

Exploiting circular economy enablers for SMEs to advance towards a more sustainable development: An empirical study in the post COVID-19 era

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ARTICLE INFO

Keywords:

Circular economy
Enablers
SMEs
COVID-19
Sustainability

ABSTRACT

The transition towards a more circular development requires the activation of several key Circular Economy (CE) enablers. Their combination generates a complex system that aims to advance towards a more sustainable development. However, the COVID-19 pandemic has created many changes in this global economy, altering the interactions between nature, people, governments, and businesses. The effects were mainly felt by Small and Medium-sized Enterprises (SMEs). This study analyzes the present state of CE enablers for SMEs considering a sustainability assessment overview. Eight CE enablers that have changed because of the pandemic were especially identified through an exhaustive literature review and have been analyzed by the involvement of 29 scholars and practitioners. The results generated with the application of a fuzzy TOPSIS methodology, evidence that 'digital technologies', 'green consumption', and 'circular entrepreneurship' are the CE enablers with the greatest potential to contribute to a more circular and sustainable development in the post-pandemic.

1. Introduction

Circular Economy (CE) is a facilitator of sustainable development that extends product life through the principles of reducing, reusing, recycling, and recovering, being projected by new and innovative business models' design (Centobelli et al., 2020; Kirchherr et al., 2017; Ranta et al., 2021; Urbinati et al., 2017). This concept comes up with several challenges, uncertainties, barriers, and obstacles that need to be overcome with the support of CE enablers. These enablers can be defined as conditions and contextual factors that facilitate the implementation of circular practices, being posited as the driving force in carrying out the transition towards CE (Bressanelli et al., 2021; de Jesus and Mendonça, 2018). They form a complex system that acts as a critical success factor for driving firms to CE achievement (Rizos et al., 2016; Sinha, 2022). This complex system was heavily impacted as a result of the COVID-19 pandemic, which brought several changes in the relations between nature, society, governments, and companies (Ibn-Mohammed et al., 2021; Mi et al., 2021) and its consequences are still being tested (Borms et al., 2023; Wuyts et al., 2020).

There is a consensus that several CE enablers were changed in the long term, influencing the rate of adoption of CE in companies (Borms et al., 2023; Ibn-Mohammed et al., 2021; Khan et al., 2021; Mi et al.,

2021; Nandi et al., 2021a; Neumeier et al., 2020; Sarkis et al., 2020). For instance, the evolution of digital technologies was a response to social distancing, while local sourcing was a response to the disruption in the supply chain. The implications of these changes are still reverberating in the daily activities of companies. Hence, it is expected that many other CE enablers have been also affected. From a transitive property of equality perspective, it could be argued that associated sustainability goals have also been influenced. However, to date, there are no studies deepening this research gap. Hence, considering the emergence of a more circular and sustainable transition for companies, the investigation of the CE enablers to advance towards a more sustainable development as a consequence of the COVID-19 pandemic is a novel and relevant topic that deserves further research effort.

Accordingly, this work is dedicated to studying the changes related to the CE enablers during the COVID-19 pandemic and to analyzing the importance of them to address a more sustainable development, also considering a ranking order of importance. The target companies for this analysis are the Small and Medium-sized Enterprises (SMEs), given the fact they face greater difficulties to implement circular practices due to human and financial resource constraints (Ormazabal et al., 2018). It is estimated that SMEs account for Europe's 60–70% of all industrial pollution and, at the same time, account for 60–70% of jobs in most

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<https://doi.org/10.1016/j.rcradv.2023.200164>

OECD countries (OECD, 2018). Therefore, they have important relevance in the global economy.

Starting from the premises above and addressing the highlighted scientific research gap, our work aims to answer the following Research Questions (RQs):

RQ1. Which CE enablers have changed because of the COVID-19 pandemic, and in what ways did they change?

RQ2. From the perspective of SMEs, what is the rank order of importance of CE enablers that changed because of the COVID-19 pandemic for achieving a more sustainable development?

To answer the research questions above, this paper adopts the Fuzzy TOPSIS methodology, which was deemed appropriate for this study, as the methodology has been widely used in research related to CE, COVID-19, and sustainability. (Mahpour, 2018; Sotoudeh-Anvari, 2022). Furthermore, the methodology takes into account the importance and characteristics of judgemental criteria whether it is a cost or a benefit; to provide a quantitatively justified ranking (Husain et al., 2021).

The results generated from the application of the Fuzzy TOPSIS methodology provide insight that the CE enablers with the greatest potential to contribute to more circular and sustainable SMEs in the post-pandemic are 'digital technologies', 'green consumption', and 'circular entrepreneurship'. Our research also addresses policymaking and managerial implications. The former pertains to the importance of government support in promoting the implementation of digital technologies, increasing sustainable consumer behavior, and fostering more circular entrepreneurship. The latter concerns the importance for companies to increase the use of digital technologies and allocate resources towards marketing campaigns aimed at raising awareness among consumers and stimulating demand for circular products and services.

The paper is structured as follows. Section 2 conducts a literature review on the topics included as background from this work. In the sequence, Section 3 highlights the rationale of the methodology pointing especially out the design of the Fuzzy TOPSIS analysis. In Section 4 the results are presented and discussed with the main implications of our study. Finally, in Section 5, we point out the conclusions, the limitations, and bring the avenues for further research on the subject.

2. Literature review

The study takes stock of existing research using a narrative literature review approach for searching, organizing, and analyzing the literature (Hammersley, 2001). This method is valuable for linking together studies on different topics, either for purposes of reinterpretation or demonstrating interconnections and relationships (Baumeister and Leary, 1997), as we conduct in this paper.

The process was divided into two themes. On the one hand, sub-Section 2.1 is dedicated to presenting the connections between CE and sustainability, with a major focus on understanding how the CE approach can contribute to achieving a more sustainable development, especially demonstrating which sustainability criteria can be applied to assess CE. On the other hand, subSection 2.2 is committed to presenting the changes generated by the emergence of the COVID-19 pandemic in the CE enablers (i.e., which CE enablers have changed and how they have changed because of the COVID-19 pandemic). As a result of the combination of these subsections, in the last subSection 2.3, we propose a framework, which comprises the variables involved in the study and how they interplay to represent the logical path driving our work.

2.1. Connecting concepts: the circular economy as an avenue to a more sustainable development

CE is a concept that is supposed to substitute the end-of-life notion with restoration and closed-loop product lifecycles. Indeed, it aims to eliminate waste, retain the value embedded into products and materials, foster the use of renewable energies and eliminate toxic chemicals (Ellen MacArthur Foundation, 2012; Kirchherr et al., 2017; Sassanelli

et al., 2019). It is activated into three main levels, micro (i.e., companies, consumers, products), meso (i.e., eco-industrial networks and supply chains), and macro (i.e., cities, regions, nations, and beyond) (Merli et al., 2018; Yuan et al., 2006).

Moving forward, by definition, sustainability is a more broader and abstract concept that is used differently in each area of study, but all the definitions form an interconnected system, creating a network between environmental protection, economic performance, and societal welfare, guided by a political will, and ethical and ecological imperatives (Glavič and Lukman, 2007). Within the business field, the concept making use of the triple bottom line principle with its three pillars: people (i.e., social), profit (i.e., economic), and planet (i.e., environment), generating a balanced integration between economic performance, social inclusiveness, and environmental resilience, to the benefit of current and future generations (Brundtland, 1987; Elkington, 1998; Geissdoerfer et al., 2017).

In terms of the main aim, the focus of CE is to increase the material circularity of a system, giving traction to economic prosperity maintaining environmental quality (Kalmykova et al., 2018; Kirchherr et al., 2017). Instead of it, the multi-dimensional focus of sustainability allows for a more comprehensive view that addresses economic, quality, environmental, health and safety, and social challenges (Nawaz and Koç, 2018). Hence, despite CE being in the early stages of development, it has to be intended as a sustainable-by-design approach and is positioning itself as an important avenue towards sustainability (Ghisellini et al., 2016).

The implementation of CE (i.e., the CE enablers, tools, practices, and techniques) can be considered the 'how', while the achievement of a more sustainable development can be considered the 'why' (Nobre and Tavares, 2021), being this an important path to be pursued by companies and society at large. For this reason, CE is expected to be either the optimal pathway or a condition to move towards a more sustainable development, improving environmental, social, and economic performance from the micro to macro levels (Corona et al., 2019; Geissdoerfer et al., 2017; Schroeder et al., 2019). In this way, within the business field, debating the CE approach about the triple bottom line approach to sustainability is a driving of no return (Pieroni et al., 2019), which contributes to a circular justice, ensuring equal conditions at all the practitioners of CE into the society (Kirchherr, 2021).

2.1.1. The criteria of sustainability and the triple bottom line approach

To find a common ground between the CE and sustainability is certainly necessary to consider a holistic view that includes all dimensions of the triple bottom line. That is, the analysis needs to consider the social, environmental, and economic dimensions, analyzing each one through the lens of specific criteria (Ahmad et al., 2018; Bocken et al., 2014). Though arguments could be made regarding the use of governance variable that should have been included in this study, however, it would have not been consistent with the scope of this research.

This analysis considers the sustainable development as the point to be pursued by the CE approach. Taking this into account, we present in the sequence the three dimensions of sustainability and its main criteria used in several studies regarding the measurement of sustainability. They are summarized in Table 1 and discussed in the next subsections. As our research interest is within the micro level, and especially in the SMEs ecosystem, we only consider the criteria that can be applied and analyzed at this level. These criteria will later become the base parameters of the Fuzzy TOPSIS methodology.

2.1.1.1. Economic dimension. The economic dimension must be considered alongside environmental and social aspects to ensure the overall viability of the CE strategy, and to justify the decisions made to support them via investments, subsidies, and taxation (Iacovidou et al., 2017). A usual way of analyzing the economic aspects of the micro level

Table 1
Identified criteria of analysis for sustainability assessment.

Sustainability dimensions	Item	Criteria of analysis	Authors
Economic	C1	Net profit	(Gharizadeh Beiragh et al., 2020; Kravanja and Čuček, 2013)
	C2	Return on investment	(Fallah and Fitzpatrick, 2022; Ghisellini et al., 2016; Siksnyte-Butkiene et al., 2020)
	C3	Operating costs	(Chong et al., 2016; Ng and Phan, 2021; Principato et al., 2019; Seddiki and Bennadji, 2019)
Environmental	C4	Emissions (e.g., CO ₂ , wastewater, waste)	(Ciccullo et al., 2018; Nußholz et al., 2019; Siksnyte-Butkiene et al., 2020)
	C5	Resource consumption	(Figge and Hahn, 2004; Oliveira Neto et al., 2018; Siksnyte-Butkiene et al., 2020; Tseng et al., 2022)
	C6	Renewable energy	(Chong et al., 2016; Oliveira Neto et al., 2018)
Social	C7	Job Creation	(De Feo et al., 2021; Safdar et al., 2020)
	C8	Employee Retention	(Auger et al., 2022; Sawe et al., 2021)
	C9	Workplace safety	(Genaidy et al., 2009; Jilcha and Kitaw, 2017)
	C10	Employment equity	(Ekener, 2019; Mohammed et al., 2018)

of CE is based on traditional performance metrics, principally adopting cost-benefit analysis (Moraga et al., 2019; Wang et al., 2016). Cost-benefit is a highly adopted tool that requires that all project-related disadvantages and advantages are identified and gathered into monetary terms (Da Cruz et al., 2014; Loiseau et al., 2016).

Accordingly, criteria related to the profit of companies, recurring costs, and investments in new projects are important to assess economic sustainability (Glover et al., 2014). For this reason, we posit three important criteria widely used in similar studies that can be important in an analysis of CE in SMEs under the sustainability overview: 'Net Profit' (Gharizadeh Beiragh et al., 2020; Kravanja and Čuček, 2013); 'Return on Investment' (Fallah and Fitzpatrick, 2022; Ghisellini et al., 2016; Siksnyte-Butkiene et al., 2020); and 'Operating Costs' (Chong et al., 2016; Ng and Phan, 2021; Principato et al., 2019; Seddiki and Bennadji, 2019).

2.1.1.2. Environmental dimension. The environmental dimension covers different issues related to biotic and abiotic factors (e.g., climate change, life below water, soil conservation) and is important for ensuring the protection of human health and ecosystems being a way to understand the environmental benefits and impacts of all circular processes (Foster, 2020; Iacovidou et al., 2017). It is often divided into two different origins of benefits and/or impacts: direct (i.e., refers to the on-site and/or internal processes), and indirect (i.e., refers to the off-site, external processes) (Lee, 2011).

Accordingly, criteria related to the emissions caused by the activity of the firm, the resource consumption to generate products, and the adoption of renewable energy are important to assess environmental sustainability (Iacovidou et al., 2017; Morseletto, 2020). For this reason, we posit three important criteria widely used in similar studies that can be important in the analysis of CE under the sustainability overview: 'Emissions' (Ciccullo et al., 2018; Nußholz et al., 2019; Siksnyte-Butkiene et al., 2020); 'Resource consumption' (Figge and Hahn, 2004; Oliveira Neto et al., 2018; Siksnyte-Butkiene et al., 2020; Tseng et al., 2022); and 'Renewable energy' (Chong et al., 2016; Oliveira Neto et al., 2018).

2.1.1.3. Social dimension. The social dimension represents one of the

biggest challenges towards a more sustainable development due to CE since it acts directly with issues and behaviours related to the individuals that form the society, ensuring the well-being and quality of life (Murray et al., 2017) being promoted mainly through legislation (Takata et al., 2012). The construction of knowledge related to indicators, metrics, and measurements is still at an early stage compared to the other dimensions of the triple bottom line (Kosmol et al., 2021; Kumar et al., 2022; Upadhyay et al., 2021).

For the definition of criteria, it is recommended to carry out the identification and analysis of the entire network of stakeholders (Iacovidou et al., 2017). However, criteria related to the environment of the workforce are the most used among scholars (Hellweg and Canals, 2014; Repp et al., 2021). Aspects related to the impact of CE on social equity and future generations are barely mentioned within the theme debate, with a reductionist perspective limited to several moments on aspects related only to the job environment (Clube, 2022; Jaeger-Erben et al., 2021). Based on this, we posit four important criteria widely used in similar studies that can be important in the analysis of CE under the sustainability overview: 'Job creation' (De Feo et al., 2021; Safdar et al., 2020); 'Employee Retention' (Auger et al., 2022; Sawe et al., 2021) 'Workplace safety' (Genaidy et al., 2009; Jilcha and Kitaw, 2017); and 'Employment equity' (Ekener, 2019; Mohammed et al., 2018).

2.2. CE enablers that have changed as a consequence of the COVID-19 pandemic

To define the CE enablers that changed because of the emergence of COVID-19 (i.e., to answer the RQ1) we carried out an extensive review of papers. The findings resulted in eight different CE enablers that changed, as shown in Table 2, and presented below.

For changes regarding the use and the dissemination of digitalization, we considered the concept of 'digital technologies' as previously adopted by several scholars (Bressanelli et al., 2018; Kristoffersen et al., 2020; Rajput and Singh, 2019; Rosa et al., 2020). The digitalization of companies was almost an imposition due to the physical distancing needed during the pandemic (Maiurova et al., 2022). Firms had to adapt quickly in terms of digital solutions to maintain the stakeholders' relationship and to avoid the stop of production, they were to be able to create new conditions to continue in operation (Akbari and Hopkins, 2022; Nandi et al., 2021b; Ranta et al., 2021). Many companies were only able to remain open due to advances in their capacity to adopt digital technologies, e.g., Industry 4.0, blockchain, Internet of Things, and machine learning (Chauhan et al., 2021; Dingel and Neiman, 2020; Ibn-Mohammed et al., 2021). Advancing, the companies that employ CE practices, were the most resilient since they already used digital technologies too (Borms et al., 2023). Finally, it is worth mentioning that digital transformation was already underway, but ended up being accelerated as a consequence of the exceptionality of the pandemic, which acted as a catalyst (Agostino et al., 2020; Amankwah-Amoah et al., 2021; Zimmerling and Chen, 2021).

For the increase in consumer awareness and responsibility for more sustainable purchases, we considered the concept of 'green consumption' as previously adopted in existing research (Akhtar et al., 2021; Hong et al., 2021). The purchasing patterns have changed mainly due to physical distancing and, in consequence, the constraints in the supply chain that changed the behavior of society (Sheth, 2020). For this reason, is posited the pandemic offered an opportunity to promote green consumption, with a noticeable shift towards sustainable consumption (Leal Filho et al., 2022). Furthermore, the pandemic strongly affected the conscience of green consumption (Dangelico et al., 2022; Gupta and Mukherjee, 2022; Tchetchik et al., 2021), especially among the new generations, as also evidenced in a survey applied in Brazil and Portugal (Severo et al., 2021).

For the increase in the collaboration between companies at a local level, operating as clusters and making voluntary exchanges we considered the concept of 'local sourcing' as previously adopted by

Table 2

The CE enablers that have changed due to the COVID-19 pandemic.

CE Enabler	Changes due to the COVID-19	Authors
Digital Technologies	Increasing the adoption of digitalization through blockchain, Industry 4.0, remote working, the Internet of Things, and machine learning	(Agostino et al., 2020; Akbari and Hopkins, 2022; Amankwah-Amoah et al., 2021; Borms et al., 2023; Chauhan et al., 2021; Dingel and Neiman, 2020; Ibn-Mohammed et al., 2021; Maiurova et al., 2022; Nandi et al., 2021b; Ranta et al., 2021; Zimmerling and Chen, 2021)
Green Consumption	Increasing the conscience of green consumption posited by re-evaluating purchasing patterns and needs with a shift towards sustainable consumption	(Dangelico et al., 2022; Gupta and Mukherjee, 2022; Leal Filho et al., 2022; Severo et al., 2021; Sheth, 2020; Tchetchik et al., 2021)
Local sourcing	Increasing the connection between firms with the tendency of manufactures to be located within a closer geographical proximity	(Akbari and Hopkins, 2022; Haller et al., 2022; Remko, 2020; Tokic, 2020)
Circular Supply Chain	Increasing the modernization of the operations that leads to greater efficiency and resilience	(Chowdhury et al., 2021; Nandi et al., 2021b; Sarkis, 2021; Sharma et al., 2020)
Eco-efficiency	Increasing the rationalization in the consumption of material due to scarcity with improvement in the production process	(Borms et al., 2023; Eggers, 2020; Ibn-Mohammed et al., 2021; Paul and Chowdhury, 2021; Zimmerling and Chen, 2021)
Circular Business Models	Increasing the innovativeness that opens space to intensify the innovation into new business models (e.g., Product-Service Systems)	(Borms et al., 2023; Khitous et al., 2022; Li et al., 2021; Tokarz et al., 2021)
Government Support	Increasing government support with more flexible taxes, exemptions, and cash transfers, using regulation as an ally	(Abate et al., 2020; Ganlin et al., 2021; Ibn-Mohammed et al., 2021)
Circular Entrepreneurs	Increasing the opportunity spaces for entrepreneurs and testing the resilience of the already existent ones	(Chhatwani et al., 2022; Henry et al., 2022; Neumeyer et al., 2020)

(Veleva and Bodkin, 2018). As a result of the pandemic, the process of globalization, with production chains dispersed around the world, signals a change in an attempt to reduce the over-reliance on China (i.e., deglobalization), with manufacturers tending to be located closer geographically (Akbari and Hopkins, 2022; Remko, 2020; Tokic, 2020; Zerbino et al., 2021). If this trend is confirmed, geographical proximity leads to greater industrial symbiosis, with waste from one company becoming a resource for others, facilitated by a geographical issue that reduces costs in moving leftovers and waste (Fraccascia et al., 2021). The formation of new alliances may catalyze the transition towards CE, as proposed in a Swedish case study on the food sector (Haller et al., 2022).

For the adoption of supply chains with more circular principles we considered the concept of 'circular supply chain' as previously adopted by (Hussain and Malik, 2020; Lahane et al., 2020). The improvement of the supply chain became necessary due to severe barriers that were imposed by the COVID-19 pandemic (Chowdhury et al., 2021). Restrictions and confinements affected the efficiency of global supply chains, and the use of digital technologies played an important role in reordering how some products move (Sharma et al., 2020). The companies that most applied digitalization and CE principles, more efficient they were in their supply chains, being more resilient to the challenges posed by the pandemic (Nandi et al., 2021b) supported by the implementation of modern operations (Sarkis, 2021).

For the adoption of practices that aim to reduce the consumption of natural resources and increase the efficiency of the processes, we considered the concept of 'eco-efficiency' as previously adopted in several studies (Geng et al., 2012; Moktadir et al., 2020). At the first moment of the pandemic, there was a reduction mainly in primary energy consumption caused by the slowing and shutting down of production and economic activities (Ibn-Mohammed et al., 2021). In the sequence of it, starts to grow a collaborative mentality, with competitors often working together to meet a set goal, or various corporations with complementary specialities partnering to problem-solve in a more efficient manner, which provided a better use of the natural resources available (Borms et al., 2023; Zimmerling and Chen, 2021). The lack of availability of natural resources, due to the constraint of production capacity, also contributed to a greater rationalization in the consumption of the existing ones (Eggers, 2020; Ibn-Mohammed et al., 2021; Paul and Chowdhury, 2021).

For the implementation of business models that aim to increase the circularity of the processes developed by the company, creating, transferring, and capturing value we considered the concept of 'circular business models' as previously adopted by some scholars (Kirchherr et al., 2017; Nußholz, 2018; Urbinati et al., 2017, 2021). With the

worsening of the pandemic, several business models have undergone changes that contribute to driving companies for more circular practises, such as the adoption of Product-Service Systems (PSSs) by firms (Khitous et al., 2022; Li et al., 2021). These changes mainly occurred by the increasing of use of digital technologies, which open space to intensify innovation, establish a long-term circular vision, and emerge new (or adaptative) circular business models (Borms et al., 2023; Li et al., 2021; Tokarz et al., 2021).

For the public support in the transition towards CE that occurs through the creation of laws, decrees, tax, and financial incentives that encourage companies to be more circular we considered the concept of 'government support' as previously adopted in existing research (Kirchherr et al., 2018; Mangla et al., 2018; Rizos et al., 2016). The pandemic has thrown the world into a financial crisis, which has been mitigated by government support with more flexible legislation, exemptions, and cash transfers, as was the case of the aviation sector from which some sustainability criteria were required as a condition for support (Abate et al., 2020), and the case of the support for SMEs that apply sustainability into their business (Ganlin et al., 2021). In addition, regulatory support for the circular transition is also an important element to be followed by governments in the post-pandemic period (Ibn-Mohammed et al., 2021).

For the processes of exploration and exploitation of opportunities in the CE domain, we considered the concept of 'circular entrepreneurship' as previously adopted by (Cullen and De Angelis, 2021; Henry et al., 2022; Suchek et al., 2022). The pandemic drove the need for new products and services that can balance resources and waste management with health and safety concerns, opening up new opportunity spaces for entrepreneurs (Neumeyer et al., 2020). Entrepreneurs went through a resilience test, where their adaptability was heavily demanded (Chhatwani et al., 2022). In the same way, the increase in technology and public policies led new entrepreneurs to implement new businesses with circular concepts (Henry et al., 2022).

2.3. The pathway from circular economy to sustainability in SMEs: a framework

Investigating the CE enablers, as well as their impacts on sustainability, is indeed a relevant issue in light of the consequence of the COVID-19 pandemic (Chiaroni et al., 2022). A period in which the world was impacted, with social distancing, lockdowns, and restrictions on urban mobility, which led to various transformations (Dwivedi et al., 2020). The job market changed, interpersonal relationships were altered, and society adapted to a new reality that left long-term consequences (Donthu and Gustafsson, 2020). Therefore, it is relevant to

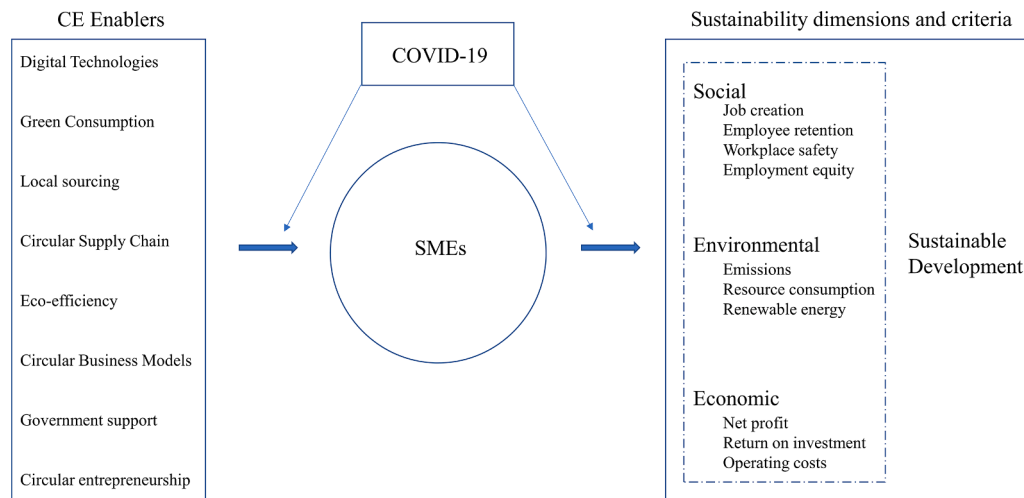


Fig. 1. The pathway from CE enablers to sustainability in SMEs under the COVID-19 pandemic.

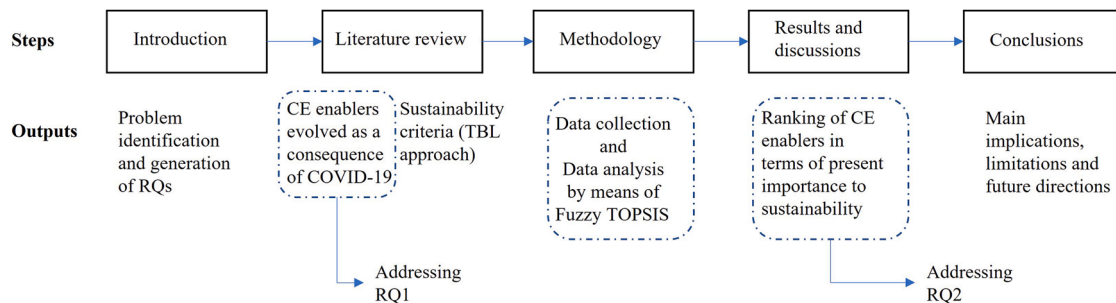


Fig. 2. Research design.

study how these consequences of the COVID-19 pandemic have affected CE enablers and their importance to the achievement of a more sustainable development. However, to date, no studies with this proposal have been identified, making it necessary to fill this research gap. This transition to a more sustainable and circular world is an emergent demand of both science and the population.

Taking stock of the premises above, a framework emerges to represent the variables involved in our research and how they interplay, as shown in Fig. 1. The COVID-19 pandemic has interfered with the CE enablers activated by SMEs and, in consequence, created changes in how these companies address the transition to sustainability. The framework proposes that there is a pathway for CE enablers towards a more sustainable development in the SMEs (i.e., micro level of CE). This pathway has undergone some changes because of the COVID-19 pandemic.

3. Methodology

In this section, we present the methodology adopted to answer the research questions of this study. The first important step is to describe

the research design that was adopted. Fig. 2 shows the rationale of the research design, combining the research methods and techniques, step-by-step, chosen to conduct this study. The most relevant outputs are synthesized to provide an overview of the entire research process. In the next subsections, we present the methods that were used.

3.1. Fuzzy set theory

The Fuzzy Set Theory was introduced and developed by (Zadeh, 1965). The fuzzy set of numbers is a system that enables efficient translation of a linguistic scale of measure such that of a Likert scale and assigns them a numeric value (Hameed et al., 2022). The argument is that a linguistic variable such as 'Extremely Low' does not necessarily represent numeric values of 1, it could also refer to a value of 1.5 Hence,

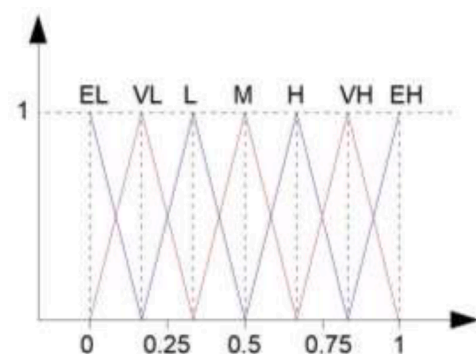


Fig. 3. Linguistic variables and their distribution (authors' construction).

Table 3

Association of Linguistic terms to fuzzy numbers (Bouzon et al., 2016).

Fuzzy Linguistic Term	Triangular Fuzzy Number
Extremely Low	(0, 0, 0.1)
Very Low	(0, 0.1, 0.3)
Low	(0.1, 0.3, 0.5)
Moderate	(0.3, 0.5, 0.7)
High	(0.5, 0.7, 0.9)
Very High	(0.7, 0.9, 1.0)
Extremely High	(0.9, 1.0, 1.0)

Table 4

Respondent profile.

Sr. No	Respondent's Position	Sector of employment	Experience (years)	Location
1	Environmental manager	Energies	10	Australia
2	Assets manager	Renewables	12	Australia
3	Professor	Education (product designer)	12	Brazil
4	Professor	Research and Development	10	Brazil
5	Professor	Research and Development	25	Brazil
6	Professor	Teaching and Research	18	Brazil
7	Economic Manager	Oil and Gas	10	Brazil
8	Environmental analyst	Public agency	10	Brazil
9	Manager/Owner	Environmental Consultancy	6	Brazil
10	Environmental Engineer	Industry	7	Brazil
11	Project Manager	Sustainability/ ESG	10	Brazil
12	Associate professor	Research and Development	10	Brazil
13	Professor and Researcher	Teaching, Research and Development	20	Brazil
14	Project manager	Machinery / electrical equipment	16	Brazil
15	Engineer	Energy	15	Germany
16	Associate professor	Research and Development	18	Italy
17	Professor	Research and Development	10	Italy
18	Professor	Research and Development	6	Italy
19	Technical Engineer	Chemical industry	10	Italy
20	Assistant Professor	Teaching and Research	8	Italy
21	CFO	Administration/ Finance department	30	Italy
22	General Manager	Machine Builders	16	Luxembourg
23	Incubation Manager	Information Technology	4	Pakistan
24	Researcher	Teaching and Research	5	Pakistan
25	HSE technician	Renewables	5	Portugal
26	Manager/Owner	Retailer of Second-Hand Articles	4	Portugal
27	Sr Analyst	Investment / RE	7	Spain
28	Researcher	Research and Development	4	Spain
29	Project Engineer	Construction	8	United States of America

to overcome this deficiency, the solution is to assign a numeric membership function (Lima Junior et al., 2014). Fuzzy numbers and their respective numerical association vary quite a lot (Kim et al., 2013). This study uses a seven-point Likert scale and its respective fuzzy membership values, which has been adopted by (Bouzon et al., 2016). The measurement scale of the importance of CE enablers under observation is shown in Table 3 and graphically represented in Fig. 3. The triangular fuzzy approach defines numbers in the form of subsets i.e. (x, y, z) where $x \leq y \leq z$. Here, x is referred to as the least possible value while z is the highest possible value for a given linguistic variable (Shen et al., 2013).

3.2. Technique for order of preference by similarity to ideal solution (TOPSIS)

This study seeks to evaluate eight CE enablers that are supposed to be changed because of the COVID-19 pandemic under the pretext that has

Table 5
Weighted decision matrix.

Alternatives → Criteria ↓	Digital Technologies	Green Consumption	Local Sourcing	Circular Supply Chain	Eco-Efficiency	Circular Business Models	Government Support	Circular Entrepreneurship	Max / Min
Net Profit	0.57	0.75	0.87	0.71	0.67	0.72	0.65	0.64	2.80
Return on investment	0.57	0.52	0.86	1.30	1.21	1.25	0.65	1.82	2.73
Operating costs	0.54	0.67	0.83	0.65	1.17	1.26	1.27	1.33	2.06
Emissions (e.g., CO ₂ , wastewater, waste)	0.43	0.68	0.96	0.70	1.08	1.14	0.59	1.29	2.06
Resource consumption	0.48	0.85	0.52	1.16	0.81	0.72	0.65	1.55	1.46
Use of Renewable energy	0.55	0.74	0.62	0.65	1.31	1.47	0.52	0.66	1.44
Job creation	0.53	0.68	1.33	1.08	1.28	1.88	0.88	1.70	2.42
Employee retention	0.71	0.89	0.62	0.62	0.79	1.41	1.15	1.12	1.35
Workplace safety	0.44	0.59	0.49	0.99	1.02	1.22	0.61	0.62	1.38
Employment Equity	0.41	0.76	0.78	1.00	0.85	2.06	0.51	1.41	2.19
	0.44	0.38	0.74	1.28	0.90	1.25	0.50	1.87	2.43
	0.41	0.57	0.74	0.39	0.44	0.93	0.58	1.15	1.78
									2.09
									1.46
									1.62

been established, i.e., sustainability criteria, which have been identified through the literature. The Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS) was introduced by previous studies (e.g., [Hwang and Yoon, 1981](#)). It revolves around the notion that there is an ideal solution to a given problem, consequently, there exists a positive ideal and a negative ideal solution ([Opricovic and Tzeng, 2004](#)). Given that there are many different solutions to a given problem, TOPSIS helps to develop a ranking that can help in pointing out how the alternatives, i.e., the enablers, perform under a set of decision criteria ([Mahpour, 2018](#)). The chosen methodology is suitable as it has a wide field of applications; it allows the use of qualitative and quantitative criteria ([Mahpour, 2018](#)). TOPSIS operates on the principle that there exists an ideal solution to a problem that has an optimized distance between a negative ideal and a positive ideal ([Prakash and Barua, 2016](#)). Respondents are asked to respond to a questionnaire using the 7-point Likert scale. The fuzzy scale is used to define the respective value of a variable, for example, the variable Medium corresponds to a function/set of numbers as explained in the previous section, rather than a whole number.

The steps performed in the Fuzzy TOPSIS analysis are as follows:

Step N°1 Import the data collected and analyze for discrepancies, missing values, and incomplete responses.

Step N°2 The data obtained contains linguistic variables, and weights are assigned to different criteria as obtained by the respondents as shown in [Eq. \(1\)](#).

$$C_i = \frac{1}{W} \{c_{1ij} + c_{2ij} + \dots + c_{ij}\} \quad (1)$$

Here, c_{ij} is the rating by a respondent for alternative i against the criteria j

Step N°3 Linguistic variables are converted into the respective fuzzy numbers as shown in [Eq. \(2\)](#).

$$D = \begin{bmatrix} z_{11} & z_{12} \dots & z_{1n} \\ z_{21} & z_{22} \dots & z_{2n} \\ \vdots & \vdots & \vdots \\ z_{m1} & z_{m2} \dots & z_{mn} \end{bmatrix} \quad (2)$$

Where $z_{mn} = (x, y, z)$ and $H_q = (h_1, h_2, \dots, h_n)$

Step N°4 Development of a fuzzy decision matrix that is normalized as shown in [Eq. \(3\)](#) and [Eq. \(4\)](#).

$$M = [m_{ij}]_{m \times n} \quad (3)$$

$$m_{ij} = \left(\frac{x_{ij}}{Z_{ij}^*}, \frac{y_{ij}}{Z_{ij}^*}, \frac{z_{ij}}{Z_{ij}^*} \right), \quad Z_{ij}^* = \max z_{ij} \quad (4)$$

Step N°5 This step is to develop fuzzy weighted normalized decision matrix, as shown in [Eq. \(5\)](#) and then [Eq. \(6\)](#).

$$F = [f_{ij}]_{m \times n} \quad (5)$$

$$f_{ij} = m_{ij} \times H_q \quad (6)$$

Step N°6 In this step the negative and positive ideals are determined as shown in [Eq. \(7\)](#) and [Eq. \(8\)](#) respectively.

$$I^+ = o_1^+, o_2^+, \dots, o_n^+ \quad (7)$$

$$I^- = o_1^-, o_2^-, \dots, o_n^- \quad (8)$$

Where $o_q^+ = (1, 1, 1)$ and $o_q^- = (0, 0, 0)$, $q = (1, 2, \dots, n)$

Step N°7 Determination of the distance of alternatives to the ideals as shown in [Eq. \(9\)](#) and [Eq. \(10\)](#).

$$P^+ = \sum_{q=1}^n d(f_{ij}, o_q^+) \quad (9)$$

$$N^- = \sum_{q=1}^n d(f_{ij}, o_q^-) \quad (10)$$

Here, d represents the distance among the fuzzy numbers.

Step N°8 Calculation of relative closeness, shown in [Eq. \(11\)](#) below.

$$RC = \frac{N^-}{(N^- + P^+)} \quad (11)$$

Step N°9 The final step of the methodology entails a ranking of the CE enablers concerning their relative closeness value. The ranking is carried out in descending order meaning that the CE enabler with the highest value is the first, while the CE enabler with the least value of relative closeness is the last.

The obtained results are presented and discussed in the following sections.

4. Results and discussions

The study was conducted with a total of 29 respondents, their profiles shown in [Table 4](#), directly involved in the sustainability, CE, and management field. 17 of the respondents belong to the industrial sector while 12 respondents are from academia. The industry respondents have varying profiles ranging from Managers to CFOs and business owners. To avoid clustering of responses from just a single industry type, industry responses were collected from varying sectors. It is worth noting that all the 17 practitioner respondents work in SMEs, which is essential for addressing the needs of RQ2. The profiles of the academia are relatively similar, i.e., most of them are involved in the research and development of new products and business models regarding SMEs, CE, and sustainable development. It is vital to procure the opinion of the academia given their up-to-date experience and knowledge about CE applications in the industry. The respondents in this study are not based in a singular primary location, however, spread out across various countries thus eliminating any geographical constraints.

The respondents were required to provide feedback on the importance of each criterion presented in [Table 1](#), from the perspective of SMEs. Following this, the respondents were asked to rate the alternatives (i.e., CE enablers that have changed because of the pandemic) with respect to the criteria of [Table 1](#) using the provided measurement scale in [Table 3](#). This generated the table for the weighted decision matrix as shown in [Table 5](#). As evident from the literature, the selected list of criteria has a distinct classification, i.e., either it is a beneficial criterion, or it is a cost criterion. The criteria 'Operation cost', 'Emissions (e.g., CO₂, wastewater, waste)' and 'Resource consumption' are the cost criteria meaning that if these hold the lowest possible value are the more significant. Hence, the maximum and the minimum values are also calculated in [Table 5](#).

After obtaining the fuzzy normalized matrix, a weighted fuzzy normalized matrix is generated along with the positive and the negative ideals as shown in [Table 6](#), steps 5 and 6 are concluded in this phase. Proceeding to step 7 of the methodology, the distances to the positive and the negative ideals are calculated as shown in [Table 7](#). Finally, the closeness coefficient was calculated alongside the ranking of the alternatives as shown in [Table 8](#) and [Fig. 4](#). It can be seen from the final [Fig. 4](#), 'digital technologies' is the most dominant CE enabler with the highest value of 0.73, while 'green consumption' is the second holding value of 0.66, and 'circular entrepreneurship' is the third with a value of 0.63. Moving towards the low-ranked enablers, the 'circular supply chain' holds the lowest value of the closeness coefficient with 0.30 and is the CE enabler that is contributing the least to developing more sustainable SMEs.

From the respondent's perspective, the final ranking represents the order of importance that each CE enabler occupies in the pathway towards sustainability. This order of importance was defined by considering the perspective of SMEs. The top-ranked enabler, i.e., 'digital

Table 6

Weighted normalized fuzzy decision matrix and ideals.

Alternatives↓ Criteria→	Net Profit			Return on investment			Operating costs			Emissions (e.g., CO ₂ , wastewater, waste)			Resource consumption
Digital Technologies	0.119	0.202	0.279	0.177	0.295	0.400	0.677	1.225	1.770	0.597	1.041	1.491	0.624
Green Consumption	0.121	0.201	0.271	0.162	0.279	0.388	0.600	1.126	1.699	0.940	1.513	1.949	0.972
Local Sourcing	0.098	0.202	0.869	0.153	0.340	0.727	0.534	1.154	2.452	0.726	2.832	5.243	0.808
Circular Supply Chain	0.149	0.429	0.502	0.203	0.513	0.602	0.868	2.942	3.663	0.975	2.065	4.655	0.854
Eco-Efficiency	0.140	0.325	0.460	0.197	0.460	0.600	0.801	1.824	3.027	1.119	3.206	2.430	1.069
Circular Business Models	0.150	0.334	0.410	0.224	0.496	0.645	0.890	1.915	2.182	0.975	2.613	3.654	0.856
Government Support	0.136	0.470	0.565	0.199	0.500	0.602	0.738	1.224	2.633	0.900	2.549	3.169	0.677
Circular Entrepreneurship	0.134	0.458	0.847	0.196	0.661	0.934	0.711	2.694	2.988	0.748	2.123	2.936	0.870
I+	0.150	0.470	0.869	0.224	0.661	0.934	0.534	1.126	1.699	0.597	1.041	1.491	0.624
I-	0.098	0.201	0.271	0.153	0.279	0.388	0.890	2.942	3.663	1.119	3.206	5.243	1.069

technologies', highlights the enormous power of digitalization to support the sustainable and circular transition, confirming the relevance of one of the hottest topics among scholars. This result places the revolutionary importance of digital technologies as a fundamental driver that permeates through all other CE enablers and opens space to SMEs dealing with the complexity of the system. Knowing that the global economy has recently experienced a massive shock, especially to SMEs, due to restrictions and other factors; digitalization provides capabilities of flexibility and an agile working environment (Juergensen et al., 2020; Khan et al., 2023). Digitalization is not just limited to the use of internet and computers but in essence the present understanding point towards the total connectivity of the system. The present usage corresponds to the use of Industry 4.0 where a massive shift is coming towards the use of integrated systems and blockchain technology, these being coupled together with present Enterprise Resource Planning (ERP) systems (Telukdarie et al., 2023). The result obtained is also verified by a study that mentions; digitalization as a whole is increasing even in developing economies thus owing to an overall increase in performance (Malodia et al., 2023).

The second-ranked enabler, i.e., 'green consumption', shares the responsibility for the success of the circular and sustainable transition with an important stakeholder, the consumer. As companies produce to meet customer demand, an increase in conscious consumption leads to greater adoption of circular practices by SMEs. The two concepts of environmentalism and futurism do indeed contribute towards achieving a more sustainable economy, consumer demands do shape the product and business (Ali et al., 2023). Green consumption remains highly relevant as it yields a positive effect on the communicated value (Testa et al., 2022). It is also a valid observation that green consumption has a link with digitalization, as digitalization yields greater communication hence a higher level of green consumption is obtained (Testa et al., 2021). Hence the first two enablers move together, and one promotes the other and vice versa, thus presenting a viable investment opportunity.

The third-ranked enabler, i.e., 'circular entrepreneurship', considers the importance of innovativeness, risk-taking, and proactiveness to drive a more circular and sustainable world, putting entrepreneurs in a key role. The process of starting a new company, or modifying an existing one, must be considered the implementation of CE practices. This enabler helps identify that presently since the pandemic there has been an increase in circular entrepreneurs, signaling that the markets have new potentials to be explored and entrepreneurs are using technology to the best of their abilities to bridge the gaps (Henry et al., 2022). There exists documented evidence that circular entrepreneurship and digitalization are related to one another. Performance measures by firms that readily adopt digitalization means have increased leading to the conclusion that the first enabler of this study helps in the promotion and uplifting of circular entrepreneurship activities (Saura et al., 2022).

The fourth-ranked enabler, i.e., 'government support', is an important driver in this transition process and some evidence already points to

this direction. This is the case of the European Union, which has approved two important actions focused on the CE and sustainability: the obligation for companies to produce sustainability reports (European Commission, 2022a) and the obligation for electronics companies to adopt a common charger, the USB-C port (i.e., reducing E-waste and permitting reuse) (European Commission, 2022b). A study conducted by (Di Vaio et al., 2023) suggests that SMEs are benefitting from present government policies and they are being provided incentives to grow. It also goes to show that without any government intervention consumers have little to no motivation to pursue green consumption (Yang et al., 2023). This links directly to the second result of this study while linking indirectly to the first.

Entering in the last 4-ranked, the fifth-ranked enabler, i.e., 'eco-efficiency', indicates the importance of the idea of producing something with the lowest possible consumption of resources, bringing benefits to the company, the environment and society. An interesting study by (Seah et al., 2022) found that SMEs can be oriented towards either the environment or the economy when pursuing eco-efficiency. Environmentally oriented SMEs are motivated by their perception of the world and customer interest in the environment, while economy-oriented SMEs are motivated by cost savings and providing lower prices to stand out from competitors. Both types of firms adopt digital resources to create a competitive advantage, with generic digital resources used to begin specialization and configurable digital resources used to enhance it, and companies foster their digitalization capabilities through a conducive organizational culture and employee training.

All the last 3-ranked CE enablers analyzed still have significant importance for achieving sustainability, given the fact that the closeness coefficient values of CE enablers do not vary by a large enough margin (between 0.3 and 0.43). They are, in the respective order 'local sourcing', 'circular business models', and 'circular supply chain'. Local sourcing is a key operation that has emerged in the post pandemic economy fostering economic growth and enabling resilience (Sarkis et al., 2020). Whereas circular business models and circular supply chains are based on communication and trust among the participating firms. These are readily realized owing to the use of technology. Having a system in place such that a blockchain enabled model allows participants to be more resource efficient, optimize resources, reduce their environmental footprint and cater to increased levels of sustainability (van Tilburg et al., 2022; Nandi et al., 2021a).

As a final consideration, we can pose that these eight CE enablers have a great potential to contribute to a more circular and sustainable development given the fact that no one of the closeness coefficient values was lower than 0.3. Hence, they all contribute to the triple bottom line dimensions of sustainability. Indeed, despite the pandemic crisis, they demonstrated to be resilient and an important ally in the transition process. The enablers and their effects are noted to be in sync with one another and provide a justification for the obtained ranking order.

Resource consumption		Use of Renewable energy			Job creation			Employee retention			Workplace safety			Employment Equity		
1.057	1.459	0.122	0.206	0.278	0.127	0.236	0.353	0.080	0.160	0.247	0.109	0.201	0.299	0.101	0.203	0.331
1.489	1.840	0.150	0.243	0.313	0.140	0.253	0.368	0.076	0.157	0.251	0.094	0.183	0.284	0.098	0.206	0.345
2.159	3.943	0.138	0.386	0.674	0.116	0.253	0.733	0.091	0.281	0.504	0.114	0.235	0.364	0.117	0.266	0.751
2.851	4.418	0.138	0.313	0.562	0.148	0.330	0.656	0.072	0.260	0.470	0.112	0.416	0.807	0.098	0.237	0.569
2.181	2.479	0.176	0.373	0.358	0.160	0.339	0.493	0.064	0.220	0.513	0.113	0.293	0.587	0.109	0.282	0.439
3.139	5.656	0.133	0.410	0.872	0.133	0.407	0.783	0.102	0.535	0.783	0.114	0.405	0.802	0.111	0.335	0.631
1.467	3.234	0.153	0.335	0.381	0.144	0.429	0.790	0.092	0.204	0.454	0.123	0.382	0.722	0.145	0.414	0.752
2.270	2.337	0.146	0.439	0.822	0.146	0.459	0.559	0.085	0.360	0.704	0.132	0.517	0.688	0.150	0.361	0.677
1.057	1.459	0.176	0.439	0.872	0.160	0.459	0.790	0.102	0.535	0.783	0.132	0.517	0.807	0.150	0.414	0.752
3.139	5.656	0.122	0.206	0.278	0.116	0.236	0.353	0.064	0.157	0.247	0.094	0.183	0.284	0.098	0.203	0.331

4.1. Theoretical, policymaking, and managerial implications

Our study empirically identified eight CE enablers that changed because of the COVID-19 pandemic. In sequence, theoretically explained these changes that occurred. In the end, tested the importance of these eight CE enablers, and their changes, in terms of their relevance to sustainability achievement, considering its social, economic, and environmental dimensions (i.e., considering the TBL approach). From a theoretical perspective, the research reinforces the studies arguing that CE is a pathway towards a more sustainable development activated mainly by CE enablers (Nobre and Tavares, 2021; Sinha, 2022). Furthermore, our research brings evidence that the eight CE enablers identified have changed in a positive way (i.e., they were resilient and became still more powerful), giving traction for the circular and sustainable transition. This could be more elaborated and further researched under the perspectives of the Resource Based Theory (Conner and Prahalad, 1996; Grant, 1991) and similarly modelled and explored with approaches like the agent-based modeling (Bonabeau, 2002). These perspectives and approaches could in theory help to create a visualization and validation that the identified enablers do indeed carry significant influence.

Based on our empirical results obtained under the light of a multi-criteria decision-making methodology, we can move forward with the theoretical implications. The top-ranked CE enabler (i.e. 'digital technologies') already is strongly connected with this pathway from CE to sustainability in several studies (Esmaeilian et al., 2020; Gholami et al., 2022; Lopes de Sousa Jabbour et al., 2018; Okorie et al., 2023; Tseng et al., 2018). However, 'green consumption' was an important addition as well as 'circular entrepreneurship'. These CE enablers are not well studied into this pathway, with some incipient contributions in a more general perspective, not considering the pathway towards sustainable development as the main goal (Coderoni and Perito, 2020; Henry et al., 2022; Le et al., 2022; Marrucci et al., 2019; Suchek et al., 2022; Tunn et al., 2019).

For the policy-making implications, the results of this study suggest that 'government support' is an important CE enabler, and, more than this, give some directions that can be followed by the public sector. They must focus on three main points: support the implementation of digital technologies, increase the sustainable behavior of the consumers, and develop more circular entrepreneurship. All these points can be addressed through regulation, education and fiscal (or monetary) incentives. By actively promoting these key ideas, governments worldwide can accelerate the transition towards a more circular and sustainable economy. Furthermore, efforts such as research sponsorships and collaborations may help to bridge the gap between the requirements of the SMEs and the offerings of the local governments.

Considering the managerial implications, the firms can focus on two

main points: increase the use of digital technologies in their business models, and, from the consumer perspective, incentive green consumption (e.g., through marketing), generating a demand for the circular products and services. It leads the authors to suggest that for SMEs, the adoption of customization and a more customer-centric business environment is healthy and sustainable. In this line of thinking, digitalization could be the key to SMEs implementing technologies that deepen their connection with customers and yield benefits. Examples of this combination include leveraging social media, increasing the use of PSSs, and designing customer programs to incentivize green consumption.

5. Conclusions

CE is considered one of the topics that are trending globally positioning itself as one of the paths towards a more sustainable development. SMEs throughout the world are trying to enact and apply the concept to their business practices and become truly circular. Within this highly complex system, the CE enablers are the driving force in carrying out this transition towards more sustainable development. However, given the onset of a disruptive event such as the COVID-19 pandemic, these CE enablers have changed, impacting the transition into a more circular and sustainable outlook. Companies and firms across the globe are trying to alter their business practices to cope with losses and be more sustainable.

The study focuses on which CE enablers have changed during the COVID-19 pandemic, and how these CE enablers have contributed to increasing the sustainability transition pathway of SMEs. Responding to RQ1, it analyzes the existing literature, and it derives eight CE enablers that help in promoting the level of circularity of companies and were changed due to the pandemic. These CE enablers demonstrated resilience during the crisis and helped to accelerate the transition towards a more circular and sustainable economy. To assess the derived variables, the study has considered evaluating them under the ranking order of importance for achieving sustainability, more so the triple bottom line dimensions. To define the ranking, ten distinct sustainability criteria were considered and measured. To answer the RQ2, the study used a multi-criteria decision-making technique known as the Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS) in a fuzzy environment.

The results show that 'digital technologies', 'green consumption', and 'circular entrepreneurship' are resulted to be the CE enablers with the greatest potential to contribute to more circular and sustainable SMEs in the post-pandemic. Altogether, new entrepreneurial activities are being carried by SMEs out using digital technologies and focusing on green consumption.

Table 7
Ideal distances.

Fuzzy Positive Ideal									Fuzzy Negative Ideal								
Digital Technologies	Green Consumption	Local Sourcing	Circular Supply Chain	Eco-Efficiency	Circular Business Models	Government Support	Circular Entrepreneurship	Digital Technologies	Green Consumption	Local Sourcing	Circular Supply Chain	Eco-Efficiency	Circular Business Models	Government Support	Circular Entrepreneurship		
0.375	0.379	0.157	0.213	0.251	0.276	0.176	0.017	0.013	0.014	0.345	0.190	0.133	0.115	0.231	0.365		
0.375	0.387	0.225	0.210	0.226	0.192	0.214	0.016	0.019	0.006	0.199	0.186	0.163	0.198	0.180	0.386		
0.108	0.038	0.435	1.556	0.880	0.572	0.555	1.176	1.481	1.553	1.264	0.012	0.744	1.041	1.160	0.428		
0.000	0.428	2.402	1.932	1.395	1.559	1.314	1.046	2.519	2.141	0.313	0.746	1.625	0.983	1.263	1.487		
0.000	0.388	1.572	2.002	0.913	2.708	1.052	0.876	2.717	2.401	1.149	0.744	1.916	0.123	1.715	1.984		
0.370	0.342	0.120	0.195	0.299	0.030	0.291	0.034	0.000	0.034	0.251	0.175	0.111	0.363	0.097	0.342		
0.284	0.271	0.126	0.107	0.185	0.034	0.019	0.134	0.006	0.020	0.220	0.184	0.103	0.267	0.276	0.176		
0.378	0.377	0.218	0.241	0.240	0.000	0.269	0.111	0.010	0.007	0.165	0.142	0.158	0.379	0.123	0.289		
0.346	0.359	0.303	0.060	0.181	0.066	0.092	0.069	0.016	0.000	0.056	0.330	0.186	0.325	0.278	0.303		
0.273	0.265	0.087	0.150	0.197	0.086	0.003	0.053	0.002	0.008	0.246	0.139	0.077	0.190	0.273	0.222		
P+ 2.508	3.234	5.646	6.667	4.768	5.524	3.984	3.531	N- 6.783	6.184	4.209	2.849	5.217	3.984	5.596	5.981		

Table 8

Closeness and ranking of the enablers.

ENABLER	CLOSENESS COEFFICIENT	RANK
DIGITAL TECHNOLOGIES	0.73	1
GREEN CONSUMPTION	0.66	2
LOCAL SOURCING	0.43	6
CIRCULAR SUPPLY CHAIN	0.30	8
ECO-EFFICIENCY	0.52	5
CIRCULAR BUSINESS MODELS	0.42	7
GOVERNMENT SUPPORT	0.58	4
CIRCULAR ENTREPRENEURSHIP	0.63	3

5.1. Research limitations

The authors of this study aimed to present a complete overview of what were the CE enablers that promote CE in SMEs and changed because of the pandemic. Nevertheless, since these enablers constitute a complex system, the research made certain simplifications to accurately represent the real world. For instance, the study grouped various changes in digital aspects under the same CE enabler, 'digital technologies'. Hence, the categorization of the CE enablers represents a simplification, as it involves grouping complex elements under a single CE enabler. This is an important limitation to consider. Subsequently, the authors chose ten criteria under the umbrella of the triple bottom line dimensions. However, sustainability can be defined in several ways for example governance is also argued to be under the same umbrella, being another important limitation the fact we have not taken this criterion into account. The last limitation is the bias of the respondents, especially industry respondents who are usually more concerned with financial aspects. Subsequently, it can be argued that the opinion of the academia would naturally be more inclined towards judgement concerning environmental and social aspects as opposed to the practitioner's point of view.

5.2. Future directions

The study highlights eight CE enablers that have changed during the pandemic and it would be interesting to see if these changes are temporary or if will they remain in the future. Another interesting avenue could be to explore and model the change concerning geographical data to understand at a deeper level how countries are looking to implement the CE enablers in SMEs and how it changed during the pandemic. Lastly, exploring the same variables against the 17 different sustainable development goals (SDGs) from the United Nations could also be a vital direction to take.

CRedit authorship contribution statement

Rodrigo Bruno Santolin: Conceptualization, Investigation, Writing – original draft, Writing – review & editing. **Hameem Bin Hameed:** Methodology, Writing – original draft, Writing – review & editing. **Andrea Urbinati:** Validation, Supervision. **Valentina Lazzarotti:** Supervision.

Declaration of Competing Interest

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

Data availability

Data will be made available on request.

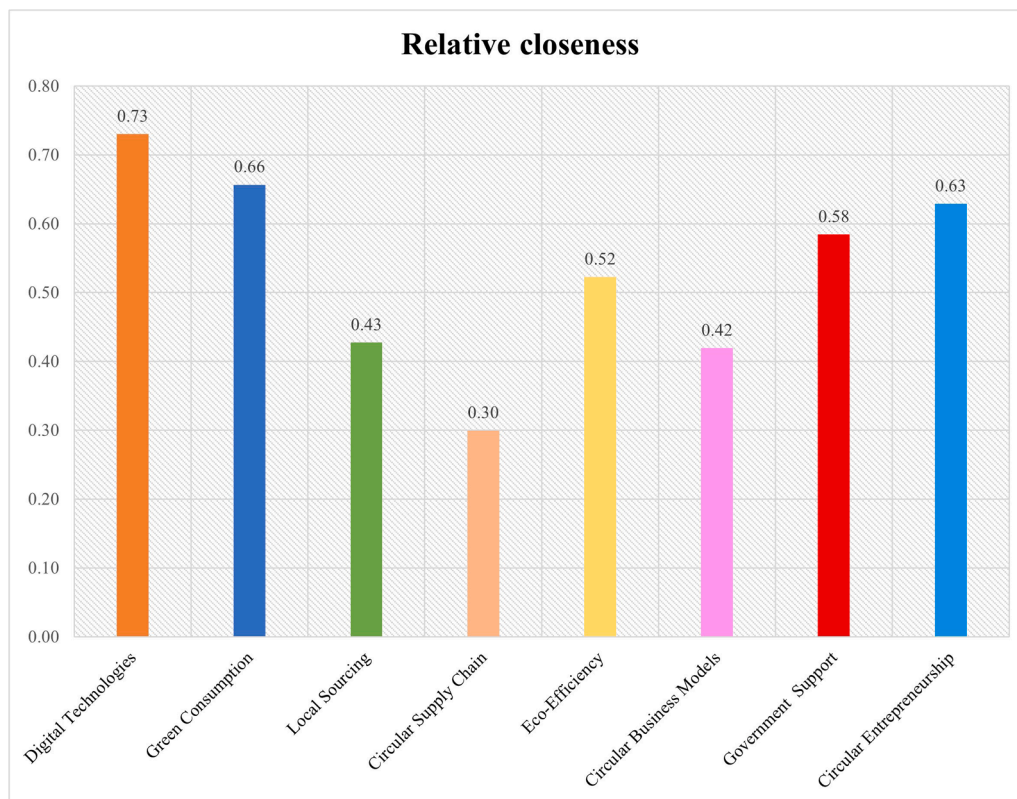


Fig. 4. Relative coefficients.

Acknowledgements

This research project is part of the initiatives of the Green Transition Hub of LIUC Università Cattaneo and is also financially supported by Intesa Sanpaolo within the research grant “The transition of companies towards a circular economy: analysis of the implications in business processes and functions”. The authors are also grateful for the support received from PON funding for “Research and Innovation” 2014–2020 financed within the FSE – REACT EU initiative, LIUC Università Cattaneo, Italy, and Federal Institute of Education, Science and Technology of Rio Grande do Sul (IFRS), Brazil.

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