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Research article

Sustainability-oriented management in the SMEs. A multilevel analysis in the European Union

Alberto Maman [a], José G. Dias [b], Francesca Bassi [a,*]

[a] Department of Statistical Sciences, University of Padua, Via Cesare Battisti, 241, 35121 Padova PD, Italy
[b] Business Research Unit (BRU – IUL), Instituto Universitário de Lisboa (ISCTE – IUL), Av. das Forças Armadas, 1649-026 Lisboa, Portugal

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ABSTRACT

This research focuses on SMEs in the EU and their acceptance of circular economy practices, with a special attention to the structural characteristics that might be significant drivers. Eight indicators of environmentally friendly practices are studied: water saving, energy saving, renewable energy, material saving, waste reduction, sale of waste materials, waste recycling, and eco-designed products. A sample of European SMEs from EU-28 data (countries at the time of the survey) is used to test hypotheses through eight multilevel probit regression models. Company- and country-level covariates are added to the multilevel models. The results showed that the number of employees, the business sector and the type of products/services sold have an impact on environmentally friendly practices. On the other hand, at the national level, per capita GDP and greenhouse gas emissions are the most relevant factors in the eight models. These findings are relevant for the implementation of the European Green Deal, which aims to increase resource efficiency through the transition to a cleaner EU and circular economy.

1. Introduction

The concept of sustainability was born in 1987, when the World Commission on Environment and Development (Brundtland Commission) in its book "Our Common Future" (WCED, 1987) defined sustainable development as "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs". Thus, the general concept means that there are limits to the availability of environmental resources and the ability of the biosphere to absorb human activities. The idea was to focus the attention on social and environmental issues and to establish guidelines to support economic growth by wasting fewer resources, conserving natural resources, and changing the direction of investments. Climate change, environmental pollution and pervasive social degradation were some of the most troublesome outcomes of the industrial age. Excessive loads affect the natural resilience of the environment and increase social tension; hence people were aware of the problem and research has tried to address these issues (Doppelt, 2003). This argument has been endorsed at the highest level by the United Nations. Its Sustainable Development Goals (SDGs) have been supported by many stakeholders operating at different levels, namely policymakers, academics, and enterprises. The Covid-19 pandemic created further specific imbalances on the socio-economic dimensions.

In this paper, we focus on the sustainability approach of small and medium-sized enterprises (SMEs) in the European Union, which can play a key role in promoting environmental and social well-being, representing 99.8% of all enterprises in the EU-28 non-financial business sector and accounting for two thirds of total employment in the EU-28 (66.4%) (European Commission, 2018a). Therefore, SMEs can introduce a significant impact on the environment and society. This study deals with the so-called environmental performance of the company, which is the sum of all the environmental efficiency practices it pursues. These actions are of various kinds; thus, many organizations have given their definition of eco-efficiency (Côté et al., 2006). We follow that proposed by the World Business Council for Sustainable Development (WBCSD), which defined eco-efficiency as "achieving more value from lower inputs of material and energy and with reduced emissions" (Côté et al., 2006, p. 544). The eco-initiatives range from innovations in processes, products, and operations to reduce consumption of energy, water and materials to environmental management strategies in which products, processes and even business models are redesigned to reduce the ecological footprint throughout the product life cycle

* Corresponding author.
E-mail addresses: alberto.maman@studenti.unipd.it (A. Maman), jose.dias@iscte-iul.pt (J.G. Dias), bassi@stat.unipd.it (F. Bassi).

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(Aragón-Correa et al., 2008).

Many entrepreneurs believe that making sustainable changes, such as sustainable internal policies or green processes, means an unprofitable investment, but sustainable entrepreneurship is at the same time focused on work, community, environment, and profit (Russo and Fouts, 1997; Zamfir et al., 2017). Eco-friendly initiatives involve costs; therefore, the decision to be sustainable is not common among SMEs and cost savings are often the most important driver of investment decisions. The existence of more attractive investment opportunities and the limited availability of capital are important barriers for not investing in energy saving technologies (Masurel, 2007). On the other hand, it is now clear that sustainable resource management is positively linked to economic performance (Porter and van der Linde, 1995; Russo and Fouts, 1997; Malesios et al., 2021), and that an important role is assigned to external pressures such as environmental policies and incentives (e.g., Altemburg and Assmann, 2017; Henriques and Sadorsky, 1996). This research focuses on European SMEs, their acceptance of circular economy practices and the impact of European legislation on these practices, as well as an assessment of the competitive advantage created by the implementation of the circular economy.

Economic growth and social development will be very important in European countries in the coming years after the Covid-19 pandemic. Circular economy and resource efficiency practices will make a significant contribution to this recovery in all sectors of economic activity. As described in many sources (see, for example, Colombelli et al., 2021; Jové-Llopis and Segarra-Blasco, 2018), the implementation of a circular economy could help manage with the consequences of the Covid-19 pandemic because it has a direct impact on the environment and because many recent studies showed that green business projects provide better business growth results than traditional ones. As already mentioned, SMEs represent 99% of all companies in Europe and are major contributors to the Gross Domestic Product of most EU countries (Rodríguez-Rebés et al., 2024). Therefore, assessing the factors influencing the adoption of CE practices is a timely research question. As, for example, Gennari (2022) showed, it is very important that SMEs are supported in their transition towards CE, this process would indeed increase the speed towards a global green transition, being SMEs better positioned regarding the local environment and the labor force than large companies.

Recent literature has examined the relationship between the willingness towards eco-friendly behavior and the structural characteristics of a given company. The most studied variables are company size (generally measured by the number of employees), the economic sector of reference, type of served market, presence of qualified green employees, nationality, and age (e.g., Bassi and Dias, 2019; Baylis et al., 1998; Hoogendoorn et al., 2015; Johnstone et al., 2004; Uhlaner et al., 2012). This study aimed to examine the factors influencing the environmental performance of European SMEs; in particular, we wanted to identify which characteristics of the SMEs lead to concrete eco-friendly initiatives. To this end, Section 2 reviews the literature to understand the importance of each eco-initiative and to identify potential explanatory factors. Section 3 introduces the country-level dimension. The link between environmental performance and company characteristics is tested based on the Flash Eurobarometer 456 – SMEs, resource efficiency and green markets; the data and the sample are described in Section 4. Section 5 presents statistical methods; Section 6 reports the results of the models' estimation; Section 7 discusses the findings, Section 8 presents policy implications and Section 9 concludes.

The originality of our contribution with respect to the abundant literature on this topic and specific papers already published with analyses on data collected by Flash Eurobarometer 456 (see, for example, Darmandieu et al., 2022; Kalar et al., 2021) is given by three factors: firstly, we test hypotheses regarding all – or at least many – possible drivers of adoption of CE practices by EU SMEs (using the same respondents), secondly, we analyzed jointly data collected in the 28 EU MSs; and finally, we applied statistical methods for hierarchical data, avoiding the ecological fallacy.

At the same time, a limit of this paper is that we did not make detailed analyses for single countries or even homogeneous groups of them, but simply considered the effect of country characteristics on the probability of implementing circular economy practices at company level. These more detailed analyses will be object of further research.

2. Literature review and research hypotheses

Starkey (1998) defined environmental management as the "management of those activities of a company that have or can have an impact on the environment" (p. 12). As this definition is very general, there are many possible corporate environmental strategies for greater environmental performance, which meet the same overall sustainability goal. These eco-initiatives range from reactive strategies aimed at meeting legal requirements and implementing pollution control, to more proactive strategies involving voluntary eco-efficient practices. The World Business Council for Sustainable Development (WBCSD, 2006) has grouped eco-initiatives into seven macro-categories based on their purpose: reduce the material intensity, reduce energy intensity, reduce the dispersion of toxic substances, enhance recyclability, maximize the use of renewable resources, extend product durability, and increase service intensity. We followed a similar subdivision that brings together initiatives for sustainable waste management, such as the reduction of all types of waste and their recycling. We also introduced a special category for measures aimed at water saving, given the importance of this resource (e.g., Hameeteman, 2013).

2.1. *Water saving*

The global water crisis in many countries poses a serious threat to water security. About 700 million people in 43 countries suffer from water stress and 1.8 billion lack access to basic sanitation (Hameeteman, 2013). Globalization, urbanization, and economic and technological development have been identified as the main causes of the worrying increase in water demand and water scarcity around the world. Water saving is a frequently discussed issue in the EU, as water consumption in Europe has decreased since the 1990s (EEA, 2018b). Measures to fix water pricing, technological improvements in water use processes and economic change in Europe may be the reason for this decrease. An important regulatory framework was introduced in 2014 with the EU's Seventh Environment Action Program (European Parliament, 2013). The program aimed to protect, preserve, and strengthen the Union's natural capital, which meant preventing or significantly reducing stress on renewable water resources by 2020. The literature highlighted the difference in water footprint between European countries (e.g., Serrano et al., 2016). Factors such as investment, policies, education, and the development of highly efficient water technologies that encourage companies to adopt water conservation practices have often been discussed. Johnstone et al. (2004) pointed out that the environmental management system (EMS) has a special role to play in encouraging companies to take water-saving measures (companies with certified EMS are more likely to implement environmental measures, in particular eco-efficient water management measures). The study supported the contention that companies with relatively high revenue growth rates were marginally more likely to take steps to reduce water consumption. Therefore, our first hypothesis is.

Hypothesis 1.1. SMEs showing economic growth are more likely to save water.

The same study found that companies that reported taking measures to reduce water consumption tended to be larger (Johnstone et al., 2004). This is in line with research showing that size is positively related to environmental performance. For instance, Baylis et al. (1998) used data from a survey on South Wales companies to show that size has a significant impact on environmental improvements. Thus, we

hypothesize that.

Hypothesis 1.2. Larger SMEs are more likely to participate in water saving actions.

The consumption of water is influenced by the type of activity that the company carries out, as the water saving activities mainly concern some economic sectors, such as the primary sector, which brings together all the activities related to the exploitation of natural resources, agriculture, fishing, livestock, and forestry, as well as industry and manufacturing companies. This is supported by the European Environmental Agency (EEA), which showed that the agricultural sector accounted for 40% of Europe's water consumption in 2015, followed by electricity, gas, steam, and air conditioning companies (27.8%), and mining and quarries, manufacturing and construction (17.7%) (EEA, 2018b). Velázquez (2006) identified direct and indirect water consumption in economic sectors and showed that water consumption varies considerably between them. For instance, the agricultural industry and textile sector represent high levels of direct consumption and low levels of indirect consumption, while the industrial and service sectors show indicators of low direct consumption and indicators of high indirect consumption. Thus, we hypothesize that.

Hypothesis 1.3. The sector to which the company belongs has an impact on environmental performance in terms of water saving.

The market served by a company can be a factor that influences business decisions about environmental practices. Although the differences between these macro-categories are well documented in the literature, their impact on environmental performance has not generally been studied. Buying behavior and attitudes towards sellers differ significantly between types of consumers. For example, sustainable business-to-consumer (B2C) behavior can directly or indirectly influence companies' image and, therefore, the attitude of consumers towards their supply (Orsato, 2006). End consumers are generally more aware of environmental issues than companies; therefore, companies that work directly with them are more likely to increase their environmental performance (Bassi and Dias, 2019). Johnson et al. (2018) showed that B2C corporations perceive greater pressure from customer-oriented stakeholders than business-to-business (B2B) companies. European and national regulations play a fundamental role in the purchasing behavior of public administrations and can therefore influence the response to market demand of business-to-government (B2G) companies. Based on these considerations, we will test the following hypothesis.

Hypothesis 1.4. B2C companies are more often involved in water saving.

There are reasons to believe that there is a link between the age of the company and the tendency to introduce more eco-friendly practices, but the results in the literature are contradictory. According to Neubaum et al. (2004), start-ups are not prone to ethical behavior as they face the responsibility for innovation, lack of resources, and concerns of survival. On the other hand, Hockerts and Wüstenhagen (2010) showed that new entrants are more oriented towards environmentally friendly behaviors, as more experienced counterparts are often less ambitious in their environmental and social goals due to their consolidated presence on the market (Ghisellini et al., 2023). Nevertheless, research disclosed that the relation between innovation and firm's age is complex (Leoncini et al., 2019). However, we hypothesize that.

Hypothesis 1.5. Younger companies are less likely to save water.

2.2. Energy saving

In recent decades, energy efficiency has become crucial for sustainable development. It has become clear that energy efficiency can bring many important economic and environmental benefits. The problem to be addressed is the growth in global energy demand, which appears to outweigh energy efficiency improvements. Therefore, it is necessary to develop energy efficiency initiatives in the industrial and economic sectors, supported by stakeholders and policy makers (IEA, 2018). In their study, Khan (2014) examined the relationship between energy consumption, economic growth, and greenhouse gas emissions in the context of 10 different regions of the world over the period 1975–2011. The results showed that energy consumption is closely linked to greenhouse gas emissions, which cause a worrying rise in global temperatures. Therefore, energy efficiency has become one of the main objectives of EU policy and its target of 20% reduction in primary energy consumption was identified in the Commission's Communication on Energy 2020 (European Commission, 2010) as a key step towards achieving long-term energy and climate goals and to support smart, sustainable, and inclusive growth. In general, the Member States have transposed the Directive and therefore promoted energy efficiency initiatives on their territory; indeed, Eurostat data showed a downward trend (−6.3%) in final energy consumption in the EU between 2000 and 2014. However, this trend varies considerably between Member States; for example, in the period 2000–2014, the highest rate of decline was recorded in Greece (−16.6%), followed by the United Kingdom (−15.3%) and Portugal (−11.8%); on the contrary, Lithuania (28.2%), Malta (22.9%), and Latvia (19.4%) were the countries with the highest final energy consumption compared to 2000 (Bertoldi et al., 2016). Sardianou (2008), who examined barriers to industrial energy investments in Greece, showed how there is a different approach to energy management between different sectors. The European Environmental Agency measured final energy consumption by economic segment and found that in 2016 the transport sector is responsible for 33.16% of final energy consumption, households 25.71%, industry 24.99%, services 13.54%, and agriculture 2.60% (EEA, 2018a). Thus, we hypothesize that.

Hypothesis 2.1. The sector to which the company belongs has an impact on environmental performance in terms of energy saving.

Another factor that can influence a company's propensity for sustainable management is the availability of funds. SMEs are generally characterized by short-term managerial strategies; therefore, investing in eco-initiatives can be expensive. On the other hand, Crals and Vereeck (2004) showed how the opportunity costs of a sustainable strategy can exceed the financial costs for SMEs and highlighted the attention of these companies towards this type of practice. However, limited financial resources must be considered. Russo and Fouts (1997) showed that the introduction of green strategies is associated with higher financial performance. This finding is supported by Johnstone et al. (2004), who exposed how revenue growth is related with the propensity to introduce eco-initiatives. Thus, we hypothesize.

Hypothesis 2.2. Companies showing economic growth are more likely to save energy.

It is also estimated that competing industrial companies with large numbers of employees are more likely to adopt an energy efficiency project. Bassi and Dias (2019), for example, supported this thesis by analyzing data on the introduction of circular economy practices in European SMEs. On the other hand, Alhourani and Saxena (2009) showed that the number of employees and the volume of sales, proxies of company size, do not significantly affect the implementation of the recommendations on energy efficiency and production. Thus, we hypothesize that.

Hypothesis 2.3. Larger SMEs are more likely to engage in energy saving practices.

One of the factors that can influence the implementation of energy saving projects in SMEs in the EU is the type of market served, i.e., if the company sells to end-consumers, other companies or public administration. Bassi and Dias (2019) showed that B2C companies are more

likely to implement such measures, in contrast to Hoogendoorn et al. (2015), who concluded that buyer type does not have a direct influence on a company's decisions to implement green processes. Thus, we hypothesize that.

Hypothesis 2.4. B2C companies are more often engaged in energy saving practices.

It is possible that there is a link between the age of the company and its attitude towards saving energy. Research showed an insignificant effect of the age of the company on efficient energy consumption (Bassi and Dias, 2019; Hoogendoorn et al., 2015). Other studies indicated how start-ups are less concerned with their environmental performance due to their priorities (e.g., Neubaum et al., 2004). Hockerts and Wüstenhagen (2010) and Ghisellini et al. (2023) reported greater attention by start-ups to environmental issues. However, since we believe that experience plays a role in the transition to CE (Leoncini et al., 2019), we formulate the hypothesis.

Hypothesis 2.5. Younger companies are less likely to engage in save energy practices.

2.3. Using renewable energy

Energy policy has always been an important part of economic and industrial policy. In 1997 most countries of the world signed the Kyoto Protocol, an international treaty that obliges countries to reduce greenhouse gas emissions based on the scientific consensus that global warming, which is very likely to result from CO_2 emissions of anthropogenic origin. Consequently, climate change and the reduction of greenhouse gas emissions have become important pillars of modern energy policy in the post-Kyoto period. Renewable energy sources and technologies have been identified as a means of reducing the impact of the energy system on the global climate, diversifying energy supplies and reducing dependence on domestic fossil fuel markets (particularly oil and gas). The International Energy Agency (IEA) defined renewable energy as energy that is collected from renewable resources that are naturally renewable over a period. The definition includes electricity and heat produced by the sun, wind, ocean, hydropower, biomass, geothermal resources, biofuels, and hydrogen from renewable sources (IEA, 2002). According to the IEA (2018), as of 2016, renewable energy accounted for 18.2% of total final energy consumption. With the Council Directive 2009/28/EC (Council of European Union, 2009b), the EU defined a general policy for the production and promotion of energy from renewable sources, so that it must satisfy up to 20% of the own energy needs by 2020. According to Eurostat,[1] several countries have already achieved their targets, such as Sweden, Finland, and Denmark. At the opposite end of the scale, the lowest shares of renewable energy sources were recorded in Luxembourg (7.0%), the Netherlands (8.8%), and Malta (8.5%). Therefore, the territorial factor seems to be very important for the use of energy from renewable sources, as seen by Bassi and Dias (2019). Rahbauer et al. (2018), in their study on the factors influencing the decision of German small and medium-sized enterprises to adopt green electricity, found that micro-enterprises are more likely to accept green electricity than larger ones. This observation contrasts with other studies that showed that smaller companies are more likely to face information barriers that potentially hinder adoption (Uhlaner et al., 2012). Rahbauer et al. (2018) attributed this unexpected finding to fewer bureaucratic obstacles and decision-making characteristics in small family-owned SMEs. According to their results, we hypothesize.

Hypothesis 3.1. Larger SMEs are more likely to use renewable energy.

The economic sector in which a company operates can be a factor influencing a company's decision to exploit energy from renewable sources. According to a report by the National Renewable Energy Laboratory, most of the national electricity for end-user consumption is consumed by industry, commercial, and public segments (NREL, 2017). However, in general, large industrial energy users have the incentive and the experience to manage their energy costs; in the commercial sector, energy costs are often a small percentage of total costs and generally do not attract the same managerial visibility and attention. There is a significant difference in behavior towards renewable energy sources between economic sectors, hence the following hypothesis.

Hypothesis 3.2. The sector to which the SMEs belong has an impact on environmental performance in terms of exploitation of renewable energies.

As we have seen, many studies have linked economic growth and green practices introduced in the business (e.g., Johnstone et al., 2004; Russo and Fouts, 1997). Thus, we set the hypothesis.

Hypothesis 3.3. SMEs that show economic growth are more likely to use renewable energy.

Regarding the type of the served market, Hoogendoorn et al. (2015) showed that it does not have a direct impact on company's decisions about the predominant use of clean energy. Bassi and Dias (2019) also reported an insignificant impact on the attitude of SMEs towards the use of energy from renewable sources, but the paper also showed that B2C companies are more interested in green practices. Thus, we hypothesize that.

Hypothesis 3.4. B2C SMEs are more likely to exploit energy from renewable sources.

Another result of Bassi and Dias (2019) is that the age factor can be correlated with the propensity to use renewable energy; they indeed showed a negative effect for the latest companies. In other words, younger companies are less likely to introduce these practices. In our study, we test the following hypothesis.

Hypothesis 3.5. Younger SMEs are less likely to use energy from renewable sources.

2.4. Waste management

Among many eco-initiatives, sustainable waste management has become increasingly important in the field of environmental protection. Waste is one of the main causes of environmental pollution; therefore, it is essential to reduce the production of possible polluting materials, in particular, total global greenhouse gas emissions are closely linked to materials management (UNEP, 2010). Waste as defined in Council Directive (2008)/98/EC (Council of European Union, 2008) is "any substance or object which the holder discards or intends or is required to discard", which can mean a significant loss of resources in the form of materials and energy. In addition, waste management and disposal can have serious environmental impacts. Landfills, for example, are becoming increasingly crowded, producing toxic and explosive gases and releasing heavy metals and toxins into groundwater and soil, and incineration pollutes the air with toxins and heavy metals. The general framework for waste management in the EU is set out in Council Directive (2008)/98/EC (Council of European Union, 2008) on waste (the Waste Framework Directive). The main priority is to prevent waste generation, which means that sustainable behavior avoids unnecessary consumption and reduces waste generation, which increases efficiency. Resource utilization is the next most favorable class of options, which includes all activities aimed at preserving materials in the productive economy and reducing pressure on the environment by reducing the need for natural materials and the absorption of waste. Where waste cannot be avoided and reduced, priority measures are the reuse of materials before they become waste, the recycling process by which waste

[1] https://ec.europa.eu/eurostat/statistics-explained/index.php/Renewable_energy_statistics (accessed on 11.05.2023).

materials are reprocessed into products for both the internal production cycle and for third parties, and energy recovery such as incineration. Final disposal is always a last resort, the waste hierarchy recognizes that certain types of waste, such as hazardous chemicals or asbestos, cannot be safely recycled; therefore, it should be treated and disposed of in accordance with regional regulations (Hansen et al., 2002). Sustainable waste management must be integrated into the circular economy framework. Much of the current EU approach to production and consumption continues to be based on a linear model in which resources are extracted, processed, used, and ultimately, mostly disposed of as waste (a "take, make and dispose of" system). At the end of the cycle, the waste is usually disposed of by incineration or landfill. According to research by the European Parliament, in 2012 the EU-28 consumed 5 billion tons of material, of which only 20% from recycled secondary raw materials and disposed of 2.5 billion tons of waste material, of which 42% in landfill (STOA, 2017). The concept of circular economy focuses on the value of materials and products that must be kept as high as possible for as long as possible. This helps reduce the need to introduce new material and thus reduce the environmental stress associated with the product life cycle, from acquisition, production, and use of resources to the end of the life cycle. The total amount of waste produced by each Member State[2] depends on population and economic size: smaller countries report lower waste generation rates and vice versa, with exceptions such as a relatively low level in Italy. Based on standardized data (kg of waste produced per capita), the highest level is reached by smaller countries, such as Finland and Belgium, with a particularly high value recorded for Estonia, where on average 27.3 tons of waste was produced per capita in 2018, around four times more than 7.1 tons per capita in the EU-28. The same Eurostat data showed that the total amount of waste produced in 2018 in the EU-28 comes from different segments; the largest share was in the construction sector (35.9%), followed by mines and quarries (26.6%), manufacturing (10.6%), and households (8.2%); the rest is waste generated from other economic activities, mainly services and energy. Uhlaner et al. (2012) concluded that the tangibility of the sector has a positive impact on the introduction of eco-friendly corporate management, leading to a greater development of such practices in the sector such as agriculture, industry, retail, and transportation. Johnstone et al. (2004) found that companies operating in the metal sector, energy and fuels, and publishing sectors are less likely to take steps to reduce solid waste. Thus, we hypothesize.

Hypothesis 4.1. The sector to which the company belongs has an impact on environmental performance in terms of waste management.

According to many studies, larger SMEs are more likely to be involved in environmental management practices than smaller SMEs (Aragón-Correa et al., 2008; Uhlaner et al., 2012). Johnstone et al. (2004) concluded that larger companies are more likely to reduce the environmental impacts of solid waste production; while Brammer et al. (2012), who examined SMEs' perceptions of the pressures and benefits of engagement with environmental issues, highlighted that medium-sized enterprises are more active in eco-friendly actions than small enterprises, especially more active in reducing waste in the manufacturing process. Basaran (2013) showed in more detail how larger companies are more likely to deliver waste to another company for recycling than smaller companies among Turkish SMEs. Thus, we test the following hypothesis.

Hypothesis 4.2. Larger SMEs are more likely to eco-manage waste.

The economic factor of the company can be important for responsible waste management. If we recall the link between economic growth and green practices (Johnstone et al., 2004; Russo and Fouts, 1997), we can hypothesize that if the company exhibits economic growth, it is more inclined to introduce environment-oriented management. The new working hypothesis is.

Hypothesis 4.3. SMEs showing economic growth are more likely to develop waste management practices through eco-management.

Possible factors that could affect the environmental performance of SMEs include the type of market served and the year of establishment. Both were analyzed by Hoogendoorn et al. (2015), who concluded that neither the age of the company nor the reference market had a significant impact on the propensity to introduce ecological practices. Studies on the impact of company age on environmental performance have reported conflicting results (Hockerts and Wüstenhagen, 2010; Neubaum et al., 2004). Nevertheless, we put forward the following hypothesis.

Hypothesis 4.4. Younger SMEs are less likely to develop waste management practices through eco-management waste practices.

Bassi and Dias (2019) showed a significant impact of the type of buyers on the implementation of waste reduction measures through recycling, reuse of waste or its sale to another company; the results showed a significant positive effect on goods and services sold directly to consumers. Thus, we hypothesize.

Hypothesis 4.5. B2C SMEs are more likely to develop waste management practices through eco-management waste practices.

2.5. Saving materials

In 2010, the global consumption of materials was 79.4 billion tons (Schandl et al., 2016). In a normal business scenario, annual consumption is estimated to increase to 180 billion tons by 2050 (Dittrich et al., 2012). This increase is due to the predominance of a linear model of resource consumption in which new resources are extracted, used as inputs for production processes, and then discarded (Ellen MacArthur Foundation, 2013). With this economic model and built-in accelerations, humanity is overstepping the limit of Earth's biological capacity.

Resource exploitation is an environmental and economic issue, so implementing the company's sustainable projects can focus on reducing the inputs needed to produce goods and services. Water and energy can be inputs, but they can also be physical raw materials.

For a company, the raw materials can be different, such as natural resources and semi-finished products. Reducing the use of materials to produce the same product is a change that brings many benefits, both economic and environmental. The reorientation of new techniques to reduce resources is an investment that involves reducing production costs while reducing waste and unnecessary stock (Porter and van der Linde, 1995). It is reasonable to believe that the attitude of SMEs towards such initiatives depends on a territorial factor. The emphasis on environmental issues by companies has been shown to differ between EU countries (Bassi and Dias, 2019).

As we have seen for energy efficiency practices, the sector in which a company operates can influence the introduction of practices aimed at the efficient use of materials. For instance, Palčič et al. (2013), who analyzed energy-saving technologies and material-saving technologies of Slovenian and Spanish manufacturing companies, argued that material-saving initiatives are mostly implemented by companies belonging to the low- and medium-tech sector (according to the OECD taxonomy). We test the hypothesis.

Hypothesis 5.1. The sector to which the SME belongs has an impact on environmental performance in terms of material savings.

Palčič et al. (2013) also concluded that the most efficient companies in terms of material consumption have, on average, high numbers of employees. This is consistent with other research showing a positive effect of the dimension on environmental performance (Russo and Fouts, 1997; Uhlaner et al., 2012). Thus, we formulate the hypothesis.

Hypothesis 5.2. Larger SMEs are more likely to engage with material

[2] https://ec.europa.eu/eurostat/statistics-explained/index.php/Waste_statistics (accessed on 2.6.2023).

saving practices.

As we have seen for other types of eco-initiatives before, material savings measures can also be associated with a positive economic performance (Russo and Fouts, 1997). Therefore, we test the hypothesis.

Hypothesis 5.3. SMEs that show economic growth are more likely to engage with material saving practices.

The type of buyer can influence the implementation of material saving measures. As we have already seen, companies are generally more sensitive to environmental issues when serving end-consumers (Orsato, 2006), but the results are generally different in the literature (e.g., Bassi and Dias, 2019; Hoogendoorn et al., 2015). Nevertheless, we hypothesize that.

Hypothesis 5.4. B2C SMEs are most likely to engage in material saving practices.

Such a discussion on the age factor can be made in the same way. The literature supports opposite conclusions (e.g., Hockerts and Wüstenhagen, 2010; Neubaum et al., 2004). Some papers support the focus of new companies on environmental issues, while others outline the limits of start-ups. We hypothesize that.

Hypothesis 5.5. Younger SMEs are less likely to engage in material saving practices.

2.6. Eco-design products

Safeguarding ecosystems through sustainability-oriented management is a key objective of EU member countries. According to the OECD, unsustainable production and consumption are increasingly deteriorating the health of the global environment and biodiversity (OECD, 2001). In particular, human consumption is the ultimate cause of all environmental damage. The environmental impact associated with consumption has been widely studied; for instance, Nijdam et al. (2008) used a method to determine detailed information on the impact of private Dutch consumption on the ecosystem. One of the tasks of companies to limit the impact on the environment due to consumption is to develop products that are durable, easy to maintain, repair or reuse.

In the EU, the European Commission identified and addressed the issue of planned obsolescence. For instance, the Directive 2009/125/EC (Council of European Union, 2009a) of the European Parliament (i.e. Eco-design Directive) allowed the Commission to set mandatory minimum reparability requirements as well as the expected lifespan of energy-related products. Some more specific initiatives addressed life requirements for a limited number of product categories, such as vacuum cleaners' components and light bulbs. In addition, in line with the EU action plan on the circular economy (European Commission, 2015) adopted in December 2015, the Commission planned to promote reparability, upgradability, durability, and recyclability by developing additional product requirements in line with the Ecodesign Directive guidelines.

Citizens' perceptions, attitudes, and practices regarding the efficient use of goods and the generation and management of waste vary considerably between Member States, in particular as regards the selection, maintenance, and disposal of durable products. For instance, Flash Eurobarometer 388 data (European Commission, 2014) showed that repairing of broken equipment is the most common waste management measure in Spain (89%), Latvia (82%) and the Netherlands (82%). Portugal (92%) has the largest share of respondents who say they repair, while the Czech Republic (56%) and Slovenia (58%) have the lowest one. Or even in Austria, Denmark, and Portugal, the main reason people do not cut waste is that repairing goods is too expensive or difficult. In contrast, only 14% of people in Estonia and 17% in Cyprus mention problems or the cost of repair. Therefore, we will have to consider the heterogeneity between European countries.

According to Rivera and Lallmahomed (2016), SMEs are very enthusiastic about innovating and can sometimes develop products faster than larger companies. Unfortunately, the business models and managerial strategies often do not allow them to easily overhaul, as their risks are much more important. Because they are primarily concerned with short-term economic survival, they are not motivated to develop an environmentally friendly product (Baylis et al., 1998; Uhlaner et al., 2012). Thus, we formulate the hypothesis.

Hypothesis 6.1. Larger SMEs are more likely to design sustainable products.

The theme of product design and development is linked to the economic segment in which the company operates. There are sectors where consumers need to achieve a high level of product reliability or the possibility of quick repairs, such as for home appliances and automobiles, while in many other manufacturing sectors, consumers usually do not care about product durability, such as in the case of goods with a low level of involvement.

Mont (2008) highlighted how eco-design strategies for extending the life of a product vary widely between product categories, as consumers' attitudes are different and force producers to develop different design strategies to address the environmental issue. It also drew attention to restrictions on product life extension for certain product groups. For instance, increasing the durability of energy-related durable goods can have a negative impact on the environment, because innovative products are generally more energy efficient than old ones. In the light of these considerations, we hypothesize.

Hypothesis 6.2. The sector to which the SME belongs influences the attitude towards the design of sustainable products.

Designing products to reduce environmental impact is a practice that increases a company's environmental performance. As can already be seen from the literature, the introduction of green strategies is associated with higher financial performance (Russo and Fouts, 1997). Furthermore, although the short-term strategy of SMEs limits their propensity to make such investments, studies point out that also for them the relationship between opportunity costs and sustainable strategy is strong and exceeds financial costs (Crals and Vereeck, 2004). For instance, eco-designed products can contribute to greater customer loyalty, as they can bring economic benefits for consumers, such as greater durability or lower energy consumption (Aoe, 2007). We define the following hypothesis.

Hypothesis 6.3. SMEs showing economic growth are more likely to design sustainable products.

The type of served market is a factor that can explain a company's attitude towards designing more environmentally friendly products. Plouffe et al. (2011) conducted an empirical study on the profitability of eco-designed products, analyzing 30 French and Canadian companies. Results showed that the B2B sector is more sensitive to eco-designed products. Companies seem to be more interested in eco-designed products than final consumers. Thus, we test the hypothesis.

Hypothesis 6.4. B2B SMEs are more likely to design sustainable products.

The behavior of companies in designing products that have less impact on the environment can be related to the age of the company. As we have seen, companies have different business models and risk perceptions depending on their age (Hockerts and Wüstenhagen, 2010); therefore, we can assume that there are also differences in the design of their products. Plouffe et al. (2011) showed that companies with less

experience in eco-design reported better economic performance. Less experienced companies are generally start-ups that do not have an established market background. This conclusion contradicts the results of Bassi and Dias (2019), who showed a positive effect in older companies. We will test the hypothesis that younger companies are more likely to design products with less impact, as these investments support business growth, i.e.

Hypothesis 6.5. Younger SMEs are more likely to design sustainable products.

3. Country-level dimensions

As we have seen, numerous studies confirmed that the country in which companies operate influences their propensity to implement eco-sustainable initiatives (see e.g., Bassi and Dias, 2020). To explain this heterogeneity between countries, we looked at the impact of country-level factors on the environmental sensitivity of businesses.

The impact of the demographic indicators on environmental degradation is often discussed in the literature. For instance, Bargaoui et al. (2014) showed that the population contributes to an increase of carbon dioxide emissions and therefore to a deterioration of the environment. Cole and Neumayer (2004), who conducted a study using panel data from 86 countries between 1975 and 1998, showed that CO_2 emissions were positively related to population size, degree of urbanization, and energy intensity consumption. Therefore, demographic indicators can explain the differences between countries in terms of attention to environmental issues and these differences can explain eco-sustainable management decisions in national companies.

Numerous studies in the literature addressed the relationship between environmental degradation and economic indices such as per capita income. For instance, Grunewald and Martínez-Zarzoso (2009) studied different income groups of countries over the period 1975–2004 and found that the impact of population growth on emissions is slightly different for upper, middle-, and low-income countries. Grossman and Krueger (1991) found an analogy with Kuznets' inverted-U relationship between income inequality and development, but numerous reviews showed some criticalities in presenting the relationship via the Kuznets' environmental curve (e.g., Copeland and Taylor, 2004; Dasgupta et al., 2002). Therefore, these articles suggested alternative views resulting from decomposition and new models but emphasizing the presence of a relationship (Kaufmann et al., 1998; Stern, 2004).

The influence of social factors on environmental degradation, such as waste production habits, has also been discussed in the literature (e.g., Banar and Özkan, 2008; Buenrostro et al., 2001; Gómez et al., 2009). These studies showed that the social characteristics of communities influence their attitude towards environmental issues. It can be hypothesized that the community's attitudes directly or indirectly affect the management of SMEs.

To consider the ecological characteristics of each country, indices that can summarize the environmental status should be introduced. The dissemination of these indicators is becoming increasingly crucial due to the growing importance of environmental issues, especially for the important and direct effects on policies (Tietenberg, 1998). We can hypothesize that attitudes towards environmental issues of the national level, summarized by dedicated indices, affect companies; for instance, if the national government is focused on green policies, national companies are likely to be more encouraged towards eco-sustainable management.

4. Data and sample

Eurobarometer is a series of opinion polls conducted on behalf of the European Commission. These surveys have been run since 1973 and address a few issues concerning the European Union and the Member States. The main purpose is to allow the European Commission to immediately become aware of public opinion, evaluate the effectiveness of the implemented policies and take decisions; the survey is in fact aimed at allowing comparisons between the Member States and at detecting the evolution over time of relevant phenomena. The data is collected through opinion polls in 28 EU Member States for a more comprehensive comparison.

To evaluate the hypotheses proposed, this paper uses the unique data from the Flash Eurobarometer 456 - SMEs, resource efficiency and green market (European Commission, 2018b). The questions concern current and planned funding resources and initiatives, obstacles to the implementation of eco-initiatives and the role and impact of external support used by SMEs. The data are particularly relevant as they measure the degree of presence in the company of eco-initiatives grouped by purpose. The survey was conducted in the 28 EU Member States in September 2017, which included the United Kingdom at that time. Information is collected on the characteristics of SMEs and their focus on eco-sustainable managerial practices. Specifically, companies are asked if they have introduced the following eight measures: water saving; energy saving; use of mainly renewable energy; saving of materials; waste reduction; sale of scrap material to another company; recycling, reusing material or waste within the company; design of products that are easier to maintain, repair or reuse.

Our analysis refers to the data collected on a sample of 12,907 SMEs, located in the 28 countries of the European Union. The sample was selected from an international business database and was representative for company size and sector in each country. Moreover, post-stratification weights were made available to researchers in order to ensure representativeness of statistical analysis (European Commission, 2018b). Table 1 contains the frequency distribution of the variables of interest, in the sample of European SMEs.

Table 2 reports the percentage of SMEs in the sample adopting each one of the CE practices, this percentage is disaggregated by the characteristics of the firms implied in our hypotheses.

The country-level variables used in the analyses and measured in the

Table 1
SMEs sample description.

	Frequency
Size	
1-9	80.1
10-49	15.8
50-249	3.1
≥ 250	1.0
Turnover	
<100,000	27.3
100,000–500,000	38.1
500,000-2mil	24.0
2-10mil	7.5
10-50mil	2.2
>50mil	1.0
Sector (NACE)[a]	
Manufacturing (C)	10.2
Retail (G)	30.5
Services (H, I, J, K, L, M)	43.3
Industry (B, D, E, F)	16.3
Age	
≤ Dec 31, 2010	77.3
1 Jan 2010–31 Dec 2012	9.5
1 Jan 2013–31 Dec 2017	12.0
≥ Jan 1, 2017	1.2

[a] NACE classification: B: Mining and Quarrying, C = Manufacturing, D = Electricity, gas, steam, and air conditioning supply, E = Water supply, sewerage, waste management and remediation, F = Construction, G = Wholesale, retail trade, repair of motorcycles and vehicles, H = Transportation and storage, I = Accommodation and food service activities, J = Information and communication, K = Financial and insurance activities, L = Real estate activities, M = Professional, scientific and technical activities.

Table 2
Percentage of European SMEs adopting CE practices by characteristics.

	Minimizing 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
Jan 1, 2017+	66.8	63.8	52.0	47.4	53.1	26.0	21.1	5.6

year 2017 are as follows: the percentage of the population living in urban areas in the EU-28 country at mid-year in 2017 is provided by the United Nations Population Division[3]; the population density, the ratio between the average annual population in 2017 and the land area from Eurostat[4]; the Gross Domestic Product (GDP) per capita in 2017 by Eurostat[5]; the unemployment rate in 2017 by Eurostat[6]; the proportion of the population aged 30 to 34 who have completed tertiary studies in 2017 (university, higher technical institution, etc.) by Eurostat[7]; the air quality index in 2017 by Eurostat[8]; and the environmental tax revenue, calculated as the proportion of environmental tax revenue in the total revenue of all taxes and social contributions by Eurostat.[9]

5. Methods

The data show a nested structure with two levels: the upper level, represented by the 28 EU Member States, and the lower level with SMEs. This type of structure is considered in data analysis by estimating multilevel regression models (Snijders and Bosker, 2012). Multilevel models are characterized by a response variable, which is always a first-level variable, and by one or more explanatory variables, which can belong to any level and allow explaining the variability of the phenomenon. First-level variables are selected to explain the variability of the phenomenon at the individual level and followed by second-level variables to explain the variability at the group level.

In multilevel regression, unobserved heterogeneity is modeled by including random effects. In our analysis, we introduced a random intercept into the model representing the heterogeneity that is not captured by fixed effects. In this way, the intercept takes on different values position between the groups and the regression curve takes a different position in the space for each group.

We considered eight response variables, each of which corresponds to a type of eco-initiative; thus, we want to model these responses according to the explanatory variables. Furthermore, depending on the binary nature of the response variables (undertaken/not undertaken), we applied a multilevel probit model and we estimated it for each one of the response variables indicating the adoption of a specific practice.

The value y_{ijk} measures the response to item k ($k = 1,\ldots,8$), equal to 1 if SME i ($i = 1,\ldots,n_j$) of country j ($j = 1,\ldots,28$) undertook activity k, and 0 otherwise. The observed response y_{ijk} is binary with the standard assumption that is Bernoulli distributed:

$$Y_{ijk}\left|\pi_{ijk} \sim Bin\left(\pi_{ijk}, 1\right)\right.$$

$$\pi_{ijk} = Pr\left(Y_{ijk} = 1 | X_{ij}, Z_j\right)$$

where π_{ijk} represents the probability that Y_{ijk} is equal to 1, given the characteristics of company i (X_{ij}) and country j (Z_j). We define the linear component of the multilevel probit model:

$$\Phi^{-1}\left(\pi_{ijk}\right) = \beta_{0jk} + \sum_{h=1}^{H} \beta_{hjk} x_{ihj}$$

$$\beta_{0jk} = \gamma_{0k} + \sum_{l=1}^{L} \gamma_{lk} z_{jl} + u_{jk}$$

where $\Phi^{-1}(.)$ denotes the inverse of the distribution function of the standard normal. x_{ihj} corresponds to the observed value of the covariate h (we have H first level covariates) for company i in country j, while β_{hjk} is the associated regression parameter. β_{0jk} represents a random component, but we expect the variation not to be completely random; thus, we can at least explain part of the variability by introducing second-level variables that operate with different intensities from one group to another, but constant within the same group. z_{jl} is the observed value for the second-level covariate l (we have L second-level covariates) for country j, while γ_{lk} is the associated regression parameter, γ_{0k} is the common intercept for all units; u_{jk} is the between-country error term, independent and normally distributed with a mean 0 and a variance σ_u^2.

[3] Data can be accessed from: https://population.un.org/wup/Download/ (accessed on 28.5.2021).
[4] Data can be accessed from: https://ec.europa.eu/eurostat/data/database (accessed on 28.5.2021).
[5] Data can be accessed from: https://ec.europa.eu/eurostat/data/database (accessed on 28.5.2021).
[6] Data can be accessed from: https://ec.europa.eu/eurostat/data/database (accessed on 28.5.2021).
[7] Data can be accessed from: https://ec.europa.eu/eurostat/data/database (accessed on 28.5.2021).
[8] Data can be accessed from: https://ec.europa.eu/eurostat/data/database (accessed on 28.5.2021).
[9] Data can be accessed from: https://ec.europa.eu/eurostat/data/database (accessed on 28.5.2021).

We apply the full maximum likelihood method to estimate the model, as it is fast in the estimation phase and allows for easy comparison between nested models. For all models, explanatory variables were selected with a backward procedure[10], using the AIC (Akaike Information Criterion)[11] as model selection criterion (Akaike, 1974).

The intra-class correlation coefficient (ICC) measures the proportion of the total dispersion that is explained by country level:

$$ICC = \frac{\sigma_u^2}{\sigma_\varepsilon^2 + \sigma_u^2}.$$

It represents the share of total variability attributable to the group effect and is useful to understand if it is necessary to estimate a multilevel model (Kreft and de Leeuw, 1998).

6. Results

The model estimates are presented in Tables 3 and 4, the dependent variable of each model represents one of the eight green actions surveyed. Estimates are based on a sample of 12,023 European SMEs with no missing values.

The likelihood ratio test confirms that the variance σ_u^2 differs significantly from zero in all models, which means that the introduction of a random intercept is useful for data modeling. The next general finding is that the inclusion of second-level variables leads to a decrease in the value of ICC with respect to the corresponding models having only first-level covariates, which confirms that country-level variables help explain the variability between European countries.

In the case of the water saving initiative (Table 3), all the first-level variables were kept in the final model by the backward procedure selection, which means that they all influence the probability of introducing water saving initiatives. We note that the probability of adopting this action increases with the size of the company; the result confirms what was previously hypothesized (hypothesis H1.2). As for the economic sector, companies belonging to the industrial sector are less likely to save water.[12] This supports hypothesis H1.3, which confirms what was seen in the EEA report (EEA, 2018b). The results on the impact of age are less clear: companies born between January 1, 2010 and January 1, 2013 are less likely to save water than older companies; however, the probability does not differ significantly between companies founded before January 1, 2010 and companies founded after January 1, 2013. Therefore, the data do not support hypothesis H1.5. The direct contact with end consumers increases the probability of introducing at least water saving initiatives, which confirms the hypothesis H1.4; B2G companies also show a propensity for such investments. Both environmental variables (gas emissions and environmental tax revenues) are statistically significant: companies in countries with a high CO_2 emissions and countries with high environmental tax revenues are less likely to save water. Demographic indicators affect the management of SMEs, the probability of water saving is lower in more urbanized countries and increases in countries with higher population densities. Country-level education shows a positive and significant effect, the unemployment rate is not statistically significant. GDP per capita was eliminated by the backward selection procedure.

In the case of energy saving (Table 3), the backward procedure led to the exclusion of the dummy variables B2B and B2G from the first-level and the variable urbanization rate from the second-level. The probability of energy saving also seems to be influenced by the size of the SMEs: the estimates obtained confirm the hypothesis H2.3, i.e., that larger SMEs are more likely to introduce energy reduction initiatives than those with fewer employees. The results seem to support hypothesis H2.1. Companies in the industrial and service sector are significantly less likely to save energy than manufacturing companies. As regards the age of the companies, hypothesis H2.5 is confirmed; indeed, consolidated companies are more likely to save energy. Hypothesis H2.4 instead shows that companies, which sell products and services to consumers, are more likely to implement energy saving initiatives. The results show that companies based in a country with a high per capita GDP, higher education rate, and densely populated are more likely to save energy, which confirms what is shown in the literature. While SMEs in countries with high CO_2 emissions are less likely to implement such initiatives. The effect of environmental taxes is positive, in the sense that living in a country with high income from environmental taxes increases the probability. The effect of the unemployment rate is not statistically significant.

The results of the model, which refers to the practice of using renewable energy sources (Table 3), confirm hypothesis H3.1: the company size has a positive effect on the probability of implementing this initiative. The hypothesis H3.2 also seems to be confirmed; in fact, SMEs belonging to the industrial sector are more likely to use renewable energy than companies in other sectors. Furthermore, this probability is lower for companies founded after January 1, 2013 than for older companies, which confirms hypothesis H3.5. Finally, we can also confirm hypothesis H3.4, as B2C companies are more interested in this type of initiative. The only significant second-level variable is the per capita GDP, which indicates a positive effect.

As for material savings (Table 3), the backward selection removed the year of foundation, which means that the age of the company does not affect the probability of material savings; thus, hypothesis H5.5 cannot be confirmed. The hypotheses H5.1, H5.2, and H5.4 are all confirmed; in fact, larger SMEs, manufacturing companies, and B2C companies are more likely to save materials. Per capita GDP and CO_2 emissions are the only two significant country-level variables; the estimates confirm what was shown in the literature: companies from richer countries with lower greenhouse gas emissions are more likely to introduce eco-sustainable practices.

To examine the factors influencing the eco-sustainable waste management actions in SMEs, we estimated three models (Table 4): the first model shows how the probability of implementing waste reduction initiatives varies among SMEs; the second model refers to sale of scrap material; and the third to the recycling of waste. The results of the fourth model reported in Table 4 refer to eco-designed products.

With reference to waste management, the results seem to support the hypotheses H4.1, H4.2, and H4.5; size has a positive effect on the probability that the company will implement waste reduction initiatives that are part of eco-sustainable waste management actions: larger SMEs are likely to reduce waste. Direct-to-consumer service also increases this probability. The economic sector influences the decision to reduce waste. The results show that manufacturing companies are more likely to implement such initiatives; instead, service companies are the least prone. Backward selection eliminated the age of the company from the model; thus, we cannot confirm hypothesis H4.4: the age of the company does not have a significant effect on the probability of reducing waste. Country-level covariates are useful in explaining the differences of SMEs between EU countries. However, the level of education, the urbanization rate, and the unemployment rate are not statistically significant. Results confirm the literature; in fact, the effect of per capita GDP and population density have a positive effect on the probability of introducing waste reduction initiatives, while the effect of emissions and environmental taxes is negative.

As for the sale of waste material, the results are quite different from

[10] This procedure controls the problem of multicollinearity: if two covariates are correlated, the weakest in explaining the dependent variable will be removed from the model.

[11] The AIC information criterion compares nested and non-nested models, it is a function of the logarithm of the maximum value of the loglikelihood function and of the number of model parameters. The model with the lowest AIC value is chosen.

[12] Manufacturing refers to NACE sector C, Industry to NACE sectors (B - Mining, D – Electricity and gas, E – Water supply and waste management, and F - construction).

Table 3
Multilevel probit model estimates (saving water, saving energy, using renewable energy, saving material).

	Saving water			Saving energy			Renewable energy			Saving material		
	estimate	s.e.	p-value	estimate	s.e.	p-value	estimate	s.e.	p-value	estimate	s.e.	p-value
Level 1 - Fixed effects												
Number of employees												
1 to 9 employees (ref.)												
10 to 49 employees	0.103	0.032	0.001	0.113	0.032	<0.001	0.183	0.039	<0.001	0.248	0.032	<0.001
50 to 250 employees	0.410	0.067	<0.001	0.442	0.072	<0.001	0.535	0.073	<0.001	0.269	0.067	<0.001
Sector												
Manufacturing (ref.)												
Retail	0.0003	0.041	0.992	0.068	0.042	0.103	−0.032	0.055	0.561	−0.190	0.042	<0.001
Services	−0.087	0.04	0.029	−0.117	0.04	0.003	0.017	0.052	0.747	−0.296	0.040	<0.001
Industry	−0.124	0.046	0.006	−0.157	0.046	<0.001	0.253	0.058	<0.001	−0.172	0.046	<0.001
Date company established												
Before Jan 1, 2010 (ref.)												
1 Jan 2010–1 Jan 2013	−0.132	0.039	<0.001	−0.117	0.039	0.003	0.012	0.051	0.812			
After Jan 1, 2013	0.018	0.033	0.585	−0.103	0.033	0.002	−0.102	0.043	0.019			
Products/services sold												
Directly to consumers	0.216	0.027	<0.001	0.255	0.024	<0.001	0.211	0.035	<0.001	0.214	0.027	<0.001
To companies or other	−0.053	0.028	0.057				0.081	0.036	0.026	0.184	0.028	<0.001
To public administration	0.068	0.027	0.012				0.056	0.034	0.097	0.060	0.027	0.025
Level 2 - Fixed effects												
GDP per capita				0.216	0.069	0.001	0.540	0.099	<0.001	0.377	0.084	<0.001
Greenhouse gas emissions	−0.056	0.017	0.001	−0.034	0.014	0.016				−0.049	0.017	0.005
Urbanization rate	−0.615	0.303	0.042									
Unemployment rate	0.020	0.01	0.052	0.013	0.008	0.098						
Education rate	0.621	0.242	0.01	0.156	0.044	<0.001						
Population density	0.179	0.059	0.002	−0.069	0.021	0.001						
Environmental tax revenue	−0.087	0.025	<0.001									
Level 2 - Random effects												
σ_u^2	0.037		<0.001	0.020		<0.001	0.020		<0.001	0.045		<0.001
ICC	0.036			0.019			0.019			0.043		

Note: Residual variance equals 1; ref. indicates the reference category used in the dummy coding of predictor variables. When using dummy coding, estimated parameters are interpreted as the average increase in the dependent variable when a specific value of the independent one is observed with respect to the reference category.

Table 4
Multilevel probit model estimates (minimizing waste, selling scrap materials, recycling waste, ecodesigning products).

	Minimizing waste			Selling scrap materials			Recycling waste			Ecodesigning products		
	estimate	s.e.	p-value	estimate	s.e.	p-value	estimate	s.e.	p-value	estimate	s.e.	p-value
Level 1 - Fixed effects												
Number of employees												
1 to 9 employees (ref.)												
10 to 49 employees	0.177	0.033	<0.001	0.479	0.034	<0.001	0.249	0.032	<0.001	0.197	0.034	<0.001
50 to 250 employees	0.530	0.074	<0.001	0.866	0.067	<0.001	0.562	0.067	<0.001	0.447	0.068	<0.001
Sector												
Manufacturing (ref.)												
Retail	−0.185	0.044	<0.001	−0.195	0.044	<0.001	0.107	0.042	0.011	−0.210	0.043	<0.001
Services	−0.313	0.042	<0.001	−0.582	0.043	<0.001	−0.147	0.040	<0.001	−0.307	0.041	<0.001
Industry	−0.138	0.049	0.005	−0.0002	0.048	0.995	0.094	0.046	0.042	−0.136	0.047	0.004
Date company established												
Before Jan 1, 2010 (ref.)												
1 Jan 2010–1 Jan 2013				−0.132	0.047	0.005				0.015	0.042	0.713
After Jan 1, 2013				−0.115	0.039	0.003				0.089	0.035	0.012
Products/services sold												
Directly to consumers	0.221	0.028	<0.001							0.129	0.083	<0.001
To companies or other	0.119	0.029	<0.001	0.230	0.030	<0.001	0.081	0.026	0.001	−0.055	0.027	0.040
To public administration	0.099	0.028	<0.001	0.143	0.029	<0.001	0.157	0.026	<0.001			
Level 2 - Fixed effects												
GDP per capita	0.548	0.111	<0.001	0.177	0.059	0.002	0.601	0.121	<0.001	0.291	0.083	<0.001
Greenhouse gas emissions	−0.067	0.020	0.001				−0.047	0.024	0.053			
Population density	0.163	0.066	0.014									
Environmental tax revenue	−0.071	0.033	0.031							−0.055	0.027	0.040
Level 2 - Random effects												
σ_u^2	0.066		<0.001	0.018		<0.001	0.104		<0.001	0.038		<0.001
ICC	0.061			0.017			0.094			0.036		

Note: Residual variance equals 1; ref. indicates the reference category used in the dummy coding of predictor variables. When using dummy coding, estimated parameters are interpreted as the average increase in the dependent variable when a specific value of the independent one is observed with respect to the reference category.

the previous model, but still support the hypotheses H4.2 and H4.1; larger SMEs are more likely to sell leftovers to other companies, with the sector least prone to such initiatives being the services sector, while the manufacturing sector being the most prone. The estimates do not support the H4.5 hypothesis, as serving directly consumers does not affect the probability of the sale of waste; however, B2B and B2G companies appear to be more prone to such behavior. Furthermore, the estimates appear to support the H4.4 hypothesis, as companies founded between January 1, 2010 and January 1, 2013 and companies founded after January 1, 2013 are less likely to sell waste materials than older companies. The only significant second-level variable is per capita GDP, which confirms the results of the previous model, i.e., that SMEs in richest countries are more likely to manage waste in an eco-sustainable way.

Table 4 also provides estimates of a third model useful for testing hypotheses on eco-sustainable waste management. The estimates highlight which factors influence European SMEs in recycling by reusing material or waste in the company. The results confirm the H4.2 hypothesis as the two previous models: larger SMEs are more likely to recycle within the company. Hypothesis H4.1 is also confirmed, showing that service companies are less likely to implement such initiatives. An interesting result is that the probability of implementing waste recycling initiatives is more likely for companies that sell products and services to the public administration, while H4.5 hypothesis is not supported, as serving consumers directly does not affect that probability. Hypothesis H4.4 is also not supported, as the effect of the year of foundation is not significant. Significant country-level variables are per capita GDP and CO_2 emissions, with opposite sign.

The last model estimated is useful for understanding which characteristics of SMEs affect the probability that they design products that are easier to maintain, repair, or reuse. Estimates confirm the H6.1 hypothesis that larger SMEs are more likely to invest in eco-sustainable initiatives. Hypothesis H6.2 is also confirmed: manufacturing companies are more likely to design eco-design products. The results confirm the hypothesis H6.5; in fact, SMEs founded after January 1, 2013 are more likely to design products that are easier to maintain, repair, or reuse than older companies. Finally, it is also more likely to design products that are easier to maintain, repair, or reuse for B2C companies (H6.4). The significant country-level covariates are per capita GDP and environmental tax revenue. The same conclusions as for the other models apply: in richer countries the probability is greater, while with the growth of environmental tax revenues it decreases. The effects of the demographic dimension are not statistically significant.

7. Discussion

Environmental sustainability is becoming more and more important thanks to the growing awareness of the value of the environment around the world. In the EU, a few recent policies serve Member States as guidelines to direct companies towards sustainability-oriented management. The emphasis of this paper is on the eco-sustainable management of SMEs in the EU, as the previously published analyses focused mainly on large companies, underestimating the importance of the impact of SMEs on the environment. The aim of this paper was to analyze the characteristics of SMEs in the EU influencing the implementation of six distinct eco-initiatives and to examine the variability of adoption across the 28 EU Member States.

When the working hypotheses were established based on the literature, we used Flash Eurobarometer 456 data provided by the European Commission. Exploratory analyses on this representative sample of European SMEs have shown that around 90% of them have already implemented at least one eco-initiative; the figures are not comforting, as 10% have not yet introduced any initiative and SMEs represent 99% of the companies in the EU. The most popular initiatives are waste reduction practices (65%), energy savings (63%), and material savings (57%). These data support evidence that they are the most popular eco-initiatives that provide companies an immediate return on investment. The data show that only 14% of SMEs predominantly use energy from renewable sources, which confirms the lack of awareness of this impact and that policies are insufficient. The main reason why sustainable product design is not widespread among European SMEs (only 25% have adopted this practice) is that many companies sell services; thus, they do not need eco-design products or products that are difficult to redesign. Sales of waste materials also do not appear to be widespread (21%), probably because many SMEs sell services or prefer to treat waste differently.

The results show that specific characteristics of companies can explain the probability of adopting eco-initiatives. The SMEs size is significant for all types of eco-initiatives, i.e., it is a very important factor for the development of sustainability-oriented management. For all types of initiatives, larger SMEs are likely to introduce sustainable management and these companies are generally characterized by greater availability of resources and a forwards-looking management vision. The sector should also influence the behavior of companies for all types of initiatives. Many practices are closely linked to the type of economic activity of the company. For instance, the activities of selling waste materials and designing sustainable products are typical of industry and manufacturing. In general, the service sector is less likely to take eco-initiatives, probably because it is made up of companies with the least environmental impact. The adoption of eco-initiatives varies significantly according to the age of SMEs. The general trend is that older companies are more inclined towards eco-sustainable management. For instance, they are more likely to save water and energy, sell waste materials, and use renewable energy. For some initiatives, the behavior is similar between companies of different ages, while younger companies are significantly more likely to design products that are easier to maintain, repair, or reuse. This confirms that established companies are reluctant to redesign their products from an environmentalist point of view, and younger companies are more flexible and innovative. The type of market served affects differently depending on the type of initiative. In general, companies that sell products directly to end-consumers are more likely to adopt sustainable management. There are exceptions; for instance, B2B companies are more likely to sell waste materials to other companies because they already participate in that market.

An interesting aspect addressed by our research is that of the variability of the behavior of SMEs across European countries. As we have shown, model estimates confirm that this variability is important for all types of initiatives, but differences emerged. For instance, waste recycling has the highest degree of variability, which means that this behavior varies greatly between companies in different countries. Our data show that in France, Ireland and the United Kingdom, over 80% of companies have taken such initiatives, while in the Baltic States they have the lowest percentage, with only 8% of companies recycling waste in Estonia. The initiatives for energy saving, the use of renewable energy sources, and the sale of waste materials are, on the other hand, the most homogeneous among the EU countries; although the variability is significant, it is not very high. To explain this variability, country-level variables selected from the literature were introduced in the model. The socio-economic characteristics of the country proved to be fundamental in explaining the behavior of SMEs. This means that companies in more successful countries are more likely to implement eco-initiatives. The impact of state welfare on corporate behavior is shown by the estimates. For instance, the effect of per capita GDP is always positive and significant, with the exception for water savings initiatives, where this effect is masked by other covariates, such as the level of education. National environmental characteristics are important in explaining companies' behavior, as the results show that companies in polluting (high-carbon) countries are less likely to introduce eco-initiatives. This means that the behavior of companies reflects countries' attention to environmental issues. As regards the environmental tax revenue, it emerges that the higher the revenue, the lower the

interest of companies in sustainable management. This result is interesting because it does not reflect what has been seen in the literature, probably the environmental tax revenue also includes proceeds from sanctions against companies for violation of environmental parameters; therefore, the greater the revenue from the sanctions, the lower the eco-initiatives implemented. The effect of environmental tax revenue is recognized as significant and negative for water and energy saving and waste reduction initiates, and countries generally impose penalties for excessive resource consumption and excessive waste generation.

8. Implications

Knowledge of the factors at company and country levels that lead enterprises to launch eco-initiatives is useful for defining EU and national policies. Thus, for instance, the availability of resources proved to be crucial for the introduction of such initiatives. Attention should therefore be paid to micro and small companies that invest little in environmental issues; young companies are also penalized, probably due to the reduced availability of resources. Some recent literature suggested that policies should be especially targeted to new companies (start-ups), that appear to be interested in monitoring their environmental performance (Ghisellini et al., 2023) and to small companies (Carfora et al., 2022).

Sharma et al. (2020) showed that Government pressure on SMEs to implement CE is not an effective step in the transition. In particular, this success is strongly dependent on management will, and training and motivation of employees. Without strong human skills, SMEs will face difficulties in achieving the target regarding climate change (see, e.g., Dey et al., 2020). For instance, the set of available funding sources for the climate transition must be better communicated to lead SMEs to access them (Demirel and Danisman, 2019). Otherwise, without organizational reconfiguration and upgrading technology and innovation, SMEs will not be prepared to catch up. This conclusion is also supported by the literature view in Suchek et al. (2021): this transition demands new business models, senior management support, and collaboration with interested parties (e.g., clients).

Furthermore, we have seen that the behavior of SMEs in European countries is heterogeneous; therefore, for the sake of European unity, the EU will have to work for greater homogenization, perhaps redesigning incentives for less prosperous countries, new environmental awareness campaigns and supporting EU Member States in environmental policies as incentives for reducing national pollution levels.

9. Conclusions

After the World Health Organization (WHO) declared the Covid-19 pandemic in March 2020, many researchers began studying the relationship between Covid-19 and the circular economy. Some papers focused on the effects of the pandemic on sustainability processes (Kanda and Kivimaa, 2020). Others outlined the importance of eco-innovation practices to accelerate economic growth in most countries. According to many scientists, the pandemic could be an opportunity to accelerate sustainability transitions (Sarkis et al., 2020) also because there is a link between the Coronavirus outbreak and unsustainable behavior (Bodenheiemer and Leidenberger, 2020). Therefore, this study also sets the stage for further research. The role of SMEs is crucial in the economic phase following the pandemic outbreak (Eggers, 2020). New analyses can focus on the behavior of companies in certain countries or on specific initiatives, expanding the potential explaining factors. The focus of this research is at country level; many policies are defined at this level and we found non-negligible heterogeneity. Therefore, future research could explore specific dimensions at a more detailed level, for example considering the complexity at regional stage within countries. Furthermore, a comparison of the behavior of SMEs with large European companies, often analyzed in the literature, can highlight the importance of SMEs at the economic and social levels (see, with reference to these aspects, Passaro et al., 2022).

The dynamics of the adoption of new green procedures in companies must be further analyzed in light of the growing awareness of the impact of our lifestyle on the environment and of the macro framework envisaged by the European Green Deal (European Commission, 2019). In particular, the impact of the age of the firm on the transition from the linear to the circular economy deserves further research as our results confirm the complexity of the effect (Leoncini et al., 2019). In the early months of the Covid-19 crisis, it became clear that the EU was heavily dependent on third countries for critical raw materials that are essential to the economy (European Commission, 2020). The European Green Deal is also part of the Covid-19 recovery strategy. One third of the 1.8 trillion euro investments from the NextGenerationEU Recovery Plan and the EU's seven-year budget will finance the European Green Deal. In this way, the European Green Deal will transform the EU into a modern and resource-efficient economy in which SMEs play a central economic role.

Finally, the approach of this paper does not delve into the merits of specific countries, it considers the sample as a whole. An internal introspection of the sample is limited to second level variables without further details by EU country or area. This is limitation of this work that deserves further research as also recent literature indicates (Zamfir et al., 2017).

CRediT authorship contribution statement

Alberto Maman: Writing – original draft, Formal analysis. **José G. Dias:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Francesca Bassi:** Writing – review & editing, Methodology, Funding acquisition, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Francesca Bassi reports financial support was provided by University of Padova. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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