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# Charting Resource Efficiency Practices Across European Firms: A Multilevel Analysis

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## ABSTRACT

The circular economy (CE) is a key sustainability paradigm, prompting European Union (EU) organizations and policymakers to move beyond linear production and consumption models. The study aimed to assess the implementation patterns of nine CE activities among EU companies and to explore how the implementation of these CE activities relates to certain firm-level characteristics. A multilevel latent class model was employed in a sample of 13,084 companies across the 27 EU Member States. The study reveals significant variation in the implementation of CE activities across countries and companies, identifying five distinct company classes ranging from those with no CE adoption to those that are advanced adopters, with all nine activities. It also identifies six geographically dispersed country groups, each with a unique composition of companies based on their CE engagement. Furthermore, companies with higher CE implementation are typically larger, despite the sample being predominantly comprised of micro and small enterprises, older (having been established for over 7 years), and reporting higher annual turnover. These firms also tend to invest a smaller proportion of their turnover in resource efficiency measures. This study advances circular economy research by integrating the resource-based view and dynamic capabilities theory, demonstrating that sustained CE implementation requires both valuable resources and the dynamic ability to reconfigure them in response to changing contexts. It also reveals significant variations in CE adoption across EU regions and firms, advocating for tailored, sector-specific policies and practical measures, such as financial incentives for SMEs and enhanced managerial training, to drive sustainable transitions.

## 1 | Introduction

The circular economy (CE) has increasingly emerged as a critical paradigm for sustainable development, prompting organizations and policymakers across the European Union (EU) to rethink traditional linear production and consumption models (Lopes and Farinha 2019; Lopes, Pinho, and Gomes 2025). At its core, CE emphasizes the reduction of waste, the continual use of resources, and the integration of environmental considerations into business practices (García-Quevedo et al. 2020). This approach seeks to decouple economic growth from resource depletion by promoting strategies such as recycling, reusing, and refurbishing products, thereby extending their lifecycle and minimizing environmental impact (Kumareswaran et al. 2024; Mora-Contreras et al. 2023). Recent statistics indicate a steady but uneven uptake of CE activities across the EU, with notable disparities among member states and industry sectors. For instance, data reveal that approximately 28.57% of European

Union (EU) companies have adopted at least one CE practice, while others lag due to factors such as limited resources, regulatory challenges, or lack of awareness (Langen et al. 2021). These barriers are particularly pronounced in small and medium-sized enterprises, which often face financial constraints and lack the technical expertise to implement CE strategies effectively (Patricio et al. 2018; Perera and Badir 2025). Conversely, sectors such as manufacturing and waste management have shown greater progress, driven by stricter regulations and market incentives (Dennison et al. 2024; Mhatre et al. 2021).

The literature in recent years has examined CE implementation, focusing on drivers, barriers, and impacts within EU companies. Dey et al. (2022) have investigated the effectiveness of various CE activities, such as eco-design, product-life extension, and resource recovery, in improving sustainability performance and competitive advantage. Additionally, Mora-Contreras et al. (2023) have increasingly explored the influence of both internal factors (like leadership commitment and employee engagement) and external factors (including policy incentives and market demand) on the success of CE initiatives.

Despite the growing recognition of the CE as a key driver for sustainability and competitiveness in the European Union, the literature reveals significant gaps in understanding the implementation of specific CE activities among companies. Few studies focus on broad adoption trends, such as the overall uptake of CE principles, but fail to explore how these activities are integrated into business operations or the contextual factors influencing these choices (Dey et al. 2022). Notably, there is limited insight into the nuanced challenges firms face when transitioning to circular business models, particularly regarding how company characteristics shape the adoption of distinct CE initiatives (Langen et al. 2021; Mora-Contreras et al. 2023) Moreover, the literature often treats CE adoption as a uniform process, overlooking the diversity of CE activities and the varying priorities or barriers different firms encounter, which limits the development of tailored strategies to enhance CE implementation across diverse business profiles (Dey et al. 2022). That said, two important questions need to be answered: (RQ1) What are the implementation patterns of distinct CE activities among EU companies? (RQ2) How do company characteristics influence the implementation of these CE activities?

This study aims to evaluate the implementation patterns of nine CE activities by EU companies and explore the relationships between the implementation of CE activities and the characteristics of these companies. To this end, this study includes data from 13,084 companies located in the 27 EU Member States.

This study makes important contributions. Theoretically, it advances CE research by integrating the resource-based view (RBV) and dynamic capabilities theory (DCT), demonstrating that sustained CE implementation relies on both valuable resources (RBV) and the dynamic ability to reconfigure them (DCT) in response to internal and external shifts, thus providing a nuanced framework for understanding CE strategies. It highlights that CE engagement depends on firms' capabilities to sense, seize, and transform resources into sustainability outcomes, while also extending RBV and DCT by showing their application must be contextualized within diverse national and sectoral ecosystems. Empirically, the research reveals significant variations in CE implementation across EU countries, regions, and firm types, advocating for tailored, region- and sector-specific policies over a uniform approach. Practically, it recommends targeted financial incentives for SMEs, engagement of business associations for peer learning, enhanced managerial training, cross-border collaboration for knowledge transfer, and integration of CE principles into education to foster long-term sustainability transitions. This dual approach directly informs the research questions: RBV helps identify how inherent firm characteristics (e.g., higher turnover enabling resource allocation for CE) influence implementation (RQ2), while DCT elucidates the adaptive processes that lead to diverse patterns of CE adoption (RQ1), such as reconfiguring supply chains for recycling or renewable energy use in response to regulatory or market pressures.

## 2 | Literature Review

### 2.1 | Theoretical Framework

Dynamic capabilities theory (DCT) is fundamentally centered on a firm's ability to adapt and evolve in response to rapidly changing environments. It emphasizes that merely possessing valuable resources is insufficient for sustained competitive advantage; instead, organizations must develop unique routines and processes that allow them to reconfigure their resource base effectively (Eisenhardt and Martin 2000; Lopes, Gomes, and Nogueira 2025). This perspective shifts focus from static resource possession to the firm's capacity to innovate, learn, and re-allocate resources dynamically, which is crucial for maintaining relevance in volatile markets. Supporting this view, evidence from diverse sectors indicates that firms excelling in dynamic capabilities are better equipped to seize new opportunities and mitigate threats, thereby enhancing overall performance (Kero and Bogale 2023). Consequently, understanding and cultivating these capabilities is vital for companies aiming to thrive amid continuous environmental shifts. In the context of this study, DCT informs the first research question by explaining how firms dynamically reconfigure their processes to adopt varying patterns of CE activities, such as shifting from linear to circular models through innovation in resource use and waste management. It also addresses the second research question by highlighting how company characteristics, like age and investment levels, enable the dynamic reconfiguration needed to influence CE implementation.

The RBV underscores that a company's sustained competitive advantage derives primarily from its unique resources and capabilities (Ferreira et al. 2023; Lopes et al. 2021). These resources, which include tangible assets, intangible assets, and organizational capabilities, must be valuable, rare, inimitable, and non-substitutable to confer long-term success (D'Oria et al. 2021). The RBV posits that firms should focus on developing and protecting these strategic assets to differentiate themselves from competitors. This resource-centric approach provides a framework for analyzing internal strengths and aligning strategic initiatives accordingly. As a result, the RBV serves as a foundational theory for understanding how firms build and sustain competitive advantages through their unique resource configurations. Specifically, RBV guides the second research question by positing that firm-level characteristics—such as size, turnover, and founding year—act as valuable resources that shape the ability to implement CE activities, while also informing the first research question through the lens of how these static resources form the basis for distinct implementation patterns across EU companies.

Integrating DCT with the RBV offers a comprehensive lens for analyzing CE activities. While RBV emphasizes the importance of possessing valuable resources, dynamic capabilities highlight the necessity of continuously evolving these resources to adapt to external changes (Ferreira et al. 2023; Lopes, Gomes, and Nogueira 2025). This integration allows researchers and practitioners to understand not only what resources are critical but also how firms can reconfigure and leverage them to innovate and explore new markets. For instance, a company might possess a strong technological resource (RBV), but without dynamic capabilities to adapt and redeploy this resource in response to market shifts, its competitive advantage may erode (Kero and Bogale 2023; Sánchez and Alfaro 2025). Therefore, combining both theories provides a robust framework for fostering entrepreneurial activities within established organizations, enabling them to sustain growth and competitive relevance in dynamic environments.

## 2.2 | CE Activities Adoption in Companies

The CE emphasizes resource conservation and sustainability, with water and energy management being pivotal (Tritto et al. 2024). Companies adopting CE principles implement water-saving strategies like low-flow fixtures, efficient manufacturing processes, and greywater recycling, reducing consumption and costs while enhancing corporate responsibility (Lopes, Gomes, and Nogueira 2025). Similarly, energy conservation through efficient machinery, optimized workflows, and smart energy systems lowers carbon emissions and operational expenses, boosting brand reputation (Daroon et al. 2023; Ding et al. 2021). Transitioning to renewable energy sources, such as solar or wind, further aligns operations with CE by cutting carbon footprints and reliance on finite resources, offering long-term economic benefits and supporting global sustainability goals (Majid et al. 2023). These integrated efforts create a synergistic impact, advancing environmental performance and sustainable resource use.

The CE promotes sustainable resource management by optimizing material use, prioritizing greener suppliers, and minimizing waste, aligning with environmental and economic goals. Companies enhance resource efficiency by adopting durable and modular product designs, which extend product lifespans and facilitate repair, reducing the need for virgin materials (Patwa et al. 2021; Vagnoni et al. 2025). Advanced manufacturing techniques further minimize scrap, lowering resource consumption and procurement costs while supporting sustainable production (Majid et al. 2023). Transitioning to greener suppliers, who use eco-certified or recycled inputs, reduces the environmental footprint of supply chains and encourages sustainable practices industry-wide, enhancing corporate reputation and meeting consumer demand for ethical goods (Lopes, Gomes, and Nogueira 2025). Additionally, CE emphasizes waste minimization through robust waste management systems that prevent waste at the source, repurpose residues, and recycle materials, transforming waste into economic value and reducing landfill use (Majid et al. 2023; Patwa et al. 2021). These integrated strategies, optimizing resource use, sourcing sustainably, and minimizing waste, collectively foster resilient, cost-effective, and environmentally responsible production systems, embodying the core principles of the circular economy.

The CE fosters sustainable resource management by transforming waste into economic value, promoting internal recycling, and designing products for longevity, aligning environmental and economic objectives. Selling residues and waste to other companies, such as scrap metal, packaging, or organic by-products, enables firms to reduce disposal costs and create closed-loop systems that enhance resource efficiency and minimize landfill use (Majid et al. 2023). This practice not only supports sustainability but also fosters new business collaborations and markets focused on waste valorization. Similarly, internal recycling, re-melting plastics, reprocessing scrap metal, or reconditioning components, reduces the demand for virgin resources and energy, with closed-loop systems in manufacturing optimizing material use and cutting costs (Moreno-Mondéjar et al. 2021). Additionally, designing products for easier maintenance, repair, or reuse through modular designs, durable materials, and standardized components extends product lifespans, reduces waste, and appeals to eco-conscious consumers (Das et al. 2025). For instance, design for disassembly in electronics allows repairs or upgrades, enhancing brand reputation and resource conservation. These strategies—waste valorization, internal recycling, and sustainable design—collectively drive cost-effective, environmentally responsible systems, embodying CE principles.

## 2.3 | Characteristics of Companies in CE Activities

To understand the landscape of European Union (EU) companies in CE, it is important to understand the size, determined by a number of employees, founding year, annual revenue, and investment in CE initiatives as a share of turnover. The size and founding year of companies within the European Union are critical parameters for understanding their economic landscape. Company size is often classified based on the number of employees, with definitions set by the European Commission and other authorities. For example, small and medium-sized enterprises (SMEs) are generally characterized as firms employing fewer than 250 employees, with additional criteria such as turnover and balance sheet totals (Lopes, Gomes, and Nogueira 2025; Milea et al. 2014). As of 2024, the EU comprised approximately 26.06 million enterprises, which collectively employed around 163 million people and generated a net turnover of €38 trillion (Espinosa 2024). The age of a company also influences its market position and innovative capacity; however, specific data on the distribution of firm ages across the EU is less standardized. Nonetheless, understanding both firm size and age helps delineate the diversity of businesses operating in the EU, from nascent startups to well-established multinational corporations, and provides context for their strategic choices, including investments in CE initiatives (Rosa and Paula 2023). From a RBV perspective, firm size and age represent valuable, rare, and often inimitable resources that enable companies to build competitive advantages in sustainability; larger and older firms may leverage their established networks and accumulated knowledge as strategic assets to pursue CE initiatives more effectively (Ferreira et al. 2023). Meanwhile, DCT suggests that these characteristics facilitate the firm's ability to sense environmental changes, seize CE opportunities, and transform operations, such as adapting processes for resource efficiency over time (Lopes, Gomes, and Nogueira 2025).

Annual turnover serves as a vital indicator of a company's economic activity and market scale. It is calculated based on the income generated from sales and services within a fiscal year, reflecting the firm's operational scale and financial health (Bologa and Doros 2012; Mereuţă 2014). Within the EU, company turnovers vary significantly, with small firms often earning less than €10 million annually, while larger corporations surpass this threshold substantially (Schöggl et al. 2023). Recent studies indicate that firms investing in CE activities tend to have higher turnovers, aligning with their greater capacity for resource allocation and strategic innovation. Moreover, the proportion of turnover dedicated to CE initiatives underscores a company's commitment to sustainability and resource efficiency. For instance, some research highlights that larger companies allocate a notable percentage of their turnover toward CE practices to meet regulatory and market demands, thereby fostering long-term competitiveness (Opferkuch et al. 2022). Under RBV, annual turnover acts as a tangible resource that provides the financial slack necessary for investing in CE, positioning it as a key driver of sustained competitive advantage in circular practices (D'Oria et al. 2021). In contrast, DCT views turnover investment in CE as a dynamic process, where firms reconfigure financial resources to respond to evolving sustainability demands, such as reallocating funds for innovative waste reduction or renewable energy adoption (Kero and Bogale 2023).

The literature provides valuable insights into the characteristics and behaviors of EU companies, especially regarding their engagement with CE activities. Studies emphasize that company size, age, and turnover are interconnected factors influencing a firm's sustainability strategies (Opferkuch et al. 2022; Reike et al. 2018; Rosa and Paula 2023). For example, firms with higher turnovers and larger employee bases are more likely to invest in CE due to their greater resource availability and strategic focus on sustainability (Tritto et al. 2024). Furthermore, research shows that the adoption of CE practices is increasingly prevalent among firms listed in sustainability rankings, with newer and larger companies leading the way (Opferkuch et al. 2022). These findings suggest that company characteristics such as size, financial capacity, and industry sector significantly shape the adoption and implementation of circular economy principles within the EU business landscape. Integrating RBV and DCT, these characteristics not only serve as static resources (RBV) that underpin CE engagement but also enable dynamic reconfiguration (DCT) in response to contextual factors, allowing firms to adapt and innovate in diverse national and sectoral ecosystems for enhanced sustainability outcomes (Ferreira et al. 2023).

## 3 | Methods

### 3.1 | Sample Collection Procedures

The data for this study were drawn from the Flash Eurobarometer 549—SMEs, Resource Efficiency and Green Markets survey, conducted by the GESIS—Leibniz Institute for the Social Sciences and published in 2025. This survey covers small and medium-sized enterprises (SMEs) across the 27 European Union (EU) Member States and 10 non-EU countries (Albania, Iceland, Moldova, Montenegro, Norway, Serbia, Switzerland, Turkey, the United Kingdom, and the United States). The questionnaire targeted individuals with decision-making authority within the company, such as managing directors, general managers, CEOs, financial directors, as well as those responsible for commercial activities (e.g., commercial, sales, or marketing managers) or legal affairs. Accordingly, only one questionnaire was completed per company by a relevant decision-maker. Data collection took place between June 3 and June 28, 2024, resulting in a total of 18,159 interviews with company managers. These companies represented 12 different economic sectors. The sample is non-probabilistic, and all interviews were conducted using computer-assisted telephone interviewing (CATI). For this study, only responses from companies located in the 27 EU Member States were included in the final analysis, yielding a sample of 13,084 companies.

### 3.2 | Variables and Measurements

#### 3.2.1 | CE Activities of Companies

In the questionnaire, SMEs were asked: "Q1. What measures does your company take to be more efficient regarding resources?". The answer allowed multiple responses among 11 CE activity options: (i) water saving; (ii) energy savings; (iii) predominant use of renewable energy (including own production with solar panels, etc.); (iv) saving materials; (v) switching to more environmentally friendly material suppliers; (vi) waste reduction; (vii) sale of residues and waste to another company; (viii) recycling, reusing material or waste within the company; (ix) designing products that are easier to maintain, repair or reuse; (x) other; (xi) none. A binary scale was assigned for data processing: 1—implemented and 0—not implemented. All of these items represent measures companies adopt to enhance resource efficiency, aligning with the principles of the circular economy model: the reduction of natural resource use, recycling, reuse, redesign, and repair.

#### 3.2.2 | Measures of Properties and Activities of SMEs

The questionnaire contains measures of different characteristics of European companies. Four variables were selected to characterize the companies of the sample: (i) company size measured by the number of employees (micro entities: 1–9 employees; small entities: 10–49 employees; medium entities: 50–249 employees; big entities: more than 250 employees); (ii) year of company foundation (measured by four categories: before 2016; between 2016 and 2018; between 2019 and 2023;

after January 1, 2023); (iii) annual turnover in 2023 (measured by nine categories: less than 25,000 euros; from 25,000 to 50,000 euros; from 50,000 to 100,000 euros; from 100,000 to 250,000 euros; from 250,000 to 500,000 euros; from 500,000 euros to 2 million euros; from 2 million euros to 10 million euros); (iv) average annual investment to improve resource efficiency (measured by five categories: less than 1% of annual turnover; 1%–5%; 6%–10%; 11%–30%; more than 30% of annual turnover).

Regarding activity measures, the reduced NACE (Nomenclature of Economic Activities) classification of economic activities in the EU was considered. Thus, the activities of European companies were divided into 12 activities according to NACE: (i) mining and quarrying; (ii) manufacturing; (iii) electricity, gas, steam, and air conditioning supply; (iv) water supply, sewerage, waste management, and remediation activities; (v) construction; (vi) wholesale and retail trade, repair of motor vehicles and motorcycles; (vii) transportation and storage; (viii) accommodation and food service activities; (ix) information and communication; (x) financial and insurance activities; (xi) real estate activities; (xii) professional, scientific, and technical activities.

## 3.3 | Sample Characterization

### 3.3.1 | CE Activities

The results of the frequency of implementation of CE activities by European companies are described in Table 1. The CE activities most implemented in EU companies are energy saving (66.1%), waste reduction (65.3%), and material saving (57.9%). The least implemented activity predominantly uses renewable energy, for example, including own production through solar panels, etc. (28.1%) and design products (28.4%). Only 6% of EU companies surveyed responded that they do not implement any resource efficiency measures, and 1% implement other resource efficiency measures in addition to those listed in Table 1.

Compared with the last wave (2021), according Lopes, Gomes, and Nogueira (2025), the most frequent implementation of CE activities by European SMEs was designing products that are easier to maintain, repair, or reuse (73.6%), energy saving (61.5%), and materials saving (56.2%).

Considering the average implementation of the 9 CE activities of companies by EU countries (Figure 1), we observe that 14 countries (51.9% of EU countries) have implemented CE measures below the average value ($M = 4.03$ CE activities). The four lowest-performing countries are Portugal ($M = 2.49$), Ireland ($M = 2.61$), Latvia ($M = 2.96$) and Cyprus ($M = 3.00$). The means were calculated using weighted data to account for variations in the number of companies across the countries included in the sample. Figures 1 and 2 illustrate the cross-country heterogeneity in adopting CE activities.

Figure 2 displays the average percentage of CE practice adoption at the country level. The color gradient, ranging from light to dark, indicates the intensity of CE activity implementation by companies, with darker shades representing higher levels of adoption.

**TABLE 1** | Frequency of implementation of CE activities.

| | Implemented (%) | Not implemented (%) |
|---|---|---|
| Saving water | 48.4 | 51.6 |
| Saving energy | 66.1 | 33.9 |
| Using predominantly renewable energy | 28.1 | 71.9 |
| Saving material | 57.9 | 42.1 |
| Switching to greener suppliers of materials | 36.5 | 63.5 |
| Minimizing waste | 65.3 | 34.7 |
| Selling your residues and waste to another company | 30.7 | 69.3 |
| Recycling, by reusing material or waste within the company | 47.4 | 52.3 |
| Designing products that are easier to maintain, repair or reuse | 28.4 | 71.6 |

### 3.3.2 | Characterization of Companies and Their Sector of Activity

The characterization of the companies in the sample is presented in Table 2. Regarding the size of the EU companies in the sample, 41.1% are micro-enterprises (1–9 employees), 34.4% are small companies (10–49 employees), 17.9% are medium-sized companies (50–249 employees), and 6.5% are large companies (more than 250 employees). The majority of companies were founded before 2016 (80.2%). In terms of annual turnover in 2023, 18.9% of companies reported a turnover between 500,000 and 2 million euros, while 15.8% had a turnover between 2 million and 10 million euros. Regarding the annual turnover investment in resource efficiency measures, 18.7% of EU companies did not invest at all, 20.7% invested less than 1%, 28.5% invested between 1% and 5%, and only 13.8% invested more than 6% of their annual turnover.

Among the sectors of activity of the companies (Table 3), the most representative in the sample are wholesale and retail trade, repair of motor vehicles and motorcycles (29%), manufacturing industry (21.1%), and construction (16.0%).

## 3.4 | Data Analysis

For data analysis, descriptive statistics were performed on the variables used in the study, using the SPSS software (V.25).

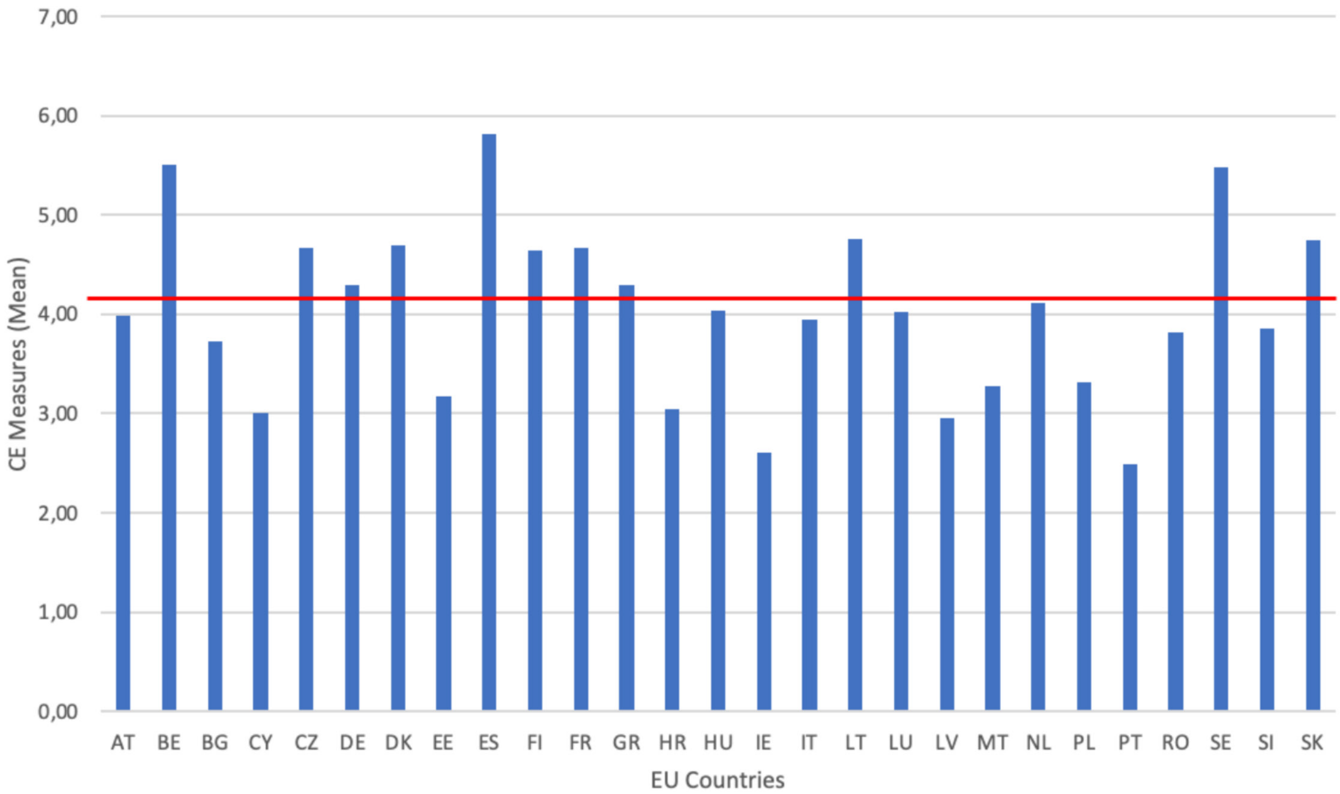


**FIGURE 1** | Country-level averages of CE activities implementation. Red line—mean: 4.03 activities. AT—Austria; BE—Belgium; BG—Bulgaria; CY—Cyprus (Republic); CZ—Czech Republic; DE—Germany; DK—Denmark; EE—Estonia; ES—Spain; FI—Finland; FR—France; GR—Greece; HR—Croatia; HU—Hungary; IE—Ireland; IT—Italy; LT—Lithuania; LU—Luxembourg; LV—Latvia; MT—Malta; NL—The Netherlands; PL—Poland; PT—Portugal; RO—Romania; SE—Sweden; SI—Slovenia; SK—Slovakia.

Then, following the methodology of Bassi and Dias (2020), Bassi and Martín (2024) and Lopes, Gomes, and Nogueira (2025), and considering the objective of this study to evaluate the heterogeneity in the adoption of CE activities by European companies both within and between countries, and given that our sample is composed of data on companies with different characteristics (size, year of foundation, and annual turnover) operating in various sectors of activity, we estimate a multi-level latent class (LC) model. We therefore identify clusters of companies and countries that adopt similar sets of CE practices within defined classes. LC models are well suited for this purpose, as they are based on the assumption that observed relationships among variables are influenced by one or more unobserved (latent) categorical variables. These models account for the categorical nature of the data and allow for the identification of underlying subgroups with distinct patterns of behavior. Specifically, multilevel LC was chosen because it allows the identification of unobserved heterogeneity at multiple hierarchical levels (e.g., individual and organizational, or regional), which is particularly relevant for sustainability research that often involves nested data structures. Unlike traditional clustering methods (such as *k*-means or hierarchical clustering), multilevel LC accounts for measurement error and latent heterogeneity rather than relying solely on observed indicators; enables the estimation of class membership probabilities, providing a probabilistic rather than deterministic classification; allows for simultaneous modeling of within-group and between-group variance, thus capturing differences across contexts (e.g., organizations, regions, industries) that are common in sustainability studies; and offers statistical criteria (AIC, BIC, entropy, LMR test) to determine the optimal number of classes, improving model robustness and interpretability (Morin et al. 2020; Oberski 2016).

Originally introduced by Lazarsfeld and Henry (1968), LC models enable the detection of heterogeneity in a sample by assuming that it is composed of distinct subpopulation, in this case, companies with different profiles of CE activity adoption. An essential assumption of the LC model is conditional independence, meaning that within each latent class, the observed CE activity variables are statistically independent. Accordingly, the probability of observing a specific pattern of responses across the CE activities, denoted as $P(Y = y)$, is modeled as the weighted average $(pk)$ of the class-specific probabilities $P(Y = y | K = k)$. This fundamental structure of an LC model can be expressed as follows:

$$
\begin{aligned}
P\left( Y_{ij} = s \right) &= \sum_{i=1}^{L} P\left(Z_{ij} = I\right) P\left(Y_{ij} = I\right) \\
&= \sum_{i=1}^{L} P\left(Z_{ij} = I\right) \prod_{k=1}^{K} P\left(Y_{ij} = s_k \mid Z_{ij} = I\right)
\end{aligned} \tag{1}
$$

Accordingly, the probability of observing a specific response pattern is modeled as the weighted average of the class-specific probability $P\left(Y_{ij} = s_k \mid Z_{ij} = I\right)$, where company $i$, located in country $j$, belongs to latent class $I$. As outlined by Vermunt (2003), multilevel LC models extend the traditional

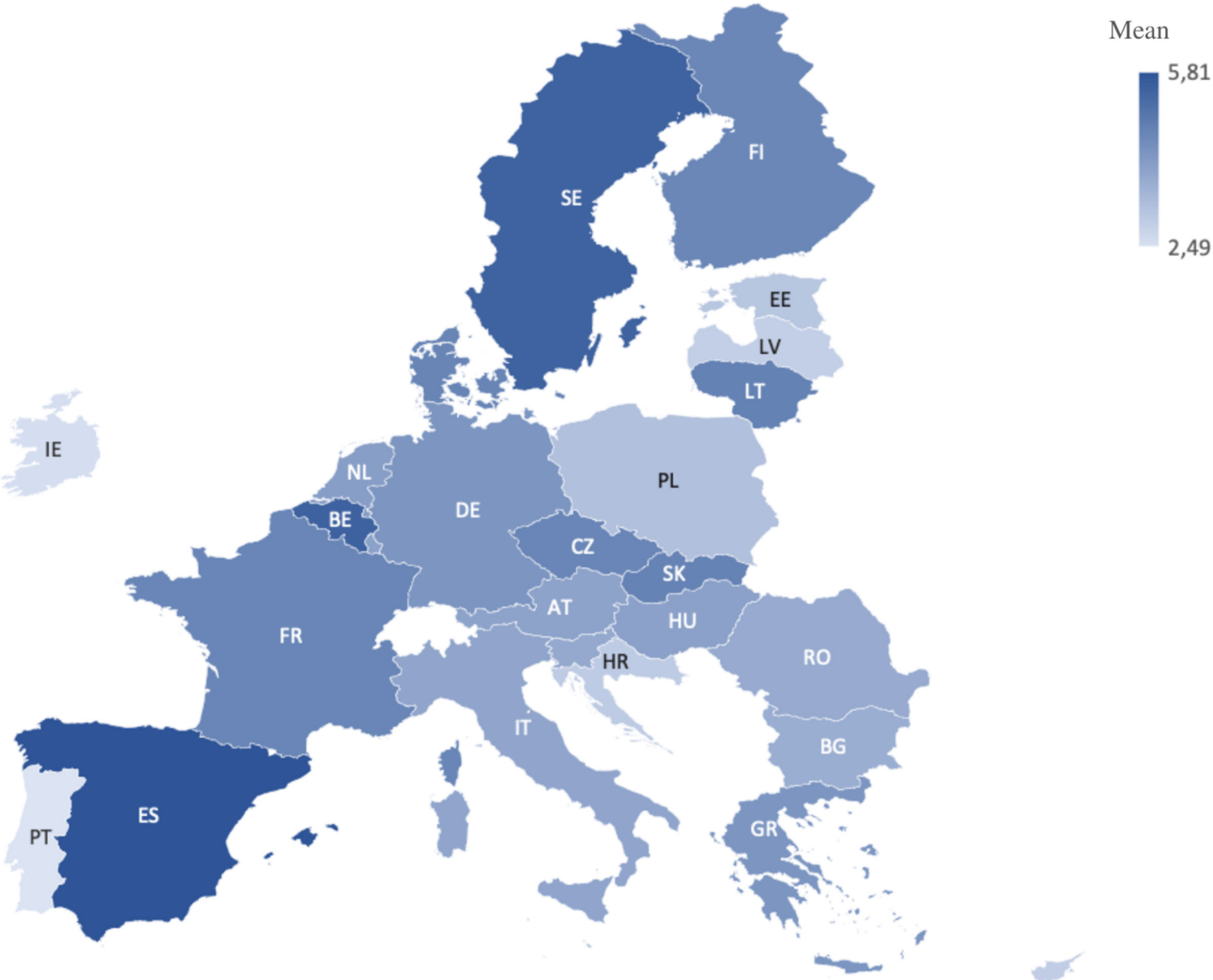


**FIGURE 2** | Comparison between countries of average adoption of CE activities. AT—Austria; BE—Belgium; BG—Bulgaria; CY—Cyprus (Republic); CZ—Czech Republic; DE—Germany; DK—Denmark; EE—Estonia; ES—Spain; FI—Finland; FR—France; GR—Greece; HR—Croatia; HU—Hungary; IE—Ireland; IT—Italy; LT—Lithuania; LU—Luxembourg; LV—Latvia; MT—Malta; NL—The Netherlands; PL—Poland; PT—Portugal; RO—Romania; SE—Sweden; SI—Slovenia; SK—Slovakia.

LC framework by allowing model parameters to vary across level-2 units or clusters (e.g., countries). Unlike standard LC models, which assume that the parameters are homogeneous across the entire sample, multilevel LC models enable the examination of how group-level (level-2) factors influence individual-level (level-1) class membership and response patterns. In this extended framework, the model is specified to include both level-1 and level-2 parameters, with a discrete latent variable defined at the group level. This allows for latent class distributions to vary across clusters, offering a more nuanced understanding of heterogeneity across contexts.

$$P(Y_{ij}=s) = \sum_{h=1}^{H}\left[P(W_j=h)\right] \prod_{i=1}^{nj}\left[P(Z_{ij}=I \mid X_{ij}=x_{ij}w_j=h)\right] \prod_{k=1}^{K} P(Y_{ij}=s_k \mid Z_{ij}=I) \quad (2)$$

In this model, $W_j$ denotes the latent variable at the country level (level-2), $Z_{ij}$ represents the latent variable at the company level (level-1), and $n_j$ indicates the number of companies in country $j$. Under this framework, companies' responses are considered conditionally independent, given their membership in a specific latent class at the country level. The latent categories at level-1 are referred to as *clusters*, while the categories at level-2 are referred to as *classes*. In the context of this study, European countries (level-2) are grouped into homogeneous classes based on the similarity of the company-level clusters (level-1) within them. Given that the data were sourced from the Flash Eurobarometer survey, as previously noted, sampling weights were applied to ensure that the sample for each country was nationally representative. This weighting is crucial, as emphasized by Vermunt (2003), because the multilevel latent class model relies on the Expectation–Maximization (EM) algorithm for parameter estimation. A known limitation of the log-likelihood function in mixture models is the EM algorithm's tendency to converge on local maxima. To mitigate this issue, 300 model runs were conducted for each combination of class numbers at the company level using the *Latent GOLD 5.0* software.

**TABLE 2** | Frequency of properties and activities measures.

| Variables | Frequency (%) |
|---|---|
| Employees | |
| 1–9 | 41.1 |
| 10–49 | 34.4 |
| 50–249 | 17.9 |
| More than 250 | 6.5 |
| Foundation year | |
| Before 2016 | 80.2 |
| Between 2016 and 2018 | 8.4 |
| Between 2019 and 2023 | 8.9 |
| After January 1, 2023 | 2.5 |
| Annual turnover (2023) | |
| < 25,000 euros | 5.0 |
| More than 25,000 to 50,000 euros | 6.3 |
| More than 50,000 to 100,000 euros | 6.9 |
| More than 100,000 to 250,000 euros | 10.7 |
| More than 250,000 to 500,000 euros | 9.8 |
| More than 500,000 euros to 2 million euros | 18.9 |
| More than 2 million euros to 10 million euros | 15.8 |
| More than 10 million euros to 50 million euros | 8.9 |
| More than 50 million euros | 4.0 |
| Annual turnover invested in CE | |
| Nothing | 18.7 |
| Less than 1% of annual turnover | 20.7 |
| 1%–5% of annual turnover | 28.5 |
| 6%–10% of annual turnover | 8.7 |
| 11%–30% of annual turnover | 3.3 |
| More than 30% of annual turnover | 1.8 |
| Do not know/no answer | 11.5 |

Among these, the solution with the highest log-likelihood was selected. The optimal number of latent classes was determined using the Bayesian Information Criterion (BIC) (Schwarz 1978). The BIC is a model selection criterion that balances model fit and complexity: it considers how well the model explains the data (likelihood) while penalizing models with more parameters to avoid overfitting. Specifically, lower BIC values indicate a better compromise between goodness of fit and parsimony. Therefore, among the estimated models, the solution with the lowest BIC value was selected as the most appropriate representation of the data (Linzer and Lewis 2011).

Figure 3 summarizes the modeling process.

**TABLE 3** | Frequency of companies by economic activity.

| Economic activity by NACE | Frequency (%) |
|---|---|
| B—mining and quarrying | 0.5 |
| C—manufacturing | 21.1 |
| D—electricity, gas, steam, and air conditioning supply | 1.2 |
| E—water supply, sewerage, waste management and remediation activities | 1.7 |
| F—construction | 16.0 |
| G—wholesale and retail trade, repair of motor vehicles and motorcycles | 29.0 |
| H—transportation and storage | 5.9 |
| I—accommodation and food service activities | 6.0 |
| J—information and communication | 4.3 |
| K—financial and insurance activities | 2.8 |
| L—real estate activities | 2.1 |
| M—professional, scientific, and technical activities | 9.5 |

## 4 | Results

Table 4 presents the outcomes of the multilevel LC model estimation, which was applied to determine the optimal number of company clusters and country-level classes. The selected model identifies five distinct clusters of companies and six classes of European countries. This configuration was chosen based on the BIC, which indicated the best model fit among various combinations of clusters and classes. Following the guidance of Linzer and Lewis (2011), the most appropriate model is the one that minimizes the BIC. In this case, the BIC consistently decreased until the model included five clusters and six classes, after which additional increases in complexity led to rising BIC values, indicating a less optimal fit.

Each cluster of European companies has a different percentage of companies that have adopted CE activities, as shown in Table 5. Firm-level cluster 1, which contains 25.03% of companies, is the largest cluster and has implemented eight CE activities; therefore, it was designated as "advanced adopters". Companies in cluster 2 (22.2% of the companies in the sample) adopted four CE activities: saving energy (conditional probability 0.6239), minimizing waste (0.7554), saving materials (0.5989), and recycling, which involves reusing materials or waste within the company (0.5308). Cluster 2 was designated as "selective adopters". Firm-level cluster 3 contains 21.58% of companies, and no CE activity was implemented; thus it was defined as "non-adopters". Cluster 4, which represents 17.17% of European companies in the sample, was designated as "moderated adopters", having implemented five CE activities: saving water (conditional probability 0.8779), saving energy (0.9348), minimizing waste (0.7984), saving materials (0.7365), and recycling, by reusing material or waste within the company (0.6624). Cluster 5 represents 14.02% of companies, and these only adopted a single CE activity (recycling, by reusing material or waste within the company—conditional probability 0.5915), and were designated as "limited adopters".

Therefore, it can be inferred that there are independent trends in how EU companies implement CE activities. These patterns represent varying levels of CE adoption, with companies differing in the extent to which they engage in these practices, consistent with the findings of Katz-Gerro and López Sintas (2019) and Lopes, Gomes, and Nogueira (2025). This suggests that companies do not follow unique or particular combinations of CE activities; rather, these activities tend to be implemented independently from one another in a systematic way.

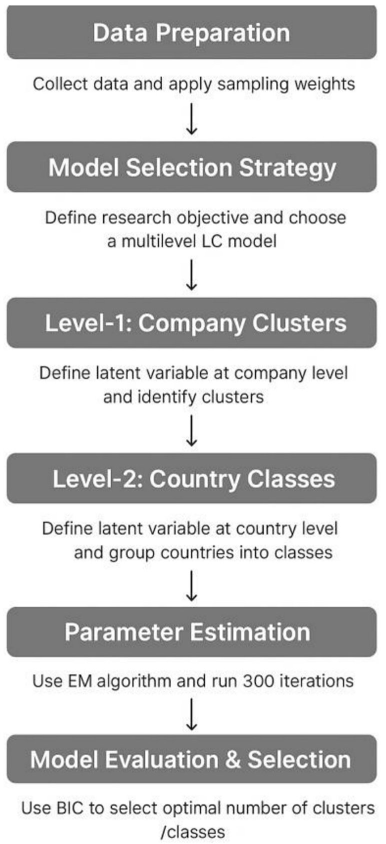


**FIGURE 3** | Modeling process.

Figure 4 shows the geographic allocation of countries to the six latent classes (representing the highest probabilities). More details are available in Table A.1. LC1 and LC2 each consist of six EU countries. LC1 includes Bulgaria, Cyprus, Estonia, Croatia, Latvia, and Poland, all from Central Europe (except for Cyprus). LC2 consists of the Czech Republic, Germany, Denmark, Finland, Romania, and Slovenia, all located in the northern hemisphere, specifically in Central, Northern, and Eastern Europe. LC3 consists of five countries (France, Greece, Hungary, Lithuania, and Slovakia); LC4 consists of four countries (Austria, Italy, Luxembourg, and the Netherlands), and LC5 and LC6 each include three countries (LC5 includes Ireland, Malta, and Portugal; LC6 includes Belgium, Spain, and Sweden).

Table 6 shows six EU groups of countries with five different types of companies. The percentages for each type of company are different. Thus, in group 1 of countries, only companies belonging to LC1, LC3, and LC4 are present; in group 2 of countries, LC1, LC2, LC3, and LC4 companies are present; in group 3, LC1, LC3, and LC4 companies are present; in group 4, LC2 companies are present; in group 5, LC5 companies are present; and in group 6, LC1 companies are present.

In the study, we consider four variables to characterize EU companies: (i) company size, measured by the number of employees; (ii) year of company foundation; (iii) annual turnover in 2023; and (iv) average annual investment in resource efficiency improvements.

Table A.2 in Appendix A describes the company profile, in terms of these characteristics, across the five classes identified within each of the six EU country groups. In Country Group 1, companies are predominantly part of Cluster 3 ("non-adopters"), characterized mainly as micro (1–9 employees) and small enterprises (10–49 employees), founded before 2016, with turnover mostly ranging between €100,000 and €10 million, and either no investment or very low investment (up to 5% of annual turnover) in resource efficiency measures. In Country Groups 2 and 6, companies are mostly part of Cluster 1 ("advanced adopters"), which also mainly consists of micro and small enterprises (1–49 employees) founded before 2016, with turnover primarily between €500,000 and €50 million, and investing between 1% and 5% of annual turnover in resource efficiency. In Country Group 3, companies predominantly fall into Cluster 4 ("moderate adopters").

**TABLE 4** | Results of multilevel LC model application.

| Model | Description | LL | BIC(LL) | AIC(LL) | *p*-value | Class. Err. | Entropy $R^2$ |
|---|---|---|---|---|---|---|---|
| Model 1 | 3-Cluster 5-GClass | −147,203 | 295,022.6 | 294,536.5 | 0.0000 | 0.0998 | 0.7481 |
| Model 2 | 3-Cluster 6-GClass | −147,178 | 295,000.5 | 294,491.9 | 0.0000 | 0.0989 | 0.7539 |
| Model 3 | 6-Cluster 3-GClass | −147,033 | 294,966.1 | 294,255.6 | 0.0000 | 0.245 | 0.6243 |
| Model 4 | 4-Cluster 5-GClass | −146,842 | 294,433.6 | 293,842.8 | 0.0475 | 0.1704 | 0.6705 |
| Model 5 | 4-Cluster 6-GClass | −146,758 | 294,301.8 | 293,681 | 0.0003 | 0.1731 | 0.6806 |
| Model 6 | 5-Cluster 4-GClass | −146,731 | 294,295.4 | 293,637.3 | 0.0000 | 0.1993 | 0.6614 |
| Model 7 | 5-Cluster 5-GClass | −146,572 | 294,024.6 | 293,329.1 | 0.0000 | 0.1951 | 0.6716 |
| Model 8 | 5-Cluster 6-GClass | −146,475 | 293,879.4 | 293,146.5 | 0.0000 | 0.1937 | 0.6803 |

*Note:* The shaded model indicates that it was selected for analysis.

**TABLE 5** | Implementation of CE activities within firm-level clusters.

| | Cluster 1, advanced adopters | Cluster 2, selective adopters | Cluster 3, non-adopters | Cluster 4, moderate adopters | Cluster 5, limited adopters | Overall |
|---|---|---|---|---|---|---|
| Cluster size | 0.2503 | 0.222 | 0.2158 | 0.1717 | 0.1402 | |
| Saving water | | | | | | |
| Non-implemented | 0.2119 | **0.6388** | **0.8606** | 0.1221 | **0.6193** | 0.4884 |
| Implemented | **0.7881** | 0.3612 | 0.1394 | **0.8779** | 0.3807 | **0.5116** |
| Saving energy | | | | | | |
| Non-implemented | 0.0429 | 0.3761 | **0.5324** | 0.0652 | **0.5696** | 0.3002 |
| Implemented | **0.9571** | **0.6239** | 0.4676 | **0.9348** | 0.4304 | **0.6998** |
| Using predominantly renewable energy (e.g., including own production through solar panels, etc.) | | | | | | |
| Non-implemented | **0.5111** | **0.6139** | **0.8272** | **0.8399** | **0.8462** | **0.7056** |
| Implemented | 0.4889 | 0.3861 | 0.1728 | 0.1601 | 0.1538 | 0.2944 |
| Saving materials | | | | | | |
| Non-implemented | 0.062 | 0.4011 | **0.686** | 0.2635 | **0.6592** | 0.3903 |
| Implemented | **0.938** | **0.5989** | 0.314 | **0.7365** | 0.3408 | **0.6097** |
| Switching to greener suppliers of materials | | | | | | |
| Non-implemented | 0.2821 | **0.6466** | **0.8571** | **0.6794** | **0.7291** | **0.618** |
| Implemented | **0.7179** | 0.3534 | 0.1429 | 0.3206 | 0.2709 | 0.382 |
| Minimizing waste | | | | | | |
| Non-implemented | 0.0212 | 0.2446 | **0.6181** | 0.2016 | **0.5934** | 0.3108 |
| Implemented | **0.9788** | **0.7554** | 0.3819 | **0.7984** | 0.4066 | **0.6892** |
| Selling your residues and waste to another company | | | | | | |
| Non-implemented | 0.4451 | **0.7195** | **0.751** | **0.7346** | **0.8456** | **0.6779** |
| Implemented | **0.5549** | 0.2805 | 0.249 | 0.2654 | 0.1544 | 0.3221 |
| Recycling, by reusing material, or waste within the company | | | | | | |
| Non-implemented | 0.2528 | 0.4692 | **0.7139** | **0.6624** | 0.4085 | 0.4925 |
| Implemented | **0.7472** | **0.5308** | 0.2861 | 0.3376 | **0.5915** | **0.5075** |
| Designing products that are easier to maintain, repair, or reuse | | | | | | |
| Non-implemented | 0.4326 | **0.6847** | **0.8806** | **0.8088** | **0.8177** | **0.7038** |
| Implemented | **0.5674** | 0.3153 | 0.1194 | 0.1912 | 0.1823 | 0.2962 |

*Note:* The bold value indicates the highest conditional probability of adopting a resource efficiency measure.

These are mainly micro enterprises (1–9 employees), almost all founded before 2016. Their turnover largely ranges between €500,000 and €50 million, and they invest little or nothing (up to 5%) in resource efficiency improvements. Country Group 4 includes companies from Cluster 2 ("selective adopters"), characterized by few employees, older founding dates (pre-2016), turnover mostly up to €2 million, and low levels of investment in resource efficiency (up to 5%). Finally, in Country Group 5, companies fall into Cluster 5 ("limited adopters"), which is composed mainly of micro-enterprises (up to 9 employees) founded before 2016, with turnover generally not exceeding €2 million and low investment in resource efficiency (up to 5% of turnover). In summary, the results show that the higher the degree of implementation of CE activities among European companies, the more likely they are to be larger (although most of the sample consists of micro and small enterprises), older (founded more than 7 years ago), have higher annual turnover, and allocate a smaller share of that turnover to resource efficiency investments.

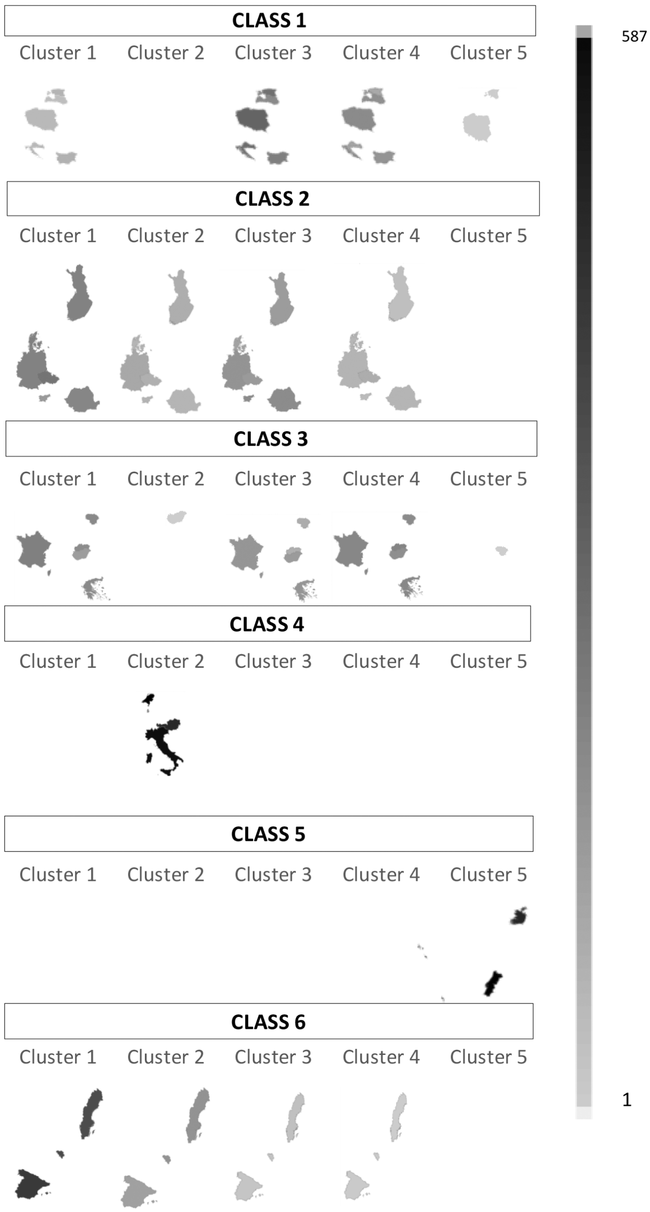


**FIGURE 4** | Country-level latent classes.

## 5 | Discussion and Implications

### 5.1 | Discussion of Results

This study investigated the implementation of nine distinct CE activities by EU companies, examining how firm-level characteristics influence this implementation. Six distinct country-level groupings and five firm-level clusters were identified, reflecting varying degrees of CE engagement. These findings underscore the multifaceted nature of CE implementation and challenge the assumption that firms uniformly adopt CE practices.

The first major insight from this study is that CE implementation patterns vary significantly across EU regions and firm profiles. The identification of six country-level latent classes demonstrates significant geographic variability in CE adoption across the EU. This regional variation suggests that macro-level factors, such as national policy frameworks, economic development levels, industrial structures, and institutional capacity, significantly influence the promotion and realization of CE strategies. As emphasized by Buyukyazici et al. (2025), advancing regional CE transitions critically depends on the presence of cohesive institutional frameworks and context-sensitive policy interventions that are responsive to the distinct territorial and economic dynamics of each region. Countries in latent class 1 (Bulgaria, Cyprus, Estonia, Croatia, Latvia, and Poland) predominantly comprise firms categorized in Cluster 3, which is defined by non-adoption of CE activities. Latent class 2 (Czech Republic, Germany, Denmark, Finland, Romania, and Slovenia) exhibits a more heterogeneous distribution across four firm-level clusters, with the highest concentration in Cluster 1 (advanced adopters) and a notable presence in Cluster 3 (non-adopters). This suggests a dual structure in CE engagement within these countries, possibly reflecting sectoral or regional disparities. Consequently, CE requires the formulation and implementation of region-specific strategies that reflect geographical

**TABLE 6** | Description of the distribution of firm-level clusters within country-level latent classes.

| | Latent classes (country level) | | | | | |
|---|---|---|---|---|---|---|
| Latent class size | 0.2202 | 0.2202 | 0.1845 | 0.1488 | 0.1131 | 0.1131 |
| Clusters (firm level) | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 0.1493 | 0.3755 | 0.3411 | 0.0000 | 0.0000 | 0.6344 |
| 2 | 0.0099 | 0.2102 | 0.0284 | 0.9340 | 0.0007 | 0.2589 |
| 3 | 0.4618 | 0.2868 | 0.2314 | 0.0004 | 0.0008 | 0.0711 |
| 4 | 0.3010 | 0.1271 | 0.3780 | 0.0242 | 0.0003 | 0.0354 |
| 5 | 0.0780 | 0.0004 | 0.0211 | 0.0413 | 0.9982 | 0.0002 |

diversity and facilitate its effective and inclusive adoption across different territorial contexts (Di et al. 2023). Country-level latent class 3 (France, Greece, Hungary, Lithuania, and Slovakia) is composed primarily of firms in Cluster 4, which represents moderate levels of CE implementation, and also demonstrates a notable presence of firms in Cluster 1 (advanced adopters). This distribution indicates a generally strong engagement with CE practices within this group of countries, suggesting both emerging leadership and ongoing expansion in the adoption of CE. Countries grouped in latent class 4 (Austria, Italy, Luxembourg, and the Netherlands) exhibit a uniform firm-level profile, with all companies belonging to Cluster 2, indicating a selective adoption of CE practices. This may reflect a limited engagement with CE practices. Although CE execution calls for transformative change (Hobson and Lynch 2016), concerns persist that entrenched policy frameworks may constrain this ambition, leading instead to incremental adjustments rather than systemic shifts (Fitch-Roy et al. 2020). Latent class 5 (Ireland, Malta, and Portugal) is exclusively composed of firms in Cluster 5, which is characterized by limited CE adoption. This concentration may point to systemic barriers to CE adoption. Finally, latent class 6 (Belgium, Spain, and Sweden) is primarily associated with firms in Cluster 1, characterized by advanced CE adoption, indicating more favorable conditions for circular practices in these national contexts. These patterns underscore the importance of tailoring CE policy interventions not only at the EU level but also according to specific national and firm-level conditions, recognizing the diversity of challenges and opportunities across the Union. This view is reinforced by findings from Bianchi et al. (2021), which demonstrate that territorial arrangements and regional economic structures have a direct impact on material efficiency patterns.

Firm-level characteristics emerge as crucial determinants of CE engagement. The analysis reveals that companies with greater annual turnover are considerably more likely to fall into clusters characterized by higher levels of CE implementation. This supports previous findings that resource availability, both financial and technical, is central to driving CE transitions (Dey et al. 2022; Ho et al. 2022). Larger firms may have better access to the capital, expertise, and strategic foresight necessary to overcome the often-substantial upfront costs associated with implementing CE practices. Interestingly, however, most firms in Cluster 1, which has a high implementation rate, are still micro or small enterprises. This finding is noteworthy as it challenges the assumption that only large firms can lead CE transitions, especially given the considerable attention these firms have received in recent years (Ho et al. 2022). While resource constraints are real, those firms may be motivated by cost-saving opportunities, regulatory pressures, or market differentiation strategies. This highlights the importance of supporting SMEs with targeted policies. Moreover, effectively embedding CE principles, such as reduction, repair, reuse, and recycling, into business practices requires a redefinition of value creation strategies and a comprehensive restructuring of core business model components (Mishra et al. 2021). Company age also appears to be a significant factor, as firms founded before 2016 are more likely to be active in CE, suggesting that maturity brings greater capacity for long-term strategic planning and sustainability investment. Moreover, these established firms are expected to have developed more advanced sustainability capabilities, which critically shape their approach to adopting and implementing diverse CE strategies (Katz-Gerro and López Sintas 2019; Ünal and Shao 2019). However, this does not imply that younger firms are disengaged; rather, they may face steeper learning curves or lack access to necessary funding and guidance. A particularly salient finding is the consistent correlation between CE implementation and investment in resource efficiency. Across all clusters, companies that invested even a modest share of their turnover (1%–5%) in resource-efficient technologies or processes were more likely to exhibit higher CE activity levels. This underscores the centrality of investment behavior as both a signal of environmental commitment and a mechanism for actualizing circular strategies. Conversely, the persistence of firms in Clusters 3 and 5 with no or low investment highlights the structural and motivational barriers that continue to limit the diffusion of CE.

The findings indicate that companies across the EU often engage in CE practices with a notable degree of operational autonomy, as shown by the consistency of implementation patterns tied to firm-specific characteristics. This suggests that many businesses initiate CE actions based on internal capacities and strategic priorities, rather than depending entirely on external mechanisms such as regulatory mandates, policy incentives, or institutional support. Such behavior reflects a form of systematic independence in CE adoption, where firms integrate circular practices proactively and autonomously, rather than as a direct response to external pressures (Lopes, Gomes, and Nogueira 2025). Nonetheless, realizing an effective and inclusive CE transition requires coordinated efforts to address complex, multi-scalar barriers. This underscores the crucial role of governmental interventions and policy design that not only promote sustainability but also actively dismantle structural obstacles that hinder broader adoption of CE strategies (Trevisan et al. 2023). Moreover, the successful transition to a CE is fundamentally contingent on the transformation of traditional, linear supply chains into self-sustaining systems that enable the repeated use of materials (Genovese et al. 2017). The conservatism of existing supply chains, characterized by their resistance to adopting new models, represents a significant barrier to CE implementation. This is particularly evident in the food sector, where the global challenge of food waste, with its profound social, economic, and environmental impacts (Caldeira et al. 2019; Ciccullo et al. 2021), underscores the urgent need for a shift towards circular practices.

The results of this research strengthen the argument that, the implementation of CE practices faces a complex array of practical barriers that span cultural, regulatory, market, and technological domains (De Pascale et al. 2023). The inherent complexity of the shift from a linear to a circular model, including its unforeseen consequences and intricate trade-offs, further decelerates its adoption (Entsalo et al. 2023). On a cultural level, the persistent societal preference for new products and a lack of awareness regarding CE principles impede widespread adoption, requiring a fundamental shift in consumer and business mindsets. Regulatory hurdles are equally significant; outdated policies, a lack of cohesive governance, and insufficient economic incentives make linear models more financially viable than circular alternatives. This is further complicated by research showing that weak multilevel governance, particularly a lack of coordination between central and subnational authorities, is a key source of implementation barriers (Luo and Leipold 2022). From a market perspective, the high initial investment costs for CE-related technologies and the underdeveloped markets for secondary materials create substantial financial risks. However, studies show that certain factors, such as increased public awareness, economic complexity, and public sector research and development, have a positive correlation with the adoption of proactive environmental innovations, while external collaboration and sectoral agglomeration have a negative influence (Yoshino et al. 2023). Finally, technological challenges persist, primarily due to the lack of advanced infrastructure for material sorting and processing, as well as the prevalent design of products that hinders disassembly and remanufacturing. This is exemplified by the complex issue of reusing and recycling water from treatment plants, which is a complex challenge, hindered by a combination of technical, social, political, and economic barriers that necessitate urgent support and incentives from local governments, especially for agricultural and industrial applications across Europe (Koseoglu-Imer et al. 2023).

Overcoming these interconnected barriers will necessitate a multi-faceted approach, including public education, policy harmonization, targeted financial support, and a collective commitment to both innovation and product design for circularity. This approach must also recognize that the expansion of CE endeavors in the EU primarily depends on regional factors, where a strong regional knowledge base facilitates business growth despite national public policies often failing to promote them (Garzás and Fuensanta 2025). A robust, multi-level governance framework that empowers local administrations is crucial for effectively advancing the CE (Mango and Vincent 2025). The delegation of authority to subnational governments is vital, as it enables the tailoring of policies and initiatives to regional socioeconomic and infrastructural specificities. Concurrently, it is imperative for policymakers to urgently prioritize specific strategies to combat the severe socio-economic consequences of delayed climate action. In this context, both end-of-waste strategies and social change are crucial for enabling widespread reuse and recycling practices, thus mitigating future environmental crises (D'Adamo et al. 2022).

It should be noted that, ineffective and limited partnerships pose a critical barrier to the large-scale implementation of circularity initiatives, particularly by creating fragmented and inefficient supply chains, underscoring the necessity for broader, more inclusive collaborations that span sectors and incorporate key stakeholders to foster disruptive innovation and expand participation (World Economic Forum 2023). This need for collaboration is supported by findings that frequent relationships with stakeholders are crucial as frequent cooperation positively influences their adoption of CE practices (Arroyave et al. 2025). To better understand this dynamic, the discussion framed by the integrated theoretical approach is necessary, leveraging both the RBV and DCT. While the RBV posits that a firm's sustained competitive advantage is derived from the possession of unique and valuable resources, the DCT provides the crucial framework for how such resources can be proactively developed and reconfigured in a dynamic context. In this integrated model, broad and inclusive stakeholder collaboration emerges as a core dynamic capability. This capability enables firms to actively sense emerging opportunities within the circular economy, seize them through the strategic acquisition of external resources, and reconfigure their existing operations to implement new circular practices. Consequently, this theoretical approach argues that collaboration is the foundational process by which firms can proactively build and reinforce the necessary resources for a systemic and large-scale circular transformation.

Nevertheless, while the CE has gained significant traction, some critics, such as Korhonen et al. (2018), view it as a disorganized and superficial concept. They argue that a more scientifically rigorous framework is necessary to replace the current destructive linear economic model and achieve sustainable development. Furthermore, the fragmentation of CE definitions, largely determined by a narrow, sector-specific focus, has resulted in the proliferation of non-replicable practices, thereby hindering an effective, large-scale response to climate change (Finamore and Oltean-Dumbrava 2024). These critiques are reflected in current EU roadmaps, which are flawed by an overemphasis on solid waste and a neglect of other essential resources like water, thus undermining the goal of holistic circularity (Mannina et al. 2022). To address this, many scholars argue that CE policies must be upscaled and mainstreamed to effectively tackle the challenges of cleaner production and consumption (Geng et al. 2009; Haas et al. 2015). However, the success of these policies also depends on public willingness to change habits, which is significantly influenced by sociodemographic factors such as gender, age, and community type (Bassi et al. 2024).

### 5.2 | Theoretical Implications

This study contributes to the theoretical advancement of CE research by integrating the RBV and DCT to explain how firms engage with CE practices. While RBV highlights the importance of unique resources, like specialized knowledge and stakeholder relationships, for a competitive edge, DCT explains how a firm develops the ability to adapt and reconfigure these resources in a changing environment. This study's unique contribution lies in demonstrating that stakeholder collaboration is a key dynamic capability that actively builds and reinforces these valuable resources, offering a more nuanced, process-oriented understanding of CE adoption that addresses the limitations of previous, isolated theoretical approaches. The findings underscore that while possessing valuable resources, as posited by the RBV, remains fundamental for firms' strategic positioning, it is the ability to continuously reconfigure, adapt, and reallocate these resources, core tenets of dynamic capabilities, that ultimately enable meaningful and sustained CE implementation.

First, the results suggest that CE engagement is not solely a function of resource availability but also of firms' capacity to dynamically deploy those resources in response to internal priorities and external environmental shifts. This reinforces the notion that dynamic capabilities are critical in translating resource endowments into concrete sustainability outcomes. Firms with higher CE engagement demonstrate behaviors aligned with sensing, seizing, and transforming capabilities, confirming the utility of DCT in the context of circular transformations. Second, the paper extends RBV by illustrating that strategic resources relevant to CE must be mobilized in adaptive ways to maintain competitive advantage. Static possession of sustainability-oriented resources is insufficient unless supported by dynamic managerial capabilities that enable resource orchestration in alignment with environmental goals. Third, by identifying patterns of firm-level CE implementation across varied institutional contexts, the research highlights the need to contextualize both theories within broader national and sectoral ecosystems. Fourth, this study highlights the need to address the unclear theoretical foundations within CE research. The current conceptual ambiguity and proliferation of fragmented definitions hinder the development of a cohesive framework for CE adoption. Therefore, it is imperative that future research focuses on establishing a more robust and integrated theoretical understanding. Such a systemic clarification would enable the delineation of clear and effective strategies and policies, eliminating conceptual misinterpretation and ensuring greater unanimity in the reading and implementation of CE principles across firms and regions. Ultimately, this study advances the theoretical understanding of how CE strategies emerge and evolve by showing that the integration of RBV and DCT offers a more nuanced and operational framework.

### 5.3 | Practical Implications

The findings of this research offer several practical implications for advancing the CE within the EU. First, the research highlights the critical need for a fundamental redesign of European CE policies, as it identifies significant variations in CE implementation across different countries, regions, and firm types. This variation indicates that companies operate within distinct regulatory environments, industrial structures, and levels of economic development. A uniform, one-size-fits-all approach across all Member States and sectors is unlikely to achieve optimal outcomes. Instead, policymakers should adopt differentiated strategies that account for the diverse characteristics and capacities of firms and regions within the EU. Second, it is crucial to introduce targeted financial incentives to support SMEs. By offering tailored financial support, such as subsidies, low-interest loans, or tax incentives, policymakers can help lower the entry barriers for these firms and foster broader CE adoption. Third, develop sector and region-specific policy measures that align regulatory frameworks with industry-specific contexts, and create localized programs to support technology adoption and skills development. This ensures that CE strategies are both practical and sustainable across diverse economic and territorial settings. Fourth, policymakers should actively engage business associations as strategic partners in the CE transition, leveraging their sectoral expertise to facilitate peer learning, disseminate best practices, provide technical support, and ensure that policy measures are closely aligned with industry-specific challenges and opportunities. Fifth, capacity building and managerial training ought to be strengthened. To successfully implement CE practices, companies require not only technical tools but also human capital capable of driving systemic change. Sixth, cross-border and interregional collaboration should be fostered. Facilitating cooperation among regions with varying levels of CE maturity can catalyze knowledge transfer, reduce redundancy in policy experimentation, and promote the diffusion of innovation. Seventh, for managers, strategies should be coupled with guidance and support mechanisms that encourage digitalization, traceability tools, and innovative business models, which not only reduce operational inefficiencies but also create competitive advantages. Finally, CE principles must be integrated into formal education systems. Achieving a long-term and inclusive transition to a CE requires shifts in cultural values and professional mindsets. Embedding CE concepts across all educational levels can cultivate future generations of professionals equipped to drive sustainability transformations across industries and governance structures.

Moreover, policymakers should tailor the revision and implementation of the EU Circular Economy Action Plan to the heterogeneous patterns of CE adoption observed across firms and regions. Countries and firms with limited or non-adoption require targeted financial incentives and technical assistance, whereas frontrunners benefit more from policies that expand innovation, harmonize regulatory frameworks, and promote cross-border knowledge transfer. Given the role of SMEs as active contributors despite limited resources, policy measures should prioritize accessible funding and capacity-building instruments to unlock their potential. Such differentiated approaches would enhance the inclusiveness and overall effectiveness of the EU's transition toward a resource-efficient economy. Rather than focusing only on regulatory compliance, policy frameworks should prioritize market-based incentives that reward innovation in resource efficiency and enable firms to capture value from circular practices. Developing infrastructure for recycling networks, repair hubs, and resource-sharing platforms would help overcome systemic bottlenecks, particularly in regions where firms lack economies of scale. Additionally, fostering cross-sectoral partnerships and stakeholder cooperation, including suppliers, customers, and industry associations, can accelerate CE adoption by diffusing knowledge and reducing transaction costs, especially for small and resource-constrained firms.

## 6 | Conclusion

The study aimed to assess the implementation patterns of nine CE activities among EU companies and to explore how the implementation of these CE activities relates to certain firm-level characteristics. The findings reveal that the implementation of CE activities varies significantly across countries and companies. Using a multilevel latent class model, five distinct classes of companies were identified, ranging from those that do not adopt any CE activities to those that fully implement all nine. Additionally, six country groups, each with a different composition of companies, were identified, although these groups are geographically dispersed.

Moreover, the implementation patterns of CE vary according to company characteristics. The results show that companies with a higher level of CE activity implementation tend to be larger (even though the majority of the sample consists of micro and small enterprises), older (founded more than 7 years ago), report higher annual turnover, and invest a smaller share of that turnover in resource efficiency measures.

The findings suggest that European CE policies should not be uniform. Still, they should be tailored to the specific types of companies in each country and customized based on the characteristics of SMEs within these groups. These results suggest that EU policies should consider both the national context and the unique characteristics of SMEs to effectively foster CE adoption.

Despite its valuable contributions, this study is not without boundaries that open avenues for further exploration. Methodological improvements led the current study to employ a multilevel latent class model, which identified six country groups with heterogeneous company profiles, differing from the four geographically based groups identified by Bassi and Dias (2020) for European SMEs. Future studies could replicate and extend this approach by classifying firms according to company size (micro, small, medium, and large enterprises) to assess whether size-based differences influence CE implementation patterns. In addition, conducting national-level latent class analyzes could reveal internal heterogeneity in larger countries. Methodologically, longitudinal designs comparing datasets (e.g., 2021 vs. 2024) would provide valuable insights into how CE implementation patterns evolve and how these are influenced by policy opportunities or regulatory barriers across Europe. Empirical expansions, while this study analyzed nine CE activities, future research could explore additional or emerging CE practices such as upcycling, product life extension, closed-loop systems, or biomimicry.

Expanding the empirical scope to include additional countries or regions would also enhance the comparative understanding of CE adoption across different economic and institutional contexts. Furthermore, future analyzes could incorporate country-level covariates (e.g., macroeconomic indicators) to better differentiate the six EU country groups in terms of their intention to adopt CE practices.

Regarding theoretical extensions, future research could further explore the relationship between the CE and corporate purpose, examining how embedding a clear, sustainability-oriented purpose within organizations can enhance the adoption of circular principles. Moreover, studies could investigate how this integration contributes to Organizational Resilience, enhancing firms' ability to adapt to uncertainty and disruption. This research avenue could build on recent theoretical developments that connect corporate sustainability, organizational resilience, and corporate purpose (Florez-Jimenez et al. 2025), thereby expanding the understanding of sustainable and regenerative business models. Another promising theoretical direction would be to analyze the dynamic capabilities that enable companies, given their path dependencies, to transform core competencies (CE-related activities) to sustain or gain a competitive advantage.


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## Consent

Written consent was obtained from all the participants involved in the study.

## Data Availability Statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

## References


Arroyave, J. J., F. J. Sáez-Martínez, P. Ruiz-Palomino, and Á. González-Moreno. 2025. "From Environmental Orientation to Circular Economy Practices: Is It Easier When Firms Frequently Cooperate With Stakeholders?" *Corporate Social Responsibility and Environmental Management* 32, no. 4: 4802–4818. https://doi.org/10.1002/csr.3209.

Bassi, F., and J. G. Dias. 2020. "Sustainable Development of Small- and Medium-Sized Enterprises in the European Union: A Taxonomy of Circular Economy Practices." *Business Strategy and the Environment* 29, no. 6: 2528–2541. https://doi.org/10.1002/bse.2518.

Bassi, F., and J. A. M. Martín. 2024. "Drivers of Sustainable Tourism in Europe: How to Design Efficient Business Strategies." *Quality and Quantity*: 1–26. https://doi.org/10.1007/s11135-023-01819-0.

Bassi, F., J. F. Vera, and J. A. Marmolejo Martín. 2024. "Profile-Based Latent Class Distance Association Analyses for Sparse Tables: Application to the Attitude of European Citizens Towards Sustainable Tourism." *Advances in Data Analysis and Classification* 18, no. 4: 953–980. https://doi.org/10.1007/s11634-023-00559-1.

Bianchi, M., I. del Valle, and C. Tapia. 2021. "Material Productivity, Socioeconomic Drivers and Economic Structures: A Panel Study for European Regions." *Ecological Economics* 183: 106948. https://doi.org/10.1016/j.ecolecon.2021.106948.

Bologa, A., and I. Doros. 2012. "Factorial Analysis of Turnover." *Quality* 13, no. Suppl.3: 487–490. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84864447369&partnerID=40&md5=c2338705146700bceb125c373c435341.

Buyukyazici, D., O. Brossard, and R. Boschma. 2025. "Circular Economy Transition of European Regions: The Role of Regulative, Normative, and Cultural-Cognitive Institutions." *SSRN*: 1–48. https://doi.org/10.2139/ssrn.5272948.

Caldeira, C., V. De Laurentiis, S. Corrado, F. van Holsteijn, and S. Sala. 2019. "Quantification of Food Waste per Product Group Along the Food Supply Chain in the European Union: A Mass Flow Analysis." *Resources, Conservation and Recycling* 149: 479–488. https://doi.org/10.1016/j.resconrec.2019.06.011.

Ciccullo, F., R. Cagliano, G. Bartezzaghi, and A. Perego. 2021. "Implementing the Circular Economy Paradigm in the Agri-Food Supply Chain: The Role of Food Waste Prevention Technologies." *Resources, Conservation and Recycling* 164: 105114. https://doi.org/10.1016/j.resconrec.2020.105114.

D'Adamo, I., M. Mazzanti, P. Morone, and P. Rosa. 2022. "Assessing the Relation Between Waste Management Policies and Circular Economy Goals." *Waste Management* 154: 27–35. https://doi.org/10.1016/j.wasman.2022.09.031.

Daroon, S., W. Wongsapai, T. Jaitiang, et al. 2023. "Tracking the Real-World Energy Efficiency Measures: Does Past Industrial Sector Performance Can Accelerate Thailand's NDC Target Achievement?" *Chemical Engineering Transactions* 106: 19–24. https://doi.org/10.3303/CET23106004.

Das, A. K., M. F. Hossain, B. U. Khan, M. M. Rahman, M. A. Z. Asad, and M. Akter. 2025. "Circular Economy: A Sustainable Model for Waste Reduction and Wealth Creation in the Textile Supply Chain." *SPE Polymers* 6, no. 1: e10171. https://doi.org/10.1002/pls2.10171.

De Pascale, A., G. Di Vita, C. Giannetto, et al. 2023. "The Circular Economy Implementation at the European Union Level. Past, Present and Future." *Journal of Cleaner Production* 423: 138658. https://doi.org/10.1016/j.jclepro.2023.138658.

Dennison, M. S., M. B. Kumar, and S. K. Jebabalan. 2024. "Realization of Circular Economy Principles in Manufacturing: Obstacles, Advancements, and Routes to Achieve a Sustainable Industry Transformation." *Discover Sustainability* 5, no. 1: 438. https://doi.org/10.1007/s43621-024-00689-2.

Dey, P. K., C. Malesios, S. Chowdhury, K. Saha, P. Budhwar, and D. De. 2022. "Adoption of Circular Economy Practices in Small and Medium-Sized Enterprises: Evidence From Europe." *International Journal of Production Economics* 248: 108496. https://doi.org/10.1016/j.ijpe.2022.108496.

Di, K., W. Chen, X. Zhang, et al. 2023. "Regional Unevenness and Synergy of Carbon Emission Reduction in China's Green Low-Carbon Circular Economy." *Journal of Cleaner Production* 420: 138436. https://doi.org/10.1016/j.jclepro.2023.138436.

Ding, L., W. Yu, and C. Shang. 2021. "Research on the Promotion of Efficient and Energy-Saving Architecture in Brand Management." *Sustainable Computing Informatics & Systems* 30: 100503. https://doi.org/10.1016/j.suscom.2020.100503.

D'Oria, L., T. R. Crook, D. J. Ketchen, D. G. Sirmon, and M. Wright. 2021. "The Evolution of Resource-Based Inquiry: A Review and Meta-Analytic Integration of the Strategic Resources–Actions–Performance Pathway." *Journal of Management* 47, no. 6: 1383–1429. https://doi.org/10.1177/0149206321994182.

Eisenhardt, K. M., and J. A. Martin. 2000. "Dynamic Capabilities: What Are They?" *Strategic Management Journal* 21, no. 10–11: 1105–1121. https://doi.org/10.1002/1097-0266(200010/11)21:10/11<1105::AID-SMJ133>3.0.CO;2-E.

Entsalo, H., H. Kalimo, P. Kautto, and T. Turunen. 2023. "Analysing Regulatory Instruments in Sustainability Transitions: A Combined 'Intervention Points' and 'Roles of Law' Approach to the European Union's Ecodesign Framework." *Sustainable Production and Consumption* 42: 125–137. https://doi.org/10.1016/j.spc.2023.09.013.

Espinosa, C. 2024. *Number of Enterprises in the Non-Financial Business Economy of the European Union (EU27) From 2008 to 2024*. Statista Retrieved June 4, 2024. https://www.statista.com/statistics/1248775/number-of-businesses-eu/.

Ferreira, J. J., J. M. Lopes, S. Gomes, and H. G. Rammal. 2023. "Industry 4.0 Implementation: Environmental and Social Sustainability in Manufacturing Multinational Enterprises." *Journal of Cleaner Production* 404: 136841. https://doi.org/10.1016/j.jclepro.2023.136841.

Finamore, M., and C. Oltean-Dumbrava. 2024. "Circular Economy in Construction – Findings From a Literature Review." *Heliyon* 10, no. 15: e34647. https://doi.org/10.1016/j.heliyon.2024.e34647.

Fitch-Roy, O., D. Benson, and D. Monciardini. 2020. "Going Around in Circles? Conceptual Recycling, Patching and Policy Layering in the EU Circular Economy Package." *Environmental Politics* 29, no. 6: 983–1003. https://doi.org/10.1080/09644016.2019.1673996.

Florez-Jimenez, M. P., A. Lleo, P. Ruiz-Palomino, and A. F. Muñoz-Villamizar. 2025. "Corporate Sustainability, Organizational Resilience, and Corporate Purpose: A Review of the Academic Traditions Connecting Them." *Review of Managerial Science* 19, no. 1: 67–104. https://doi.org/10.1007/s11846-024-00735-3.

García-Quevedo, J., E. Jové-Llopis, and E. Martínez-Ros. 2020. "Barriers to the Circular Economy in European Small and Medium-Sized Firms." *Business Strategy and the Environment* 29, no. 6: 2450–2464. https://doi.org/10.1002/bse.2513.

Garzás, M., and M. J. Fuensanta. 2025. "Analysing the Expansion of the Circular Economy in the European Union: How Important Is the Regional Context?" *Ecological Economics* 231: 108560. https://doi.org/10.1016/j.ecolecon.2025.108560.

Geng, Y., Q. Zhu, B. Doberstein, and T. Fujita. 2009. "Implementing China's Circular Economy Concept at the Regional Level: A Review of Progress in Dalian, China." *Waste Management* 29, no. 2: 996–1002. https://doi.org/10.1016/j.wasman.2008.06.036.

Genovese, A., A. A. Acquaye, A. Figueroa, and S. C. L. Koh. 2017. "Sustainable Supply Chain Management and the Transition Towards a Circular Economy: Evidence and Some Applications." *Omega* 66: 344–357. https://doi.org/10.1016/j.omega.2015.05.015.

Haas, W., F. Krausmann, D. Wiedenhofer, and M. Heinz. 2015. "How Circular Is the Global Economy?: An Assessment of Material Flows, Waste Production, and Recycling in the European Union and the World in 2005." *Journal of Industrial Ecology* 19, no. 5: 765–777. https://doi.org/10.1111/jiec.12244.

Ho, C.-H., S. Böhm, and D. Monciardini. 2022. "The Collaborative and Contested Interplay Between Business and Civil Society in Circular Economy Transitions." *Business Strategy and the Environment* 31, no. 6: 2714–2727. https://doi.org/10.1002/bse.3001.

Hobson, K., and N. Lynch. 2016. "Diversifying and de-Growing the Circular Economy: Radical Social Transformation in a Resource-Scarce World." *Futures* 82: 15–25. https://doi.org/10.1016/j.futures.2016.05.012.

Katz-Gerro, T., and J. López Sintas. 2019. "Mapping Circular Economy Activities in the European Union: Patterns of Implementation and Their Correlates in Small and Medium-Sized Enterprises." *Business Strategy and the Environment* 28, no. 4: 485–496. https://doi.org/10.1002/bse.2259.

Kero, C. A., and A. T. Bogale. 2023. "A Systematic Review of Resource-Based View and Dynamic Capabilities of Firms and Future Research Avenues." *International Journal of Sustainable Development and Planning* 18, no. 10: 3137–3154. https://doi.org/10.18280/ijsdp.181016.

Korhonen, J., A. Honkasalo, and J. Seppälä. 2018. "Circular Economy: The Concept and Its Limitations." *Ecological Economics* 143: 37–46. https://doi.org/10.1016/j.ecolecon.2017.06.041.

Koseoglu-Imer, D. Y., H. V. Oral, C. S. Coutinho Calheiros, et al. 2023. "Current Challenges and Future Perspectives for the Full Circular Economy of Water in European Countries." *Journal of Environmental Management* 345: 118627. https://doi.org/10.1016/j.jenvman.2023.118627.

Kumareswaran, K., S. Ranasinghe, G. Y. Jayasinghe, and K. B. Dassanayake. 2024. "Systematic Review on Liquid Organic Waste (LOW) Characteristics, Processing Technologies, and Their Potential Applications: Towards Circular Economy and Resource Efficiency." *Journal of Cleaner Production* 447: 141286. https://doi.org/10.1016/j.jclepro.2024.141286.

Langen, S., C. Vassillo, P. Ghisellini, D. Restaino, R. Passaro, and S. Ulgiati. 2021. "Promoting Circular Economy Transition: A Study About Perceptions and Awareness by Different Stakeholders Groups." *Journal of Cleaner Production* 316: 128166. https://doi.org/10.1016/j.jclepro.2021.128166.

Lazarsfeld, P. F., and N. W. Henry. 1968. *Latent Structure Analysis*. Houghton, Mifflin.

Linzer, D. A., and J. B. Lewis. 2011. "poLCA: An R Package for Polytomous Variable Latent Class Analysis." *Journal of Statistical Software* 42, no. 10: 1–29. https://doi.org/10.18637/jss.v042.i10.

Lopes, J., and L. Farinha. 2019. "Industrial Symbiosis in a Circular Economy: Towards Firms' Sustainable Competitive Advantage." *International Journal of Mechatronics and Applied Mechanics*, no. 5: 206–220.

Lopes, J., J. J. Ferreira, and L. Farinha. 2021. "Entrepreneurship and the Resource-Based View: What Is the Linkage? A Bibliometric Approach." *International Journal of Entrepreneurial Venturing* 13, no. 2: 137–164. https://doi.org/10.1504/IJEV.2021.114408.

Lopes, J. M., S. Gomes, and E. Nogueira. 2025. "Pathways to Circularity: Engagement Patterns of European SMEs in the Circular Economy." *Business Strategy and the Environment* 34, no. 3: 3848–3864. https://doi.org/10.1002/bse.4192.

Lopes, J. M., M. Pinho, and S. Gomes. 2025. "Green to Gold: Consumer Circular Choices May Boost Circular Business Models." *Environment, Development and Sustainability* 27, no. 10: 24505–24533. https://doi.org/10.1007/s10668-023-03930-6.

Luo, A., and S. Leipold. 2022. "Chinese Lessons on Upscaling Environmental Policy Concepts? A Review of Policy-Oriented Circular Economy Research." *Journal of Cleaner Production* 333: 130047. https://doi.org/10.1016/j.jclepro.2021.130047.

Majid, S., X. Zhang, M. B. Khaskheli, F. Hong, P. J. H. King, and I. H. Shamsi. 2023. "Eco-Efficiency, Environmental and Sustainable Innovation in Recycling Energy and Their Effect on Business Performance: Evidence From European SMEs." *Sustainability* 15, no. 12: 9465. https://doi.org/10.3390/su15129465.

Mango, F., and R. C. Vincent. 2025. "Does Polycentric Climate Governance Drive the Circular Economy? Evidence From Subnational Spending and Dematerialization of Production in the EU." *Ecological Economics* 231: 108533. https://doi.org/10.1016/j.ecolecon.2025.108533.

Mannina, G., H. Gulhan, and B.-J. Ni. 2022. "Water Reuse From Wastewater Treatment: The Transition Towards Circular Economy in the Water Sector." *Bioresource Technology* 363: 127951. https://doi.org/10.1016/j.biortech.2022.127951.

Mereuţă, C. 2014. "The Multi-Criteria Nodal Analysis of the System of Companies Resident in Romania." *Romanian Journal of Economic Forecasting* 17, no. 4: 94–108. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84921864955&partnerID=40&md5=bd8c919cc3aa293137a03e4ef494e846.

Mhatre, P., R. Panchal, A. Singh, and S. Bibyan. 2021. "A Systematic Literature Review on the Circular Economy Initiatives in the European Union." *Sustainable Production and Consumption* 26: 187–202. https://doi.org/10.1016/j.spc.2020.09.008.

Milea, O. M., E. Pascu, and P. S. Nedea. 2014. "SMEs in the European Economy." *Quality* 15, no. Suppl.2: 215–219. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84906503381&partnerID=40&md5=177b510eb0317fdf649d91363a3ec17f.

Mishra, S., S. Jain, and G. Malhotra. 2021. "The Anatomy of Circular Economy Transition in the Fashion Industry." *Social Responsibility Journal* 17, no. 4: 524–542. https://doi.org/10.1108/SRJ-06-2019-0216.

Mora-Contreras, R., L. E. Torres-Guevara, A. Mejia-Villa, M. Ormazabal, and V. Prieto-Sandoval. 2023. "Unraveling the Effect of Circular Economy Practices on Companies' Sustainability Performance: Evidence From a Literature Review." *Sustainable Production and Consumption* 35: 95–115. https://doi.org/10.1016/j.spc.2022.10.022.

Moreno-Mondéjar, L., Á. Triguero, and M. C. Cuerva. 2021. "Exploring the Association Between Circular Economy Strategies and Green Jobs in European Companies." *Journal of Environmental Management* 297: 113437. https://doi.org/10.1016/j.jenvman.2021.113437.

Morin, A. J., M. J. McLarnon, and D. Litalien. 2020. "Mixture Modeling for Organizational Behavior Research." In *Handbook on the Temporal Dynamics of Organizational Behavior*, 351–379. Edward Elgar Publishing.

Oberski, D. 2016. "Mixture Models: Latent Profile and Latent Class Analysis." In *Modern Statistical Methods for HCI*, edited by J. Robertson and M. Kaptein, 275–287. Springer International Publishing. https://doi.org/10.1007/978-3-319-26633-6_12.

Opferkuch, K., S. Caeiro, R. Salomone, and T. B. Ramos. 2022. "Circular Economy Disclosure in Corporate Sustainability Reports: The Case of European Companies in Sustainability Rankings." *Sustainable Production and Consumption* 32: 436–456. https://doi.org/10.1016/j.spc.2022.05.003.

Patricio, J., L. Axelsson, S. Blomé, and L. Rosado. 2018. "Enabling Industrial Symbiosis Collaborations Between SMEs From a Regional Perspective." *Journal of Cleaner Production* 202: 1120–1130. https://doi.org/10.1016/j.jclepro.2018.07.230.

Patwa, N., U. Sivarajah, A. Seetharaman, S. Sarkar, K. Maiti, and K. Hingorani. 2021. "Towards a Circular Economy: An Emerging Economies Context." *Journal of Business Research* 122: 725–735. https://doi.org/10.1016/j.jbusres.2020.05.015.

Perera, R., and Y. Badir. 2025. "Bridging the Gap Between the Source of Innovation and the Implementation of Circular Economy Principles in SMEs Within Emerging Economies: The Mediating Role of Frugal Innovation." *Business Strategy and the Environment* 34, no. 2: 1847–1863. https://doi.org/10.1002/bse.4074.

Reike, D., W. J. V. Vermeulen, and S. Witjes. 2018. "The Circular Economy: New or Refurbished as CE 3.0?—Exploring Controversies in the Conceptualization of the Circular Economy Through a Focus on History and Resource Value Retention Options." *Resources, Conservation and Recycling* 135: 246–264. https://doi.org/10.1016/j.resconrec.2017.08.027.

Rosa, B. O., and F. d. O. Paula. 2023. "Circular Economy Adoption by European Small and Medium-Sized Enterprises: Influence on Firm Performance." *Review of Business Management* 25: 421–438. https://doi.org/10.7819/rbgn.v25i3.4232.

Sánchez, I., and S. Alfaro. 2025. "The Circular Economy Disclosure in EU Setting." In *The Development of Non-Financial Reporting: The Role of Sustainability Reporting and Integrated Reporting in Corporate Strategy*, edited by V. Minutiello, 45–66. Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-83181-2_2.

Schöggl, J.-P., M. Rusch, L. Stumpf, and R. J. Baumgartner. 2023. "Implementation of Digital Technologies for a Circular Economy and Sustainability Management in the Manufacturing Sector." *Sustainable Production and Consumption* 35: 401–420. https://doi.org/10.1016/j.spc.2022.11.012.

Schwarz, G. 1978. "Estimating the Dimension of a Model." *Annals of Statistics* 6, no. 2: 461–464. http://www.jstor.org/stable/2958889.

Trevisan, A. H., A. Lobo, D. Guzzo, L. A. d. V. Gomes, and J. Mascarenhas. 2023. "Barriers to Employing Digital Technologies for a Circular Economy: A Multi-Level Perspective." *Journal of Environmental Management* 332: 117437. https://doi.org/10.1016/j.jenvman.2023.117437.

Tritto, N., J. G. Dias, and F. Bassi. 2024. "SMEs Circular Economy Practices in the European Union: Multilevel Implications for Sustainability." *Social Indicators Research* 175, no. 3: 965–988. https://doi.org/10.1007/s11205-023-03191-w.

Ünal, E., and J. Shao. 2019. "A Taxonomy of Circular Economy Implementation Strategies for Manufacturing Firms: Analysis of 391 Cradle-To-Cradle Products." *Journal of Cleaner Production* 212: 754–765. https://doi.org/10.1016/j.jclepro.2018.11.291.

Vagnoni, E., C. Cavicchi, M. Borghesi, E. Trincanato, and S. Bonnini. 2025. "Greener Pathways, Strategy, and Economic Performance: A Cross-National Study on European Service SMEs." *Business Strategy and the Environment* 34, no. 3: 3194–3208. https://doi.org/10.1002/bse.4135.

Vermunt, J. K. 2003. "7. Multilevel Latent Class Models." *Sociological Methodology* 33, no. 1: 213–239. https://doi.org/10.1111/j.0081-1750.2003.t01-1-00131.x.

World Economic Forum. 2023. Circular Transformation of Industries: Unlocking New Value in a Resource-Constrained World. https://www.weforum.org/publications/circular-transformation-of-industries-unlocking-new-value-in-a-resource-constrained-world/.

Yoshino, M., B. Sadlek, M. Yarime, and A. Ali. 2023. "Knowledge Absorption Pathways for Eco-Innovation: An Empirical Analysis of Small and Medium-Sized Enterprises in the European Union." *European Journal of Innovation Management* 28, no. 2: 426–453. https://doi.org/10.1108/ejim-02-2023-0136.

## Appendix A

**TABLE A.1** | Country-level latent classes.

| | Class 1 | | | | | Class 2 | | | | | | Class 3 | | | | | | | Class 4 | | | Class 5 | | | Class 6 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cluster** | **1** | **3** | **4** | **5** | **Total** | | **1** | **2** | **3** | **4** | **Total** | | **1** | **2** | **3** | **4** | **5** | **Total** | | **2** | **Total** | | **5** | **Total** | | **1** | **2** | **3** | **4** | **Total** |
| BG | 79 | 224 | 162 | | 465 | CZ | 253 | 84 | 145 | 92 | 574 | FR | 221 | | 158 | 201 | | 580 | AT | 499 | 499 | IE | 462 | 462 | BE | 382 | 167 | 28 | 10 | 587 |
| CY | 28 | 147 | 47 | | 222 | DE | 214 | 105 | 164 | 72 | 555 | GR | 192 | | 161 | 200 | | 553 | IT | 573 | 573 | MT | 239 | 239 | ES | 432 | 127 | 24 | 10 | 593 |
| EE | 72 | 265 | 102 | 1 | 440 | DK | 221 | 69 | 121 | 65 | 476 | HU | 137 | 1 | 143 | 178 | | 459 | LU | 247 | 247 | PT | 547 | 547 | SE | 375 | 166 | 38 | 5 | 584 |
| HR | 59 | 276 | 116 | | 451 | FI | 215 | 88 | 140 | 40 | 483 | LT | 194 | | 93 | 188 | 1 | 476 | NL | 587 | 587 | | | | | | | | | |
| LV | 43 | 192 | 174 | | 409 | RO | 202 | 70 | 186 | 70 | 528 | SK | 187 | | 85 | 209 | | 481 | | | | | | | | | | | | |
| PL | 58 | 303 | 190 | 4 | 555 | SI | 147 | 75 | 186 | 51 | 459 | | | | | | | | | | | | | | | | | | | |
| Total | 339 | 1407 | 791 | 5 | 2542 | | 1252 | 491 | 942 | 390 | 3075 | | 931 | 1 | 640 | 976 | 1 | 2549 | | 1906 | 1906 | | 1248 | 1248 | | 1189 | 460 | 90 | 25 | 1764 |

**TABLE A.2** | Companies' characteristics in firm-level latent clusters (within country-level classes).

| | Class 1 | | | | | Class 2 | | | | | Class 3 | | | | | | Class 4 | | Class 5 | | Class 6 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cluster** | **1** | **3** | **4** | **5** | **Total** | **1** | **2** | **3** | **4** | **Total** | **1** | **2** | **3** | **4** | **5** | **Total** | **2** | **Total** | **5** | **Total** | **1** | **2** | **3** | **4** | **Total** |
| Employees | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1–9 employees | 111 | 663 | 386 | | 1160 | 416 | 201 | 420 | 155 | 1192 | 319 | | 251 | 438 | 1 | 1009 | 727 | 727 | 545 | 545 | 352 | 180 | 45 | 14 | 591 |
| 10–49 employees | 122 | 497 | 247 | 1 | 867 | 437 | 173 | 330 | 142 | 1082 | 323 | | 245 | 323 | | 891 | 642 | 642 | 400 | 400 | 429 | 182 | 32 | 9 | 652 |
| 50–249 employees | 80 | 198 | 120 | 3 | 401 | 255 | 88 | 154 | 69 | 566 | 214 | | 110 | 173 | | 497 | 379 | 379 | 222 | 222 | 277 | 72 | 10 | 2 | 361 |
| 250–499 employees | 16 | 38 | 27 | 1 | 82 | 63 | 17 | 15 | 6 | 101 | 41 | 1 | 23 | 25 | | 90 | 158 | 158 | 81 | 81 | 46 | 11 | 1 | | 58 |
| 250–499 employees | 10 | 11 | 10 | | 31 | 79 | 12 | 22 | 16 | 129 | 33 | | 11 | 17 | | 61 | | | | | 85 | 15 | 2 | | 102 |
| Do not know/no answer | | | 1 | | 1 | 2 | | 1 | 2 | 5 | 1 | | | | | 1 | | | | | | | | | |
| Total | 339 | 1407 | 791 | 5 | 2542 | 1252 | 491 | 942 | 390 | 3075 | 931 | 1 | 640 | 976 | 1 | 2549 | 1906 | 1906 | 1248 | 1248 | 1189 | 460 | 90 | 25 | 1764 |
| Year foundation | | | | | | | | | | | | | | | | | | | | | | | | | |
| Before 2016 | 287 | 1177 | 655 | 5 | 2124 | 1050 | 383 | 768 | 323 | 2524 | 784 | 1 | 541 | 825 | 1 | 2152 | 1323 | 1323 | 881 | 881 | 1042 | 400 | 76 | 21 | 1539 |
| Between 2016 and 2018 | 26 | 103 | 61 | | 190 | 86 | 54 | 76 | 32 | 248 | 61 | | 51 | 78 | | 190 | 199 | 199 | 128 | 128 | 78 | 30 | 4 | 2 | 114 |
| Between 2019 and 2023 | 21 | 115 | 61 | | 197 | 103 | 50 | 90 | 31 | 274 | 62 | | 36 | 62 | | 160 | 247 | 247 | 168 | 168 | 57 | 27 | 10 | 2 | 96 |
| After January 1, 2023 | 4 | 4 | 9 | | 17 | 10 | 4 | 5 | 3 | 22 | 21 | | 11 | 9 | | 41 | 126 | 126 | 43 | 43 | 11 | 3 | | | 14 |
| Do not know/no answer | 1 | 8 | 5 | | 14 | 3 | | 3 | 1 | 7 | 3 | | 1 | 2 | | 6 | 11 | 11 | 28 | 28 | 1 | | | | 1 |
| Total | 339 | 1407 | 791 | 5 | 2542 | 1252 | 491 | 942 | 390 | 3075 | 931 | 1 | 640 | 976 | 1 | 2549 | 1906 | 1906 | 1248 | 1248 | 1189 | 460 | 90 | 25 | 1764 |
| Total turnover in 2023 | | | | | | | | | | | | | | | | | | | | | | | | | |

(Continues)

**TABLE A.2** | (Continued)

| | Class 1 | | | | | Class 2 | | | | | Class 3 | | | | | | Class 4 | | Class 5 | | Class 6 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cluster** | **1** | **3** | **4** | **5** | **Total** | **1** | **2** | **3** | **4** | **Total** | **1** | **2** | **3** | **4** | **5** | **Total** | **2** | **Total** | **5** | **Total** | **1** | **2** | **3** | **4** | **Total** |
| 25,000 euros or less | 17 | 83 | 68 | | 168 | 52 | 28 | 71 | 21 | 172 | 26 | | 13 | 53 | | 92 | 78 | 78 | 73 | 73 | 22 | 13 | 3 | 2 | 40 |
| More than €25,000 to €50,000 | 21 | 114 | 70 | | 205 | 50 | 25 | 66 | 20 | 161 | 48 | | 24 | 65 | | 137 | 139 | 139 | 116 | 116 | 27 | 5 | 6 | 2 | 40 |
| More than €50,000 to €100,000 | 21 | 98 | 66 | | 185 | 66 | 39 | 71 | 20 | 196 | 53 | | 45 | 67 | 1 | 166 | 140 | 140 | 147 | 147 | 39 | 19 | 1 | 2 | 61 |
| More than €100,000 to €250,000 | 25 | 170 | 100 | | 295 | 106 | 57 | 88 | 39 | 290 | 74 | | 54 | 105 | | 233 | 229 | 229 | 215 | 215 | 70 | 32 | 11 | 1 | 114 |
| More than €250,000 to €500,000 | 24 | 154 | 81 | 1 | 260 | 71 | 27 | 73 | 43 | 214 | 87 | | 60 | 111 | | 258 | 265 | 265 | 156 | 156 | 80 | 33 | 10 | 2 | 125 |
| More than €500,000 to €2 million | 65 | 264 | 122 | 3 | 454 | 206 | 87 | 160 | 64 | 517 | 169 | | 157 | 197 | | 523 | 429 | 429 | 221 | 221 | 206 | 94 | 24 | 4 | 328 |
| More than €2 million to €10 million | 60 | 172 | 113 | | 345 | 240 | 82 | 181 | 72 | 575 | 213 | | 139 | 167 | | 519 | 194 | 194 | 68 | 68 | 270 | 129 | 16 | 6 | 421 |
| More than €10 million to €50 million | 37 | 59 | 44 | | 140 | 163 | 49 | 85 | 29 | 326 | 108 | | 51 | 85 | | 244 | 172 | 172 | 44 | 44 | 212 | 58 | 10 | 4 | 284 |
| More than €50 million | 15 | 25 | 13 | | 53 | 123 | 27 | 30 | 17 | 197 | 44 | 1 | 20 | 20 | | 85 | 29 | 29 | 7 | 7 | 147 | 29 | 3 | | 179 |

(Continues)

**TABLE A.2** | (Continued)

| | Class 1 | | | | | Class 2 | | | | | Class 3 | | | | | | Class 4 | | Class 5 | | Class 6 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cluster** | **1** | **3** | **4** | **5** | **Total** | **1** | **2** | **3** | **4** | **Total** | **1** | **2** | **3** | **4** | **5** | **Total** | **2** | **Total** | **5** | **Total** | **1** | **2** | **3** | **4** | **Total** |
| Do not know/no answer | 54 | 268 | 114 | 1 | 437 | 175 | 70 | 117 | 65 | 427 | 109 | | 77 | 106 | | 292 | 231 | 231 | 201 | 201 | 116 | 48 | 6 | 2 | 172 |
| Total | 339 | 1407 | 791 | 5 | 2542 | 1252 | 491 | 942 | 390 | 3075 | 931 | 1 | 640 | 976 | 1 | 2549 | 1906 | 1906 | 1248 | 1248 | 1189 | 460 | 90 | 25 | 1764 |
| Average annual investment to improve resource efficiency | | | | | | | | | | | | | | | | | | | | | | | | | |
| Nothing | 27 | 414 | 182 | 1 | 624 | 101 | 103 | 298 | 93 | 595 | 105 | | 207 | 222 | 1 | 535 | 392 | 392 | 202 | 202 | 107 | 117 | 40 | 9 | 273 |
| Less than 1% of annual turnover | 58 | 312 | 194 | 1 | 565 | 245 | 103 | 250 | 102 | 700 | 194 | | 162 | 272 | | 628 | 489 | 489 | 173 | 173 | 210 | 119 | 15 | 8 | 352 |
| 1%–5% of annual turnover | 144 | 364 | 244 | 1 | 753 | 498 | 148 | 191 | 111 | 948 | 340 | | 147 | 269 | | 756 | 519 | 519 | 354 | 354 | 505 | 141 | 20 | 4 | 670 |
| 6%–10% of annual turnover | 49 | 102 | 62 | | 213 | 167 | 48 | 69 | 28 | 312 | 125 | | 42 | 82 | | 249 | 91 | 91 | 158 | 158 | 169 | 22 | 6 | 1 | 198 |
| 11%–30% of annual turnover | 21 | 46 | 25 | | 92 | 62 | 28 | 25 | 9 | 124 | 44 | | 22 | 22 | | 88 | 55 | 55 | 43 | 43 | 47 | 14 | 5 | | 66 |
| More than 30% of annual turnover | 12 | 24 | 25 | | 61 | 23 | 9 | 22 | 3 | 57 | 14 | | 11 | 10 | | 35 | 43 | 43 | 29 | 29 | 18 | 4 | 1 | | 23 |
| Do not know/no answer | 28 | 145 | 59 | 2 | 234 | 156 | 52 | 87 | 44 | 339 | 109 | 1 | 49 | 99 | | 258 | 317 | 317 | 289 | 289 | 133 | 43 | 3 | 3 | 182 |
| Total | 339 | 1407 | 791 | 5 | 2542 | 1252 | 491 | 942 | 390 | 3075 | 931 | 1 | 640 | 976 | 1 | 2549 | 1906 | 1906 | 1248 | 1248 | 1189 | 460 | 90 | 25 | 1764 |