

Cainelli, Giulio, Alessio D'Amato, and Massimiliano Mazzanti. 2020. "Resource Efficient Eco-Innovations for a Circular Economy: Evidence from EU Firms." *Research Policy* 49 (1). Elsevier: 103827. doi:10.1016/j.respol.2019.103827.

Calik, E., and F. Bardudeen. 2016. "A Measurement Scale to Evaluate Sustainable Innovation Performance in Manufacturing Organizations." In *Procedia CIRP*, 40:449–54. New York, NY, USA: Elsevier B.V. doi:10.1016/j.procir.2016.01.091.

Cecere, Grazia, Nicoletta Corrocher, Cédric Gossart, and Muge Ozman. 2014. "Technological Pervasiveness and Variety of Innovators in Green ICT: A Patent-Based Analysis." *Research Policy* 43 (10): 1827–39. doi:10.1016/j.respol.2014.06.004.

Chassagnon, Virgile, and Naciba Haned. 2015. "The Relevance of Innovation

Leadership for Environmental Benefits: A Firm-Level Empirical Analysis on French Firms." *Technological Forecasting and Social Change* 91. Elsevier Inc.: 194–207. doi:10.1016/j.techfore.2014.02.012.

Corona, Blanca, Li Shen, Denise Reike, Jesús Rosales Carreón, and Ernst Worrell. 2019. "Towards Sustainable Development through the Circular Economy—A Review and Critical Assessment on Current Circularity Metrics." *Resources, Conservation and Recycling* 151 (September). Elsevier: 104498. doi:10.1016/j.resconrec.2019.104498.

Daddi, Tiberio, Niccolò Maria Todaro, Maria Rosa De Giacomo, and Marco Frey. 2018. "A Systematic Review of the Use of Organization and Management Theories in Climate Change Studies." *Business Strategy and the Environment* 27 (4): 456–74. doi:10.1002/bse.2015.

David, Bertrand, Rene Chalon, and Chuantao Yin. 2016. "Collaborative Systems & Shared Economy (Uberization): Principles & Case Study." In *2016 International Conference on Collaboration Technologies and Systems, CTS 2016*, 57–63. doi:10.1109/cts.2016.0029.

Ding, Ma. 2014. "Supply Chain Collaboration toward Eco-Innovation: An SEM Analysis of the Inner Mechanism." In *Proceedings of 2014 IEEE International Conference on Service Operations and Logistics, and Informatics, SOLI 2014*, 129–34. doi:10.1109/SOLI.2014.6960706.

Dixon, Sarah, Klaus Meyer, and Marc Day. 2014. "Building Dynamic Capabilities of Adaptation and Innovation: A Study of Micro-Foundations in a Transition Economy." *Long Range Planning* 47 (4): 186–205. doi:10.1016/j.lrp.2013.08.011.

European Commission. 2018. "A European Strategy for Plastics in a Circular Economy COM(2018) 28 Final." *Communication from the Commission to the Euroepan Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions*. Vol. SWD (2018). doi:10.1021/acs.est.7b02368.

García-Muiña, Fernando E., and Rocío González-Sánchez. 2017. "Absorptive Routines and International Patent Performance." *Business Research Quartely* 20 (2): 96–111. doi:10.1016/j.brq.2017.04.002.

Ghisetti, Claudia, and Federico Pontoni. 2015. "Investigating Policy and R&D Effects on Environmental Innovation: A Meta-Analysis." *Ecological Economics* 118: 57–66. doi:10.1016/j.ecolecon.2015.07.009.

Gitelman, Lazar, Elena Magaril, Mikhail Kozhevnikov, and Elena Cristina Rada. 2019. "Rational Behavior of an Enterprise in the Energy Market in a Circular Economy." *Resources* 8 (2). doi:10.3390/resources8020073.

Hair, Joe F., Christian M. Ringle, and Marko Sarstedt. 2011. "PLS-SEM: Indeed a Silver Bullet." *The Journal of Marketing Theory and Practice* 19 (2): 139–52. doi:10.2753/MTP1069-6679190202.

Halila, Fawzi, and Jonas Rundquist. 2011. "The Development and Market Success of Eco-Innovations: A Comparative Study of Eco-Innovations and 'Other' Innovations in Sweden." *European Journal of Innovation Management* 14 (3): 278–302. doi:10.1108/14601061111148807.

Hayduk, Leslie A. 1987. *Structural Equation Modeling with LISREL: Essentials and Advances*. *Structural Equation Modeling with LISREL: Essentials and Advances*.

Baltimore and London: The Johns Hopkins University Press.

Herrero-Luna, Sonia, Marta Ferrer-Serrano, and María Pilar Latorre-Martínez. 2022. "Circular Economy and Innovation: A Systematic Literature Review." *Central European Business Review* 11 (1). Central European Business Review: 65–84. doi:10.18267/j.cebr.275.

Higgins, Brian W. 2003. "Adding Business Value: A Strategy for Identifying and Patenting Environmental-Related Inventions and Avoiding Patent Infringement." *Business Strategy and the Environment* 12 (2): 118–28. doi:10.1002/bse.349.

Horbach, Jens. 2008. "Determinants of Environmental Innovation-New Evidence from German Panel Data Sources." *Research Policy* 37 (1): 163–73. doi:10.1016/j.respol.2007.08.006.

Huang, Kuo Feng, and Tsung Chi Cheng. 2015. "Determinants of Firms' Patenting or Not Patenting Behaviors." *Journal of Engineering and Technology Management - JET-M* 36. Elsevier B.V.: 52–77. doi:10.1016/j.jengtecman.2015.05.003.

Iñigo, Edurne A., and Laura Albareda. 2016. "Understanding Sustainable Innovation as a Complex Adaptive System: A Systemic Approach to the Firm." *Journal of Cleaner Production*. doi:10.1016/j.jclepro.2016.03.036.

Kapp, K. William. 1965. "Economic Development in a New Perspective: Existential Minima and Substantive Rationality." *Kyklos* 18 (1): 49–79. doi:10.1111/j.1467-6435.1965.tb02471.x.

Katz Gerro, Tally, and Jordi López Sintas. 2019. "Mapping Circular Economy Activities in the European Union: Patterns of Implementation and Their Correlates in Small and Medium-sized Enterprises." *Business Strategy and the Environment* 28 (1): 485–96. doi:10.1002/bse.2259.

Khan, Owais, Tiberio Daddi, and Fabio Iraldo. 2020. "Microfoundations of Dynamic Capabilities: Insights from Circular Economy Business Cases." *Business Strategy and the Environment* 29 (3): 1479–93. doi:10.1002/bse.2447.

Kiefer, Christoph P., Pablo del Río, and Javier Carrillo-Hermosilla. 2021. "On the Contribution of Eco-Innovation Features to a Circular Economy: A Microlevel Quantitative Approach." *Business Strategy and the Environment* 30 (4): 1531–47. doi:10.1002/bse.2688.

Kim, Jeeeun, and Sungjoo Lee. 2015. "Patent Databases for Innovation Studies: A Comparative Analysis of USPTO, EPO, JPO and KIPO." *Technological Forecasting and Social Change* 92. Elsevier Inc.: 332–45. doi:10.1016/j.techfore.2015.01.009.

Kristoffersen, Eivind, Patrick Mikalef, Fenna Blomsma, and Jingyue Li. 2021. "The Effects of Business Analytics Capability on Circular Economy Implementation, Resource Orchestration Capability, and Firm Performance." *International Journal of Production Economics* 239 (May). Elsevier B.V.: 108205. doi:10.1016/j.ijpe.2021.108205.

Kuzma, Edson Luis, Simone Sehnem, Ana Beatriz Lopes de Sousa Jabbour, and Lucila M.S. Campos. 2022. "Circular Economy Indicators and Levels of Innovation: An Innovative Systematic Literature Review." *International Journal of Productivity and Performance Management* 71 (3). Emerald Group Holdings Ltd.: 952–80. doi:10.1108/IJPPM-10-2020-0549.

Marín-Vinuesa, Luz María, Pilar Portillo-Tarragona, and Sabina Scarpellini. 2021. "Firms' Capabilities Management for Waste Patents in a Circular Economy." *International Journal of Productivity and Performance Management* IN PRESS: 1–24. doi:10.1108/ijppm-08-2021-0451.

Marín-Vinuesa, Luz María, Sabina Scarpellini, Pilar Portillo-Tarragona, and José M. Moneva. 2020. "The Impact of Eco-Innovation on Performance Through the Measurement of Financial Resources and Green Patents." *Organization & Environment* 33 (2): 285–310. doi:10.1177/1086026618819103.

Marrucci, Luca, Fabio Iannone, Tiberio Daddi, and Fabio Iraldo. 2021. "Antecedents of Absorptive Capacity in the Development of Circular Economy Business Models of Small and Medium Enterprises." *Business Strategy and the Environment* 31 (1). John Wiley and Sons Ltd: 532–44. doi:10.1002/bse.2908.

Momete, Daniela Cristina. 2020. "A Unified Framework for Assessing the Readiness of European Union Economies to Migrate to a Circular Modelling." *Science of the Total Environment* 718. Elsevier B.V.: 137375. doi:10.1016/j.scitotenv.2020.137375.

Motohashi, Kazuyuki, and Shingo Muramatsu. 2012. "Examining the University Industry Collaboration Policy in Japan: Patent Analysis." *Technology in Society* 34 (2): 149-162research policy. doi:10.1016/j.techsoc.2012.02.006.

Mousavi, Seyedesmaeil, Bart Bossink, and Mario van Vliet. 2018. "Dynamic Capabilities and Organizational Routines for Managing Innovation towards Sustainability." *Journal of Cleaner Production* 203. Elsevier Ltd: 224–39. doi:10.1016/j.jclepro.2018.08.215.

Narayan, Rumy, and Annika Tidström. 2020. "Tokenizing Coopetition in a Blockchain for a Transition to Circular Economy." *Journal of Cleaner Production* 263. doi:10.1016/j.jclepro.2020.121437.

Pacheco, Diego Augusto de Jesus, Carla Schwengber ten Caten, Carlos Fernando Jung, Helena Victorovna Guitiss Navas, and Virgílio Antônio Cruz-Machado. 2018. "Eco-Innovation Determinants in Manufacturing SMEs from Emerging Markets: Systematic Literature Review and Challenges." *Journal of Engineering and Technology Management - JET-M* 48 (April). Elsevier: 44–63. doi:10.1016/j.jengtecman.2018.04.002.

Ponta, Linda, Gloria Puliga, and Raffaella Manzini. 2021. "A Measure of Innovation Performance: The Innovation Patent Index." *Management Decision* 59 (13): 73–98. doi:10.1108/MD-05-2020-0545.

Portillo-Tarragona, Pilar, Sabina Scarpellini, Jose Moneva, Jesus Valero-Gil, and Alfonso Aranda-Usón. 2018. "Classification and Measurement of the Firms' Resources and Capabilities Applied to Eco-Innovation Projects from a Resource-Based View Perspective." *Sustainability* 10 (9): 3161. doi:10.3390/su10093161.

Przychodzen, Wojciech, Dante I. Leyva-de la Hiz, and Justyna Przychodzen. 2019. "First-mover Advantages in Green Innovation—Opportunities and Threats for Financial Performance: A Longitudinal Analysis." *Corporate Social Responsibility and Environmental Management*, no. IN PRESS: 1–19. doi:10.1002/csr.1809.

Ribeiro, Barbara, and Philip Shapira. 2020. "Private and Public Values of Innovation : A Patent Analysis of Synthetic Biology." *Research Policy* 49 (1). Elsevier: 103875 in press. doi:10.1016/j.respol.2019.103875.

Ringle, C M, S Wende, and J.M. Decker. 2015. "Smart PLS 3." *SmartPLS GmbH*. doi:10.15358/9783800644377_564.

Rodriguez, Jorge A., and Frank Wiengarten. 2017. "The Role of Process Innovativeness in the Development of Environmental Innovativeness Capability." *Journal of Cleaner Production* 142 (4): 2423–34. doi:10.1016/j.jclepro.2016.11.033.

Sánchez-Alegría, Santiago, Fermín Lizarraga-Dalloa, and Luz María Marín-Vinuesa. 2021. "Is Quality Management a Competitive Advantage? A Study after the Spanish Financial Crisis in the Furniture Industry." *Total Quality Management and Business Excellence* 0 (0). Taylor & Francis: 1–22. doi:10.1080/14783363.2021.1954899.

Scarpellini, Sabina. 2022. "Social Impacts of a Circular Business Model: An Approach from a Sustainability Accounting and Reporting Perspective." *Corporate Social Responsibility and Environmental Management* 29 (3): 646–56. doi:10.1002/csr.2226.

Scarpellini, Sabina, Pilar Portillo-Tarragona, and Luz Maria Marin-Vinuesa. 2019. "Green Patents: A Way to Guide the Eco-Innovation Success Process?" *Academia Revista Latinoamericana de Administración* 32 (2): 225–43. doi:10.1108/arla-07-2017-0233.

Scarpellini, Sabina, Jesus Valero-Gil, José M. Moneva, and Michele Andreaus. 2020. "Environmental Management Capabilities for a 'Circular Eco-Innovation.'" *Business Strategy and the Environment* 29 (5): 1850–64. doi:10.1002/bse.2472.

Sehnem, Simone, Adriane A.Farias S.L. de Queiroz, Susana Carla Farias Pereira, Gabriel dos Santos Correia, and Edson Kuzma. 2022. "Circular Economy and Innovation: A Look from the Perspective of Organizational Capabilities." *Business Strategy and the Environment* 31 (1): 236–50. doi:10.1002/bse.2884.

Smol, Marzena, Joanna Kulczycka, and Anna Avdiushchenko. 2017. "Circular Economy Indicators in Relation to Eco-Innovation in European Regions." *Clean Technologies and Environmental Policy* 19 (3): 669–78. doi:10.1007/s10098-016-1323-8.

Suchek, Nathalia, Cristina I. Fernandes, Sascha Kraus, Matthias Filser, and Helena Sjögrén. 2021. "Innovation and the Circular Economy: A Systematic Literature Review." *Business Strategy and the Environment* 30 (8): 3686–3702. doi:10.1002/bse.2834.

Sun, Yamei, Yonglong Lu, Tieyu Wang, Hua Ma, and Guizhen He. 2008. "Pattern of Patent-Based Environmental Technology Innovation in China." *Technological Forecasting and Social Change* 75 (7): 1032–42. doi:10.1016/j.techfore.2007.09.004.

Teece, David J, Gary Pisano, and Amy Shuen. 1997. "Dynamic Capabilities and Strategic Management." *Strategic Management Journal* 18 (7): 509–33. doi:Doi 10.1002/(Sici)1097-0266(199708)18:7<509::Aid-Smj882>3.0.Co;2-Z.

Vuţă, Mariana, Mihai Vuţă, Adrian Enciu, and Sorin Iulian Cioaca. 2018. "Assessment of the Circular Economy's Impact in the Eu Economic Growth." *Amfiteatru Economic* 20 (48): 248–61. doi:10.24818/EA/2018/48/248.

Wang, Yixuan, Bowen Jiang, and Yukihiro Wakuta. 2022. "How Digital Platform Leaders Can Foster Dynamic Capabilities through Innovation Processes: The Case of Taobao." *Technology Analysis and Strategic Management* IN PRESS. Routledge. doi:10.1080/09537325.2022.2050690.

Yin, Jingyu, and Dan Wang. 2021. "Dynamic Evaluation of Green Innovation Efficiency of Patent-Intensive Industries: Evidence from the New Equipment Manufacturing." *Technology Analysis and Strategic Management* IN PRESS. Routledge. doi:10.1080/09537325.2021.1963428.