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CIRCULAR ECONOMY IN SMALL AND MEDIUM-SIZED ENTERPRISES IN THE EUROPEAN UNION: HETEROGENEITY BETWEEN AND WITHIN COUNTRIES

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Abstract*. In this paper, we analyze the different behavior of small and medium-sized enterprises (SMEs) with reference to eight specific Circular Economy (CE) actions. Data come from a Flash Eurobarometer survey that investigates efficiency in use of resources. We estimated classification trees (CART) in order to identify homogeneous groups of European countries with regard to the adoption of CE practices by SMEs and multilevel regression models to measure differences among SMEs in adopting sustainability management, considering firms' characteristics. Results of the analyses revealed heterogeneity between and within European countries. Five groups of countries are identified, with SMEs having a similar attitude towards CE. Within each group of factors, however, specific firms' characteristics have a non-negligible effect on firms' decision to adhere to sustainability.*

Keywords*: Efficiency of resources, Circular Economy, SMEs, CART, multilevel analysis.*

1. INTRODUCTION

In this paper, we analyze the different behavior of small and medium-sized enterprises (SMEs) with reference to eight specific Circular Economy (CE) actions. The transition from a linear economic context to a circular one implies for products and services a change from a production system with the phases of conception, construction, use and disposal, to a system committed to having less waste and to environmental issues. The market is giving way to a circular idea of the value chain, which means that the environmental impact, that the materials that compose it will have, is assessed from the very beginning of the production phase, from its conceptualization and design (Suárez-Eiroa et al., 2019). Therefore, in the last few decades, the major companies begun to consider as a new resource the opportunity of processing the materials released by production and the products themselves, once their use is finished. Reuse, and recycling are among the Rs on which the Circular Economy is based (Vermeulen et al., 2019).

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In order to understand how SMEs are dealing with CE and specifically to evaluate heterogeneity of behavior in European countries, we analyzed the data collected with a Eurobarometer survey, precisely with Flash Eurobarometer 456, conducted from 11th to 26th September 2017 on sample of European firms. These data refer to eight green actions to be implemented in the production process: saving water, saving energy, using renewable energy, saving materials, minimizing waste, recycling, designing products that are easy to maintain or repair, selling scrap material to another company.

In this paper, we will use classification trees (CART, Breiman et al. 1984) in order to identify homogeneous groups of European countries with regard to the adoption of CE practices by SMEs and multilevel regression models (Hox, 2002) to measure differences among SMEs in adopting sustainability management, considering firms' characteristics.

The paper is organized as follows: section 2 reviews the concept of CE and the recent reference literature, with a specific attention to SMEs; section 3 describes the data; section 4 presents the results of the analyses and section 5 concludes.

2. CIRCULAR ECONOMY: ORIGINS, DEVELPOMENT AND IMPLEMENTATIONI IN SEMS

The origin of the modern idea of industry started at the end of the eighteenth century with the Industrial Revolution, this era was characterized by the overproduction of goods and the extensive use of fossil energy sources. Only during the World Wars, companies were forced to reconsider a really different method of using raw materials, due to the enormous costs to support the war front. The dynamics of the production system of the time consists in proceeding from virgin raw materials to transformation, consumption and final conferment in landfill; this production model can be defined as linear. The linear model can be improved and optimized, but still what remains is waste, pollutants and scraps of industrial production and consumption with negative environmental and social implications (Sharma et al., 2021). The introduction of the concept of Circular Economy dates back to the end of the twentieth century, when several publications arouse the attention of scholars (Lieder and Rashid, 2016). Several authors, such as Andersen (2007), Ghisellini et al. (2016), and Su et al. (2013) attributed the introduction of the concept to Pearce and Turner (1989) in their work "Economics of Natural Resources and the Environment". These authors wrote how natural resources sustain the economy by providing inputs for production and consumption, but, at the same time, natural resources produce outputs, which are represented almost

entirely from waste. From these considerations, the idea of Circular Economy was formulated. Pearce and Turner were influenced by the work of Boulding (1966), who described the Earth as a circular and closed system with limited assimilation capacity, deducing that the economy and the environment should coexist in equilibrium. Stahel and Reday (1976) introduced some features to this economic approach, with a particular focus on the industrial sector; they devised a continuous cycle economy to write industrial strategies on waste prevention, job creation, resource efficiency and dematerialization. Later, Stahel (1982) further stressed that granting use, instead of relinquishing ownership of goods, is the most relevant sustainable business model for a closed economy, thus allowing companies to profit from waste without having costs and risks deriving from them. The term Circular Economy was coined in China in 2002, when the government approved the first CE Promotion Law of the People's Republic of China, which became effective in January 2009 (The Standing Committee of the National People's Congress China, 2008). The main goal was to reduce pollution and protect the planet by making important public decisions. After this turning point, institutions from all over the world, including the European Union, had to inevitably adapt to addressing these problems. The first European countries to adopt CE practices were Sweden, the United Kingdom and Spain (Lieder and Rashid, 2016).

The use of the term CE has evolved in the business world in an attempt to find a compromise between economic growth and environmental protection. This idea of economy wants to be in contrast with the linear one. The most renowned definition of CE was given by the Ellen MacArthur Foundation (2015), introducing the Circular Economy as "a restorative industrial economy or regenerative in intention and design", from then, many different ways to describe the process were proposed. Thinking about the eco-environmental industry, the CE can also be defined as a closed flow of materials within a well-structured economic system (Geng and Doberstein, 2008). Kirchherr et al. (2017) analyzed over one hundred definitions of Circular Economy and concluded that all are in line with 3Rs (Reduction, Reuse and Recycling) paradigm, which purpose is to make the flow of materials closed or circular (Yuan et al., 2006). The fact that the present economic development model has taken a dead-end way, it is recognized not only by those who work in the sectors directly concerned, but by the majority of the people. It is evident that it is necessary to rearrange the bases of the production system in order to guarantee adequate well-being to future generations.

The European Union is encouraging the business activities to seriously face ethical problems, which concern the economic cycle in an active way. (European Commission, 2008; Dalhammar 2015). The rules to guide the cycle of a product can

be summarized as it follows: prohibition of dangerous substances, products energy-efficient and correct disposal of materials after their use. The European Union presented in 2015 an executive plan for CE, which includes legislative proposals and measures for the management of the production, consumption and waste (Dalhammar, 2016). The plan is divided into two parts: the first part explains how CE measures can be introduced into the product life cycle and the second one, instead, is devoted to the care and the specific treatment of scraps (European Commission, 2014).

One of the objectives of the recommendations is to inform and address not only the behavior of companies, but also that of consumers. Therefore, the goal is making everyone more aware that the cycle of a product involves the whole of society and that the gain following a correct behavior is for everyone's life, not only for the economic benefit. The action plan seeks to put industries in a sustainable but competitive context, stimulate economic growth and create new types of jobs. From this, it arises the need for companies to have a qualified workforce with new and specific green skills (Bassi and Guidolin, 2021, ⁄beda-García et al. 2021). The professions that fall into this category can be defined in many ways, Burger et al. (2019), for example, did an in-depth exploration of the US market.

This transition, however, has a very high cost. The European Commission is moving in this direction, with measures to encourage the adoption of CE practices and employment growth. The first action plan (European Commission, 2014) was designed for the entire life cycle of a product: from production to consumption, from repair to regeneration, to waste management. The intent was to direct it to all the administrations involved, starting from the member States of the European Union, then passing through the regions, cities, businesses and finally citizens. The European Commission attributes a very important role to the production phase in the chain, encouraging companies to replace harmful chemicals and/or to have innovative technologies for production processes. For this reason, the European Resource Efficiency Excellence Center was created, helping companies to improve their production efficiency. The devised action plan takes into account also the contribution and the responsible choices that consumers will make in the purchasing phase, this in fact is an element that will directly affect the functioning of the CE. An example regards the fact the price of a product that has been conceived and put on the market using sustainable production techniques with a good environmental impact, will be higher. It is important that customers appreciate this effort and are willing to pay the additional cost. The cost of a product with these characteristics will be proportional to the attention it has for the environmental effects, the companies in this will be supported through incentives from the European Union

but the consumer will have a great responsibility in considering environmental protection as a quality during the purchase (European Commission, 2018a). In the European Union the CE regards almost exclusively small and medium-sized enterprises (SMEs), which represent over 99% of all European companies and around two thirds of total employment. SMEs have been defined by the European Commission as companies that have less than 250 employees and whose turnover does not exceed 50 million euros and/or whose total balance sheet does not exceed 43 million (European Commission, 2003). In detail, micro enterprises are those with less than 10 workers and an annual balance sheet lower than 2 million euros; small businesses are those with less than 50 workers and a budget of less than 10 million; businesses are defined medium-sized if they have between 50 and 250 workers and a budget between 10 and 43 million euros. From the annual report of the European Commission on SMEs 2018/2019 (European Commission, 2020b), it emerged that in the European Union about 25.1 million SMEs are operating: 23.3 million micro-enterprises, 1.47 million small ones and about 236 thousand medium-sized enterprises. It is estimated that SMEs create between 60 and 70% of total air pollution (Hoogendoorn et al., 2015). The European Union considers the contribution of SMEs to be fundamental to the CE also because they should be more active and predisposed to changes in the sectors of recycling, repair and product innovation. The distribution of SMEs in the EU is not homogeneous, compared to an average of 92% on all active companies, this figure can vary considerably from state to state. For example, in Germany, SMEs represent 82% of all businesses, unlike countries like Greece, Poland or the Czech Republic where they are over 96%.

The circular chain is a model based on the supply of renewable, recyclable and biodegradable products. With the recovery of resources, at the end of a production process, waste continues to have an intrinsic value and can be used in further transformation processes. The sharing model promotes collaboration between users of goods and services in order to exploit overcapacity and underutilization. To implement the transition to sustainable and Circular Economy models, the European action plan defines 54 measures to close the loop life of products, identifying five priority areas to accelerate the transition along their value chain (plastics, food waste, essential raw materials, construction and demolition, biomass and materials biological, European Commission, 2015). The plan places a strong emphasis on creating a solid foundation on which investment and innovation can thrive. The transition is financially supported by the European Structural and Investment Funds, from Horizon 2020, from the European Fund for Strategic Investments (EFSI) and the LIFE program, founded in 1992 to promote protection strategies of the environment. A recent step taken by the European Union was to

implement the second action plan for the Circular Economy on 11th March 2020 (European Commission, 2020a). This initiative is one of the main measures of the European Green Deal, defined as the roadmap to make the EU economy as sustainable. The new plan describes the way to progress towards a climate-neutral and competitive economy, in which consumers are empowered. The objectives are: making sustainable products as the standard within the Union. The Commission proposed a legislative action on the strategy for sustainable products to ensure that they are designed to last longer, easy to reuse, repair and recycle, and contain as much recycled materials as possible rather than primary raw materials. The measures will also limit single-use products, they will deal with premature obsolescence and ban the destruction of unsold durable goods. Secondly, the empowerment of consumers who will have access to reliable information on issues such as reparability and durability of products so they can make better informed choices. As Najami et al. (2020) noted, sustainability cannot be fulfilled without the collaboration of end consumers.

Finally, it is important to recognized that the Circular Economy will produce net assets in terms of GDP growth and job creation; it is estimated that the application of ambitious Circular Economy measures in Europe will be able to increase GDP by a further 0.5% between now and 2030, creating around 700.000 new jobs (European Commission 2020a).

3. THE DATA

Our data were collected within the Flash Eurobarometer 456 survey, conceived and proposed by the European Commission. The data collection period is included between 11th September 2017 and 26th September 2017; questions were answered by 13,117 SMEs belonging to the 28 countries of the European Union (before the Brexit)[2]. The intent was to understand how many efficiency measures were developed by firms. With reference to the single SME, the following "demographic" information was collected: country, economic activity sector, number of workers, year of foundation, if turnover changed or remained stable in the past two years, turnover in 2016, type of output, whether products or services were sold.

Eight specific CE actions were investigated: paying attention to the waste and reuse of water; minimize energy use while maximizing performance; using mainly renewable energy (including own production through solar panels or other); saving

[2] Quota sampling was used with quotas applied to company size and sector, adjusted according to country's universe. Interviews were conducted by CATI mode.2 For the analyses the software R was used.

of raw materials; waste minimization; the permission to other companies of the use of waste; recycling, reusing materials or waste from the company itself; creation of products that are easier to maintain, repair or reuse. With reference to these eight actions, SMEs had to declare if they were implemented in the preceding two years and/or if there was the intention to consider them for the future two years. Additional information with reference to these actions was collected, regarding costs, percentage of turnover invested, eventual financial support received and from which source, workers employed in green jobs, difficulties and needs related to the implementation of sustainability practices.

We expected that the size of the company had direct effects on the choice to undertake activities related to the CE (Bianchi and Noci, 1998). Larger companies have access to more resources to invest, while smaller ones can suffer from the absence of a strong economic structure that supports them for investments and measures that have a targeted production scheme to recycling (Hogg et al., 2011). From the point of view of sustainability, all companies have the goal of creating a type of environmental economics. It is noted that companies that generate one low portion of waste in relation to what they produce are less motivated to think about recycling methods (Reike et al., 2018). On the other hand, in large companies, ethics plays a central role in their behavior as they are more importantly exposed to criticism and it is therefore a necessity to preserve their reputation (Inigo and Blok, 2019).

The age of an SME has a direct effect on the willingness to undertake Circular Economy practices (Hoogendoorn et al., 2015). The competence and social responsibility of a company can derive precisely from the experience that has been accumulated in the area (Trencansky and Tsaparlidis, 2014). Social responsibility derives from an economic and corporate stability. When business procedures for the environment are put in place although costs might increase, it is in all respects a way to please stakeholders. The same concept also applies to new companies, who, having to set up new working strategies, can gain in considering the idea of the Circular Economy as a new perspective model both for the environment and from the business point of view. Older and newer SMEs have more interest in undertaking a business model that follows the CE, more than companies with an intermediate age.

The sector in which an SME operates influences its willingness to undertake sustainable activities or to follow green economy policies (Bradford and Fraster, 2008). SMEs operating in sectors with production processes are more tangible and producing greater quantities of waste are the keenest to follow CE expedients. The sectors that are most inclined to suggest sustainable activities are manufacturing, construction, agriculture and waste management. In these sectors, the production process disperses a lot of waste and this leads to requesting and having large

quantities of raw materials. Furthermore, strict environmental and corporate parameters have been devised by nations and by institutions to stem waste and give a common direction to SMEs (European Commission, 2018b)). The need for greater quantities of materials for the sectors with the most organic value chain composed of tangible materials is an element that makes the sustainable choice of SMEs a priority. In fact, in the EU action plan, the plastics, food and raw materials sectors, constructions and demolitions, biomasses and products biologicals have priority for the implementation of efficiency measures.

SMEs that participated in the survey employ on average 18 workers: 80.4% of them have between 1 and 9 employees, 15.5% between 10 and 49, 3.0% between 50 and 249, and 1.1%, large companies, have more than 250 employees. 57.4% of SMEs have no employees engaged in a green job. The average age of SMEs is 25.7 years: 76.9% were founded before to 2010, 9.3% between 2010 and 2012, 23.3% between 2013 and 2016, and only 1.5% were founded in 2017. For what regards economic activity sector, 10.1% of SMEs belong to the manufacturing sector, 15.9% to the industrial one, 30.1% are active in retail, and 43.9% in services. Another relevant aspect to consider to assess the propensity of a company to undertake CE actions is its annual turnover. In the two years preceding the questionnaire, the turnover of SMEs grew for 42.5% of them, decreased for 21.2% while it remained almost the same for the other 20.1%. 19.6% of SMEs have a turnover of less than 100,000 euro in the reference year, 23.3% a turnover between 100 and 500 thousand, 22.8% between 500 thousand and 2 million, 18.8% between 2 and 10 million, 10.4% between 10 and 50 million and only 5.1% had a turnover that is greater than 50 million euros.

As already introduced, the survey aimed at measuring the adoption of specific CE practices by European SMEs. The most adopted efficiency action was the minimization of waste, undertaken by 65.5% of SMEs; minimizing energy use by keeping stable or increasing performance was adopted by 63.2% of them, saving materials regards 56.8% of SMEs, and minimization of water waste is adopted by 47.3%. Recycling inside company through reuse and use of waste was undertaken by 41.8% of companies; designing ad hoc of products that are easier to maintain, repair or reuse them is applied by 25.4% of firms. The sale of waste to other companies is done by 21.1% European SMEs, while the least adopted sustainability practice is the choice to use mainly renewable energy (14.0%).

Table 1 shows the relationship between the adoption of sustainability practices and the characteristics of the firms by number of employees, economic activity sector, age, turnover in 2016; all relationships are statistically significant according to the Chi-squared test.

Tab. 1: Percentage of European SMEs adopting CE practices by characteristics.

	Minim. waste	Saving energy	Saving materials	Saving water	Recycling	Design products	Selling scrap	Renewable energy
EU 28	65.5	63.2	56.8	47.3	41.8	25.4	21.1	14.0
Size								
1-9	64.7	62.3	55.4	46.9	40.1	24.3	18.0	12.6
10-49	66.3	64.1	62.3	46.1	45.9	28.2	31.5	17.4
50-249	77.2	75.9	64.7	56.3	58.6	38.1	47.7	30.2
250+	80.3	81.9	62.0	69.6	59.1	26.8	29.7	26.8
Turnover								
-100,000	57.0	58.1	54.2	43.4	38.0	21.2	17.2	11.6
100,00-500,000	66.7	63.3	57.0	48.3	39.0	26.5	18.8	14.6
500,000-2mil	68.8	67.1	59.7	46.4	46.1	28.9	26.6	15.5
2-10mil	71.3	69.5	63.6	46.5	47.4	22.3	30.0	17.7
10-50mil	78.4	77.9	72.4	58.0	56.9	42.9	53.0	43.3
+50mil	84.7	80.9	64.5	68.5	50.5	17.3	23.4	21.6
Sector								
Manufacturing	71.3	64.6	64.2	43.4	41.9	33.2	31.5	12.7
Retail	65.1	66.9	56.9	48.3	44.1	24.3	21.6	11.7
Services	62.7	61.3	54.2	46.4	38.5	23.2	15.1	14.1
Industry	70.4	60.4	59.1	46.5	46.4	28.1	30.0	18.7
Age								
-31 Dec 2010	66.7	64.4	57.2	47.9	41.7	25.3	22.4	14.4
1 Jan 2010-31 Dec 2012	62.2	59.3	55.8	42.0	41.9	24.5	16.3	13.3
1 Jan 2013-31 Dec 2017	61.0	58.5	55.1	46.7	40.2	26.5	17.5	13.0
1 Jan 2017+	66.8	63.8	52.0	47.4	53.1	26.0	21.1	5.6

Entrepreneurial sustainability is by definition linked to the social and economic context. In developed countries, both legal framework and financial resources are very solid, favoring sustainable entrepreneurship. In developing countries, transition to Circular Economy is more challenging, especially in terms of infrastructures and new technologies (Abarca Guerrero et al., 2020). The legal context is one of the factors which varies most from state to state also in the European Union; even if our analyses do not directly focus on this aspect, it is an element that must be kept in consideration for appropriate comparisons. Economic indicators at national level are also important to understand the wealth of the country since the economic dimension of sustainability coincides with the large amount of liquidity that can be used to satisfy the needs and requests of stakeholders. In more developed countries, investment policies are directed mostly to the private sector, since it is more inclined

to support innovation and competitiveness, which favor a sustainable growth (Cadil et al., 2018). The level of innovation goes hand in hand with new technologies, which can also be considered a prerequisite. Although SMEs do not usually make innovation as the most important aspect of their structure, there is significant financial support by the European Union to increase their performance in terms of sustainability. The reference literature shows that entrepreneurial sustainability is also influenced by factors such as gender, age, education, skills, family context and community background. Therefore, differences between countries with regard to CE practices are the result of the complex mixture of all aspects mentioned above (Spangenberg et al., 2002). Table 2 lists the percentage of firms implementing each sustainability action in the 28 European MSs.

A preliminary exploratory cluster analysis on the data reported in Table 2 classifies the 28 EU MSs in four homogeneous groups for the percentage of SMEs operating in the country and adopting CE practices. The greenest firms are located in France, Ireland, Portugal, Spain, Sweden and Great Britain, countries were the percentage of SMEs adopting CE practices is higher than the average for at least seven among the eight considered actions, except for the efficiency practice of using renewable energy. A second group is formed by Austria, Belgium, Croatia, Czech Republic, Denmark, Finland, Germany, Italy, Luxemburg, Poland, Slovenia, The Netherlands; in these countries the percentage of firms adopting CE practices is higher than the average for many practices, these percentages, however, are lower than those observed for SMEs located in the first group of countries. The percentage of firms in these countries that are saving water and energy is lower than that in the average sample. The third group refers to Greece, Hungary, Latvia and Slovakia whose SMEs implement only in small percentages, lower than those observed at European level, the majority of actions; however, in these countries, firms are involved in selling scrap material to other companies. Finally, in the last group of countries, Bulgaria, Cyprus, Estonia, Lithuania, Malta, and Romania only a very small percentage of SMEs adopts green practices. This first result highlights the presence of a discrete level of heterogeneity in adopting efficiency practices in the 28 European countries, this evidence will be further explored in the next section of the paper.

Tab. 2: Percentage of European SMEs adopting CE practices by country, figures in *italics* indicate a value greater than the average.

	Minim. waste	Saving energy	Saving materials	Saving water	Recycling	Design products	Selling scrap	Renewable energy
EU 28	65.5	63.2	56.8	47.3	41.8	25.4	21.1	14.0
Austria AT	60.0	*71.8*	52.3	44.1	*47.7*	*31.3*	*25.6*	*32.3*
Belgium BE	*75.0*	*69.8*	61.6	46.7	40.5	25.3	*25.6*	*19.9*
Bulgaria BG	27.7	36.4	30.6	29.5	16.9	9.8	16.3	4.4
Cyprus CY	28.6	50.0	28.6	28.6	*46.4*	7.1	14.3	7.1
Czech Republic CZ	64.0	60.9	46.2	42.4	34.7	*32.6*	*29.1*	7.2
Germany DE	61.3	*70.2*	57.1	35.8	38.6	24.1	23.0	*32.0*
Denmark DK	50.0	56.3	52.3	41.4	28.9	*26.6*	*26.4*	9.4
Estonia EE	8.6	20.0	14.3	8.6	11.8	5.7	5.7	2.9
Spain ES	65.5	*72.4*	*69.5*	*54.8*	*56.9*	*31.9*	20.0	7.4
Finland FI	55.2	50.7	53.7	26.9	31.6	23.3	18.7	*14.3*
France FR	*83.1*	*71.2*	*59.4*	*67.8*	*42.5*	*32.7*	18.0	5.5
Great Britain GB	*81.9*	*66.8*	*61.8*	*55.7*	*70.2*	*25.8*	*28.8*	*16.3*
Greece GR	36.8	51.4	45.4	32.8	30.1	18.3	*25.9*	12.3
Croatia HR	64.3	*65.5*	*62.4*	*51.2*	29.8	17.9	*28.2*	8.3
Hungary HU	40.1	57.8	45.0	40.1	18.8	16.3	20.9	7.4
Ireland IE	*84.9*	*68.5*	*57.4*	*59.3*	*70.4*	24.5	*25.9*	*18.5*
Italy IT	*73.6*	57.3	52.5	44.4	37.3	23.0	15.2	*15.0*
Lithuania LT	20.5	42.0	33.0	35.2	6.8	6.8	15.9	3.4
Luxemburg LU	60.0	50.0	52.4	33.3	*45.0*	*28.6*	25.0	*15.0*
Latvia LV	34.5	60.0	54.5	43.6	14.5	16.4	10.9	3.6
Malta MT	64.3	*71.4*	35.7	28.6	*50.0*	14.3	21.4	*14.3*
Netherlands NL	65.2	*64.7*	*61.3*	32.1	36.9	20.6	*25.7*	*26.7*
Poland PO	55.1	57.3	*59.9*	*49.5*	23.6	16.7	21.1	4.1
Portugal PT	55.1	*75.6*	*74.8*	*63.1*	*65.9*	*42.2*	*23.7*	9.2
Romania RO	31.0	32.9	29.5	23.4	21.5	6.3	12.0	4.4
Sweden SE	*76.3*	57.9	*66.1*	36.1	*61.1*	*32.4*	*26.3*	*35.3*
Slovenia SI	50.7	47.9	52.1	35.6	32.9	*26.0*	21.9	*16.4*
Slovakia SK	44.1	57.7	43.6	44.9	35.7	14.5	15.9	5.7

4. STATISTICAL ANALYSIS[3]: METHODS AND RESULTS

4.1 CLASSIFICATION TREE

In order to identify homogeneous groups of countries with reference to the number of CE practices, among the eight considered in the survey, adopted by SMEs, we

[3] For the analyses the software R was used.

estimated a classification tree (CART) (Breiman et al., 1984). CART is a statistical method of a-priori segmentation, i.e, segments are identified on the basis of a criterion variable *Y*. In our application, this variable quantifies the adherence of a generic SME to the efficiency measures proposed in the questionnaire with the following three categories: 5 or more measures adopted (class 1), between 1 and 4 CE practices (class 2), no sustainable measures (class 3). From the dataset, it emerged that 36.4% of SMEs in the sample belong to the first class, 52.3% to the second one and 11.3% had not carried out any efficiency action in the reference period. As independent variable for the classification tree, we considered: the countries where the SME operates (28 levels). Considering these values for all SMEs operating in the 28 European countries, the CART algorithm identifies the best partition of countries through an iterative algorithm, which is reported in Table 3. These groups will be the starting point to analyze and quantify the heterogeneity between EU member states (MSs), in terms of adopted resource efficiency variable *Y* for a generic SME in each of the five groups of countries identified by the CART algorithm. The CART procedure can be divided into two distinct parts: tree growing and tree pruning. In the first part of the model, the response variable is repeatedly split, starting with the variable that has the highest association with it. The splitting continues till a predetermined stopping criteria (Zhang, 2016). In the pruning phase of the algorithm, which is performed on another subsample of data in order to avoid overfitting, the best grouping is identified on a basis of a measure of fit; we used total deviance.

Tab. 3: Groups of homogeneous countries: CART best partition.

Group of countries	
A	Austria, Belgium, France, Great Britain, Ireland, Portugal, Sweden Spain
B	Croatia, Germany, Italy, Malta, Slovakia, The Netherlands
C	Czech Republic, Denmark, Luxemburg, Poland
D	Cyprus, Finland, Greece, Hungary, Latvia, Slovenia
E	Bulgaria, Estonia, Lithuania, Romania

Tab. 4: Probabilities (%) of belonging to the three classes of variable *Y* in the five groups of countries

Group of countries	Class 1 5+ actions	Class 2 1-4 actions	Class 3 No actions
A	42.63	51.95	5.42
B	30.98	60.76	8.26
C	28.89	56.45	14.66
D	20.60	57.77	21.63
E	8.68	58.32	33.01

Groups of countries in the Tables 3 and 4 are ordered by decreasing probabilities of adopting CE practices by SMEs operating in their territories. There is a big difference of behavior between firms in groups A and E; for example, the percentage of SMEs that do not implement efficiency actions increases from 5.42% to 33.01%. In group A we find the European countries with the greenest businesses; in group E, the least green ones. Group B includes countries belonging to Western and Southern Europe; the proportion of SMEs not activating sustainability practices is a bit higher than that of group A, 8.26%. Group C is composed of only four countries, where a high percentage of SMEs is adopting at least one CE practice. Countries in group D are the most different for what concerns location in Europe and with one fifth of them not implementing CE practices. Finally, countries in group E are all located in Eastern Europe.

4.2 MULTILEVEL ANALYSIS

The CART analysis identified homogeneous groups of European Union MSs, confirming heterogeneity of behavior between countries. In each group, however, it is important to explore further differences among SMEs, especially in relation to their characteristics that might affect their decision to adopt CE. The identification of homogeneity and heterogeneity among European countries must be followed by an appropriate analysis of heterogeneity within each MS. As written in the introduction, there is a rich literature on the factors affecting companies' decision to comply with sustainability; some of these evidences are confirmed also by the descriptive analyses of our data as reported in section 1. In order to face this problem, it is necessary to use statistical methods for hierarchical data (Hox, 2002). In our specific sample, SMEs are nested into countries and this originates a multilevel dataset. In this section of the paper, we will explore how decisions towards CE actions are related to factors as size, turnover, number of workers, etc., i.e., we aim to quantify how the probability of adopting CE actions is determined by SMEs characteristics. A second goal of the analyses is to understand how economic investment affects environmental measures and if this aspect varies among the groups of countries. And finally, we will look at the eight specific CE actions considered in the survey to evaluate which factors are specifically determinant in their adoption. We now indicate with Y_{ij} the number of resource efficiency actions undertaken by the *i*-th SME belonging to the *j*-th group with *j=1,..,28*, as we are considering the 28 EU MSs; Y_{ij} will assume values from 1 to 8. Our multilevel model is given by equation (1):

$$\ln\left(\mu_{ij}\right) = \beta_{o\,j} + \beta_{1\,j}\, x_{ij} + R_{ij}$$

where Y_{ij} is assumed to follow a Poisson distribution with mean μ_{ij}. In the random

intercept model, β_{0j} are random variables representing differences among groups:

$$\beta_{0j} = \gamma_{00} + U_{0j}$$

and U_{0j} is a random effect, at state level, following a Normal distribution with 0 mean and variance equal to σ_U^2. As independent variables (vector $\boldsymbol{X}$), we consider: SME dimension, the year of foundation, average turnover in the reference year, the sector of economic activity; the number of full-time workers employed in green jobs. Tables 5 and 6 list the result of the estimation of this multilevel random intercept model with our dataset, the estimates refer to the best fitting model assessed with the lowest values of AIC and BIC indexes.

Tab. 5: Estimated parameters: random intercept model

	Estimate	Standard deviation	p-value
Intercept	0.966	0.059	<0.001
# workers			
-9 ref. category			
10-49	0.097	0.019	<0.001
50-249	0.058	0.046	0.209
250+	0.119	0.067	0.041
Age			
-31 Dec 2010 ref. category			
1 Jan 2010-31 Dec 2012	-0.026	0.017	0.128
1 Jan 2013-31 Dec 2017	-0.007	0.015	0.620
1 Jan 2017+	-0.037	0.041	0.042
Turnover			
-100,000 ref- category			
100,00-500,000	0.048	0.013	<0.001
500,000-2 million	0.077	0.015	<0.001
2-10 million	0.086	0.022	<0.001
+10 million	0.265	0.030	<0.001
Sector			
Manufacturing ref. category			
Retail	-0.068	0.017	<0.001
Services	-0.166	0.016	<0.001
Industry	-0.062	0.018	0.002
# workers in green jobs			
0 ref. category			
1-5	0.320	0.010	<0.001
6-9	0.283	0.026	<0.001
10-50	0.512	0.025	<0.001
51-99	0.504	0.084	<0.001
100+	0.713	0.115	0.003
var(μ_j)	0.086	0.021	<0.001

Tab 6. Countries' effects: random intercept model

AT	3.261	EE	1.145	HU	2.398	NL	3.108
BE	3.348	ES	3.416	IE	3.668	PL	2.624
BG	1.730	FI	2.442	IT	2.734	PT	3.656
CY	2.172	FR	3.587	LT	1.718	RO	1.532
CZ	2.875	GB	3.954	LU	2.724	SE	3.350
DE	3.023	GR	2.247	LV	2.109	SI	2.721
DK	2.693	HR	2.770	MT	3.015	SK	2.337

The magnitudes of country intercepts mirror the groups obtained with the regression tree analysis. In general, from Table 5 we see which are the factors significantly affecting the decision to implement resource efficiency practices and how they might act. For example, yearly turnover and the number of workers employed in green jobs have a direct effect on the number of implemented actions, while the manufacturing is the sector where SMEs are more prone to sustainability activities. There is also a non-negligible effect of dimension and age, in the sense that bigger and older firms are more inclined to resource efficiency practices. For what regards dimension, small and large firms adopt a greater number of CE practices, while medium businesses do not.

Starting from the above evidences, we consider important to explore another aspect related to the effect of economic investments on sustainability. The question is "do equal investments for sustainable measures led to a proportional total adhesion to CE in the homogeneous groups of countries obtained with the CART segmentation procedure?". The dataset contains the information on the amount invested on average per year by each SME in order to become more resource efficient. This information gives rise to a categorical variable with the following classes: no investment, less than 1% of yearly turnover, between 1 and 5%, between 6 and 10% and more than 10%. Le Y_i the number of CE practices adopted by SME *i*, that is assumed to follow a Poisson distribution with mean μ_i, we estimate the model in equation (2) separately for the SMEs in the five groups of countries in Table 3.

$$ln(\mu_i) = \eta_i + x_{ik}\beta_k + z_i y \tag{2}$$

where $k=1,..,5$, x_k are the covariates used in the multilevel regression model and z is the categorical variable indicating the amount of yearly turnover invested to improve the sustainability of the business by SME *i*. Table 7 lists the results of the estimation of the generalized linear model (GLM) in equation (2) for the SMEs operating in the five groups of countries described in Table 3; i.e., 5 GLMs are estimated.

Tab. 7: GLMs: estimation results

Group A	Estimate of γ	Standard error	p-value
0% ref. category			
<1%	0.335	0.019	<0.001
1-5%	0.419	0.018	<0.001
6-10%	0.516	0.030	<0.001
>10%	0.610	0.045	0.002
Group B			
0% ref. category			
<1%	0.407	0.025	<0.001
1-5%	0.575	0.024	<0.001
6-10%	0.598	0.033	<0.001
>10%	0.726	0.056	<0.001
Group C			
0% ref. category			
<1%	0.700	0.039	<0.001
1-5%	0.743	0.040	<0.001
6-10%	0.746	0.059	<0.001
>10%	0.410	0.099	<0.001
Group D			
0% ref. category			
<1%	1.030	0.061	<0.001
1-5%	1.019	0.058	<0.001
6-10%	0,976	0.082	<0.001
>10%	1.016	0.099	<0.001
Group E			
0% ref. category			
<1%	1.311	0.095	<0.001
1-5%	1.347	0.105	<0.001
6-10%	1.208	0.153	0.003
>10%	1.506	0.144	<0.001

Values of estimated parameters clearly show that the higher the percentage of turnover invested, the higher the number of CE practice adopted by SMEs in all five groups of countries. However, this relationship has a different magnitude in the five groups, increasing from SMEs operating in countries classified in group A to SME operating in European countries classified in group E. In countries of group A, SMEs implement the highest number of sustainability practices, for this reason the result that in this group investments have the lowest impact deserves attention. In our opinion, this evidence shows that the transition from a linear economic system to a circular one in these countries, once started, does not require high

extra investments to be maintained, we can briefly say that a Circular Economy system, once implemented, continues to increase business sustainability, somehow self-expanding.

As a further analysis, we want to obtain a measure of adhesion for each state to the single actions studied; to answer this question, again we must apply a statistical method that takes into account the hierarchical nature of the data.

For this scope, we define a new variable Y_{ij} that takes value 1 if SME *i*, operating in European country *j*, adopted the specific considered efficiency action, while it takes value 0, otherwise; the following multilevel logit model in equation (3) is estimated for the eight surveyed actions:

$$\log\left[P\left(Y_{ij} = 1 \middle| \mu_j \right)\right] = x_{1ij}\,\beta_1 + x_{2ij}\,\beta_2 + x_{3ij}\,\beta_3 + x_{4ij}\,\beta_4 + x_{5ij}\,\beta_5 + \mu_j \qquad (3)$$

x_1 represents the number of workers, x_2 the age of the SME, x_3 average yearly turnover, x_4 the sector of economic activity and x_5 the number of workers employed in green jobs; μ_j is the random intercept with Normal distribution with mean 0 and variance σ^2_μ. Table 8 lists the values of the random intercepts for the eight models, estimated for the corresponding efficiency actions, obtained for each European country and refer to micro-enterprises with a number of employees between 1 and 9, founded before 1st January 2010, belonging to the sector manufacturing, with an average yearly turnover of less than 100 thousand euros and without any workers in green jobs. The eight actions are: minimize waste of water, minimize energy use, use of renewable energy, attention to raw materials, waste minimization, selling of waste to other companies, recycling of waste or others materials and designing of sustainable products ready for reuse, reuse or with minimal environmental impacts. Figures in the table show that preferences in adopting specific CE actions are different in the 28 MSs; these evidences emerged also from descriptive statistics in Table 2; they are confirmed taken into account the multilevel structure of our data.

Tab. 8: Random intercepts

	Minimizing waste	Saving energy	Saving materials	Saving water	Recycling	Design products	Selling scrap	Renewable energy
AT	0.35	0.63	0.23	0.51	0.56	0.26	0.38	0.25
BE	0.39	0.64	0.14	0.62	0.73	0.26	0.33	0.24
BG	0.26	0.33	0.04	0.34	0.30	0.22	0.14	0.12
CY	0.27	0.47	0.07	0.39	0.63	0.21	0.37	0.14
CZ	0.38	0.58	0.06	0.49	0.65	0.32	0.30	0.33
DE	0.28	0.62	0.23	0.56	0.57	0.22	0.29	0.22
DK	0.36	0.50	0.06	0.52	0.47	0.25	0.22	0.25
EE	0.17	0.29	0.04	0.28	0.17	0.19	0.15	0.08
ES	0.45	0.64	0.05	0.68	0.61	0.21	0.47	0.29
FI	0.21	0.42	0.09	0.51	0.50	0.20	0.24	0.21
FR	0.64	0.67	0.04	0.62	0.83	0.19	0.36	0.33
GB	0.50	0.63	0.13	0.65	0.84	0.34	0.66	0.26
GR	0.25	0.41	0.08	0.43	0.32	0.27	0.22	0.17
HR	0.38	0.53	0.05	0.58	0.57	0.25	0.22	0.15
HU	0.36	0.54	0.07	0.48	0.40	0.24	0.16	0.17
IE	0.47	0.60	0.12	0.57	0.81	0.25	0.60	0.22
IT	0.33	0.45	0.10	0.49	0.69	0.15	0.19	0.27
LT	0.33	0.41	0.04	0.38	0.23	0.21	0.08	0.11
LU	0.28	0.45	0.09	0.51	0.53	0.24	0.34	0.22
LV	0.32	0.48	0.03	0.51	0.31	0.18	0.12	0.15
MT	0.32	0.61	0.10	0.46	0.62	0.23	0.42	0.19
NL	0.26	0.58	0.20	0.62	0.64	0.29	0.30	0.20
PO	0.41	0.49	0.03	0.60	0.53	0.23	0.18	0.16
PT	0.54	0.67	0.06	0.73	0.51	0.27	0.58	0.40
RO	0.19	0.27	0.03	0.30	0.29	0.16	0.17	0.07
SE	0.27	0.47	0.24	0.62	0.73	0.25	0-32	0.28
SI	0.47	0.44	0.11	0.54	0.50	0.18	0.29	0.25
SK	0.36	0.49	0.04	0.41	0.39	0.42	0.27	0.13

The sector of economic activity and the dimension of the firm have a different effect on the different actions. For example, actions as 2 (minimize energy use), 3 (use of renewable energy) and 6 (sale of waste to other companies), which require large investments, are more chosen by larger SMEs.

5. CONCLUDING REMARKS

The scope of this paper is to investigate differences in behavior towards sustainability practices of European SMEs. Heterogeneity emerges both between and within

European countries.

Segmentation analysis identified five groups of European countries, homogeneous for the attitude of SMEs to CE actions. In eight states, Austria, Belgium, Spain, France, Great Britain, Ireland, Portugal and Sweden, (group A), firms show the highest level of innovation in the field of sustainability, only a very small percentage of businesses (5.4%) do not adopt any efficiency measure. In this group of countries, the average number of green actions implemented by each SME is 3.9, out of the eight investigated by the Flash Eurobarometer survey. The estimation of a multilevel regression model shows a similar behavior among the eight nations, i.e., low level of within group heterogeneity. On the opposite side we find SMEs that operate in countries classified in group E, Latvia, Lithuania, Romania and Estonia, where we found the lowest attention to Circular Economy practices; SMEs adopt on average only 1.4 CE actions.

For what concerns firms' characteristics, the yearly turnover and the sector of economic activity proved to be significant in determining an efficient business management; SMEs in the manufacturing sector are the most inclined to perform green actions. The presence or absence of employees involved in green jobs is another important factor. The proportion of yearly turnover invested in sustainability directly affects the number of resource efficiency actions implemented by European SMEs, i.e, as investment increases, more actions are implemented; however, this effect is not the same in its magnitude in the five groups of homogenous countries, it is lower in the group of greenest countries. This result shows that investment in sustainability has decreasing marginal returns on implementation of resource efficiency actions.

As a general consideration, results from our analyses show that, for what regards CE attitudes in European SMEs, there is a lot of between and within country heterogeneity. Policies that aim to increase CE practices adoption must take these differences into account and therefore should be tailored for specific SMEs within each country. For what concerns countries, differences are related to geographical location, SMEs in Western-European countries exhibit more attention to green matters that SMEs in Eastern-European countries. However, there are some exceptions. Moreover, the geographical location is strictly correlated to economic and social conditions in the European MSs. A limitation of this study is that we did not insert in our models covariates collected at country level; this is a topic that deserves further attention. Further attention has to be paid also to the specific CE actions; also in this case there are difference between and within countries. These differences are related to SMEs' characteristics and to costs of implementation. Incentives to favor green economy should consider these elements as well.

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