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RESEARCH ARTICLE

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Eco-innovation and firm growth in the circular economy: Evidence from European small- and medium-sized enterprises

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Abstract

As the circular economy (CE) concept gains growing popularity among consumers and producers, small- and medium-sized enterprises (SMEs) increasingly look for ways to reorganize their offering and operations to integrate into the CE. This study examines the impact of (a) circular eco-innovations and (b) external funding available for CE activities on the growth of European SMEs using a data set of 5,100 SMEs across 28 European countries in 2016. Findings reveal that a significant threshold investment (i.e., higher than 10% of revenues) into circular eco-innovations is required for SMEs to benefit from investing into the CE. Moreover, the majority of circular eco-innovations fail to boost the growth rates of SMEs, with the exception of investments into eco-design innovations. Although traditional forms of debt and grant finance targeted to CE activities are found to have no or negative impact on the growth of SMEs, equity finance (i.e., angel and venture capital investments) contributes positively to their growth. The study offers insights into the lower levels of SME engagement in the CE as well as policy implications for improving engagement.

KEYWORDS

circular economy, eco-design, eco-innovation, entrepreneurship, finance, growth, SMEs

1 | INTRODUCTION

Circular economy (CE) emphasizes a shift away from the linear economic production and consumption models of "take-make-use-dispose" towards circular systems and business models where the objective is to eliminate waste of all kinds. It is strongly aligned with the United Nations Development Goal 12 of "Responsible Production and Consumption," even though applications of the CE span over most other UN development goals (United Nations, n.d.). Various innovation trends that can be classified under technology push (e.g., intelligent decentralization of production and reusable and longer-life materials) and market pull (e.g., sharing society, barter cultures, repair cafes, and green consumerism) are paving the way for a shift towards the CE (Stahel, 2019).

Making the existing production and consumption patterns more circular includes a broad spectrum of challenges from minimizing the environmental impact of production and ensuring effective reuse and recycling of products to introducing social interventions that align consumer behaviour with the principles of the CE (Bocken, Olivetti, Cullen, Potting, & Lifset, 2017; Geissdoerfer, Savaget, Bocken, & Hultink, 2017; Ghisellini, Cialani, & Ulgiati, 2016; Zucchella & Previtali, 2019). Pro-CE eco-innovations (or circular eco-innovations [EIs] from here onwards) is a term used to refer to EI that target recirculation of resources in loops of reuse, recycling, and renewal (De Jesus & Mendonça, 2018), and they are crucial in the resolution of environmental challenges (Zubeltzu-Jaka, Erauskin-Tolosa, & Heras-Saizarbitoria, 2018).[1]

[1]Much of the eco-innovation (EI) literature builds on the EI definition of "production, assimilation or exploitation of a good, service, production process, organizational structure, or management or business method that is novel to the firm or user and which results, throughout its lifecycle, in a reduction of environmental risk, pollution and the negative impacts of resources use (including energy use) compared with relevant alternatives" (Kemp & Pearson, 2007, p. 7) even though alternatives with different emphasis on different elements can be found in the literature (Zubeltzu-Jaka et al., 2018).

Alongside the circular initiatives of large businesses, recent years have seen numerous environmental start-ups introduce circular EI and create entirely new market categories through circular business models. For instance, *iFixit*, with a wiki-based business model, teaches people how to repair things and has transformed consumers' relationship with their electronic devices (iFixit, n.d.). It has recently partnered with Motorola to extend the life of Motorola devices by supplying official Motorola repair kits. Another environmental start-up, *Cup Club* is launched with a mission to eliminate disposable cups without removing the convenience of disposable cups (CupClub, n.d.). Their ubiquitously designed, reusable, and intelligent (i.e., Radio Frequency Identification (RFID) tagged) cups can be picked up at coffee shops by consumers and dropped off at collection points to re-enter circulation after cleaning (i.e., reusable cups "as a service" is the business model). Entrepreneurial success stories, like the abovementioned, suggest the presence of strong economic returns to circular EI investments reflected in growth and profitability (Ghisellini et al., 2016) even though there is little systematic evidence to generalize this to the broader population of start-ups and small businesses. Integration of SMEs to the CE remains a challenge despite their significant numbers and economic impact in Europe (Ormazabal, Prieto-Sandoval, Puga-Leal, & Jaca, 2018; Rizos, Behrens, Kafyeke, Hirschnitz-Garbera, & Ioannou, 2015).

This paper examines the relationship between circular EI and firm growth among Europe's small- and medium-sized enterprises (SMEs) based on a unique database of 5,100 SMEs from 28 EU countries acquired by the Flash EuroBarometer 441 survey (European SMEs and the CE) in 2016. In doing so, the paper makes three important contributions to the field. First, it sheds light on an underresearched area in the CE and EI literatures by (a) investigating the different types of circular EI introduced by SMEs and (b) how different forms of circular EI affect SMEs' growth performance. The innovative activity in the CE is vaguely defined due to the nascence of circular concepts and the limited data availability (Katz-Gerro & Sintas, 2018). Although the circular activities of large firms are more widely publicized and discussed, we particularly lack systematic evidence on the extent to which SMEs currently take part in the CE and how this affects their offering, operations, and performance (Ellen MacArthur Foundation, 2015; Ormazabal et al., 2018; Rizos et al., 2015). The paper aims to remedy this shortcoming by providing a detailed analysis of the circular EI of European SMEs using the largest and most comprehensive data set currently available. Second, the paper reveals a significant barrier to the participation of SMEs in the CE by demonstrating that only extremely high levels of circular EI investments (i.e., higher than 10% of firm revenues) positively affect SME growth. We evaluate the implications of such a high investment threshold for Europe's CE strategy (EC, n.d.) and the necessary policy interventions required to foster the growth potential of circular EI for SMEs. Finally, and relevant to the high levels of CE investments required of SMEs, the paper explores how the availability of external finance for CE activities affects the growth of SMEs. Limited access to external finance can deter EI investments and negatively affect the growth of green SMEs (Cuerva, Triguero-Cano, & Córcoles, 2014; Kunapatarawong & Martínez-Ros, 2016). Yet we know less about the different forms of finance (e.g., debt, investment, and grant) SMEs use to finance their circular EI and how this affects their growth. We remedy this shortcoming by examining the European financial ecosystem surrounding EI and the CE and add to a growing body of literature that highlights the structural changes required to elevate the financial ecosystem for sustainability transitions (Migendt, Polzin, Schock, Täube, & von Flotow, 2017; Polzin, 2017).

The paper consists of five sections. Section 2 introduces the conceptual framework and the relevant strands of literature, followed by Section 3, which describes the data and methodology, and Section 4, which presents the results. Section 5 concludes with discussions of the findings as well as managerial and policy implications of the paper.

2 | CE AND SME GROWTH—CONCEPTUAL FRAMEWORK AND EMPIRICAL EVIDENCE

The principles of a CE are based on the application of the reduction, reuse, and recycle principles to production, consumption, and circulation at the micro (i.e., firm and consumer), meso (eco-industrial parks), and macro (city, province, region, and nation) levels (Ghisellini et al., 2016; Lieder & Rashid, 2016). It refers to a restorative and regenerative system that minimizes resource use, energy leakage, and waste by closing the energy and material loops (De Jesus & Mendonça, 2018; Ellen MacArthur Foundation, 2015; Geissdoerfer et al., 2017). This section presents the theoretical and empirical literature surrounding circular EI, economic returns to circular EI, and the relevance of external finance for SMEs undertaking circular EI.

2.1 | The impact of circular EI on firm growth

The thinking around the CE offers an alternative to neoclassical economic theories that focus on continuous economic growth with little or no emphasis on material and natural resource constraints (Lieder & Rashid, 2016). With a view to closing the loop on material and energy flows, CE introduces a way to decouple economic growth and material use (Lieder & Rashid, 2016; Prieto-Sandoval, Ormazabal, Jaca, & Viles, 2018). Although the main purpose in CE is to minimize waste and pollution, it also has the potential to deliver economic benefits to participants and the general public (Geissdoerfer et al., 2017). For example, it is estimated that moving to a more CE could lead to a net economic benefit of €1.8 trillion for Europe by 2030, $700 billion annually at a global scale for fast moving consumer goods sector, create a net of 50,000 recycling and remanufacturing jobs in the United Kingdom, and create around 54,000 jobs in Netherlands within the metals and electronics sectors besides significant environmental benefits (Ellen MacArthur Foundation, 2015; Rizos et al., 2015).[2]

Closely related to the CE—although rarely explicitly connected—the EI literature also uses "win-win" arguments to suggest that the

[2]It should be noted that the paper focuses on the economic growth potential of the CE with a distinctly different view to alternative approaches such as the sustainable degrowth proposal. The latter argues that further growth cannot be achieved sustainably given the existing resource and carbon limitations our planet is facing (Weiss & Cattaneo, 2017).

trade-off between economic growth and environmental conservation at the firm level can be resolved through EI such as cleaner production and eco-design of products (Beckmann, Hielscher, & Pies, 2014; Doran & Ryan, 2016; Jové-Llopis & Segarra-Blasco, 2018b, among others). European Commission defines EI as "… all forms of innovation—technological and non-technological—that creates business opportunities and benefits the environment by preventing or reducing their impact, or by optimising the use of resources" (European Commission, 2018, p. 1). The literature has come to appreciate EI to be more than just green technologies but more broadly as "enablers of entire value chain transformations" to green the operations of the firm (De Jesus & Mendonça, 2018, p. 77). EI do not only reduce the environmental impact of firms but hold the potential to empower firm growth through cost reductions arising from lower levels of waste, better management of environmental regulations, and reduced volatility of resource prices and supply chain risks and through an increase in the market share of environmental products (Kunapatarawong & Martínez-Ros, 2016; Stucki, 2018).

CE investments are typically channelled into two main areas of EI, namely, eco-design (also referred as "green design" or "design for the environment") and clean production (De Jesus & Mendonça, 2018; Ghisetti & Montresor, 2018). Whereas the former is a typical example of *product EI* that can present in different ways such as incorporation of environmentally benign materials, longer life cycle, or an entirely new product category, the latter is a *process EI* that aims to improve eco-efficiency through reduced material and energy use by redesigning the manufacturing and operational processes (Demirel, Iatridis, & Kesidou, 2018; Klewitz & Hansen, 2014). Product and process innovations are known to complement one another, as well as triggering each other (Battisti & Stoneman, 2010) even though their impact on firm growth occurs through different channels. Although product innovations tend to deliver growth effects through increasing firms' market share or facilitating their entry into new markets, process innovations boost growth through efficiency gains and lower costs (Coad, Segarra, & Teruel, 2016; Doran & Ryan, 2016).

Positive economic returns to circular EI of firms are well accepted within the CE model (De Jesus & Mendonça, 2018; Prieto-Sandoval et al., 2018) even though there are no systematic large-scale studies scrutinizing this strong assumption. This is an oversight, particularly on the basis of the economics of innovation literature where the assumption that "more innovative firms grow faster than non-innovative firms" has come under question in the last decade (Audretsch, Coad, & Segarra, 2014). A growing literature demonstrates that the positive impact of innovations on firm growth is highly conditional on certain firm characteristics (e.g., age and size; Coad et al., 2016) and specific innovation strategies (Coad & Rao, 2008) as well as the industry context and structure (Mazzucato & Parris, 2015). The broader EI literature has also long tested the returns to firms' environmental investments with the overarching question of "does it pay to be green?" (Cheng, Yang, & Sheu, 2014; Eccles, Ioannou, & Serafeim, 2014; Hart & Ahuja, 1996; King & Lenox, 2001). In line with the abovementioned economics of innovation literature, it concludes that it is not always possible for firms to reap economic benefits from EI investments (Stucki, 2018). Instead, only certain types of firms under certain circumstances are likely to grow and profit out of their EI investments. It has been noted that firms that are research and development (R&D) intensive, positioned in highly regulated pollution-intensive sectors, focusing on energy and resource efficiency innovations, and selling products to the public sector and other businesses are more likely to financially benefit from EI (Ambec & Lanoie, 2008; Ghisetti & Rennings, 2014; Kunapatarawong & Martínez-Ros, 2016).

Most EI studies focus on profits and broader measures of financial performance with a small minority focusing on firm growth. In particular, Leoncini, Marzucchi, Montresor, Rentocchini, and Rizzo (2017) and Colombelli, Krafft, and Quatraro (2015) find that invention of green technologies affect firm growth more positively compared with non-green technologies even though Leoncini et al. (2017) note that this does not apply to the fastest and slowest growing firms. Jové-Llopis and Segarra-Blasco (2018a) find that EI generally drives firm growth contrary to Cainelli, Mazzanti, and Zoboli (2011) who show that EI affects employment and sales growth negatively. Kunapatarawong and Martínez-Ros (2016) introduce the caveat that firm growth led by EI is more likely in pollution-intensive sectors and when EI are undertaken voluntarily instead of in response to compliance pressures. Finally, Shrivastava and Tamvada (2017) find that different EI strategies (internally/externally motivated, with tangible/intangible outcomes) affect growth differently for firms of different ages. None of these empirical EI studies are positioned within the broader context of the CE.

2.2 | SMEs within the CE

SMEs account for 99% of all European businesses and generate two thirds of the jobs in Europe (OECD, 2010), yet their involvement in the CE remains limited as their activities are typically determined by large firms they provide for in supply chains (Klewitz & Hansen, 2014; Ormazabal, Prieto-Sandoval, Jaca, & Santos, 2016). The EI literature cites lack of access to finance, low technological competencies to introduce and absorb EI, low priority assigned to environmental matters, not viewing environmental actions within their responsibility, and not perceiving clear benefits to EI among the main barriers for SMEs' involvement in EI (Del Río, Carrillo-Hermosilla, & Könnölä, 2010; van Hemel & Cramer, 2002; Klewitz & Hansen, 2014; Marin, Marzucchi, & Zoboli, 2015). On the other hand, the CE literature argues that the lack of support from demand and supply networks, lack of financial resources and know-how, and administrative burden are the most significant barriers to undertaking CE activities for European SMEs (Rizos et al., 2015).

Despite the weak EI capabilities of most SMEs in the economy, a significant subset of SMEs—often referred as green entrepreneurs—can dramatically alter markets through radical product innovations and entrepreneurship (Dean & McMullen, 2007; Demirel, Li, Rentocchini, & Tamvada, 2017; Hockerts & Wüstenhagen, 2010; Jiang, Chai, Shao, & Feng, 2018; Schaper, 2010; Wigger & Shepherd, 2019). Even though the central idea of resource efficiency in the CE is not new to companies and has been core to concepts around lean manufacturing for many decades (Charter, 2018), the CE still presents a drastically different way of operating for most established large businesses. On the other hand, for green entrepreneurs, the CE presents unique opportunities to transform traditional industry contexts through radical product EI. In doing so, SMEs hold the potential to profit and grow as a result of EI investments (Dean & McMullen, 2007). Literature on how EI and CE participation affect the growth of SMEs remains thin yet Shrivastava and Tamvada (2017) offer some evidence that SMEs with less than 250 employees are likely to benefit from green product and service innovations whereas SMEs with less than 50 employees also endure benefits if they undertake “beyond compliance” EI that is internally motivated.

2.3 | Access to finance for circular EI

Evidence shows that lack of financial resources is a major deterrent for SMEs' engagement with EI (Álvarez Jaramillo, Zartha Sossa, & Orozco Mendoza, 2018; Caldera, Desha, & Dawes, 2019; Ghisetti, Mancinelli, Mazzanti, & Zoli, 2017). In the absence of internal financial resources, SMEs are forced to consider external finance, which is often limited in availability, further constraining the innovation and growth of SMEs (Revest & Sapio, 2012). Green SMEs arguably face even higher levels of financial rationing than non-green SMEs, due to various factors including a lower supply of external finance for green innovations due to their elevated risk profile both politically and technologically, high information asymmetries, the long time frames required to bring green technologies to the market, and the changing regulatory environments (Criscuolo & Menon, 2015; Mrkajic, Murtinu, & Scalera, 2017; Petkova, Wadhwa, Yao, & Jain, 2013; Randjelovic, O'Rourke, & Orsato, 2003). Yet a detailed examination of the financial ecosystem surrounding green SMEs is rarely the focus of empirical analysis in the literature. Exceptions to this include Demirel and Parris (2015) who map out the availability of different sources of external finance for environmental British SMEs and Migendt et al. (2017) who undertake a detailed analysis of the financial ecosystem around clean technology start-ups. This paper investigates the availability of different sources of finance for European SMEs to use for circular EI investments and how, in turn, this affects their growth.

3 | DATA AND METHODOLOGY

3.1 | Data

In this paper, we use data collected through the “Flash EuroBarometer 441: European SMEs and the Circular Economy” survey coordinated by the European Commission Directorate General Environment and undertaken by TNS Political & Social network in April 2016. The survey was held across 28 European countries, covering 10,618 SMEs with less than 250 employees, with a view to better understand the drivers of and barriers to SMEs' involvement in CE activities that SMEs declare to undertake. For our analysis, we considered the subsample covering only the firms where the information on revenues was available, consisting of 5,100 SMEs. Whereas Table A1 provides information on the list of countries and the corresponding number of SMEs included in the sample, Table A2 displays the industry breakdown of the SMEs using NACE categories.

3.2 | Variables and methodology

Table 1 displays the detailed description of the variables employed in the analysis. We use firm growth (GR) as the dependent variable, which is calculated based on annual revenue growth between 2015 and 2016, measured as a percentage. Table 2 presents the descriptive statistics on the variables, and it is observed that the average growth of SMEs in our sample is 3.72%. The types of circular EI included in the model are EI with a focus on (1) replanning of water usage to minimize use and maximize reuse (WATER), (2) using renewable energy (RENEWABLE), (3) replanning energy usage to minimize use (ENERGY), (4) minimizing waste by recycling, reusing, or selling to another company (WASTE), and (5) redesigning products and services to minimize the use of materials or use recycled materials (ECO-DESIGN). The first four types (1)–(4) of circular EI are typical examples of process EI that utilize the principles of subsystem change or system change in order to increase the eco-effectiveness of the operations (Demirel & Kesidou, 2019; Kiefer, González, & Carrillo-Hermosilla, 2019). The fifth category, ECO-DESIGN, on the other hand, is typically considered a form of product EI. It ensures the incorporation of recyclable or recycled materials into the product as well as minimizing the environmental impact throughout product life cycle (Santolaria, Oliver-Solà, Gasol, Morales-Pinzón, & Rieradevall, 2011). Kiefer et al. (2019) posit that not all types of EI contribute to the CE equally, and therefore, a better understanding of the different types of circular EI and their implications for firms is essential. Each type of circular EI is coded dichotomously in the database to assume the value of 1 if the firm has either implemented the particular circular EI or is in the process of implementing it and 0, otherwise. Table 2 indicates that minimizing waste is the most common type of circular EI in our sample with 39% of the firms reporting positively on the WASTE variable. It is followed by the following circular EI types: replanning energy (26%), redesigning products and services (22%), renewable energy (13%), and replanning water (12%). The total investments into circular EI (INVEST) is measured as a percentage of turnover over the last 3 years (2013–2016) and is coded as a categorical variable that is classified into four categories: (1) 0%, (2) 1–5%, (3) 6–10%, and (4) 11% or more. It is observed from Table 2 that 69% of the firms invest into circular EI with a breakdown of 56% of the firms investing 1–5% of their total turnover, 9% of the firms investing 6–10% of their turnover, and 4% of the firms investing 11% or more of their turnover.

In order to account for the costs of circular EI, the model considers the role of external finance available for circular EI as a determinant of growth. A distinction between (a) traditional forms of finance (TRADFIN) that firms have used or would consider using for CE

TABLE 1 Description of the variables

Name of variables	Description
Dependent variable	
Firm growth variable (GR)	Annual revenue growth measured as a percentage between 2015 and 2016
Independent variables	
Types of CE innovations	
Replanning of water (WATER)	Takes the value of 1 if the firm has implemented or is in the process of implementing replanning of water usage to minimize use and maximize reuse and 0, otherwise
Renewable energy (RENEWABLE)	Takes the value of 1 if the firm is using or in the process of using renewable energy and 0, otherwise
Replanning energy (ENERGY)	Takes the value 1 if the firm is replanning or in the process of replanning energy usage to minimize use and 0, otherwise
Minimizing waste (WASTE)	Takes the value of 1 if the firm is minimizing or in the process of minimizing waste by recycling, reusing or selling to another company and 0, otherwise
Redesigning products and services (ECO-DESIGN)	Takes the value of 1 if the firm is redesigning or in the process of redesigning products and services to minimize the use of materials or use recycled materials and 0, otherwise
Total investments into CE (INVEST)	It is measured as a percentage of turnover invested into CE activities over the last 3 years (2013–2016). It is coded as a categorical variable that is classified into four categories: (1) 0%, (2) 1–5%, (3) 6–10%, and (4) 11% or more.
External finance- Traditional forms (TRADFIN)	
Bank loans (BANK)	A dummy variable equals to 1 if the firm financed its CE activities through standard bank loans.
Green loans (GREENLOAN)	A dummy variable equals to 1 if the firm financed its CE activities through green loans.
EU funds (EUFUND)	A dummy variable equals to 1 if the firm financed its CE activities through EU-related funds.
Government grants (GOVGRANT)	A dummy variable equals to 1 if the firm financed its CE activities through government grants.
External finance—alternative sources (ALTFIN)	A dummy variable that takes value of 1 if the firm uses any of the following alternative forms of finance: crowdfunding, venture capital, green banks, peer-to-peer investments, business angels, and the capital market and 0, otherwise.
Crowdfunding (CROWDFUND)	A dummy variable that takes value of 1 if crowdfunding is available to the firm as alternative source of funding and 0, otherwise.
Venture Capital (VC)	A dummy variable that takes value of 1 if the firm uses venture or risk capital as alternative finance and 0, otherwise.
Green banks (GREENBANK)	A dummy variable that takes value of 1 if the firm uses green banks or other private institutions stimulating CE and green investment and 0, otherwise.
Peer-to-peer investments (P2P)	A dummy variable that takes value of 1 if the firm uses peer-to-peer lending as alternative finance and 0, otherwise.
Business angels (ANGEL)	A dummy variable that takes value of 1 if the firm uses business angels as alternative finance and 0, otherwise.
Capital market (CAPMARKET)	A dummy variable that takes value of 1 if the firm uses capital markets as alternative finance and 0, otherwise.
Research and development expenditures (R&D)	Research and development (R&D) expenditures measured as a percentage of company revenue in 2015
Firm size (SIZE)	The natural logarithm of revenues in 2015
Firm age (AGE)	Number of years since establishment. It is coded as dummy variables out of three categories: (1) age = 1 year (AGE1), (2) 1 year < age < =5 years (AGE1–5), and (3) age > 5 years (AGE > 5)
Business to customers (B2C)	A dummy variable indicating that the firm deals solely with customers, that is, sells products directly to consumers or services directly to consumers
Business to businesses (B2B)	A dummy variable indicating that the firm deals solely with businesses, that is, sells products to companies or other organizations or services to companies or other organizations

Note. This table shows the list of variables used in the analysis and their brief descriptions. CE, circular economy.

activities and (b) alternative sources of finance (ALTFIN) available to them is available in the survey and utilized in the model. TRADFIN includes bank loans (BANK), green loans (GREENLOAN), EU funds (EUFUND), and government grants (GOVGRANT) that are either used or could be used for undertaking circular EI. The most common traditional form of finance is bank loans with 11% of the firms utilizing them. It is followed by EU funds (5%), government grants (4%), and green loans (1%). ALTFIN covers crowdfunding (CROWDFUND),

TABLE 2 Descriptive statistics

	Obs.	Mean	Min	Max	Median	Stand. dev.
Firm growth variable (GR)	4,231	3.72%	−100%	100%	1%	21%
Types of CE innovations						
Replanning of water (WATER)	5,100	0.12	0	1	0	0.33
Renewable energy (RENEWABLE)	5,100	0.13	0	1	0	0.34
Replanning energy (ENERGY)	5,100	0.26	0	1	0	0.44
Minimizing waste (WASTE)	5,100	0.39	0	1	0	0.49
Redesigning products and services (ECO-DESIGN)	5,100	0.22	0	1	0	0.41
Total investments into CE (INVEST)	3,700	1.87	1	4	2	0.74
(1) 0%	1,137 (31%)					
(2) 1–5%	2,068 (56%)					
(3) 6–10%	337 (9%)					
(4) 11% or more	158 (4%)					
External finance—traditional forms						
Bank loans (BANK)	5,100	0.11	0	1	0	0.32
Green loans (GREENLOAN)	5,100	0.01	0	1	0	0.10
EU funds (EUFUND)	5,100	0.05	0	1	0	0.22
Government grants (GOVGRANT)	5,100	0.04	0	1	0	0.19
Alternative finance (ALTFIN)	5,100	0.01	0	1	0	0.11
Crowdfunding (CROWDFUND)	5,100	0.12	0	1	0	0.33
Venture capital (VC)	5,100	0.15	0	1	0	0.35
Green banks (GREENBANK)	5,100	0.18	0	1	0	0.38
Peer-to-peer investments (P2P)	5,100	0.11	0	1	0	0.31
Business angels (ANGEL)	5,100	0.09	0	1	0	0.28
Capital market (CAPMARKET)	5,100	0.19	0	1	0	0.39
Other control variables						
Research and development expenditures (R&D)	4,686	3.53%	0.00%	100.00%	0.00%	10.88%
Firm size (SIZE)	5,100	13.37	0	18	13	2.49
Firm age (AGE)						
Age = 1 year (AGE1)	5,100	0.02	0	1	0	0.13
1 year < age < =5 years (AGE1–5)	5,100	0.14	0	1	0	0.34
Age > 5 years (AGE > 5)	5,100	0.85	0	1	1	0.36
Business to customers (B2C)	5,100	0.41	0	1	0	0.49
Business to businesses (B2B)	5,100	0.18	0	1	0	0.39

Note. The table shows summary statistics for the variables. CE, circular economy.

venture capital (VC), green banks (GREENBANK), peer-to-peer investments (P2P), business angels (ANGEL), and the capital market (CAPMARKET). Each variable is dichotomously coded to reflect whether the firm felt that the particular source of external finance is or would be available to them. Note that the most prevalent type of alternative funding is capital markets with 19% of the firms using capital markets for finance, followed by green banks (18%), venture capital (15%), crowdfunding (12%), peer-to-peer investments (11%), and business angels (9%).

The model controls for firms' R&D expenditures measured in 2015 as a percentage of company revenue. Additionally, as traditionally found in firm growth studies, the model includes firm size (SIZE), which is the natural logarithm of revenues in 2015 as well as firm age (AGE; Audretsch et al., 2014; Coad et al., 2016; Jové-Llopis & Segarra-Blasco, 2018a; Leoncini et al., 2017). Firm age is coded in dummy variables representing the three categories: (1) age = 1 year (AGE1), (2) 1 year < age < =5 years (AGE1–5), and (3) age > 5 years (AGE > 5). Additionally, dummy variables that indicate whether the firm solely deals with customers (B2C) or solely with other businesses (B2B) are included to capture interfirm differences. Industry and country dummies are included in all estimations.

The study uses a simple growth model and the robust cross-sectional regression estimation technique to investigate how (a) the five different types of circular EI, (b) the level of total investment into circular EI, and (c) the external funding available to the firm for circular EI affect the growth of SMEs.

4 | RESULTS

The findings of the econometric estimations are reported in Table 3. Column 1 displays the results where we first explore the impact of the five different types of circular EI on SME growth. It is evident that only the ECO-DESIGN variable exerts a positive impact on firm growth, whereas none of the other types of circular EI (WATER, RENEWABLE, ENERGY, and WASTE) has a significant impact on driving firm growth.

Next, we move away from using dichotomous circular EI variables and take a closer look at the relationship between circular EI and firm growth by focusing on the levels of investment firms put into circular EI. Although a great majority of the firms in our sample invest less than 10% of their revenues into circular EI, Column 2 indicates that only investments in excess of 10% are likely to produce growth returns.

Finally, we consider how access to external finance for circular EI affects the growth of firms by including various traditional (i.e., bank loans, green loans, EU funds, and government funding) and alternative (i.e., crowdfunding, venture capital, green banks, peer-to-peer

TABLE 3 Results

	(1)	(2)	(3)	(4)
WATER	−0.784 (0.63)		−0.893 (0.64)	
RENEWABLE	−0.11 (0.61)		−0.073 (0.61)	
ENERGY	−0. (0.48)		−0.268 (0.48)	
WASTE	0.259 (0.45)		0.188 (0.45)	
ECO-DESIGN	1.084** (0.51)		1.091** (0.51)	
INVEST (1–5%)		0.336 (0.48)		0.325 (0.48)
INVEST (6–10%)		0.355 (0.80)		0.439 (0.80)
INVEST (11% OR MORE)		2.211* (1.17)		2.240* (1.17)
BANK	−0.921 (0.60)	−0.589 (0.68)	−1.019* (0.61)	−0.655 (0.69)
GREENLOAN	1.231 (1.79)	2.142 (2.51)	1.08 (1.80)	2.542 (2.52)
EUFUND	−3.727*** (0.91)	−2.486 (1.80)	−3.912*** (0.92)	−2.362 (1.80)
GOVGRANT	−0.532 (1.02)	−0.086 (1.99)	−0.624 (1.02)	−0.099 (2.00)
ALTFIN	4.792*** (1.60)	3.305 (2.05)		
CROWDFUND			0.464 (0.70)	0.96 (0.76)
ANGEL			2.211*** (0.85)	0.924 (0.93)
VC			1.659** (0.68)	1.587** (0.75)
CAPMARKET			−0.895 (0.56)	−0.316 (0.61)
P2P			−0.771 (0.71)	−0.36 (0.77)
GREENBANK			−0.175 (0.56)	−0.859 (0.60)
SIZE	0.568*** (0.09)	0.502*** (0.10)	0.547*** (0.09)	0.492*** (0.10)
AGE1	2.784* (1.62)	2.655 (2.05)	2.489 (1.63)	2.613 (2.05)
AGE1–5	3.660*** (0.57)	3.468*** (0.64)	3.617*** (0.57)	3.477*** (0.64)
RD	0.111*** (0.02)	0.103*** (0.02)	0.116*** (0.02)	0.104*** (0.02)
B2B	0.082 (0.44)	0.194 (0.49)	0.071 (0.44)	0.123 (0.49)
B2C	−1.336** (0.55)	−1.378** (0.61)	−1.201** (0.56)	−1.278** (0.62)
CONSTANT	−5.603 (3.80)	−5.567 (3.91)	−5.991 (3.83)	−5.857 (3.92)
Observations	3,981	2,932	3,981	2,932
Industry dummies	YES	YES	YES	YES
Country dummies	YES	YES	YES	YES

Note. The table shows the regression results where we investigate the effect of five different types of CE innovations (Column 1), the level of total investment into CE innovations (Column 2), and the traditional and alternative types of external funding (Columns 3 and 4) on the growth of SMEs. We use robust cross-sectional regression estimation techniques where industry and country dummies are included. Standard errors in parentheses.

*p < .10. **p < .05. ***p < .010.

investments, business angels, and the capital market) finance sources cited in the database. Findings reveal that the traditional forms of external funding are unlikely to have a positive impact on SME growth whereas access to alternative sources of finance has a positive impact (Columns 1 and 2). Delving deeper into the impact of different types of alternative funding (Columns 3 and 4) reveals that it is the venture capital and angel funding that can drive SME growth.

Many of the firm-specific control variables used in the model exert a significant impact on SME growth. For instance, larger and older firms are found to have higher growth rates, possibly indicating the positive impact of accumulated resources of a firm on its survival and growth (Coad, Frankish, Roberts, & Storey, 2013). Moreover, the firms' R&D expenditures have a positive impact on firm growth. Findings suggest that although dealing solely with customers lead to a decrease in growth, dealing solely with businesses has no significant impact on firm growth.

The next section evaluates these findings in light of the prior literature and concludes with policy and managerial implications as well as further avenues for research.

5 | DISCUSSIONS AND CONCLUSIONS

The paper examines the relationship between circular EI and firm growth for SMEs by unpacking this relationship to consider (a) the different types of circular EI and (b) the different levels of firm investment into circular EI. Its findings emphasize the importance of eco-design as the sole circular EI that produces significant growth returns for SMEs. As eco-design is a form of product EI, this finding is in line with prior literature that suggests SMEs are more likely to focus on and benefit from product innovations as opposed to process innovations in most markets (Coad et al., 2016) including the green markets (Dean & McMullen, 2007; Doran & Ryan, 2016). The positive impact of eco-design on firm growth is argued to result from a combination of energy/materials-based cost savings due to more eco-efficient design, increased revenues due to satisfying green consumer demand and increased firm competitiveness due to the improved public image and regulatory compliance records of the firm (Plouffe, Lanoie, Berneman, & Vernier, 2011). Eco-design capabilities are important sustainability-oriented capabilities (Demirel & Kesidou, 2019) that are strongly correlated with SMEs' ability to introduce EI and business model innovations (Ghisetti & Montresor, 2018; Prendeville, O'Connor, Bocken, & Bakker, 2017). Our findings extend this notion by demonstrating that eco-design also contributes to SME growth and therefore point to the importance of raising the eco-design capabilities of SMEs in order to enhance their integration to the CE.

The lack of a significant relationship between most types of process circular EI (WATER, RENEWABLE, ENERGY, and WASTE) and firm growth is accompanied with a similar finding in the context of the levels of investment to circular EI. The findings indicate that a very high investment threshold (i.e., 10% of revenues) exists for circular EI to deliver economic growth returns to SMEs. This threshold is above the average innovation investments of the world's largest businesses (Coad, 2018) and is exceptionally high for most SMEs. Indeed, the findings suggest that circular EI investments only benefit 4% of the SMEs (that spend over 10%) in our data set. This implies that the majority of SMEs find little economic rationale to integrate into the CE, and it is important to consider strategies and policies that can reduce this threshold to reasonable levels. Indeed, policy interventions in the form of demand (e.g., environmental standards, taxes, and targets to shift consumer preferences) and supply (e.g., tax credits, grants, and loans to support eco R&D) side policies are in place across Europe to strengthen the economic returns to EI investments (Prieto-Sandoval et al., 2018). Yet our findings suggest that these current interventions mostly fall short of creating a playing ground that favours circular EI investments and green entrepreneurship in Europe.

Related to the last point, the findings also demonstrate that the majority of the public EU and government funds earmarked for CE fail to drive firm growth. Green public investments of most European countries remain subpar and within the framework of less involved market-fixing strategies with the exception of some countries such as Germany (Mazzucato & Parris, 2015). Our findings suggest that the current grant funding strategies of European governments are not working efficiently for the CE and require rethinking to ensure that governments can provide the right amounts of funding through visionary strategies to boost green entrepreneurship. Additionally, although we find that venture capital and angel finance are the two sources of external finance that are most closely associated with the growth of SMEs in the CE, we note that only a small percentage of SMEs present the profiles to attract equity finance. Equity investors lack the patient capital to see through the development of capital intensive and risky clean technologies (Demirel & Parris, 2015). In particular, ventures developing deep technologies, including hardware, new materials, and chemicals, are unlikely to scale in short periods of time and fail to attract investment funding despite their central importance for the CE (Gaddy, Sivaram, Jones, & Wayman, 2017). Therefore, the positive impact of equity finance on firm growth, although a welcome finding, should be interpreted with caution due to the small subset of SMEs that could attract VC or angel funds. It is also worth mentioning that the recently popularized financial instruments of peer-to-peer finance and crowdfunding fail to play a significant role in SME growth.

The paper presents some limitations that evoke ideas to be addressed in future research. First, the data set we use is a cross-sectional data set. It does not allow us to take firms' prior growth profiles and circular EI into account using dynamic panel data estimation techniques. The lack of longitudinal data is a widespread shortcoming in EI studies, and our study tries to mitigate this shortcoming by using lagged independent variables where possible (e.g., investments in circular EI in the last 3 years). However, it is essential for future work to adopt a more dynamic analysis of the relationship between circular EI and firm performance as longitudinal data sets become available. Second, a closer investigation of the contextual factors that shape the participation of SMEs in the CE at the individual country or industry level would be helpful for a more coherent understanding of firm growth dynamics within the CE. Third, in the light of the growing literature on eco-design, further investigations of the factors that foster eco-design capabilities in SMEs is an important avenue for further research.

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APPENDIX A

TABLE A1 List of countries and corresponding number of SMEs

Country	Number of SMEs	Country	Number of SMEs
Austria	242	Italy	183
Belgium	257	Latvia	85
Bulgaria	121	Lithuania	216
Croatia	174	Luxembourg	103
Cyprus	80	Malta	14
Czech Republic	203	Netherlands	283
Denmark	228	Poland	164
Estonia	23	Portugal	180
Finland	302	Romania	190
France	307	Slovakia	125
Germany	200	Slovenia	259
Greece	242	Spain	167
Hungary	79	Sweden	361
Ireland	189	United Kingdom	123
		Total	5,100

Note. This table displays the list of 28 European countries and numbers of SMEs in our sample. SME, small- and medium-sized enterprise.

TABLE A2 Industry breakdown

NACE Industries	Number of SMEs	% of total
B, Mining and quarrying	15	0.3
C, Manufacturing	717	14
D, Electricity, gas, steam and air conditioning supply	32	1
E, Water supply; sewerage; waste management and remediation activities	54	1
F, Construction	645	13
G, Wholesale and retail trade	1,652	32
H, Transporting and storage	289	6
I, Accommodation and food service activities	307	6
J, Information and communication	262	5
K, Financial and insurance activities	177	3
M, Professional, scientific and technical activities	698	14
N, Administrative and support service activities	252	5
Grand total	5,100	

Note. This table displays the industry breakdown of the sample according to NACE standards. SME, small- and medium-sized enterprise.