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ORIGINAL RESEARCH

SMEs Circular Economy Practices in the European Union: Multilevel Implications for Sustainability

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Abstract
This paper examines the willingness of small and medium-sized enterprises (SMEs) in the European Union (EU) to implement Circular Economy (CE) practices, i.e. re-planning the use of water to reduce consumption and maximize reuse, using of renewable energy sources, re-planning energy consumption to reduce its use, reducing waste by recycling or reusing waste or selling it to another company, redesigning products and services to reduce the use of materials or using recycled materials. These aspects are conceived as indicators of the willingness to implement CE practices, which is explained by factors at the company and country levels.

The dataset comes from a unique survey involving more than 10,000 SMEs in the EU. This hierarchical structure – companies within countries – was analyzed using a multilevel factor model that takes into account the heterogeneity between countries. The variables at the company-level are: company size (number of employees and total turnover in 2015), company foundation, sector of economic activity, type of clients and goods, and percentage of the turnover invested in R&D. Country-level covariates cover different dimensions of sustainability: per capita GDP, illiteracy rate, waste generation, and corruption perception index.

At the levels of company and country, there are factors that explain the attitude towards CE. Finally, factor scores at both levels show a split between Western and Eastern European countries (with few exceptions) regarding the willingness of SMEs to implement CE activities that define the regional implications of EU policies towards CE, in particular in the context of the European Green Deal.

Keywords Circular economy · Sustainability · European Union · Small and medium-sized enterprises (SMEs) · Multilevel models · European Green Deal

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1 Introduction

In the last century, the quality of human life has improved exponentially thanks to science and technological innovation, especially in the fields of Medicine and Information & Communication Technology (ICT). However, this improvement has also led to further outcomes that threaten the balance of ecosystems. The high population growth has caused in particular the lack of resources and the use of oil as an energy source has been linked to the greenhouse effect. Scientific research documents that communities and individuals deal with climate change and many official institutions promote a sustainable lifestyle. Many contributions focus on green consumer behavior, others focus on the supply industries and their commitment to preserving our planet. In this context, small and medium-sized enterprises (SMEs) have acquired little importance, despite being the engine of the world economy.

The introduction of the concept of Circular Economy (CE) can be traced back at the end of the 20th century, when seminal papers attracted the attention of many scholars (Lieder & Rashid, 2016). The CE terminology was officially adopted in China in 2002, when the government passed the first EC Promotion Act, which came into effect in January 2009 (The Standing Committee of the Chinese National People's Assembly, 2008). The main goal was to reduce pollution and protect the planet. From then on, global institutions (including the EU) inevitably face these problems, which could also give companies a competitive advantage. In recent years, the number of academic papers related to CE has been steadily increasing.

The CE concept was developed in the business world in an attempt to find a compromise between economic growth and environmental protection. This concept is in contrast to the more widespread idea of a linear economy, i.e. take-make-use-dispose. There are different definitions of CE depending on the area they focus on (Lieder & Rashid, 2016). If we consider eco-industrial development, CE can be defined as the creation of a closed flow of material throughout the economic system (Geng & Doberstein, 2008). In accordance with the principles of the 3Rs (reduction, reuse, and recycling), the objective of the CE is the circular (closed) flow of materials, the use of raw materials, and energy through different phases (Yuan et al., 2006). In general, CE can be defined "as a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling" (Geissdoerfer et al., 2017, p. 759).

The term sustainability is closely related to the concept of CE. In fact, sustainability is such a broader topic that Johnston et al. (2007) found about 300 definitions. Geissdoerfer et al. (2017) tried to find similarities and differences between sustainability and CE. These terms are generally used interchangeably, with no basic differences. The study showed that the concept of CE is seen as a condition of sustainability; consequently, there are several differences in motivations, goals, and beneficiaries. However, the research revealed some commonalities, especially in the business world (such as business model innovation as a key transformation) and in efforts to protect the environment. Furthermore, the concept of sustainable development has advanced in recent years, adding a deeper notion of progress to the term sustainability. In 2015, the United Nations set the Sustainable Development Goals (SDGs), 17 targets to be reached by 2030 in the perspective of a better future (United

Nations, 2015). The European Union is committed to achieving the SDGs in both domestic and foreign policies.

This paper aims to analyze the willingness of SMEs in the European Union to undertake specific activities related to Circular Economy (CE) and to identify specific drivers of this behavior. The data is collected from a sample of SMEs operating in the 28 EU Member States at the time of the survey. Country-level characteristics are also included and their impact on the overall willingness to carry out CE activities is assessed. The data collected is hierarchical: SMEs are nested within the countries; this required the specification and estimation of multilevel models to assess the impact of factors at company and country level on the latent structure. The paper is organized as follows: Section 1 overviews the concept of Circular Economy in the European Union and its importance in the context of small and medium-size enterprises. Section 2 reviews the literature and advances with the hypotheses to be tested. Section 3 describes the data. Section 4 introduces statistical methods. Section 5 presents the results and Section 6 discusses the results and research limitations and concludes.

2 The Circular Economy In The European Union

2.1 European Union Policies Towards The CE

The EU business world must deal with the environmental issue for ethical reasons, but also because the European Union developed environmental policies for the product life cycle (European Commission, 2003; van Rossem et al., 2010; CSES/Oxford Research, 2012; Arditi and Toulouse, 2012; Dalhammar, 2015). Product-oriented regulations cover three parts: prohibition of hazardous substances, energy-efficient products, and proper waste disposal after use (Dalhammar, 2016). In December 2015, the European Commission presented the CE Action Plan, which included legislative proposals and measures in the sectors of production (product design and production processes), consumption and waste management. The Action Plan was divided into two parts: a communication on how to introduce the CE at different stages of the life cycle and a specific part dedicated to waste management. Particular consideration includes the objective of the European Commission's Action Plan to take into consideration not only industry, but also consumers and their behavior, with definitive information on CE disruptions in daily life and related economic benefits. The Action Plan aims to push companies into a sustainable competitive environment in order to accelerate economic growth and create new jobs. Therefore, companies need a skilled workforce and the development of new and specific skills. This training requires high costs for companies. The European Commission is moving in this direction with measures to promote the green economy and increase employment. The CE Action Plan focuses on all stages of the value chain (i.e. from production to consumption, repair and remanufacturing, waste management, and secondary raw materials such as reclaimed products) and on all kinds of issues from Member States, regions and cities, companies and citizens.

In terms of the value chain, the production phase highlighted in the Action Plan plays an important role for companies in terms of inefficient use of resources which leads to high waste generation and sustainable use of primary raw materials, included renewables. In particular, the European Commission wants to encourage SMEs to improve resource efficiency

by establishing a European Resource Efficiency Excellence Centre, which helps companies to replace chemical dangerous substances or facilitate the access to innovative technologies (Bodar et al., 2018). Additionally, the European Circular Economy Platform provides information about CE issues (Rocca et al., 2023).

2.2 Small and Medium-sized Enterprises and Circular Economy

The European Commission defines small and medium-sized enterprises (SMEs) as companies with fewer than 250 employees and an annual turnover not exceeding € 50 million, or an annual balance sheet total not exceeding € 43 million euros (European Commission, 2003). SMEs are classified into: micro enterprises with fewer than 10 employees and annual turnover or balance sheet total of less than € 2 million; small businesses with fewer than 50 employees and annual turnover or annual balance sheet total of less than € 10 million; and medium-sized enterprises with a number of employees between 50 and 250 and an annual turnover between 10 and 50 million euros or an annual balance sheet total between 10 and 43 million euros.

In 2015, over 99% of EU enterprises could be classified as SMEs; they covered about two thirds (66.3%) of total employment (and the percentage is continuously growing) and 55.8% of total turnover (Papadopoulos et al., 2018). These figures show the importance of SMEs in the EU economy. At the same time, SMEs have a strong impact on the environment (Musa & Chinniah, 2016). In fact, it is estimated that around 60–70% of total pollution is caused by SMEs (Hoogendoorn et al., 2015).

For the EU, SMEs are essential for CE because they are more active in sectors such as recycling, repair, and innovation; on the other hand, they find it difficult to apply for funding and to comply with CE principles if their business is not directly involved (European Commission, 2015; Gennari, 2022). Some papers addressed environmental management practices in small companies in specific areas of the world, such as Redmond et al. (2008), who studied waste management in small businesses in Western Australia and Aragòn-Correa et al. (2008) relating to Spain.

In recent years, several papers have been published that addressed the integration of SMEs in terms of sustainable actions and possible variables capable of reducing their impact on the environment. For example, some papers focused on barriers and enablers in the implementation of CE-related actions (Rizos et al., 2016); others were more generally concerned with encouraging SMEs to use CE practices (see Hoogendoorn et al., 2015).

3 Review of The Literature and Hypotheses

Much research has been conducted to identify the factors that can trigger and maintain companies' willingness to promote CE. These factors can be divided into two categories: specific business characteristics that can play a role in carrying out CE activities and factors at the country level, macro initiatives that strengthen or create barriers to the development of sustainable companies.

3.1 Factors at Company Level

The size of the company influences the choice to carry out CE activities (Bianchi & Noci, 1998). Larger companies have access to more resources, while smaller companies struggle with a lack of financial resources to invest in even simple sustainable businesses, such as building and managing recycling schemes (Eunomia Research & Consulting, 2011; Hollins, 2011; Rademaekers et al., 2011). All companies strive to create a sustainable environment inside or outside the company (Cambra-Fierro et al., 2008). Small and large companies are very similar in terms of abstract regulatory environmental principles (Bucar et al., 2003), but differ in the embodiment of these principles (Lahdesmaki, 2005). SMEs tend to be more active on waste, recycling, and innovation. However, they may encounter difficulties such as finding resources that can influence the implementation of CE activities, especially if the company is not directly interested in them (European Commission, 2015). Furthermore, low-waste companies are less motivated to recycle (WRAP, 2007). On the other hand, ethics plays a central role in larger companies because they are more exposed and need to save their reputation (Lawal et al., 2016) by using marketing, communication and public relations tools (Cambra-Fierro et al., 2008). Although the trend of environmental activities is growing in both small and large companies, the latter are more likely to engage in these activities (Isusi, 2002). However, these differences can also be found in the SME category. Although the relationship may be less obvious, all the issues described above relating to resources, stakeholders' pressure and reputation are the same for larger and smaller SMEs (Uhlaner et al., 2012). Thus, our first hypothesis states:

H1.1 Larger SMEs are more willing to develop CE activities.

The age of SMEs has been shown to influence the willingness of implementing CE practices (Hoogendoorn et al., 2015). The experience and social responsibility of a company can also be derived from its seniority (Trencansky & Tsaparlidis, 2014). Godos-Diez et al. (2011) stated that there is a positive and important link between the age of company and Corporate Social Responsibility (CSR), as CSR activities are implemented, "stakeholders' expectations increase and the company is forced to meet them and even reinforce them" (Trencansky & Tsaparlidis, 2014, p. 43). On the other hand, the creation of new start-ups facilitates the implementation of sustainable activities rather than, for example, modifying production processes, which can have higher costs (Rizos et al., 2016). Our second hypothesis is therefore:

H1.2 Older SMEs have a greater interest in establishing a CE business model and newly founded SMEs also exhibit this behavior.

The willingness of SMEs to pursue sustainable activities and to adopt attitudes towards green policies depends on the sector of activity (Bradford & Fraser, 2008). In particular, SMEs from the more tangible sectors (manufacturing, construction, agriculture and waste management) are more inclined to start CE activities (Perrini et al., 2007; Brand & Dam, 2009). In these sectors the production process generates more waste and requires more raw materials; moreover, the process is rigidly reviewed with environmental parameters set by national and international institutions (Uhlaner et al., 2012; FUSION, 2014). An example is

the textile industry in Europe, which is obliged to observe a more sustainable use of water, which is an increasingly limited natural resource (Vajnhandl and Volmajer Valh, 2014). On the other hand, SMEs in these tangible sectors, which need more resources, need to save their reputations and then adopt environmental strategies (Williamson et al., 2006). In addition, in the CE Action Plan, the EU sectors of plastics, food waste, critical raw materials, construction and demolition, biomass and bio-based products have the priority measures to implement the CE business model "because of the specificities of their products or value-chains, their environmental footprint or dependency on material from outside Europe" (European Commission, 2015, p. 13). Thus, our third hypothesis states:

H1.3 SMEs in more tangible sectors are more likely to invest in "green" activities.

In addition to the type of industry in which the company operates, i.e., service-oriented or product-oriented, its role in the production chain – Business-to-Business (B2B) and Business-to-Consumer (B2C) companies – can lead to heterogeneous practices related to the activities of CE. B2C companies have stronger motivations to use sustainable businesses than B2B; the formers sell products or services to end consumers who are exposed and must meet customer needs to gain a competitive advantage (Källman, 2016; Cambra-Fierro et al., 2008). For the same reason, B2C companies are more likely to invest in product innovation (Orsato, 2006). Consumers, in fact, are more cautious about the environmental characteristics of products and services. On the contrary, B2B companies (especially in the case of semi-finished products) have more difficulty to differentiate their products intended for the final consumer. Therefore, companies serving commercial markets are less likely to invest in environmental processes and goods (Hoogendorn et al., 2015). Thus, our fourth hypothesis establishes that:

H1.4 B2C SMEs are more willing to implement CE business models than B2B.

Investments in Research and Development (R&D) are fundamental for the implementation of CE business models, i.e. without innovative technologies, it is almost impossible to develop environmental sustainable ideas; for example, total R&D spending is very important for a company seeking to apply sustainable actions such as CO_2 reduction (Fernàndez et al., 2018). For these reasons it is hypothesized that:

H1.5 SMEs that invest more money in R&D are more willing to carry out CE activities.

3.2 Factors at Country Level

The implementation process of the CE is bounded by factors at country level that define different phases for the development of the concept of sustainability. In 1995, the Commission of Sustainable Development (CSD) developed a set of indicators to review progress in sustainability development and set specific targets (Bartelmus, 1994). Based on the CSD approach, sustainable development has four dimensions: social, economic, environmental, and institutional (Spangenberg, 2002b). The use of indicators at the country level can be fundamental for understanding and solving the problems of sustainable development (Diaz-

Chavez, 2003). These dimensions at the country level influence the implementation of the CE business model at the company level.

Social indicators measure social trends and conditions that affect people's well-being (Bulmer, 1976). These indicators include areas such as health, safety, human rights, child labor, labor issues (e.g., gender discrimination), community initiatives, and employment benefits (Mani et al., 2014). While the environmental and economic dimensions are more intuitive to understand (Glachant, 2009), only a few studies have been conducted on the social dimension of sustainable development (Carrera & Mack, 2010). This is probably due to the need for in-depth studies to find some valid indicators and quantify them (Diaz-Chavez, 2014). In recent years, companies have understood the importance of social sustainability, especially with regard to the role of supply chain management in terms of competitive advantage (Andersen & Skjoett-Larsen, 2009). In particular, the "best supply chain practices require more transparency along the chain because the social implications of an organization are the sum of the impacts from the inputs and outputs generated throughout the supply chain on the society" (Vachon & Mao, 2008, p. 1554). Therefore, companies that understand social sustainability issues need to improve their "sustainability performance". Thus, the first hypothesis, which considers the social dimension at country level, states that:

H2.1 The social dimension at country level has a positive effect on the implementation of CE activities.

Economic indicators are important for perceiving the wealth of a country (Banait & Tamošiūnienė, 2016). From a company point of view, the economic dimension of sustainability coincides with the large amount of liquidity that can be used to meet stakeholders' requirements, including those related to sustainability (Yadav et al., 2018). Furthermore, in developed countries, most investment policies are aimed at the private sector because it is more inclined to support innovation and consequently competitiveness, which reinforces sustainable growth (Cadil et al., 2018). On the other hand, developing countries require the introduction of specific national policies to promote practices of efficient use of resources (Ferronato et al., 2019). Thus, the second hypothesis at the country level states that:

H2.2 The economic dimension at country level has a positive impact on CE activities.

The environmental dimension is closely linked to the idea of sustainable development. It can be defined as "the sum of all the bio-geological processes and the elements involved in them" (Spangenberg, 2002b, p. 3). The environmental dimension helps understanding environmental policy (Banait & Tamošiūnienė, 2016) and can be divided into macro areas such as atmosphere, consumption and production patterns, land, water, ocean and sea, and biodiversity (United Nations, 2007). However, the first two areas are more related to our research. In terms of the atmosphere, suffice it to say that only 100 companies have produced more than 70% of global greenhouse gas emissions since 1988 (Griffin, 2017). On the other hand, some sub-themes of consumption and production patterns are energy use and waste generation and management, which are the two most important areas of CE (United Nations, 2007). It seems obvious that for a country showing a reduction in pollutants, CE action can be a strong strategic response (Busch et al., 2014; Peters et al., 2007; Wang & Chang, 2014). The most emblematic example is China, which according to CE is the most

active country in the world and at the same time the largest emitter of greenhouse gases (Liu et al., 2018). Thus, the third hypothesis at the country level states that:

H2.3 The environmental dimension at country level has a positive impact on CE activities.

The institutional dimension can be defined as "the rules by which political decision-making and implementation are structured" (Spangenberg, 2002b, p. 5). It determines the values on which the country is based and the influence of institutions on society's expectations, values, and principles. Institutions can facilitate decision-making focused on all actions related to the sustainability paradigm. Furthermore, they can also facilitate the implementation of political decisions about possible sustainable actions (Spangenberg, 2002a). Thus, it is possible that a country with good rules has a positive impact on the implementation of the CE business model. Thus, the fourth hypothesis at the country level states that:

H2.4 The institutional level at country level has a positive impact on the implementation of CE activities.

Table 1 summarizes all the hypotheses, at firm and country-level, that this research aims at testing together with the main corresponding references in the scientific literature. All these hypotheses are dealt with in the next sections with appropriate statistical analysis.

Table 1 Hypotheses to be tested with main references

	Hypothesis	References
Company level		
H1.1	Larger SMEs are more willing to develop CE activities.	Isusi (2002) and Uhlaner et al. (2012)
H1.2	Older SMEs have a greater interest in establishing a CE business model and newly founded SMEs also exhibit this behavior.	Hoogendoorn et al. (2015)
H1.3	SMEs in more tangible sectors are more likely to invest in "green" activities.	Perrini et al. (2007) and Brand and Dam (2009)
H1.4	B2C SMEs are more willing to implement CE business models than B2B.	Källman (2016) and Cambra-Fierro et al. (2008)
H1.5	SMEs that invest more money in R&D are more willing to carry out CE activities.	Fernandez et al. (2018)
Country level		
H2.1	The social dimension at country level has a positive effect on the implementation of CE activities.	Andersen and Skjoett-Larsen (2009)
H2.2	The economic dimension at country level has a positive impact on CE activities.	Yadav et al. (2018) and Cadil et al. (2018)
H2.3	The environmental dimension at country level has a positive impact on CE activities.	Banait and Tamošiūnienė (2016) and Liu et al. (2018)
H2.4	The institutional level at country level has a positive impact on the implementation of CE activities.	Spangenberg (2002a, b)

4 Data

4.1 Data at Company Level

The data comes from a unique Eurobarometer survey conducted in April 2016, which covered the 28 EU countries at the time[1] for a total of 10,618 CATI interviews. The number of interviews is almost the same in all countries (400), except in the smaller countries: Cyprus, Luxembourg, and Malta (200). Interviews were conducted with key-decision makers by company in their mother tongue. The variables size of the company (with three ranges: 1–9, 10–49 and 50–250 employees) and sector (Retail, Services, Manufacturing, and Industry) are balanced by country: quotas were applied. To carry over statistical analysis with sound inferential procedures, post-stratification weights are made available along with the collected data so that results are representative of the population of SMEs in the EU (European Commission, 2016).

The data set contains five ordinal indicators on the implementation of CE practices over the past three years: (1) Re-plan of water use to reduce consumption and maximize reuse; (2) Use of renewable energy sources; (3) Re-plan energy consumption to reduce consumption; (4) Reduce the amount of waste by recycling or reusing waste or selling it to another company; and (5) Redesign products and services to reduce the use of materials or the use recycled materials.

The survey poses five items under the following question: "Has your company undertaken any of the following activities in the last 3 years?" The answer to each of the five items contains four ordinal categories: No, and we do not plan to do so; No, but we plan to do so; Yes, activities are underway; and Yes, activities have been implemented. The survey collects various characteristics of the company: the number of employees, total turnover in 2015, age, sector of economic activity, type of goods and services sold, and percentage of company turnover in 2015 invested in Research and Development.

4.2 Data at Country Level

All the dimensions created by the Commission of Sustainable Development and described in Sect. 2 are useful for identifying covariates at the country level. Despite the numerous indicators for each dimension, the literature focuses on the most important ones related to the CE and business world. The values of these variables are available on the Eurostat website. Several indicators are available for each of four dimensions at the country level; however, there is a problem of multicollinearity between indicators relating to the same dimension. For this reason, we only selected one variable per dimension. Table 2 shows the country-level variables we took to estimate the model. We took into consideration the values of the covariates in 2016; in footnote source is reported[2].

[1] The 28 countries covered by Flash Eurobarometer 441 are: Austria, Belgium, Bulgaria, Cyprus, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.Data are available, after registration, at this link https://data.europa.eu/data/datasets/s2110_441_eng?locale=it.

[2] We formerly considered also other potential country-level covariates: life expectancy (social dimension), gross fixed capital formation as % of GDP and unemployment rate (economic dimension), greenhouse gas emissions per capita (environmental dimension) and total taxes as % of GDP (institutional dimension). Model

Table 2 Description of the variables at the country level

Dimension	Variable
Social	Illiteracy rate (Lower than primary, primary and lower secondary education (levels 0–2))
Economic	Per capita GDP (Euro)
Environmental	Production of waste excluding major mineral wastes per GDP unit (Kg per thousand euro)
Institutional	Corruption perception index (score scale of 0 (highly corrupt) to 100 (very clean))

Notes: Data from Eurostat, https://ec.europa.eu/eurostat/data/database (accessed on 21.10.2022)

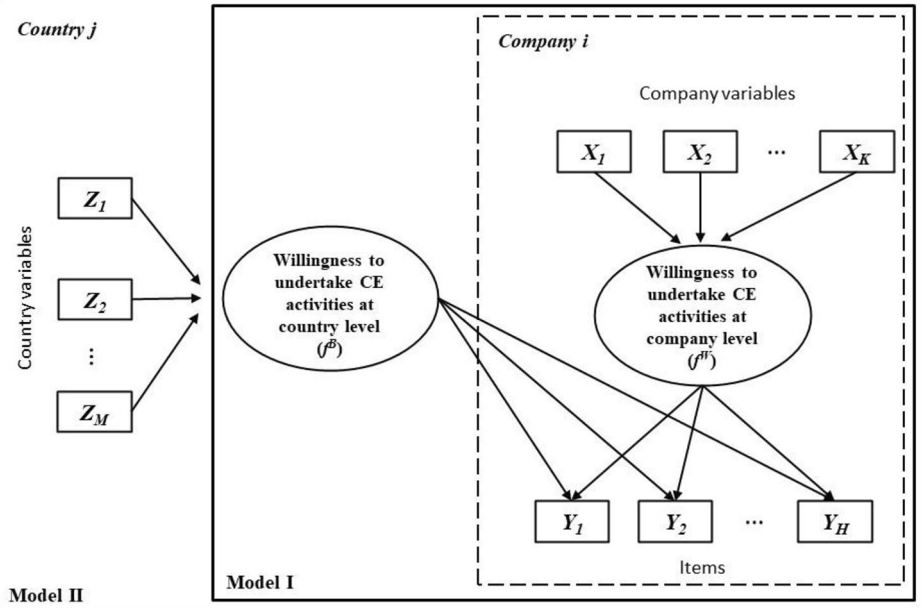

Fig. 1 Conceptual model

5 Methods

5.1 Conceptual Framework

The aim of this section is to describe the statistical methods used to analyze our data, in particular the confirmatory factor analysis (CFA) and the multilevel factor model. In both cases, the ordinal nature of the items is considered, the data are weighted to reproduce the distribution of SMEs in each country and the Maximum Likelihood (ML) method with Gaussian integration is used to estimate the parameters.

Figure 1 summarizes the conceptual model. Two latent variables represent the willingness to carry out CE activities: one at the company level (f^w), which is a measure of the latent variable within the country, and one at country level (f^B), which is measured

estimation with all nine 9 macro variables resulted in many not significant coefficients, due to a problem of multicollinearity. After several attempts, the best results were obtained using the variables for each sustainable development dimension reported in Table 2.

between countries. The H items Y_h correspond to the dependent variables of interest to us; the K variables X_k are the covariates at company level; and the set of M variables Z_m are country-level covariates.

This conceptual model represents a combination of a factorial model that links the latent constructs with the H items Y_h and a linear model that regresses the two latent variables on their corresponding covariates at the company and country level in a multilevel setting. Therefore, the final model assumes unidimensionality, i.e., a single individual latent variable that explains all the observed items. The estimation of this model allows testing the hypotheses presented in the previous section.

5.2 The Multilevel Factor Model

Factor analysis is one of the most important methods for understanding latent constructs and testing them. The confirmatory factor analysis (CFA) is used if the researcher a priori knows, eventually after an exploratory analysis, the number of latent factors and all the possible relationships between them and between these and the observed indicators. The basic assumption is that the correlation between items can be explained by the existence of one or more latent variables (Brown, 2014). The multilevel factor model (MFM) is an extension of the CFA for hierarchical data: the first level uses company-related variables to explain the latent construct; the second level measures the impact of covariates at the country level. Since companies of the same country share characteristics, the assumption of independence is not valid and the data nesting structure must be considered (Hox et al., 2010; Costa & Dias, 2015).

In our two-level data, y_{ijh} denotes the response of company i in country j to item h on an ordinal scale. The multilevel factor model is usually estimated from the hypothesis of continuous observed variables. Since the items are measured on an ordinal scale, a continuous latent variable y^*_{ijh} measures the propensity of company i in country j to be in category l of item h. The relationship between the original variables and the latent variable y^*_{ijh} is determined by Eq. (1):

$$y_{ijh} = l \quad \text{if} \quad \tau_{h,l-1} < y^*_{ijh} \leq \tau_{h,l} \tag{1}$$

where $\tau_{h,l}$ is the threshold of item h, which separates the categories $l = 1, \ldots, 4$ with $\tau_{h,0} = -\infty$ and $\tau_{h,5} = +\infty$. Consequently, the upper (the lower) values of y^*_{ijh} correspond to the higher (or lower) observed ordinal categories. Each item has five categories; thus, there are four thresholds to be estimated for each item.

The factor model at company level is given by Eq. (2):

$$y^*_{ijh} = \mu_{jh} + \lambda^W_h f^W_{ij} + \upsilon_{ij} \tag{2}$$

where μ_{jh} is the random intercept of the item h for country j, λ^W_h is the loading at company level for item h, and f^W_{ij} is the score of the latent variable at the company level. Finally, υ_{ij} is the residual random variable (measurement error) with distribution $\upsilon_{ij} \sim N(0, \sigma^2_w)$, where σ^2_w corresponds to the variability within groups.

The random intercept measures between-country variability and is given by:

$$\mu_{jh} = \mu_h + \lambda_h^B f_j^B + u_j \tag{3}$$

where μ_h is the intercept for each item (set to zero for the thresholds), λ_h^B is the loading at the country level for the item h and f_j^B is the score at the country level. Finally, it is assumed that $u_j \sim N(0, \sigma_b^2)$), where σ_b^2 corresponds to the variance between groups. Residual random variables v_{ij} and u_j are assumed to be independent. Both models (Eqs. 2 and 3) can be combined into a single equation:

$$y_{ijh}^* = \lambda_h^B f_j^B + \lambda_h^W f_{ij}^W + u_j + v_{ij} \tag{4}$$

Comparing factorial structures between different groups or populations requires more attention (Reeskens and Hooge, 2008; Tomyn et al., 2013; Moksnes et al., 2014). For example, for each country all items are present; second, there is a scale invariance because loadings, λ_h^B and λ_h^W, are defined as invariant across countries. The final assumption is that intercepts are invariant across countries (Dias & Trindade, 2016).

The MIMIC (Multiple Indicators and Multiple Causes) structure is used to study the influence of company characteristics on the latent variable at the individual level (f_{ij}^W). This model contains a set of observed variables that are multiple indicators and multiple causes for a single latent variable. The MIMIC model is analogous to a regression model in which a dependent variable cannot be observable (i.e. a latent variable) and is measured with error by a set of indicators through a factor analysis sub-model. The latent variable at company level is regressed using K independent variables at the individual level given by the linear component:

$$E(f_{ij}^W) = \gamma_1 x_{ij1} + \ldots + \gamma_K x_{ijK}, \tag{5}$$

where x_{ijk} are the K covariates at the company level and γ_k the corresponding slopes. The same structure is used for the latent variable at the country level (f_j^B):

$$E(f_j^B) = \delta_1 z_{j1} + \cdots + \delta_M z_{jM} \tag{6}$$

where z_{jm} are the M covariates at the country level and δ_m are the corresponding slopes. In summary, the final model combines a structural equation model (SEM) with observed and unobserved variables embedded in a multilevel structure. Model parameters are estimated by the maximum likelihood method using software Mplus 6.1.

The intra-class correlation coefficient (ICC) is the proportion of variability related to different countries. It represents the correlation between two companies of the same country due to the fact that they share observed characteristics and some other non-directly observable values. In other words, it is a measure of similarity between companies from the same countries and is calculated as follows:

$$ICC = \sigma_b^2/(\sigma_w^2 + \sigma_b^2) \tag{7}$$

where σ_b^2 is the between-country variance and σ_w^2 is the within-country variance: this is the ratio of the between variance to the total variance, then it varies from 0 to 1. If the ICC value is high, much of the variability is due to heterogeneity resulting from different char-

acteristics of the countries, a multilevel approach is justified. Otherwise, if countries are not heterogeneous, the resulting low ICC does not justify the use of multilevel modeling. The minimum ICC value justifying a multilevel approach was found to be 0.05 (Hox et al., 2010).

6 Results

This section presents the results of the hypotheses testing and heterogeneity analysis. First, a confirmatory factor model with ordinal variables is estimated, which assumes the a priori presence of only one latent variable. The covariates described in Sect. 3 are then included in the model by estimating the multilevel factor model. Two different models are estimated: the first one with covariates at the company level (Model I), the second one with covariates at both levels (Model II). A comparison between these two models helps understanding the importance of the covariates at the country level (see Fig. 1).

Confirmatory factor analysis (CFA) with one latent variable and five items has a good fit to the data: RMSEA has a value less than 0.05 (0.039); CFI and TLI indices are greater than 0.95 (0.977 and 0.953, respectively).

Table 3 shows factor loadings at company and country level, indicating the direct effects of willingness to carry out CE activities on the items. To identify the model, one of the factor loadings is fixed at 1 (in this case, the one related to the act of re-planning the way water is used to reduce consumption and maximize re-use). All standardized factor loadings are greater than 0.7 (Hair et al., 2010). At company level, the average weight assigned to the latent variable relating to the willingness to undertake CE activities increases more than proportionally to the value of the variable that represents CE activity in re-planning of energy consumption to reduce consumption. For the variables relating to re-planning of water use, the use of renewable energy sources, the reduction of waste, and the redesign of products and services; on the other hand, the increase is less than proportional. At the country level, the only loading greater than 1 relates to a variable describing waste reduction actions. The variances of latent variables at the company and country level are statistically significant and consider the presence of variability within and between countries. As expected, the

Table 3 Factor loadings and variances

	Individual level			Country level		
	Estimate	S.E.	p-value	Estimate	S.E.	p-value
Loadings						
Re-plan of the way water is used to minimize usage and maximize re-usage	1	-	-	1	-	-
Use of renewable energy	0.891	0.059	0.000	0.708	0.236	0.003
Re-plan energy usage to minimize consumption	1.081	0.057	0.000	0.890	0.161	0.000
Minimize waste by recycling or reusing waste or selling it to another company	0.817	0.053	0.000	1.270	0.168	0.000
Redesign products and services to minimize the use of materials or use recycled materials	0.945	0.062	0.000	0.795	0.108	0.000
Variance	2.427	0.229	0.000	0.471	0.161	0.003

variance of the latent variable at the company level (2.427) is greater than that at country level (0.471): within-country heterogeneity is greater than that between countries. Of the estimated ICC of 0.163, the between-country heterogeneity is 16.3% of the total variance.

Table 4 shows the estimated thresholds, which are cut-points of the latent variable used to separate categories of each item. Each variable has four categories and thus three thresholds. For example, if the score of the latent variable is 1.2, then the observation is classified into category 1 of the Re-plan of the way water is used to minimize usage and maximize re-usage and Use of renewable energy; in category 3 of Re-plan energy usage to minimize consumption and Redesign products and services to minimize the use of materials or use recycled materials, and in category 4 of Minimize waste by recycling or reusing waste or selling it to another company.

The next step in the analysis is to examine the impact of company and country level covariates on the latent variable, i.e., the willingness to undertake CE practices. We estimated two nested models: the first one without country covariates (Model I) and the second with these covariates (Model II). The results are then compared with the hypotheses formulated in Sect. 2 (Table 5).

In general, it can be observed that the differences between the two models in terms of estimated coefficient values, standard errors and p-values, as expected, are negligible. The introduction of country-level variables into the model does not affect other estimates. The estimated variance does not change much due to the introduction of upper-level variables into the model.

The values in Table 5 show that the size of the company has a positive effect on the willingness to carry out CE activities. Depending on the number of employees, small (10–49 employees) and medium-sized (50–249 employees) companies are more likely to carry out CE activities than micro (1–9 employees), which is the baseline group. Furthermore, there is a strictly positive relationship between the number of employees and the willingness to undertake CE practices: the higher slope refers to medium-sized companies. The relationship between company's turnover in 2015 and the performance of CE activities is linear and positive. Hypothesis 1.1 is therefore supported by data, i.e., larger SMEs are more willing to develop CE activities.

The undertaking of CE activities does not depend on the age of the company. Therefore, hypothesis 1.2, which states that old and new SMEs have a greater interest in undertaking the CE business model, is not supported.

Table 4 Estimated threshold for each item

	Threshold1		Threshold2		Threshold3	
	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
Re-plan of the way water is used to minimize usage and maximize re-usage	1.523	0.162	2.100	0.165	2.826	0.204
Use of renewable energy	1.207	0.133	2.188	0.170	2.782	0.213
Re-plan energy usage to minimize consumption	0.024	0.124	0.784	0.138	1.766	0.177
Minimize waste by recycling or reusing waste or selling it to another company	-0.494	0.156	-0.219	0.160	0.910	0.226
Redesign products and services to minimize the use of materials or use recycled materials	0.444	0.107	0.944	0.116	1.918	0.190

Table 5 Company-level covariate effects

		Model I			Model II		
		Estimate	S.E.	p-value	Estimate	S.E.	p-value
Sector of activity (ref: Manufacturing)							
	Manufacturing						
	Retail	-0.239	0.091	0.008	-0.242	0.091	0.008
	Services	-0.331	0.098	0.001	-0.336	0.098	0.001
	Industry	-0.072	0.068	0.286	-0.075	0.068	0.266
Number of employees (ref: 1 to 9 employees)							
	10 to 49 employees	0.329	0.069	0.000	0.334	0.069	0.000
	50 to 250 employees	0.620	0.097	0.000	0.631	0.097	0.000
Company foundation (ref: Before 1 January 2010)							
	Between 1 January 2010 and 1 January 2015	0.012	0.058	0.838	0.012	0.058	0.832
	After 1 January 2015	-0.097	0.206	0.638	-0.101	0.207	0.625
Company's total turnover (2015) (ref: Less than 25 000 euros)							
	More than 25 000 to 50 000 euros	-0.022	0.121	0.856	-0.025	0.120	0.832
	More than 50 000 to 100 000 euros	0.010	0.106	0.928	0.003	0.105	0.976
	More than 100 000 to 250 000 euros	0.094	0.121	0.435	0.086	0.118	0.470
	More than 250 000 to 500 000 euros	0.257	0.123	0.036	0.245	0.120	0.041
	More than 500 000 to 2 million euros	0.308	0.122	0.012	0.293	0.120	0.015
	More than 2 to 10 million euros	0.418	0.122	0.001	0.400	0.120	0.001
	More than 10 million euros (M)	0.719	0.165	0.000	0.700	0.163	0.000
Company sells (multiple choice):							
	Products directly to consumers	0.254	0.058	0.000	0.253	0.059	0.000
	Products to companies or other organisations	0.184	0.072	0.010	0.183	0.072	0.011
	Services directly to consumers	0.488	0.053	0.000	0.490	0.053	0.000
	Services to companies or other organisations	0.001	0.054	0.990	0.000	0.054	0.998
Company's turnover in 2015 was invested in R & D (%) (ref: Less than 5%)							
	From 5–9.9%	0.595	0.076	0.000	0.596	0.076	0.000
	From 10–14.9%	0.708	0.057	0.000	0.709	0.057	0.000
	From 15–19.9%	0.834	0.166	0.000	0.834	0.165	0.000
	20% or more	0.666	0.129	0.000	0.668	0.129	0.000
Variance		1.962	0.215	0.000	1.967	0.216	0.000

Table 6 Country-level covariates effects

	Model I			Model II		
	Estimate	S.E.	p-value	Estimate	S.E.	p-value
Illiteracy rate				0.024	0.007	0.001
GDP per capita (ln transformed)				0.230	0.318	0.470
Generation waste per GDP				-0.002	0.001	0.003
Corruption perception index				0.005	0.013	0.689
Variance	0.435	0.141	0.002	0.214	0.105	0.042
ICC	0.181			0.098		

Table 7 Estimated factor scores at company (as mean for each country) and country level

Country	Country-level scores	Individual-level scores	
	(estimate)	(aggregate statistics)	
		Mean	Standard-deviation
Austria	3.348	0.858	1.309
Belgium	3.579	0.683	1.198
Bulgaria	2.041	0.334	1.085
Croatia	3.087	0.675	1.138
Cyprus	2.618	0.844	1.305
Czech Republic	2.796	0.613	1.030
Denmark	2.369	0.901	1.321
Estonia	1.744	0.488	1.192
Finland	3.725	0.714	1.396
France	3.302	0.699	1.287
Germany	3.003	0.886	1.324
Greece	2.850	0.683	1.180
Hungary	2.794	0.633	1.242
Ireland	4.367	0.614	1.164
Italy	3.030	0.649	1.126
Latvia	2.216	0.603	1.234
Lithuania	2.063	0.631	1.234
Luxembourg	3.748	0.761	1.250
Malta	3.823	0.710	1.153
Poland	2.666	0.673	1.124
Portugal	3.929	0.694	1.183
Romania	3.150	0.630	1.228
Slovakia	2.619	0.539	1.069
Slovenia	2.553	0.751	1.185
Spain	3.489	0.554	1.081
Sweden	2.871	0.643	1.305
The Netherlands	3.248	0.707	1.290
United Kingdom	4.337	0.579	1.291

The implementation of CE practices is more widespread in companies belonging to more tangible sectors. Table 5 shows that all slopes are negative, which means that companies in the manufacturing sector (reference category) are the most active in undertaking CE activities. At the same time, the effect of the industrial sector on the willingness to undertake CE

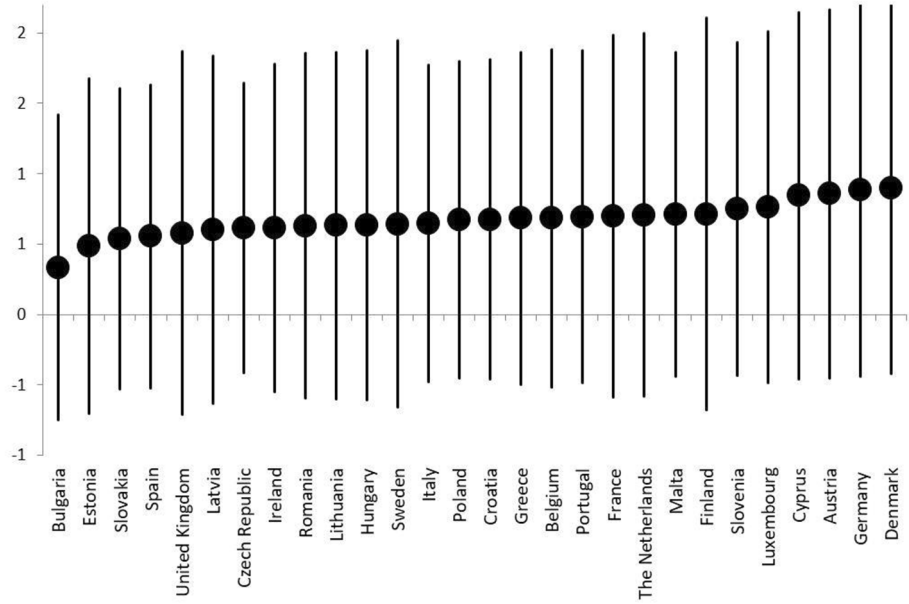

Fig. 2 Factors scores at country level

practices is the same as the manufacturing one, as the estimated slope is not significant. The category that refers to companies that sell services directly to consumers has the greatest slope. The second highest and significant slope relates to companies that sell products directly to consumers. As a result, companies that sell directly to consumers are more likely to engage in CE activities. The slope associated with companies selling services to companies or other organizations was not statistically significant. In conclusion, hypothesis 1.3 (i.e. SMEs from more tangible sectors are more likely to undertake CE activities) was partially supported, while hypothesis 1.4, was supported, i.e., B2C SMEs are more likely to implement CE business models than B2B companies.

Table 5 shows the positive relationship between the percentage of turnover invested in R&D and the willingness to implement CE practices: the estimated coefficients are positive and significant (with the baseline category less than 5%, all categories affect the willingness to undertake CE practices in different ways). On the other hand, there does not appear to be a close positive relationship between them: the estimated coefficient associated with a category from 15 to 19.9% is higher than that of a category by 20% or more. Furthermore, we can conclude that hypothesis 1.5 (SMEs that invest more in R&D are more likely to undertake CE activities) is only partially supported.

Table 6 lists the estimated coefficients for both models: without (Model I) and with covariates at country-level (Model II). The estimated coefficients are compared with the hypotheses in Sect. 2. The illiteracy rate has a significant and positive but low slope (0.024). This is probably due to the scale of the variable. It can be argued that an increase in the illiteracy rate corresponds to an increase in the willingness to undertake CE activities, the social dimension has a negative impact and hypothesis 2.1 is not supported. Per capita GDP (log-transformed) has a slope with a positive sign but is not significant; thus, hypothesis 2.2,

which states that the economic dimension has a positive impact on CE activities, is not supported. An increase in the variable generation of waste per GDP has a negative impact on the latent variable. The estimated slope instead shows a very low value (-0.002): hypothesis 2.3 on the environmental dimension and its positive impact on CE is not supported.

Finally, the Corruption Perception Index has a negative but not statistically significant impact on undertaking CE activities: hypothesis 2.4 (country-level institutional dimension positively affects undertaking CE activities) is not supported.

The most important objective of the analyses is to evaluate how these country-level variables explain the hierarchical structure of the model by modifying the variances between groups and consequently the ICCs. In the model without the upper level covariates, the between variance is 0.435 and ICC is 0.181. In this case, 18.1% of the total variability of the latent variable – willingness to undertake CE activities – is due to the upper level of the data structure. As expected, the between variability and ICC are smaller in the model with country-level covariates (respectively 0.214 and 0.098). This means that the heterogeneity between countries accounts for 9.8% of the total variance. In short, the differences between these two estimates reveal that information from the variables at the country level explains the heterogeneity between countries.

Table 7 compares the scores of the factors at both levels of the analysis to examine the impact of the company and country on the willingness to undertake CE activities. From the point of view of the company level, scores are computed as an estimated mean with standard deviation (SD) of each individual factor score (f_{ij}^{W}) for each country. In Fig. 2, countries are ranked with increasing values of company-level average factor scores. All countries have a positive average willingness to undertake CE activities. If we focus on the first half of the list, we can see that nine out of 14 countries are geographically located in the Eastern part of Europe (Bulgaria, Estonia, Slovakia, Latvia, Czech Republic, Romania, Lithuania, Hungary, and Poland). On the other hand, countries with the highest values are mostly developed countries in Central and Western Europe (Belgium, Portugal, France, the Netherlands, Finland, Luxembourg, Austria, Germany, and Denmark). Figure 2 also shows the dispersion within countries. It is particularly high in the Scandinavian countries (Finland and Sweden) and in the United Kingdom.

Based on the estimated country-level factor scores, it can be seen that the ranking described above is still valid, albeit in some countries with completely different positions: for example, while from a business point of view the Great Britain and Ireland have lower factor scores, their estimates of factor scores at upper level are the highest. This is another reason to justify the hierarchical structure of the model and the heterogeneity between countries. In short, the rankings are more or less expected in both cases.

7 Discussion of Results, Limitations and Conclusions

Regarding the size of the company, hypothesis 1.1 is supported. In fact, larger SMEs, both in terms of number of employees and turnover, are more likely to undertake CE practices and this relationship is strictly monotonous, although companies with a turnover up to 250,000 euros have the same effect on the latent variable. Therefore, it is confirmed that the presence of more human resources or liquidity helps companies to invest in sustainable activities (Eunomia Research & Consulting, 2011; Hollins, 2011; Rademaekers et al., 2011). Accord-

ing to Hoogendoorn et al. (2015) and Bassi and Dias (2019), a variable linked to company age has no impact on the willingness to adopt CE practices. SMEs in the more tangible sector are more likely to implement CE practices; SMEs operating in the manufacturing sector are more willing to adopt green behaviors. The market to which the SMEs refer is linked to the CE activity, although this relationship is not statistically significant for all categories. Sector and reference market are closely linked to the core business, but the same company can sell other goods or services that could complement each other. The boundaries of the tangible sector are not well defined in this regard; thus, we cannot conclude that hypothesis 1.3 is fully supported by the analysis.

The variable on what a company sells also provides information about the type of client. It may happen that a company sells to customers or companies or other organizations at the same time. We have already seen that companies targeting the B2C market are more likely to operate in a sustainably way (hypothesis 1.4). It is therefore confirmed that greater customer focus on sustainable concepts encourages companies to invest in CE. Research conducted by Nielsen shows that sales of products with sustainable claims are growing faster: sales of chocolate, coffee and bath products increased by 5% in 52 weeks (from March 2017 to March 2018) with sustainable claims, instead of 2% without them.[3] Investments in R&D have a positive effect on the willingness to undertake CE practices, but the results differ from the hypothesis stated. We expected a strictly positive relationship; on the contrary, SMEs that invest 15–19.9% of their turnover in R&D are more likely to invest in CE than companies that invest ever lower and higher percentages. Therefore, the relationship is in the shape of an inverted U with an optimum point between 15% and 19.9%. In this study, excess R&D investment (as a percentage of turnover) reduces the value of the latent variable. It would be interesting to look at the impact of R&D investments in euros on the willingness to implement CE practices, but we do not have this data.

The second model introduced country-level variables where the number of covariates was limited to one for each sustainability dimension in order to avoid multicollinearity between the covariates. All our hypotheses formulated in the Sect. 2 were not supported by our analysis. This may be due to the choice of country-level variables, although there is support in the literature. The increase in the illiteracy rate has a positive effect on the willingness to undertake CE activities. No support for this result is found in the literature: it is not reasonable that a country with less education is more inclined to invest in sustainability. Through the descriptive analysis, we observed that, apart from Greece and Spain, the range of this value by country is very small, which probably leads to biased results. As a proxy of the economic dimension, we used per capita GDP and found that it has no effect on the willingness to undertake CE practices. In recent years, the globalization and a more open economy in general have facilitated economic growth. However, it has also undermined the environmental conditions of our planet and the scarcity of its resources (Tampakoudis, 2013). The growth of the amount of waste has a negative effect on the willingness to undertake CE practices. As stated before on waste, the idea of a linear economy ("collect and dispose") is still widespread in EU and there are difficulties in creating new resources from waste (Lee et al., 2017). Therefore, countries with more waste (and consequently higher production and consumption) pollute more. The Corruption Perception Index does not have a significant impact on the willingness to undertake CE activities. Although corruption in

[3] https://nielseniq.com/global/en/insights/report/2018/whats-sustainability-got-to-do-with-it/ (accessed on 27/10/2022).

institutions is a social nuisance affecting the country's economy, it has been found that SMEs are not typically involved in such practices (Suleimenova, 2018).

Although two of the four country-level variables do not have significant estimated coefficients, we observed that the intra-class correlation coefficients (ICCs) in both models (excluding and with country-level covariates) differ significantly. Therefore, the data provided by these indicators is important, despite a variability of almost 10% between countries, which is explained by other country-level variables.

The final results obtained in Sect. 5 refer to the estimated factor scores at the company and country level. In both cases, the country rankings are similar with a few exceptions; Eastern countries show lower values than Western ones. On the other hand, the within-country dispersion reveals that there are no important differences between countries. This result is supported by descriptive statistics of country-level variables, which underline that the differences in indicators regarding the dimensions of sustainable development in countries are not large; this result is also supported by estimates at the upper level.

The topic of country-level effects on the implementation of CE practices deserves therefore further investigation. The non-significant effects estimated by our model might be due to many possible reasons, for example, a wrong choice of the indicators selected for each dimension, confounding effects due to factors that we did not explicitly consider as different policies to favor CE practices adopted in the various EU MSs, difference in accessibility to financial support by SMEs. The decrease in the ICC, however, encourages further research that can be conducted with eventually more recent data collected with other Eurobarometer surveys.

At this stage, it is also important to highlight the limitations and possible development of the analysis. The whole model was intended to summarize data on five items into a single latent variable that measured the overall willingness and to examine the impact of a small number of covariates at two levels in order to have a parsimonious model. At company level it was decided to examine the covariates linked to the characteristics of companies, but it was also possible to introduce variables on the perception of the companies towards the concept of CE. The selection of the country-level covariates was based on the literature. As we have already explained, there are other indicators that can explain the willingness to undertake CE practices and require more in-depth research on it. A second limitation includes the type of data analyzed. Usually, surveys have social desirability bias problem, which is the tendency of respondents to answer the question in order to give a better image of themselves, even if the survey is anonymous. This can negatively affect the validity of the research and there are no tools to avoid it. However, the introduction of country-level covariates helps reducing this problem because the heterogeneity at the country-level is a good indicator of the differences between respondents in cross-cultural research (Hoogendoorn et al., 2015).

Other possible developments of this research include the introduction of micro variables related to company's perception of access to information and resources for possible CE activities. More broadly speaking, this methodology can be applied to multilevel data sets with multilevel structure such as the European Social Survey (Mingo & Faggiano, 2020).

The findings of this research may impact on the implementation of the European Green Deal, which aims to increase resource efficiency through the transition to a clean and EU circular economy. National and European policies should consider both firms and countries

characteristics to have a real impact on implementation by SMEs of CE practices that are strictly linked SDGs.

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Declarations

Conflict of Interest The authors declare no conflicts of interests.

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