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Which SMEs are greening? Cross-country evidence from one million websites

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By Lenka Wildnerova, Carlo Menon, Robert Dehghan, Jan Kinne and David Lenz

Small and Medium-sized Enterprises (SMEs) could play a pivotal role in the pursuit of climate objectives. SMEs have a significant carbon footprint on aggregate, but they can also contribute to reaching net zero through their innovations and commitment to the use of environmentally friendly practices. This study develops a novel metric to identify environmental engagement, also referred to as "greening". The study harnesses the power of machine-learning and analyses the content of over one million websites of firms from 15 OECD countries encompassing about 10 billion words. Greening is identified based on firms' self-declared information about products or processes on their websites. The resulting indicator is then evaluated considering firms' characteristics. The results show that: (1) About one-third of SMEs are environmentally engaged, albeit with considerable variations across countries; (2) Greening SMEs are more productive, pay higher wages and their sales grow faster than non-greening SMEs; (3) Solar energy is the most cited action among greening SMEs, followed by recycling and energy efficiency, (4) Sectors with higher greenhouse gas emission reduction over the past decade also display higher levels of environmental engagement.

JEL codes: L25; Q50; Q56
Keywords: Firm Performance; Environmental Performance; Sustainability; Machine learning; SMEs

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Executive summary

Despite their significant contribution to climate change, little information exists on SMEs' engagement in greening practices. Across OECD countries, SMEs represent 99% of all firms and collectively account for about 40% of industrial pollution, commercial waste and greenhouse gas (GHG) emissions. However, research and regulatory scrutiny have focused largely on large corporations. Consequently, the environmental efforts and advancements made by SMEs, as well as knowledge on these are relatively uncharted territory.

This study addresses this knowledge gap through the development of an innovative 'greening' indicator. Using information available on one million corporate websites, the indicator provides information on firms' (self-declared) environmental strategies and sustainable initiatives. The approach takes segments of text from a sample of firms' websites, manually classified to greening actions, which form the basis of an automated machine learning model applied to all 1 000 000 firms. The indicator is available for nearly one-third of small firms and half of the medium-sized firms in the private business sector of 15 OECD countries in 2022.

Self-declared environmental engagement is linked to an actual reduction in GHG emissions. Aggregate emission data confirm that sector-country pairs with a high share of greening SMEs (according to the new indicator) also demonstrate significantly reduced emissions. Yet, the new indicator shows that disparities in environmental efforts persist across different groups of SMEs. Larger and more productive SMEs tend to showcase their environmental engagement more prominently than other SMEs. SMEs that offer higher wages are also more environmentally engaged.

A considerable share of SMEs in the 15 countries examined engage in improving environmental outcomes, albeit to a smaller extent than larger firms. Nearly one-third of SMEs and 10% of micro-sized firms covered by this study display at least some environmental engagement, compared to around 50% of medium-sized firms. The variation across the 15 countries in the sample[1] is considerable with Belgian, French, Slovenian and Swedish SMEs greening more frequently. Conversely, SMEs in Baltic countries, Eastern European countries, and Finland exhibit the lowest prevalence of environmentally engaged firms.

Recycling, solar energy, energy efficiency and renewables are the themes most often mentioned by environmentally engaged SMEs. Solar energy, in particular, is referenced on nearly 15% of environmentally engaged SME websites. Considerable variation exists in the environmental themes embraced by greening firms across countries. Belgian, Latvian and Spanish SMEs most frequently cited the keyword "solar" (such as solar energy or solar panels), and recycling concepts dominated narratives of SMEs in the UK, France, and Finland.

Established SMEs are more likely to be greening, but micro firms are increasingly "born green". On average, established SMEs, aged 20 years or older and with 10 employees or more, demonstrate a higher propensity to be environmentally engaged than younger firms of similar size. However, new firms are increasingly born with environmental strategies incorporated into their business plan. This trend is visible among young micro firms, defined as firms with less than 10 employees incorporated 5 years or less before the date of the reporting, which are more likely to be identified as environmentally engaged than micro firms aged over 5 years.

The new greening indicator can enhance the ability to identify policy gaps and provide valuable insights to policymakers. Policymakers need information about the actual uptake of greening practices to identify the segments of the business sector in which progress is slower and construct targeted strategies. Up to now, such evidence has been lacking and the existing information relies on estimations and surveys that cover a limited number of firms or survey only some sectors. The timely cross-country evidence presented in this study gives an understanding of variation in SMEs' environmental engagement. Policies which governments can monitor more effectively with the new indicator include (1) enabling and co-ordinating public and private-sector investment in green projects, (2) sharing information, or (3) supporting green entrepreneurship and offering incentives to encourage environmental innovation.

1 No net zero without SMEs

Firms have had a large responsibility for the degradation of the environment. They also carry a potential for addressing the damage and implementing sustainable growth models. Environmental impact of firms combines their influence on biodiversity, water scarcity, climate change, local or global pollution, and waste. In this paper, "greening" encompasses any activity that directly or indirectly reduce the firm's impact on the environment, from resource efficiency to emissions reduction to implementation of circular economy principles. Around three-quarters of economic activity in OECD countries is generated by the business sector, which relies on the use of natural assets and energy, with concomitant impacts on the environment whether through GHG emissions or other negative externalities such as waste. Using renewable energy sources, increasing recycled or bio-degradable solutions, and reducing or eliminating waste in the production process and for the end-user are all strategies that can and are implemented by firms to reduce their environmental footprint. Firms can also enable other economic actors in their environmental transition and adaptation.

Firms have financial incentives to showcase their environmental efforts. In recent years, there is growing evidence that environmental practices can be beneficial for firm growth, confounding earlier beliefs that these were incompatible with growth (Dechezleprêtre and Kruse, 2018[1]). In the case of small and medium-sized enterprises (SMEs), an important motivation to implement more sustainable practices is the cost reduction linked to input efficiency use, but other motivations are increasingly playing a role. SMEs are often suppliers of large corporations, which face increasing scrutiny on the sustainability of their value chains. The ability to demonstrate greening credentials can also unlock access to green financing (OECD, 2022[2]). A firm's engagement in minimising its environmental footprint can drive innovation, improve investor confidence, and reduce exposure to regulatory uncertainty (OECD, 2011[3]; Zhang and Chen, 2023[4]). Moreover, customers are increasingly willing to pay a premium for sustainable products (NIELSEN, 2015[5]). The choice of protecting the environment is also often linked to the motivation of the entrepreneur or firm leadership. Some entrepreneurs build their businesses around ensuring sustainable and ethical production, especially those in the social and solidarity economy (OECD/European Commission, 2022[6]). In addition, environmental branding can strengthen the reputation of a firm and its products and lead to employee retention and better community relations.

It is however crucial to control for "greenwashing", i.e., a practice where companies misrepresent their products or activities as environmentally friendly when they are not (see Box 2.1). Governments and regulatory bodies are implementing stricter disclosure requirements and setting clearer standards for environmental claims. Third-party certifications and auditing are increasingly used to verify environmental claims, promoting a more authentic and accountable approach to environmental sustainability in business practices. Moreover, inaction can be costly. Firms might face reputational risk if they fail to adapt to consumer preferences, and this may translate into a loss of revenue.[2]

SMEs are less in the spotlight than larger firms but they are large contributors to environmental footprints. In the 15 countries covered by this report, SMEs account for about 40% of greenhouse gas emissions, at least half of the industrial pollution and commercial waste, and from one-fifth to three-quarters of energy use, electricity and gas use, depending on the country where the evidence comes from (OECD, 2023[7]). However, until recently SMEs have often been absent from the "greening" debate. The focus has been on large emitters, in part because data on the environmental footprint of SMEs were scarce. When

smaller companies were part of the debate, this was mostly in the context of green entrepreneurship and eco-innovation (OECD, 2021[8])

Granular data beyond sectoral averages are needed to measure greening among firms. Even a detailed sectoral disaggregation would fail to capture the heterogeneity in environmental efforts across countries and types of firms. The new indicator shows that greening firms operate in all sectors of the economy. Industries making the most progress in reducing emissions and increasing their sustainability are those typically considered "brown", as extractive industries (discussed in Section 3). Estimating the environmental impact of firms involves gathering data from the production process in the firm, but also pollution generated from upstream suppliers and downstream consumers.

The "Greenhouse Gas Protocol" is the most widely used accounting standard for greenhouse gases, classifying emissions into three "scopes".[3] Scope 1 emissions are represented by direct emissions generated by company facilities or company vehicles. These include process emissions from on-site manufacturing activities or other activities at the firm level. Scope 2 emissions are indirect emissions, resulting from purchased electricity, steam, heating and cooling for the company's use. Finally, Scope 3 emissions are the indirect emissions occurring in the upstream and downstream value chain linked to the firm's operations. Scope 3 emissions are the hardest to control and capture, as they occur outside of the firm's decision and monitoring power. The upstream Scope 3 emissions include emissions from the production of goods and services purchased by the firms, but also business travel, or employee commuting. Emissions generated by downstream activities include the use of firm products by end customers, including the waste that the product generates at the end of the lifecycle. As an example, Apple, a consumer electronics, computer software and online services company, reported that nearly all of its 2020 carbon footprint totalling 22.6 million metric tonnes of CO_2 is composed of Scope 3 emissions. This includes 71% of product manufacturing emissions and 19% of emissions generated by using and disposing of their products.[4]

Yet, quantifying and reporting emissions is for the most part voluntary and only large companies systematically collect and report data. Large firms can face public scrutiny, hence a loss of revenue and potential loss of investments. To avoid such backlash, they tend to report their progress on their environmental goals as a part of corporate strategies.[5] Reporting on the Scope 1 and Scope 2 emissions is mandatory in some countries for the largest firms.[6] The estimation of Scope 3 emissions is voluntary in most countries. Even among firms that do report on their Scope 1 and 2 emissions, most show little evidence of emission reductions within their operations (Ruiz Manuel and Blok, 2023[9]). Another global corporate renewable energy initiative, RE100, helps the largest firms in committing to 100% renewable energy sourcing. RE100 estimated that 45% of electricity consumption by 350 of the world's largest firms was from renewable sources in 2021, an increase from 41% in 2020.[7] Large firms also use certifications, including B CORP certification or ISO 14001, to evaluate the combination of all their environmental (and social) practices, and follow up with regular re-certifications. As businesses engage in a variety of activities with different pollution intensities and different environmental concerns, the quantification of environmental performance is a complex process.

Data on the environmental footprint of SMEs are scarce. The literature mostly focuses on the potential of green entrepreneurship and eco-innovation (OECD, 2021[8]). Little is known about SMEs' strategies and drivers of the adoption of environmentally friendly practices. Second, SMEs face a different set of difficulties in reducing their environmental footprint. The certifications and audits are rare as some earlier estimates report that less than 1% of SMEs have a certified environmental management system. Even if the supply chain and customer pressure are drivers to adopting an environmental management system, SMEs face a lack of resources, knowledge and technical capacity to do so (Calogirou, 2010[10]; Mazur, 2012[11]).

But the evidence suggests that SME uptake is growing. Recent surveys show that across OECD countries nearly three-quarters of SMEs are stepping up and attempting to reduce their environmental footprint (ERC, 2020[12]; European Commission, 2022[13]). Moreover, one-third of start-ups implement

environmental sustainability in their business operations and products. SMEs have more room for a pivotal change. They can introduce new environmental strategies and innovative practices to the market faster compared to large firms with established business methods (Koirala, 2019[14]). They also scale the existing technologies and invent new ones, usually more readily than large firms.

2 A new greening indicator from contextual analysis of firms' websites

The lack of information about SMEs' environmental engagement creates space for experimental methods in data collection. The indicator of environmental engagement (also referred to as firm "greening") is built using the qualitative information extracted from the websites of over 1.2 million firms. The extracted information is processed using machine-learning algorithms to ensure that the information is used in the environmental context that displays a firm's intention or action. A small sample of the text is classified manually, and the full sample is classified by a machine learning model trained on the small manual sample. Generic statements in which the firm's action is undetectable are not considered an indication of "greening".

The indicator of environmental engagement used in this study is based on self-reported information on greening practices that are concrete and action-oriented. The indicator builds upon website text that describes the action the firm declares it has implemented, is implementing or will implement to reduce its environmental impact. The topics relevant for the analysis include (1) sustainability practices, (2) strategies, (3) outcomes or (4) business model.

The advantage of machine learning is its ability to use input and knowledge learned from existing data to analyse new information, allowing for evaluation beyond human capacity. Machine learning algorithms make it possible to analyse the content of over one million websites to search for information on greening within a reasonable time frame. The process relies on three major steps. The first is text classification, followed by training, and the final step is the application.

Step 0: Definition of environmental engagement in the firms' operations

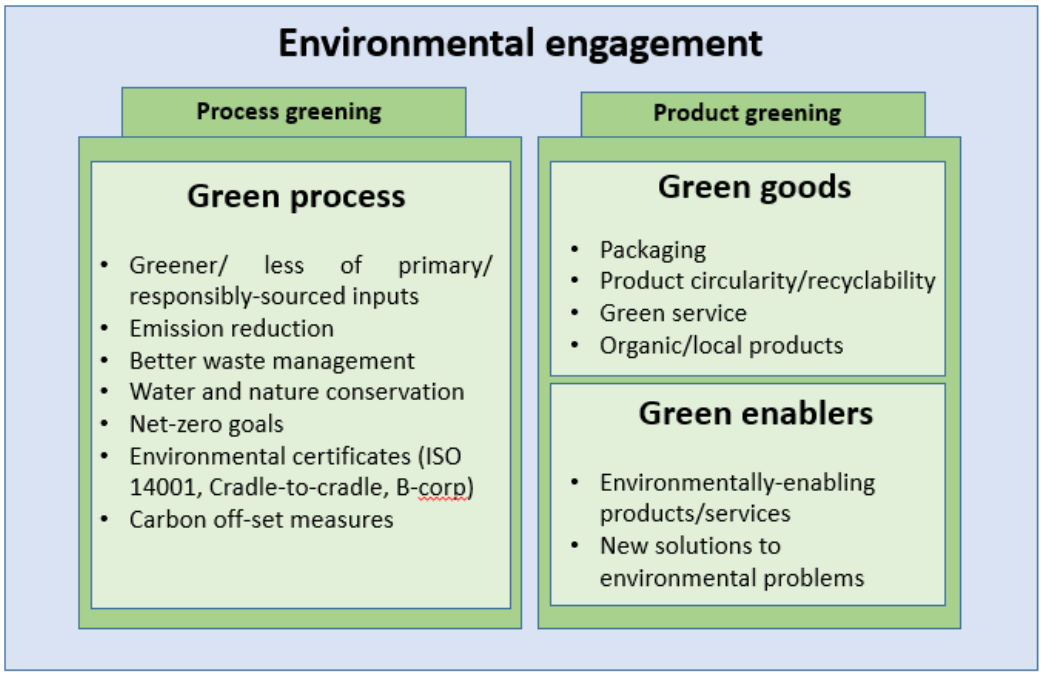
The greening of enterprises refers to improving resource productivity and environmental performance (ILO (2016[15]), OECD (2011[16])). In practical terms, firms can improve their production process by changing their inputs and operations or they can improve products. Both types of improvements are considered as implementing a technological change in the way a firm functions. A second type of environmental improvement involves innovative approaches in marketing, organisational structures, and institutional frameworks. For example, a company might adopt new marketing strategies that emphasise sustainability, or reorganise its management to better integrate environmental considerations. Similarly, institutions may develop new regulations or policies that incentivise green practices. These changes, though non-technical, can have a profound impact on a firm's environmental footprint and can drive industry-wide shifts towards more sustainable practices. However, they often require more complex coordination and a broader organisational change, making them more challenging to implement compared to direct technological changes (OECD, 2013[17]).

Production- and product-related environmental aspects tend to be presented separately in firms' website statements. The literature shows that both aspects can be well distinguished as headings on websites and sections in sustainability reports (Guziana and Dobers, 2012[18]). Hence, machine learning techniques have the potential to identify both aspects of greening.

Every firm, even the less polluting ones, can make adjustments to their carbon footprint by making adjustments in the way they produce or procure their inputs. Often, the production issues linked to the overall carbon footprint of the company are the first to be addressed by firms aiming at improving their environmental performance.[8] Optimising energy consumption and energy savings, besides being an environmentally friendly adjustment, produces also monetary benefits, although may require substantial investments. Another energy consumption change is firms' switching to renewable energy. If relevant, firms can also minimise transport emissions generated by the production process or employee travel such as switching to electric cars or incentivising cycling to work. Beyond environmentally friendly choices for their operations, firms can also choose inputs from local providers, eco-friendly inputs, or optimise input use, reduce scrap and improve waste treatment. Finally, some firms decide to take steps towards offsetting those carbon emissions that are too costly or take too long to be reduced directly, although the effectiveness of current offsetting schemes is debated (Fankhauser et al., 2021[19]).

In this study, "environmental engagement" encompasses firms' decisions to enhance environmental performance in production or products (Figure 1). Making the production process greener include decreasing energy consumption, minimising waste generation, changing to greener inputs, or investing in environmental projects that are related to the firm's areas of activity (possibly with the objective of "compensating" for the environmental impact of the production processes). Within the product category, either the product itself is "green" (e.g., recyclable, ecological, services performed with less harmful substances), or the product of the firm helps the user minimise their impact on the environment (i.e. installing solar panels or constructing self-sufficient buildings). Demand-side mitigation policies that enable consumers to opt for sustainable goods and services are instead out of the scope of this work, as the focus is on firms. Nevertheless, they indirectly also play an important role, as they create the incentives for firms to adopt greener practices.

Figure 1. Process and product greening in firms



Note: A firm can engage in multiple actions at the same time.
Source: Guziana and Dobers (2012[18]) and the OECD compilation from the text labelling process.

Firms have many incentives to be transparent on their websites and to refer to tangible and accountable actions. The validity of the environmental indicator developed in this study depends on the truthfulness and representativeness of the information shared on the websites of firms. The firm's website is a communication channel with its consumers and business partners. For many firms, their website is the most comprehensive information channel for the outside world. Conditional on having a website, firms use websites to share information on their practices, including environmental practices, especially if they find the information valuable in producing the image they intend to have. It is assumed that firms presenting concrete plans to reduce environmental footprint have at least willingness, and therefore higher potential, to embark on the actual improvement course. In the assessment, priority is given to tangible outcomes, such as actual measures of pollution generated or prevented by firms. Firm environmental certifications are another tangible proof of environmental engagement. On the other side of the spectrum, the firm can report over-ambitious goals or declare engagement in practices that remain unrealised. Therefore, the environmental indicator captures engagement instead of actual greening. Such biases are considered and tackled in the building of the indicator and analysis itself (Box 2.1).

Box 2.1. Bias from self-disclosed information and the non-randomness of website existence

Identification of greening faces two types of bias. The first bias comes from the over-declaration of environmental engagement by firms, so-called “greenwashing”. The second bias goes in the opposite direction. It arises when firms underreport their environmental engagement.

Greenwashing identifies a voluntary or involuntary sharing of deceiving information on greening actions firms declare to be taking. A common example of voluntary greenwashing is the use of green colour packaging even if the product is no more environmentally friendly than any other product. Involuntary greenwashing might include setting some unachievable targets. Companies might set aggressive targets, and then find out that their goals are hardly achievable due to the lack of technology, speed of change, or lack of control.

The manual text classification plays a crucial role in limiting the greenwashing bias. The text evaluators categorised the text as environmentally engaged when the firm declared its willingness to progress or described accomplishment in minimising its environmental impact. Therefore, a firm that is willing to do better is considered engaged. Admittedly, the intensity of greening in terms of actual pollution reduction cannot be identified unless systematic and compulsory reporting is put in place. Therefore, greenwashing cannot be eliminated in the analysis, but the validation of the indicator in this paper and earlier studies reject systematic greenwashing identified by environmental engagement (Schmidt et al., 2022[20]). The keyword list is also designed to minimise the greenwashing bias, as it contains text that links to verifiable information, such as environmental certificates (e.g. ISO 14001 certifications). Keyword analysis in this paper allows to identify the specific strategies that firms pursue. The more specialised keywords, such as solar or recycling, permit understanding the concrete actions firms make towards improving their environmental footprint.

The second bias arises when firms disclose only partial information about their greening strategy or fail to disclose their environmental engagement at all. This can happen when firms see no benefit in disclosing their practices. However, as customers value green products, firms have a financial incentive to report on their greening choices. If underreporting arises, it is more likely to happen among smaller firms, firms with a smaller environmental footprint and firms with a less direct relationship with consumers, including business customers.

It is also possible that differences in culture or language across countries influence how much greening firms report in a given country, or is picked up by our algorithm. Certain terminologies or phrases that signify environmental commitment in one language might not have direct equivalents in another. This discrepancy can lead to challenges in accurately capturing and comparing the extent of environmental efforts across different countries. In countries with larger environmental awareness or customers that are more exigent about the carbon footprint, firms will discuss their greening more extensively.

Finally, the results apply to the subset of firms that have a website. These firms tend to be larger and younger than the average firm in the database that serves as sampling frame for this analysis. However, the sample still covers a large share of the SMEs (see the discussion on coverage). Results are, therefore, representative of the selected sample. Given that larger and younger firms are also more likely to be greening, the sample selection may lead to an upward bias in the share of firms that are greening.

The advantage of contextual analysis algorithms is that they can distinguish action-oriented greening statements from vague statements via proper text classification. The machine learning exercise consists of a search of specific keywords used in the context of greening across websites in the first step. In the second and third steps, the machine learning models determine the context in which the keyword is mentioned as they are trained with input data from other websites that contain paragraphs with the greening keywords and that were classified manually. As a result, this study identifies environmental engagement if firms declare one or more instances that they take action to minimise their environmental footprint in their production process, improve the environmental impact of utilisation and disposal of the products, or their product is enabling its users to become more environmentally friendly.

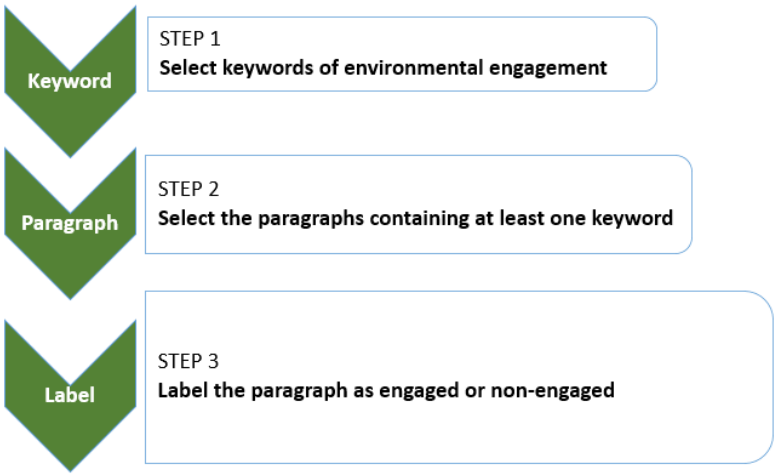
Step 1: Text classification of firms' environmental engagement

Text classification is a manual process that assigns the topic or meaning to the pieces of text. Text classification is the "human part" of a machine learning exercise where a small share of text is categorised into topics. The text classification permits the application of the same concept of what it takes to be environmentally engaged to a large amount of text subsequently analysed by the machine learning models.

Text classification of environmental engagement identifies concrete actions or willingness of firms to pursue environmental goals. Text is classified following the rule that an environmentally engaged firm is a firm that gives a position on its website about its action towards environmental improvement. Such a distinction of actual action plays a key role in the indicator as a large share of selected paragraphs might talk about a concept, or ideas, or give references to environmental issues. However, only the paragraphs where it is possible to refer to the action of a firm classify firms as environmentally engaged. One example is the newspaper or blog article website that might report on environmental news, but the company reporting the news is not environmentally engaged itself.

The text classification process has three parts: Keyword identification, paragraph selection, and text classification itself (labelling) (Figure 2). The process starts with an identification of the keywords that are frequently mentioned in the context of firm greening. These keywords are used to extract all text pieces from the websites, called paragraphs. A random selection of these paragraphs is then manually evaluated and assigned a label of *environmentally engaged* or *not engaged*. The outcome of the human text classification process is a dataset called a training sample which is used as training input for machine learning models which then learn and understand the common characteristics of the paragraphs and their corresponding labels. Finally, one-quarter of the paragraphs and associated labels are retained from the training sample and are used to test the accuracy of the machine learning model.

Figure 2. Steps in the text classification to identify environmental engagement



Source: OECD elaboration.

Keywords

The keywords were selected after multiple iterations of the text classification process.[9] Most of the time, the paragraph that discusses environmental engagement uses more than one keyword. Hence, even if the keyword list might not be exhaustive, the environmental engagement will likely be captured thanks to the other keywords used. The first iterations were run with a large set of keywords that could identify the environmental context. Some of the initial keywords were removed from the list to minimise the possible misleading identification as they were more likely to identify non-environmental issues.[10] The English keywords are translated into 14 additional languages.[11]

Most of the environmental engagement keywords can be used both in the greening of the production process and the product. For example, the word *environment* might be used for both the production process that protects the environment as well as a product that minimises the impact on the environment. The keywords can also identify a concept that has nothing to do with environmental protection, e.g., a dynamic work *environment*.

The firm websites are scraped to extract all paragraphs that mention at least one of the keywords. Only paragraphs with at least 5 words are considered, hence all titles, short product names or links are excluded. In addition, two paragraphs preceding and succeeding the paragraph with keyword hit are considered in the text analysis.

Labels

Each text paragraph in the training sample is labelled as *Environmentally engaged* or *Not engaged* by human classifiers. The training sample is composed of a random selection of 2 600 paragraphs. The labelling and cross-checking of the paragraphs were done in-house by a team of data scientists, and resulted in about 60% of the paragraphs being labelled as “engaged”.

The paragraphs are labelled as **environmentally engaged** if the text mentions at least one of the following actions:

1. **Process greening:** The firm reports that they have made or are planning to make improvements to the way they produce their products aimed at reducing their environmental footprint. The evaluated text contains one or multiple of the following notions:
    a. **Certifications:** The text explains that the firm has obtained certifications classifying its operations and products as environmentally friendly. The most common certifications that firms obtain for this purpose are ISO 14001 (and other ISO certifications from the 14000-family), B-corp, Cradle-to-cradle, or other (usually national) certifications of environmental excellence.
    b. **Goal-setting:** The text states that the firm has set or achieved a net-zero target of emission reduction.
    c. **Responsible sourcing:** If physical inputs are used, the firm engages in using less raw/non-renewable materials, more reusable or recycled materials, inputs that come from responsible sources, or to ensure that their supply chain is using environmentally friendly practices.
    d. **Clean(er) process:** A firm improves the way it produces its product or service. This includes:
        i. Reducing energy consumption or switching to renewable sources of energy or enabling energy savings;
        ii. Waste reduction, reusing scrap material, recycling;
        iii. Ensuring the waste is treated and does not harm the local environment;
        iv. Creating employee awareness and engagement.
    e. **Offset measures and caring actions:** For the part of the GHG emissions that are costly to reduce, the firm might engage in other activities that can absorb an equivalent amount of carbon from the atmosphere at a lower marginal cost. Firms can also engage in altruistic behaviour.
        i. Protecting biodiversity, and minimising habitat loss;
        ii. Engage in carbon offset measures.
2. **Product greening:** The product of the firm is a greener version of an existing product or it is a new, green(er) product. Alternatively, the product can enable its users to minimise their negative environmental impact.
    a. **Green(er) goods:** The text of the website explains that the firm offers products or services that are green or greener than an alternative. These might include:
        i. Sellers of organic or local products or products with a smaller negative impact on the environment such as organic cotton or electric cars;
        ii. Products that are constructed with circularity in mind or recyclable products;
        iii. Environmentally friendly or recyclable packaging;
        iv. Services that use an environmentally friendly version of products such as cleaning services without the use of dangerous chemicals.
    b. **Environmental enablers:** products or services that enable others to be greener. Enabling a product or service can, but might not be a firm's sole business product.

The paragraphs are labelled as **non-engaged** if the text contains at least one of the keywords, but is unrelated to the environmental engagement of the firm. The following are the most frequent possibilities:

1. Text is not environmentally related. The keyword is used in other than environmental context;
2. The text contains no information about the product or service – it might give information about an environmental issue in general, but it is impossible to identify the firm's actions. This includes general blog posts or news reports about environmental issues, etc.

Step 2: Training

The training sample is used to develop multiple machine-learning models. The algorithm uses a random selection equal to three-quarters of the training sample to learn about the environmental engagement concept. The remaining quarter of the paragraphs are used in a later process for measuring the accuracy of the predictions of the machine-learning models. As environmental engagement is a binary indicator, three types of predictions can arise from the evaluation. The model can identify the paragraph correctly (i.e. paragraph labelled as environmentally engaged is identified as the same by the algorithm), or it can identify the false positives (i.e. paragraph labelled as not engaged is identified as environmentally engaged by the algorithm), and false negatives (i.e. paragraph is labelled as engaged, but the algorithm identifies it as not engaged). An accuracy rate of 90% and higher is considered a good outcome.

The accuracy of prediction increases by testing a set of models. The machine learning evaluation is based on an ensemble of text classifiers of a multilingual language model based on the XLM - RoBERTa architecture (Conneau et al., 2020[21]). This model belongs to the Transformers model class (Vaswani et al., 2017[22]). As a pre-trained model, it has a basic understanding of language (Malte and Ratadiya, 2019[23]). An advantage of the pre-trained model is that it needs relatively little training data and only a few adaptions are necessary to be applied to new use cases. Another method that helps to improve the accuracy and precision of an automatic labelling process is the implementation of an ensemble method for the machine learning model (Brown, 2011[24]). Variants of the training data are applied to a total of 11 multilingual language models combining hyperparameter tuning. All the individual decisions of the 11 models are then combined and the final category is determined by a majority vote. The overall accuracy of the prediction is 90%.

Step 3: Prediction of the environmental engagement for each firm

Once the machine learning models are fine-tuned, the algorithm evaluates all web-scraped text paragraphs that contain at least one keyword hit. The paragraphs are extracted from all subpages of the websites, excluding PDF files, graphics, and videos. Nearly 1.2 million websites[12] are evaluated initially. Websites can contain multiple text paragraphs identified as engaged or not engaged. If the website has at least one paragraph identified as environmentally engaged, then the firm is considered to be environmentally engaged. In addition, the following data from the text analysis is collected for each firm:

- Number of environmentally-engaged paragraphs
- Number of non-engaged paragraphs that contain at least one keyword
- List of all keyword hits found on the website
- Length of the website (in number of characters)

Step 4: Validation with external sources

Benchmarking the new indicator with existing pollution measures at the sector-country level supports its validity. The sector-level outcomes of generating and reducing atmospheric pollution, sourced from Eurostat, confirm that the sectors with higher rates of firms declaring environmental engagement have reduced pollution levels the most. The evidence also holds within countries (see the next section for details).

At the firm level, the new indicator correlates positively with participation in the EU Emission Trading Scheme (EU ETS) data. The evidence shows that most firms participating in the ETS scheme are also environmentally engaged. Furthermore, comparing firms' actual pollution levels and changes in pollution over the years, the results confirm that environmentally-engaged firms decreased the pollution per employee more than the firms that declared no engagement on their website. Due to the small sample size of the EU ETS data, the statistical significance is harder to establish for less-represented sectors (see a detailed benchmarking analysis with EU ETS data in Annex A).

3 Evidence of the environmental engagement of SMEs

Data: firm-level information and coverage

The indicator of environmental engagement from the text analysis is linked to the latest available information on firm balance sheet data from the OECD-Orbis dataset. The OECD-Orbis is a commercial dataset that provides information from firms' annual balance sheet reporting. In the OECD-Orbis dataset, a "firm" is defined as a business entity, uniquely identified by its legal unit within each country. The advantage of this firm-level dataset is its large cross-country coverage. The OECD-Orbis includes millions of listed and unlisted firms which makes a comparison of firm performance across countries possible. Moreover, over the years, the coverage of small firms has improved. Out of 15 countries covered in this study, 8 had a (nearly) universal coverage of small and medium-sized firms. Even the micro firm coverage has continuously improved. In 6 countries, the OECD-Orbis covers at least one in two micro-sized firms (see Figure A A.1 in the Annex).

Sample coverage

The indicator of environmental engagement can be only assigned to firms that have a working website in 2022. The coverage of the indicator across countries therefore varies for two reasons. First, coverage in the OECD-Orbis dataset presents some variability across countries, reflecting different reporting obligations for smaller firms and different levels of access to business registries and similar sources. Second, the share of firms with a website changes across countries and not all firms have a website listed in the ORBIS database. Across countries, attrition also reduces the coverage. The firm reporting in the OECD-Orbis dates to 2019 and the web scraping was done in 2022. The website is likely to be non-existent for firms that exited the market in the years 2020 and 2021.

More than one-third of firms in the sample have a website on their contact information sheet. However, the share falls to 9% of the total number of firms (including micro firms with less than 10 employees) that had a working website in 2022 when the web scraping was initiated. This varies from 4.6% of Italian firms to nearly one-half of firms in Greece present in the OECD-Orbis dataset in 2019 (Figure A A.2, Table A A.1 in the Annex).

The environmental indicator covers nearly one-third of small firms and half of medium-sized firms operating in 15 OECD countries in 2019. The highest coverage is in Estonia, where 61 and 71% of small (10 to 49 employees) and medium-sized (50 to 249 employees) firms respectively are covered by the indicator. Among 15 researched countries, coverage of small firms is under 30% only in the UK (11%), France (13%), Poland (20%), and Germany (21%). Medium-sized firms are universally well covered. At least one-third of medium-sized are evaluated for environmental engagement in each country (see the coverage by country and size group in Figure A A.3 in the Annex). The resulting dataset contains 904 817 firms. More than one-third of the sample, or about 325 000 firms, are identified as environmentally engaged (Table 3.1).

Key variables

- The variable of interest is a binary indicator of environmental engagement. Environmental engagement takes the value of one if the firm's website describes its environmental proceedings at least once on its website. It is equal to zero if the website existed during the web scraping exercise but carried no mention of environmental engagement.
- The website length is the indicator of the size of the website in the number of characters.
- The employment growth and turnover growth are three-year growth rates, calculated as the change of the variable values between 2016 and 2019, relative to their values in 2016, in percentage. The growth rates are windsorised to remove the extreme values. The productivity estimation underwent cleaning and harmonisation procedures as described in Gal (2013[25]).
- Cost of materials and wage bills are values of spending by firms in the local currency. The cost of materials is also averaged between the years 2017 to 2019 to exclude potential volatility in the firms' input decisions.
- The size groups, with the upper cut-off of 10 employees for micro-sized firms, 50 for small firms, and 250 for medium-sized firms, are constructed using the number of employees in the firm in 2019, as reported in the OECD-Orbis dataset. For most countries, the number of employees refers to the headcount at a given date – most often at the end of the calendar year.
- Turnover is defined as the value of the operating revenue turnover.
- The age group is defined as years from the incorporation date.

Table 3.1. Descriptive statistics for the evaluated sample

Number of observations, mean, median, and standard variation for the variables of interest

	n	mean	median	Sd
Environmentally engaged	904 817	0.36	0	0.48
Age	902 835	20.55	17	17.03
Employment	904 817	63.40	8	1738.62
Turnover	742 251	20.14 mil	1.1 mil	754.80 mil
Website length (log)	904 817	10.41	10.77	1.60
Wage bill	608 625	2.26 mil	1.74 mil	60.40 mil
Costs of materials	482 800	6.70 mil	0.27 mil	427.54 mil
Productivity	138 027	10.80	10.75	0.95
Employment growth (3y, %)	723 564	18.8	0	65.8
Turnover growth (3y, %)	595 017	36.3	11.8	123.0

Source: OECD calculations based on OECD-Orbis database and ISTARI.ai web-scraped data for year 2019.

Empirical framework

The probability of a firm being environmentally engaged is examined in relation to its characteristics such as age, size, sector, and performance in an econometric model. The correlations are estimated using probit regressions as the dependent variable – i.e., environmental engagement – is a binary variable. The regressions control for the number of characteristics beyond the variables of interest. Notably, each regression, unless stated otherwise, includes dummy variables for the two-digit Nace 2 Rev. 2 sector and the country of location of the firm. This enables the partialing out of all observable and unobservable characteristics of the firm that are common to all firms in the given country, such as national policy framework or economic growth in the country. The sector dummies remove all the effects that are common across firms within the same sector, such as intensity of input use, product characteristics, or supply-chain conditions.

The following equation is estimated:

$$y_{i,s,c} = \beta_0 + \beta_1\, economic\ performance_{i,s,c} + \beta_3\, firm\ controls_{i,s,c} + \alpha_c + \gamma_s + \varepsilon_{i,s,c}$$

Where $y_{i,s,c}$ is the indicator of environmental engagement. Variable $economic\ performance_{i,s,c}$ takes values of growth, productivity, wages, assets, value-added or material use. The regressions control for a set of characteristics of firms, denoted by $firm\ controls_{i,s,c}$, which are firm size (in employment) and website size (in the number of characters). The remaining terms are the country dummy, α_c, and the sector dummy, γ_s, and the error term, $\varepsilon_{i,s,c}$. Variables enter the model in logarithmic form, except for growth and age. The marginal effect is estimated at the mean values which can then be interpreted as the percentage change in the given variable, when other independent variables are at their mean value, increasing or decreasing the chance of the firm being environmentally engaged.

Results: micro and small firms lag behind in greening

Medium-sized firms are nearly twice as likely to be greening as small firms and three or more times as likely as micro firms. There is a large gap in the share of greening firms between micro or small SMEs and larger firms across all countries in the sample. On average across countries, the share of small firms with a working website that declare some environmental engagement (38%) is about 14 percentage points lower than the share of medium-sized firms greening (52%) (Figure 3.1). This might happen for three major reasons. Greening requires long-term investment and persistent strategies. Such undertakings are proportionately costlier for smaller firms as they tend to lack financial resources and adequate skills. One-third of European SMEs covered by a survey in 2020 reported that a lack of financial resources prevents their enterprise from becoming sustainable. Over 15% of these firms state that they lack the skills needed for the transition.[13] Larger firms might also be able to dedicate additional resources to describe their environmental engagement in detail on their websites. Second, smaller SMEs might lack awareness about their impact and ways of minimising it, as well as about the reputational benefits from informing the public about their actions. Finally, smaller firms face less public scrutiny and hence might perceive that the benefits of environmental action are negligible for the reputation of the product or service they provide.

Among large firms, about half are environmentally engaged. This is in line with estimates showing that about one-third of firms listed in the S&P 500 stock index have set ambitious environmental targets, and one-quarter have set weak targets, with the remaining 40% of firms having no environmental target.[14] A survey administered in the year 2020 showed that for the majority of large firms, the lack of customer demand for transformation is the main reason for inaction (European Comission, 2020[26]).

There is ample space for environmental catching up across countries

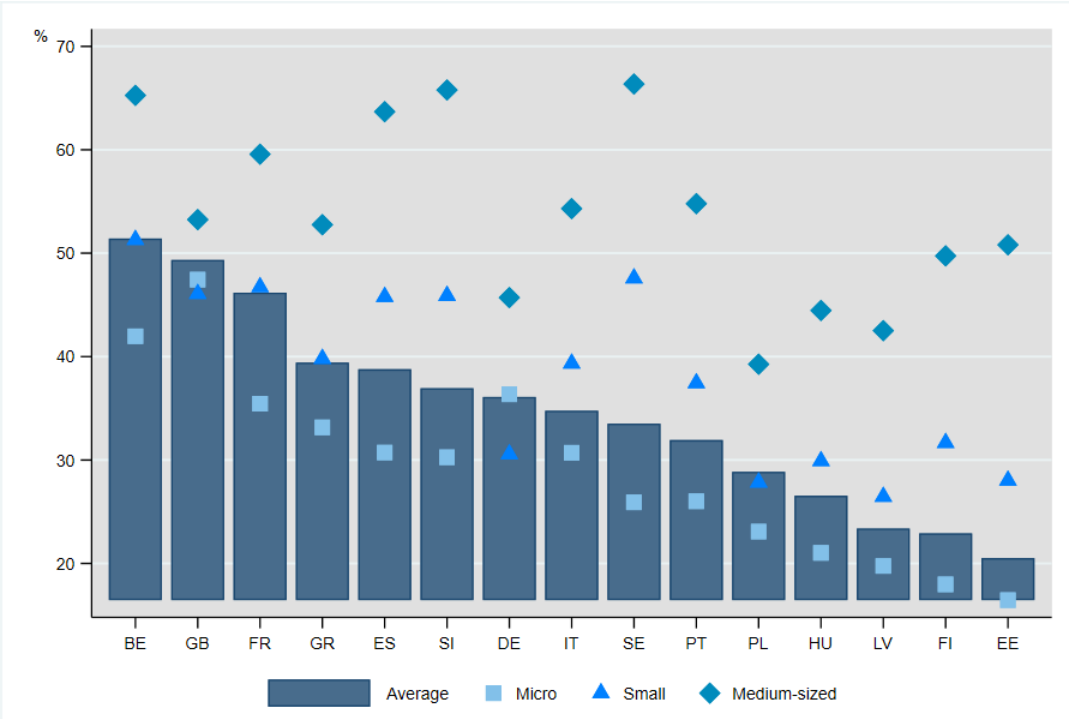
Of the 15 countries covered in this analysis, the percentage of greening firms ranges from 20% in Estonia to 50% in Belgium. About 4-5 in 10 firms in Belgium, the United Kingdom, France and Greece are environmentally engaged. Hungary, Latvia, and Finland are on the opposite side of the distribution, with about 20-25% of their firms declaring at least some environmental engagement.[15] The cross-country average ranking is driven by micro and small firms, which are more numerous. The picture is more nuanced when it comes to medium-sized firms. For example, Belgian and French small and medium-sized firms are on average as likely to be greening as firms of the same size in Slovenia and Sweden. Among these countries, two-thirds of medium-sized firms are environmentally engaged, and nearly half of the small firms are. However, Slovenian and Swedish micro firms are less frequently engaged, driving the average engagement values down as compared to Belgium or France (Figure 3.1).

Results are similar when controlling for the different characteristics of firms across countries. Taking into account the potentially confounding effects of sector, size and website length with multivariate econometric analysis, firms in Belgium, the UK, and France are significantly more likely to be greening by around 20 percentage points than firms in Poland, Germany, Hungary, Estonia, and Latvia (Figure A A.4).

The higher share of greening SMEs in Belgium and the UK resonates with the implementation of dedicated policies in the two countries. Although each country is different and might require a different set of measures to advance on their environmental goals, countries lagging behind can learn from the best practices of the greening frontrunners. For instance, the UK Government launched a campaign “Together for our planet” with an explicit focus on SMEs achieving net-zero goals.[16] Belgium’s programme “Build Back Circular” specifically targets SMEs to raise awareness about the importance of a circular economy in the transition to sustainable production.[17] Overall, most countries have various programmes in place to help SMEs in their transition to a net-zero future, however with substantial variation in invested resources and scope (Turner, Katris and Race, 2020[27]).

Figure 3.1. Larger SMEs are more likely to declare their greening efforts

Share of greening firms by country and size group in 2022



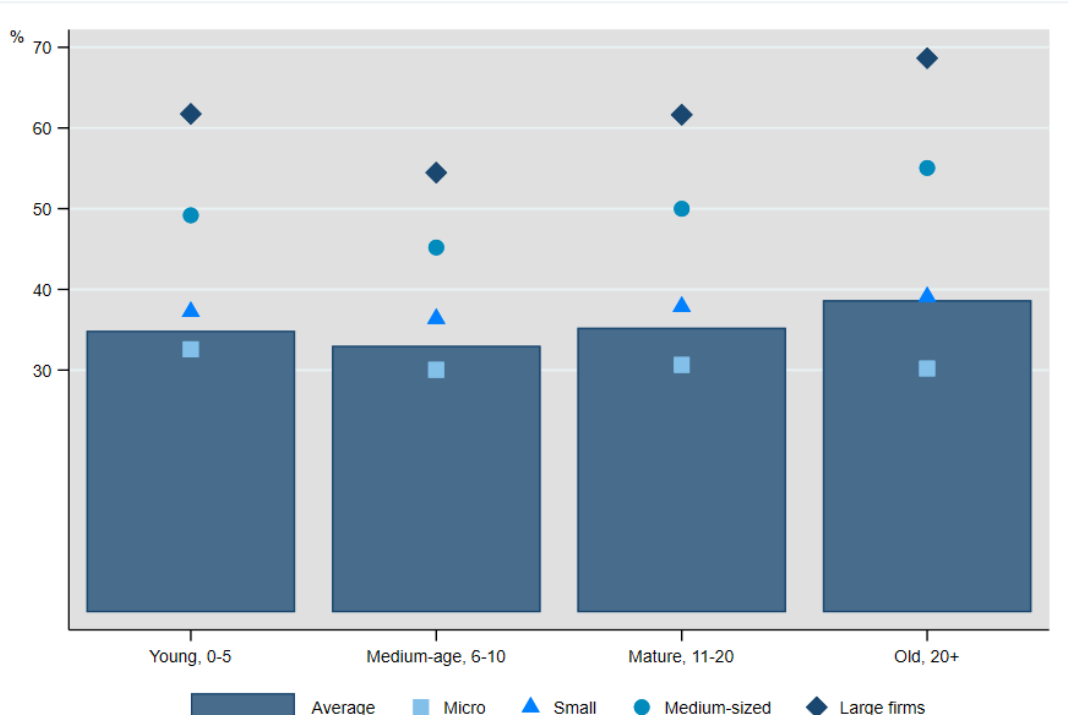
Note: The average value from the year 2019 for all firms that had a functioning website in 2022. See the discussion on the sample coverage in the Data description part. A total of 904 817 observations are evaluated, from nearly 12 000 Slovenian firms to over 192 000 German firms. In some countries, the coverage of the indicator is substantially below others. This concerns large-sized firms in France, Greece, Italy, Portugal, and Sweden (less than 50% of websites of large firms were searched for environmental engagement), medium-sized firms in Germany, Finland, the UK, Greece, Italy, Sweden (less than 50% of all medium-sized firms); small firms in Germany, France, the UK, Greece, Italy, and Poland (less than 30% of all small firms), and micro firms in Belgium, France, the UK, Greece, and Poland (less than 3% of micro firms). See the discussion on coverage in Annex. If the selection of the firms is not random but selects better firms, the greening indicator can be higher in less well-represented countries such as the UK, France, and Greece. See also Figure A A.4 that controls for firm characterises, adjusting for some of the coverage discrepancies.
Source: OECD calculations based on OECD-Orbis database and ISTARI.ai web-scraped data.

Older SMEs are more likely to be greening, but the opposite holds for micro firms

Environmental engagement is higher in SMEs that have been operating for 20 years or more, especially if they are larger. Out of five old firms, two are environmentally engaged on average across all size classes. The probability to be greening increases when old firms are larger: every other medium-sized old firm is greening. Therefore, among established firms, greening takes time to be incorporated into the business strategy. Green investments might often be long-term projects: it takes time to undertake (and report on) environmental engagement among firms that did not embed such actions into their functioning from the start. Yet, micro firms with less than 10 employees are more likely to be greening if they are young than older micro firms. These young start-ups that are “born green” are likely to be a recent phenomenon as firms aged 6 to 10 years are less environmentally engaged across size categories than the youngest firms, incorporated between 2014 and 2019. These young and potentially innovative firms might be a driving force not only for a greener future but also be the creators of new solutions to existing problems.

Figure 3.2. Firms are increasingly born green

Share of greening firms by age and size class in 2022



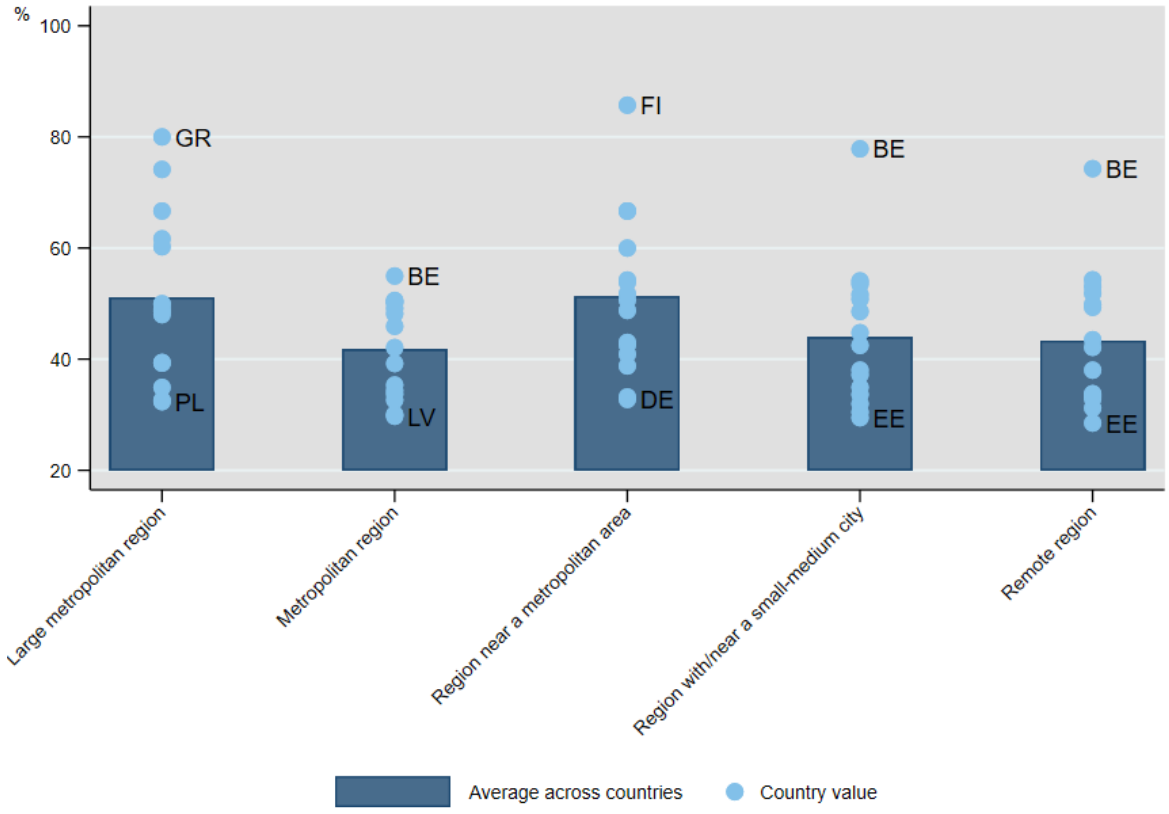
Note: The average value from the year 2019 for all firms that had a functioning website in 2022 in the following countries: Belgium, Germany, Estonia, Spain, Estonia, Finland, France, the United Kingdom, Greece, Hungary, Italy, Latvia, Poland, Portugal, Sweden, and Slovenia. See the discussion on the coverage. The sample size is 904 817 firms.
Source: OECD calculations based on OECD-Orbis database and ISTARI.ai web-scraped data.

Greening firms are located both in cities and remote areas

SMEs exhibit a similar level of environmental engagement across urban, suburban, and remote areas. One in two SMEs is greening in the regions that are near a city with at least 250 thousand inhabitants or regions with a very large city with more than 1.5 million inhabitants. In regions further away from large cities, those with a small-medium city between 50 and 250 thousand inhabitants or remote regions, about two in five SMEs are greening on average (Figure 3.3). Metropolitan regions, or regions containing cities with populations of 250 thousand inhabitants or more, exhibit the lowest percentage of SMEs engaged in greening practices, though this figure still stands at 42%. There is some regional variation within countries. Belgium remains the country with a consistently high number of SMEs greening, a pattern similarly observed in the UK and Spain across all five types of regions. In contrast, Finland, Greece, and Estonia have the highest variations of environmental engagement across regions. In those countries, firms in large metropolitan regions are more environmentally engaged compared to remote regions where around 30% of SMEs are greening. Finally, German, Polish, and Hungarian regions have around one-third of SMEs greening across different types of regions.

Figure 3.3. Firms in distant regions show similar environmental engagement as in large cities

Share of greening firms by region in 2019



Note: The average value from the year 2019 for all firms that had a functioning website in 2022 in the following countries: Belgium (BE), Germany (DE), Estonia (EE), Spain (ES), Finland (FI), France (FR), the United Kingdom (GB), Greece (GR), Hungary (HU), Italy (IT), Latvia (LV), Poland (PL), Portugal (PT), Sweden (SE), and Slovenia (SI). See the discussion on the coverage. The sample size is 373 433 SMEs.
Source: OECD calculations based on OECD-Orbis database and ISTARI.ai web-scraped data.

Successful SME performance predicts environmental engagement

Productivity is a predictor of firm greening. The probability of greening for a firm of average size increases by 0.5 percentage points when productivity is 10% higher than the average (column (7) in Table 3.2). The direction in which productivity influences the environmental performance of firms is less clear. Productivity and greening might be both an outcome of better management techniques. Alternatively, being environmentally engaged can lead to better economic performance thanks to, for example, increased consumer demand. While causality is yet to be established, other results might partially explain why greening efforts can improve firm performance.

Other indicators of better performance predict greening. SMEs that grow faster in turnover between 2016 and 2019 tend to be greener three years later (column (2) in Table 3.2). An increase in the 3-year turnover growth rate by 10 percentage points is associated with a 0.6 percentage points increase in the probability to be greening. However, there is a small and negative association between employment growth rate and greening. Firms that prioritise employment growth tend to be therefore less likely to invest in their environmental engagement in the short run.

Firms paying higher wages are more likely to engage in greening. This holds even if productivity is taken into account. On one hand, such correlation can be driven by self-selection: better-paid employees want to work for firms that have environmental (and social) priorities. At the same time, a well-paid workforce can engage in environmental activism and lead the transition within the firm. The relationship is statistically significant but the effect is relatively small in magnitude. An SME that pays an average salary twice as large as the mean value is one percentage point more likely to be environmentally engaged three years later.

Previous empirical evidence documents a positive association between firm performance and greening (Dechezleprêtre and Kruse, 2018[1])**.** Environmental performance can improve economic performance by increasing revenue or decreasing the cost of production. Firms embarking on a greener journey can increase their revenue by (1) improving their access to markets and (2) differentiating their product. Consumers, increasingly concerned about the environmental impact of the products they buy, are willing to pay a premium cost for greener products. New products produced with green technologies are linked to firm profitability (Palmer and Truong, 2017[28]). The production costs tend to fall by adopting environmentally friendly practices because (1) the cost of material and energy falls, (2) the cost related to risk management diminishes, and (3) the firm can accumulate savings through labour retention and better working conditions. For example, creating awareness of how to minimise fuel consumption changed the behaviour of employees, implying cost savings (Gosnell, List and Metcalfe, 2019[29]). Overall, environmental performance is associated with greater financial performance and profitability (see Dechezleprêtre and Kruse (2018[1]) for the literature review). However, the causal relationship between growth and greening faces a challenge of unobserved factors such as management practices that can drive both better performance and environmental engagement.

Table 3.2. Faster growth and higher wages, and productivity are predictors of greening firms

Marginal effects at the mean/median value

	(1)		(2)		(3)	(4)	(5)	(6)	(7)
Dep. variable:	Probability to be a greening firm								
	Empl. growth (at mean value)	Empl. growth (at median value)	Turnover growth (at mean value)	Turnover growth (at median value)	Materials (at mean value)	Assets (at mean value)	Value Added (at mean value)	Wage bill (at mean value)	Productivity (at mean value)
Empl. growth, 3y	-0.0039***	-0.0037***							
	(0.0012)	(0.0011)							
Turnover growth, 3y			0.0062***	0.0058***					
			(0.0007)	(0.0006)					
Cost of materials (log)					0.0108***				
					(0.0011)				
Assets (log)						0.0206***			
						(0.0016)			
Value added (log)							0.0216***		
							(0.0016)		
Wage bill (log)								0.0126***	
								(0.0013)	
Productivity (log)									0.0507***
									(0.0034)
Observations	722,780	722,780	594,573	594,573	479,377	829,342	455,674	594,015	138,027
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Size controls (log employment, Log of website size in characters)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

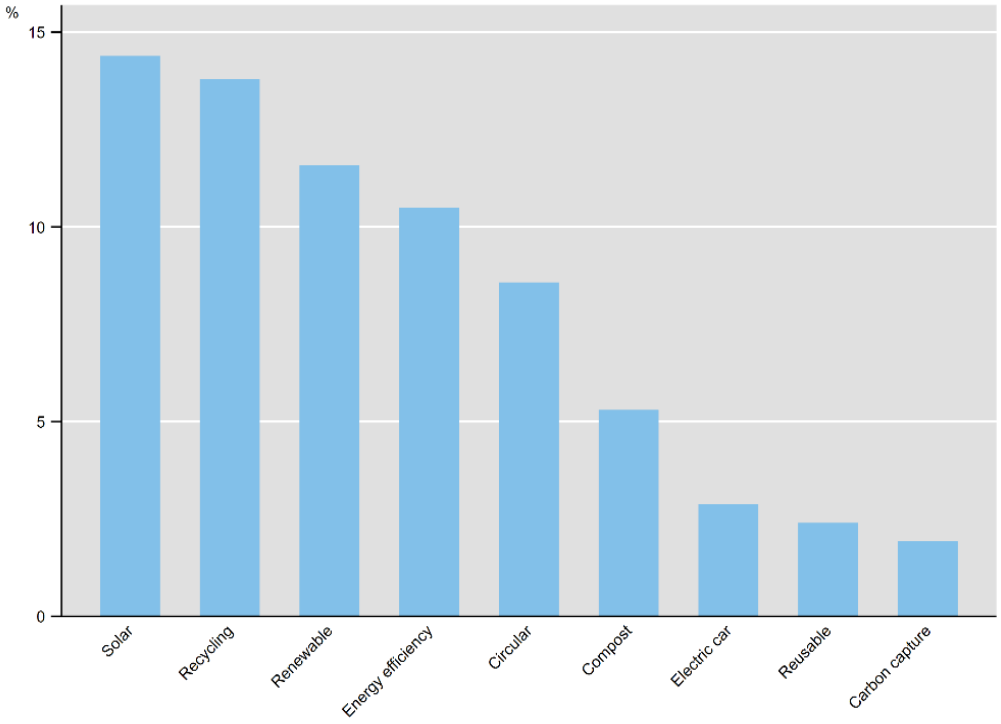
Note: Robust standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Probit regression. The table reports the marginal effect of the independent variables on the dependent variable (binary value for environmental engagement). The coefficients can be interpreted as a percentage shift in the independent variable correlating with a percentage shift in the dependent variable. Wage bill and Productivity regressions include the log value of employment as opposed to the employment group to be able to control for the size of the firm more precisely. The number of observations varies depending on the coverage of the given variable. Balance sheet values refer to year 2019; the greening indicator to year 2022. The sample is restricted to firms with a functioning website in 2022.
Source: OECD calculations based on OECD-Orbis database and ISTARI.ai web-scraped data.

SMEs are greening mainly through renewables and recycling

Solar energy installations, recycling, renewables, or circularity are among the most popular topics mentioned by greening firms (Figure 3.4). The analysis of the keywords mentioned on the websites of greening SMEs illustrates the diffusion of the different greening strategies.[18] Harnessing solar energy seems to be the most popular choice of firms. Over 14% of greening SMEs on average across countries mention a "solar" keyword 13%, from 4% in Portugal to 27% in Belgium. The keyword "recycling" follows with nearly 14% of environmentally engaged firms mentioning it on their websites, led by SMEs in the United Kingdom (24%), followed by Belgium (22%) and France (22%). Circularity is another popular concept, which appears on 8% of websites. Belgian firms are leading in circularity (17%), while Polish, Swedish, and Hungarian SMEs consider such notions in smaller proportions with only 3-4% of greening SMEs mention circularity on their website (Figure 3.5).

Figure 3.4. Solar, recycling and renewables are the most frequent greening strategies

Share of environmentally engaged firms that mention the keyword on their website in 2022

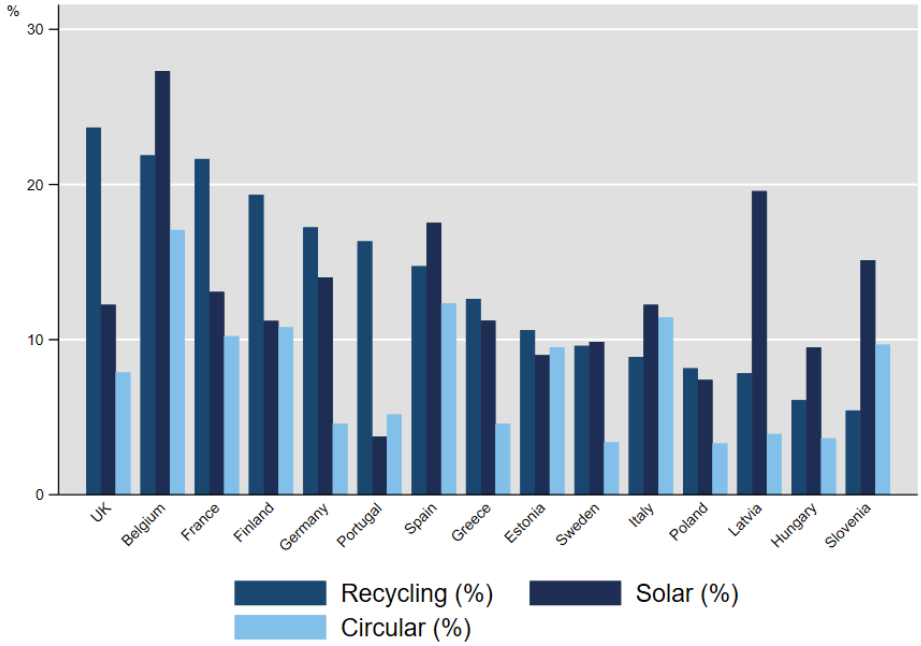


Note: The share of firms among all greening firms that mention the given "action" keyword on their website and are identified in the same or another paragraph as environmentally engaged. The "action" keyword is identified in this context as some concrete solution for improving the environmental footprint of the firm, as opposed to "generic" keywords such as *environment, ISO 14001*, or *sustainable*. The website can include multiple keywords – in total, 44% of environmentally engaged firms mention at least one of these keywords.
Based on 327 000 observations of firms, which were also identified as environmentally engaged.
The keywords are considered in all languages. The keyword "Electric car" includes the keyword "Electric vehicle"; "Circular" includes the keyword "Cradle to cradle"; "Energy efficiency" includes also mentions of "Energy efficient".
Source: OECD calculations based on OECD-Orbis database and ISTARI.ai web-scraped data.

Differences in the way firms discuss their engagement could inform in "real-time" the design of greening policies and could point to some areas that require further interventions. Based on the data reported in this paper, for instance, it appears that Portuguese SMEs could benefit from information campaigns on the circular economy and solar energy. Conversely, Latvian firms are communicating the most among their neighbours in solar energy (20%), possibly indicating that they are considering its adoption or are already implementing solutions to benefit from such a clean energy source. These firms could benefit from support such as financing availability.

Figure 3.5. Solar dominates in Belgium and Latvia

Share of greening SMEs that mention the keyword at least once on their website by country in 2022

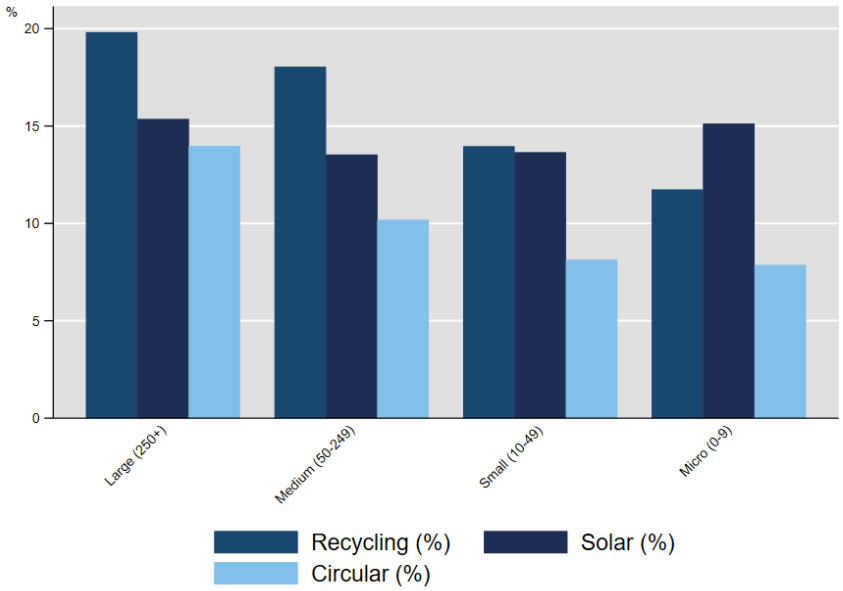


Note: The share of firms among all greening firms with at least 10 and at most 249 employees that mention the given keyword on their website and are identified in the same or another paragraph as environmentally engaged. The website can include multiple keywords. Based on 161 000 observations: from 1200 greening SMEs in Latvia to 35 000 greening SMEs in Germany.
Source: OECD calculations based on OECD-Orbis database and ISTARI.ai web-scraped data.

Solar energy remains the most popular renewable energy solution for firms across size groups. About 15% to 20% of greening firms mention solar energy on their websites, with similar shares across size classes. In 2022, *solar* is an even more popular subject than energy efficiency, which has been routinely identified as one of the most adopted environmentally friendly actions, especially among firms of smaller size. In micro firms, the *solar* keyword overtakes recycling as the most popular environmental "action" subject.[19] As firms grow, they mention recycling and circularity more: larger firms tend to mention such resource-saving measures more frequently. Circularity, for example, is discussed by 8% of micro and small firms that are greening, and 10 to 14% of medium-sized and large firms respectively (Figure 3.6).

Figure 3.6. Recycling is more often mentioned by large firms

Share of greening SMEs that mention the keyword at least once on their website by size group in 2022



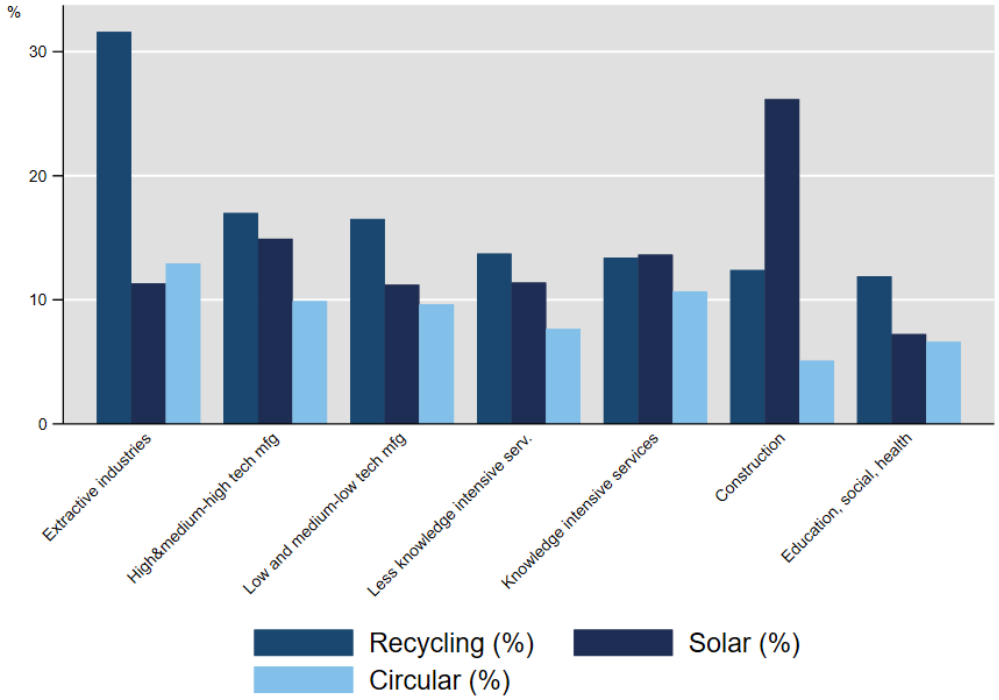
Note: The share of firms among all greening firms that mention the given keyword on their website and among firms identified in the same or another context as environmentally engaged by size group. The website can include multiple keywords. Based on 327 000 observations: from 151 000 greening micro firms to 15 000 greening large firms.
Source: OECD calculations based on OECD-Orbis database and ISTARI.ai web-scraped data.

One out of three greening SMEs in the extractive sector mentions *recycling*. Recycling is, to a certain extent, possible in all types of processes. The topic is relatively popular across all sectors of economic activity. Nearly one-third of greening SMEs in extractive industries (the highest share) to 12% of education, social, and health sector SMEs that are greening (the lowest share) mention recycling (Figure 3.9). The construction sector SMEs mention the most solar energy (26%), possibly because these might be also the firms installing the solar panels or providing support for such infrastructure, but they are the least likely to mention circularity (5%).

The service sectors display a higher variety of greening strategies. In the extractive sector, more than 50% of greening SMEs mention at least one of the "action" keywords, favouring *recycling* over *solar* and *circular*. The other sector groups show a more balanced distribution of the three keywords. In particular, in less knowledge-intensive services and the education, social, and health sectors 40% and 30% of greening SMEs mention at least one of the "action" keywords, respectively. In those sectors, other popular keywords are *renewables* and *energy efficiency*. This suggests that SMEs in different sectors may respond differently to greening incentives and may require targeted policies based on the greening mix that they are likely to adopt. Recycling solutions, circularity measures, and solar energy could be adopted across the SME spectrum.

Figure 3.7. *Solar* dominates among construction SMEs, extractive firms mention *recycling* the most

Share of greening SMEs that mention the keyword at least once on their website by sectoral group in 2022



Note: The share of firms among all greening firms with at least 10 and at most 249 employees that mention the given keyword on their website and are identified in the same or another context as environmentally engaged. The website can include multiple keywords. Based on 161 000 observations: from 800 greening SMEs in Extractive industries to 59 000 greening SMEs in less knowledge-intensive services. The firms in the following countries are considered: Belgium, Germany, Estonia, Finland, France, Greece, Hungary, Italy, Latvia, Poland, Portugal, Spain, Sweden, Slovenia, and the United Kingdom. See the discussion on the coverage for more information.
Source: OECD calculations based on OECD-Orbis database and ISTARI.ai web-scraped data.

Environmental engagement is higher in "brown" industries such as extractive industries and manufacturing

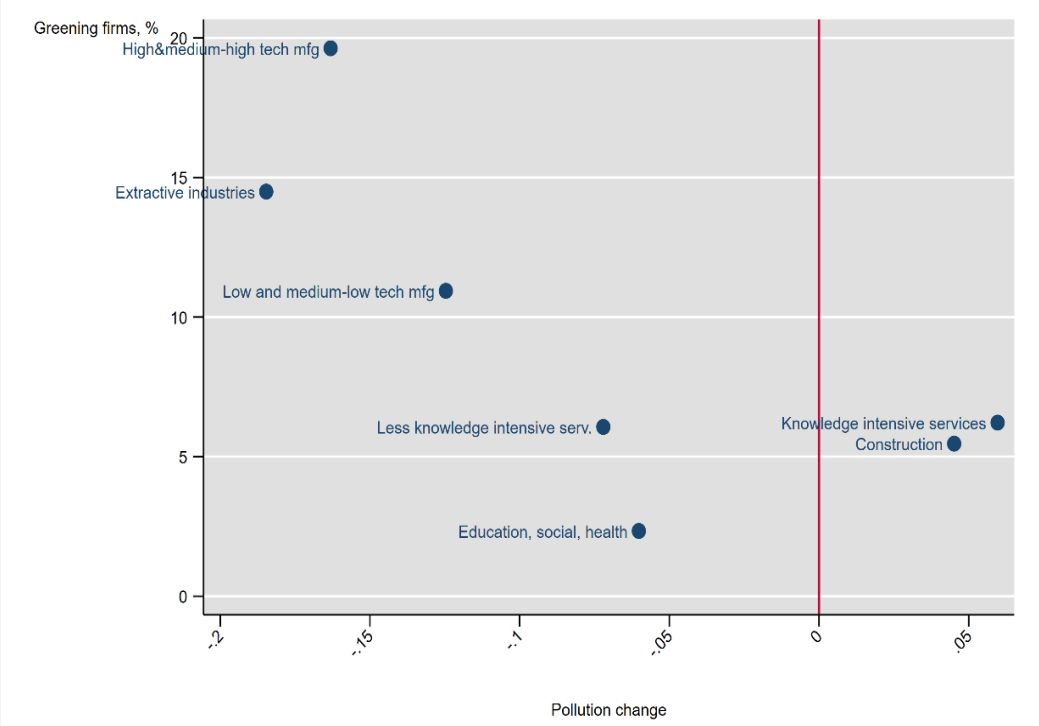
Environmental engagement is closely linked to the pollution that firm activity generates. SMEs that pollute more have also more opportunities to reduce their impact or take actions to offset their emissions. They are in the spotlight of environmental backlash, and their inaction might create consumer retaliation. One of the starkest examples is energy and petrochemical companies that are investing intensively to support environmental causes. These firms have also reduced pollution the most. Between 2010 and 2019, the firms in extractive industries in 15 EU countries reduced the amount of pollution they generated by nearly 20%. They also tend to display environmental engagement more frequently than firms in other industries (Figure 3.8)

The biggest polluters are also most likely to report on their greening efforts. In 2019 across 15 countries, an average mining firm emitted 3.2 tons of greenhouse gasses into the atmosphere. Firms in high- and medium-high technology manufacturing emitted nearly 800 kg of emissions on average, and the remaining manufacturing firms emitted on average about 370 kg of emissions.[20] The new indicator shows that these sectors are also more likely to report on their environmental engagement: 15% of mining firms, 20% and 11% of high and medium-high-tech and low and medium-low-tech manufacturing firms are identified as environmentally engaged on average across countries, respectively. Firms in those sectors

are two to three times more likely to report on their greening efforts than firms in the other sectors of the economy (Figure 3.8).

Figure 3.8. Industries more engaged in greening reduce pollution the most

Correlation of environmental engagement in 2022 and pollution change in sectors between 2010 and 2019

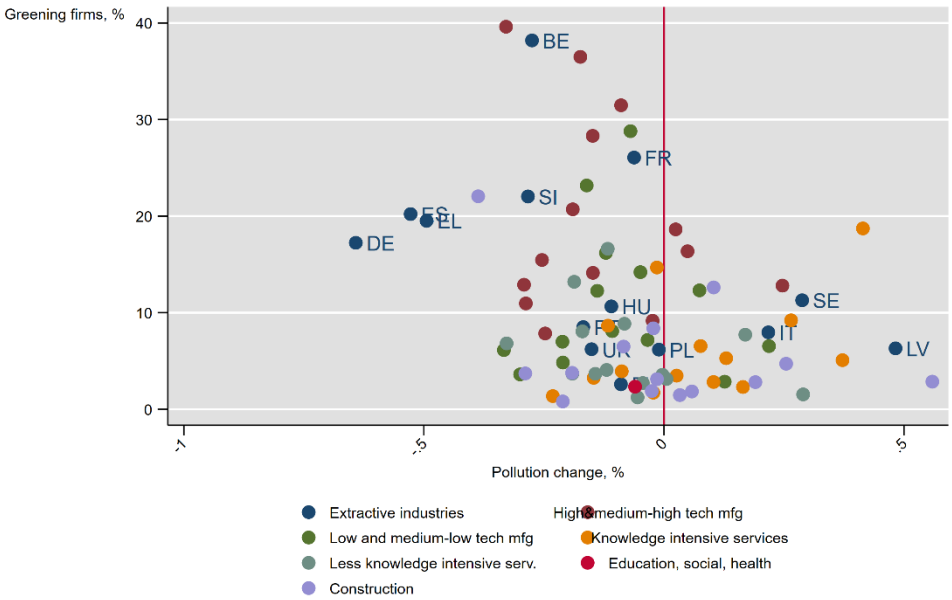


Note: The points represent an unweighted average value of change of pollution in the given sector across countries and the share of greening firms in this sector. The pollution is measured as overall GHG emissions emitted by the sector. The change in pollution is calculated as the difference between total pollution levels in 2019 and 2010, over the baseline level in 2010.
Source: OECD calculations based on OECD-Orbis database, ISTARI.ai web-scraped data and Eurostat Air emissions accounts by NACE Rev. 2 activity. Accessed from https://ec.europa.eu/eurostat/databrowser/view/ENV_AC_AINAH_R2__custom_3025505/default/table?lang=en in June 2022.

The positive correlation between the share of environmentally engaged firms and emission reduction holds also within countries. Across country-sector pairs, for every 10-percentage point drop in pollution, there is a corresponding increase of 4 percentage points in the proportion of environmentally engaged firms. To illustrate, within the extractive industries in Italy, Sweden, and Latvia, where pollution increased, there is a below-average level of engagement (Figure 3.9). However, there are also exceptions of sectors decreasing significantly pollution, but not being vocal about it. This is evident in the high-technology manufacturing sectors of the UK and Italy, which achieved pollution reductions of 25% and 29%, respectively. Yet, there are only 8% and 11% of firms in this sector that are environmentally engaged in high-technology manufacturing in the two countries. Conversely, some sectors reduced pollution only marginally, yet exhibited higher levels of environmental disclosure. For example, the extractive industry in France decreased its pollution output marginally, yet more than 25% of firms in this sector are classified as environmentally engaged.

Figure 3.9. Environmental engagement is strongly associated with pollution reduction

Correlation of environmental engagement in 2022 and pollution change in sectors by country from 2010 to 2019



Note: The points represent the amount of pollution change in the given sector across countries and the share of greening firms in this sector. The pollution is measured as overall GHG emissions emitted by the sector. The change in pollution is calculated as the difference between total pollution levels in 2019 and 2010, over the baseline level in 2010.
Source: OECD calculations based on OECD-Orbis database, ISTARI.ai web-scraped data and Eurostat Air emissions accounts by NACE Rev. 2 activity. Accessed from https://ec.europa.eu/eurostat/databrowser/view/ENV_AC_AINAH_R2__custom_3025505/default/table?lang=en. In June 2022.

Box 3.1. Environmental engagement goes beyond emission reduction

Environmental engagement is an encompassing concept that goes beyond the on-site generated emissions. Firms can launch a multitude of actions that might alter the on-site emission outcomes only marginally, yet can still improve their overall environmental footprint. The indicator of environmental engagement covers environmental progress beyond quantified measurements, although the actual reduction in pollution correlates with the indicator of engagement.

For example, reduction in waste and water use, or adoption of carbon offset measures would fail to figure in the aggregate GHG datasets, but they might still have a considerable positive impact on the environment. Another example of high engagement is when firms themselves are not major polluters, but their products or services might generate positive (or negative) externalities on the environment. These firms help customers reduce their environmental impact. In data, one such example is the construction sector. Construction firms are generally one of the lowest per-firm GHG emitters, emitting about 20kg on average per firm. Yet, construction firms can choose to use more sustainable materials or to build more energy-efficient buildings. The collected data highlights such greening tendencies of construction firms. About 9% of construction firms declare that they are environmentally engaged on their websites.

Another example of environmental engagement beyond tackling emission reduction is the sectors of Education, Human Health and Social Work Activities. On average, over 12% of SMEs in this sector are greening (Figure 3.8). The least polluting firms can still take different steps to tackle environmental problems, even if their environmental footprint is small. Most tend to do so by reducing or reusing materials, but also by saving energy, switching to sustainable energy sources, and reducing consumption of natural resources.[21] Many of such environmentally-friendly choices are available to all types of firms, including the least polluting and least raw-resources-dependent SMEs.

4 Conclusion and policy discussion

In 2018, Mantis World, a UK textile producer, committed to reducing 50% of their Scope 1 and 2 emissions by 2030.[22] Remarkably, they surpassed this target in 2020 already, demonstrating their dedication to sustainability. Mantis World is just one of 940 SMEs out of a total of 4 400 firms that, as of 2023, have set emissions reduction goals through the Science Based Targets Initiative. This initiative, focused on private sector companies, encourages them to establish and report on their progress toward emission reduction goals.[23] Mantis World's commitment to sustainability extends beyond emissions reduction; it is embedded in its business model. From its inception in 2000, Mantis World's mission has revolved around respecting the planet and its finite resources. The company uses organic materials for garment production, opts for sea or road transport to reduce emissions, minimises packaging waste, and utilise only recyclable packaging materials. Furthermore, Mantis World provides consumers with tools to understand the impact of their purchases through an impact calculator. The firm holds numerous certifications for its use of organic and recycled inputs and employs ISO 14000 standards (Environmental Management) for its life cycle assessments.

Anecdotal evidence suggests that Mantis World's environmental engagement is not an isolated case among SMEs, but progress is hard to measure in the absence of data. Unlike larger corporations, which often face public scrutiny and have integrated sustainability into their operations, SMEs encounter unique financial and organisational obstacles when attempting to reduce their environmental footprint. The scarcity of data on how smaller firms address net-zero challenges remains a significant challenge, with existing insights primarily derived from surveys that tend to cover only a small sample of firms.

This work contributes to the understanding of SME environmental engagement by introducing a new indicator and providing evidence for over 900 000 firms in 15 OECD countries. The insights gained from self-declared information on firms' websites reveal a noteworthy commitment among SMEs to improve their environmental impact. However, SMEs still lag behind their larger counterparts in terms of environmental engagement. Even within the realm of larger corporations, there remains substantial room for improvement, as only about half of them are identified as environmentally engaged.

Solar energy emerged as one of the most frequently mentioned green topics on SME websites in 2022, signalling the potential for significant transformations in energy consumption, even among the smallest firms, due to recent advancements in the availability and affordability of solar installations.

Firms operating in the manufacturing sectors, like Mantis World, tend to exhibit higher probabilities of environmental engagement. Such a trend is similarly observed among firms in the Extractive industries. These sectors are notable for their high energy use, heightened emissions and substantial environmental consequences stemming from the utilisation of raw materials. The findings show that one in five SMEs within these sectors actively communicates credible strategies and actions aimed at environmental sustainability. In practical terms, these actions encompass a broad spectrum, ranging from fine-tuning production processes to introducing innovative products designed to assist customers in reducing their ecological footprint. For example, Mantis World chose to minimise environmental impact from multiple stages in its production process. It describes its strategy of environmental sustainability as the protection and preservation of the local environment including consideration of scarce resources,

careful waste management, policy to reduce, reuse and recycle, and ensuring water treatment plants are in place to prevent water pollution.

The journey towards environmental engagement takes time. Two out of five old firms with a market presence of at least 20 years are environmentally engaged compared to one in three young SMEs. However, there is a growing trend among firms to be 'born green,' with young companies with less than 10 employees increasingly being environmentally engaged. This evolution reflects a broader shift towards sustainability.

Better performance is correlated with more greening. If a firm is 10% more productive, it is a half percentage point more likely to be environmentally engaged. One potential channel is the quality of the material used, as environmentally engaged firms tend to invest more in materials that are both higher in quality and more environmentally friendly than cheaper alternatives.

Policies to increase environmental engagement in SMEs

Small firms face several constraints and bottlenecks that can be addressed with the right policy mix. A good environmental policy mix should be tailored to the characteristics of the local firms. New indicators based on website contents may help design and monitor tailored policy strategies for different groups of SMEs at a local level.

In the formulation of environmental policies, it is essential to acknowledge the distinct challenges that Small and Medium-sized Enterprises (SMEs) encounter. At the OECD SME and Entrepreneurship Ministerial Meeting in 2023, the governments of OECD member countries stressed the important contributions that SMEs and entrepreneurs can make to address the global climate crisis. Governments also committed to reducing unnecessary regulatory burdens, streamlining administrative processes and improving access to information for SMEs. Green policy initiatives should be designed to facilitate, rather than obstruct, the environmental progress of SMEs, by considering their specific operational contexts and capabilities. Regulations crafted with large corporations in mind prove to be impractical and overly demanding for SMEs, given their limited capacity for extensive reporting and compliance. Enabling SMEs to comply with regulations, rather than providing size-contingent exemptions that may result in disincentives to growth, should be the preferred policy approach (OECD, 2023[30]).

Very few green policy instruments currently target SMEs. Some estimates suggest that the measures targeting SMEs comprise less than 5% of policy instruments in place across countries (OECD, 2021[8]). There are three categories of environmental policy instruments: (1) regulatory tools, (2) information-based instruments, and (3) economic incentives and financial instruments. Often, green policies can be introduced concurrently with other policy objectives, such as digital transformation or within recovery packages, as has been the case for some of the COVID-19 recovery funds.

Regulatory tools are policy measures that incentivise the adoption of environmentally friendly practices. The most widespread measures are emission trading schemes and standards for environmental performance. However, SMEs face relatively higher administrative and regulatory costs when responding to environmental legislation (Calogirou, 2010[10]). This might be one of the reasons why regulatory tools tend to be less effective for SMEs than for larger firms. For example, carbon taxes and rising energy prices reduce energy consumption less in SMEs than in large firms (Dussaux, 2020[31]). Although countries lack regulatory tools specifically aimed at SMEs, increasingly, environmental regulations establish separate regimes for low-risk installations, which tend to be mostly SMEs (OECD, 2021[8]).

Information-based instruments address firms' lack of knowledge about possible opportunities and binding legislation. Information campaigns can also work to influence the attitudes of entrepreneurs. Policies aiming to increase awareness about environmental engagement for SMEs can for example assist

SMEs in complying with the regulation, increase dissemination of information and provide direct capacity building. Certifications and eco-labelling, albeit costly, are also information policy tools supporting a transition to greener business methods. Such policy incentives are effective in inciting compliance of SMEs with environmental regulation, increasing awareness and reducing pollution (see, for example, Federation of Small Businesses (2012[32]), Labonne (2006[33])).

A final set of policy instruments are economic incentives that provide financial support for green investment and financial instruments such as tax exemptions, grants and public procurement for eco-innovations and environmental transition. The transition to net zero economies requires high levels of both public and private investments. Policies could also ensure synergies between private and public investment for maximum efficiency. Government-backed green investment banks, for instance, can help to scale up low-carbon investments, especially for SMEs that struggle with securing affordable finances for their projects.

Notes

[1] The countries included are Belgium, Great Britain, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Poland, Portugal, Slovenia, Spain and Sweden.

[2] The costs of inaction extend far beyond reputational risks. Firms also face the potential for direct climate-related damages, increased operational costs due to resource scarcity or damage, and the risk of government regulation and policy changes. These risks can lead to significant financial impacts, such as increased insurance premiums, loss of assets, and additional costs for compliance with new regulations.

[3] See https://ghgprotocol.org/scope-3-calculation-guidance-2 (accessed on 18 January 2024).

[4]Apple Environmental Progress Report 2021, accessed on 30.11.2021 from https://www.apple.com/environment/pdf/Apple_Environmental_Progress_Report_2021.pdf

[5] Organisations such as Science Based Targets, which signed up over 2 000 corporations to set emission reduction goals and follow up on their progress in regular reporting, report a collective reduction of emissions by 25% between 2015 and 2019 for nearly 350 large companies with sufficient emission data.

[6] See https://www.ul.com/news/mandatory-emissions-reporting-around-globe

[7] Accessed on 12.1.2022 from https://www.there100.org/stepping-re100-gathers-speed-challenging-markets

[8] See https://www.mckinsey.com/capabilities/operations/our-insights/building-sustainability-into-operations (visited on 18 January 2024).

[9]The baseline keywords indicating environmental engagement in English are the following: Circular, Emissions, Environment, Sustainable, Carbon capture, Carbon footprint, Carbon neutral, Carbon dioxide, Climate change, CO2, electric vehicle, electric car, energy efficiency, energy efficient, energy transition, net zero, renewable, reusable, solar, sustainability, photovoltaic, B-corp, compostable, compost, cradle to cradle, footprint, ghg, ISO 14001, food waste, wind farms, pollution, energy saving, energy efficient, recycle, recycling. Other keywords derive from this list to ensure that the keyword list identifies all potentially relevant issues and serves as a coarse filter. Downstream AI model then identifies the actual engagement and willingness of firms to perform environmentally-friendly actions. That can include keywords such as cleantech, clean energy, energy cost, energy, natural, organic, sustainable, etc. The keyword list was adjusted during the evaluation process: different issues were first identified using a coarse list of keywords, and the list was further refined during the text classification exercise.

[10] This includes words such as green or fair, which are commonly used in other contexts or have different implications in different languages.

[11] The language list is the following: English, Spanish, Italian, German, Swedish, Finnish, Slovenian, Hungarian, French, Estonian, Latvian, Polish, Portuguese, Greek, and Dutch.

[12]Additional cleaning and restricting the analysis to a single year cuts down the number of firms used for the analytical part to 904 817.

[13] Survey of over 12 000 firms in EU Member states between February and May 2020: SMEs, Start-ups, Scale-ups and Entrepreneurship: Flash Eurobarometer 486. Accessed from https://europa.eu/eurobarometer/surveys/detail/2244 in August 2022.

[14] Reported by Institutional Shareholder Services, an investor advisory on corporate issues.

[15] The cross-country results should be interpreted considering the coverage and factoring in possible nuances in culture or language differences across countries, as discussed in the Annex on coverage and in the Section 2 on Bias from self-disclosed information and the non-randomness of website existence.

[16] The UK government calling for small businesses to lead the net zero transition before 2050 was initiated in 2021. The details published on https://www.gov.uk/government/news/calling-all-small-businesses-to-lead-the-charge-to-net-zero. Accessed in August 2022.

[17] National resilience plan for Belgium, accessed in August 2022 via https://dermine.belgium.be/sites/default/files/articles/FR%20-%20Plan%20national%20pour%20la%20reprise%20et%20la%20re%CC%81silience.pdf.

[18] Firms mention these keywords on their websites and machine learning models identify that these firms are environmentally engaged. It is, however, possible that the environmental engagement is identified in another paragraph than the one mentioning given keyword. The appearance of the keyword should be therefore interpreted as a possibility that the firm is interested, considering, or have applied such changes to its operations.

[19] Other, “generic” keywords such as environment/environmental are mentioned even more often. The analysis in this section focuses solely on “action” keywords, i.e. some concrete solution for improving the environmental footprint of the firm.

[20] Calculation form the Eurostat dataset Calculation form the Eurostat dataset Air emissions accounts by NACE Rev.2 activity accessed in June 2022 from

https://ec.europa.eu/eurostat/databrowser/view/ENV_AC_AINAH_R2__custom_3025505/default/table?lang=en.

[21] Survey of over 12 000 firms in EU Member states between February and May 2020: SMEs, Start-ups, Scale-ups and Entrepreneurship: Flash Eurobarometer 486. Accessed from https://europa.eu/eurobarometer/surveys/detail/2244 in August 2022

[22] Extracted from the Target Progress Data from https://sciencebasedtargets.org/reports/sbti-progress-report-2021/progress-data-dashboard#Downloads in September 2023.

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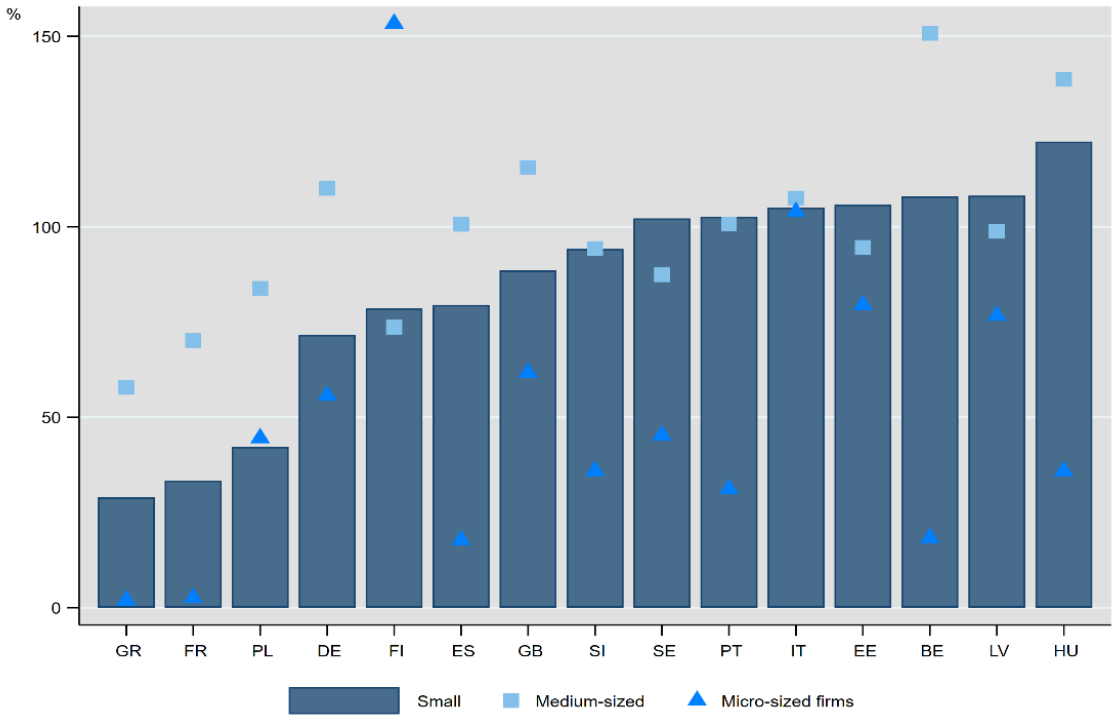
Annex A. Further methodological details

Data coverage

The OECD-ORBIS dataset covers only a share of firms in all 15 countries researched in this study. There is a considerable variation in coverage across countries, however, in all countries, more than one-half of medium-sized firms are covered by the OECD-Orbis dataset, and in 12 out of 15 countries, at least one-half of small firms are covered (Figure A A.1).

Figure A A.1. Most SMEs are covered by the OECD-Orbis dataset

OECD-Orbis coverage of the national data in 2019

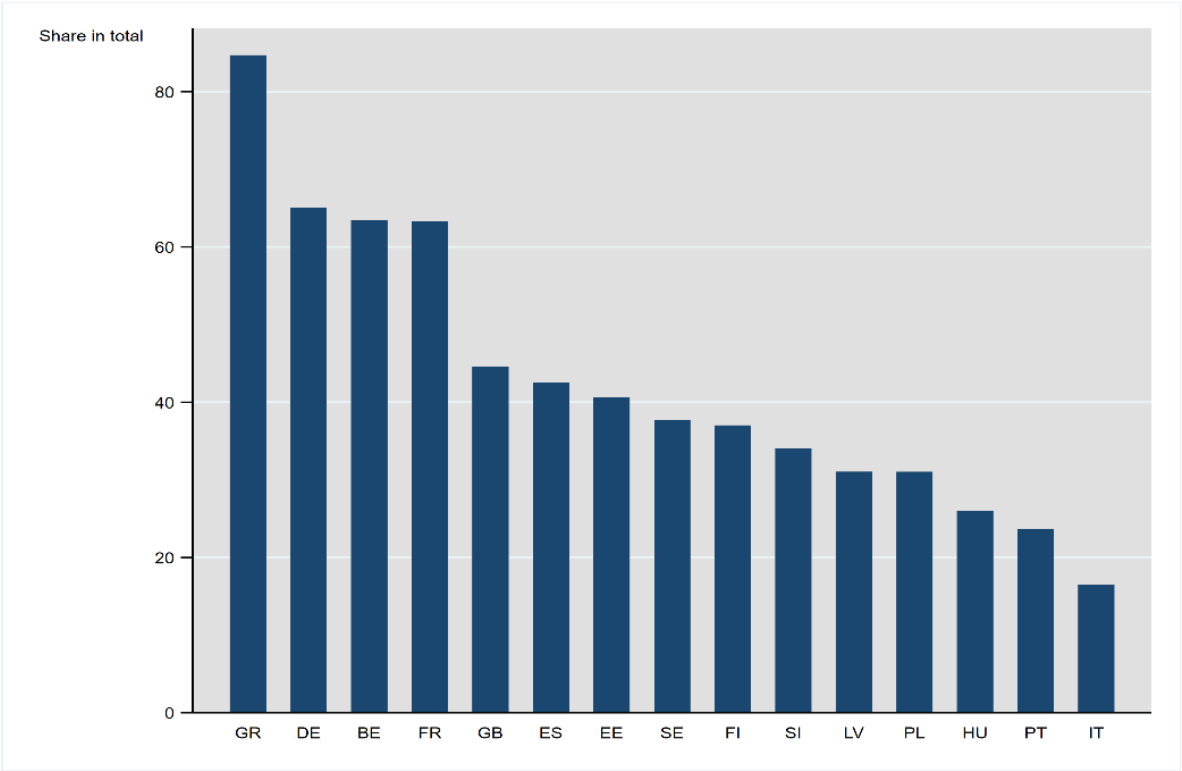


Note: The coverage in the OECD-Orbis is universal if it reaches the level of 100%. In such a case, the number of firms reported by the national statistical offices to the OECD is the same as the number of firms the OECD-Orbis dataset covers. Shares over 100% might mean that a different definition of size group is used by the national statistical offices that were used to define size group in the OECD-Orbis. For example, the National Statistical Office may consider a full-time equivalent employment count instead of a headcount.
Source: OECD calculations based on the OECD-Orbis database and OECD.dot.stat database.

The indicator of environmental engagement can be extracted only for firms that have a website. The OECD-Orbis dataset has website information for 18% of Italian firms present in the dataset (the lowest share) to over 80% of Greek firms (Figure A A.2).

Figure A A.2. Web coverage among the firms in the OECD-Orbis is high

Share of firms in the OECD-Orbis dataset that have a website in 2019



Note: The higher share signifies that more firms present in the OECD-Orbis dataset have a website. However, the national website coverage is conditional on the coverage of the firms in the OECD-Orbis.
Source: OECD calculations based on the OECD-Orbis database.

The dataset includes data on a total of 10 million firms in 2019, although only between 5% and 49% of firms in each country have a website, thus are available to study for the research question of this paper (Table A A.1). This is still an exceptional coverage as it considers websites of micro firms, which often exist without websites.

Table A A.1. The SME presence by country and their average environmental engagement

Number of firms by size group and their coverage for the environmental engagement indicator in 2019 and 2022

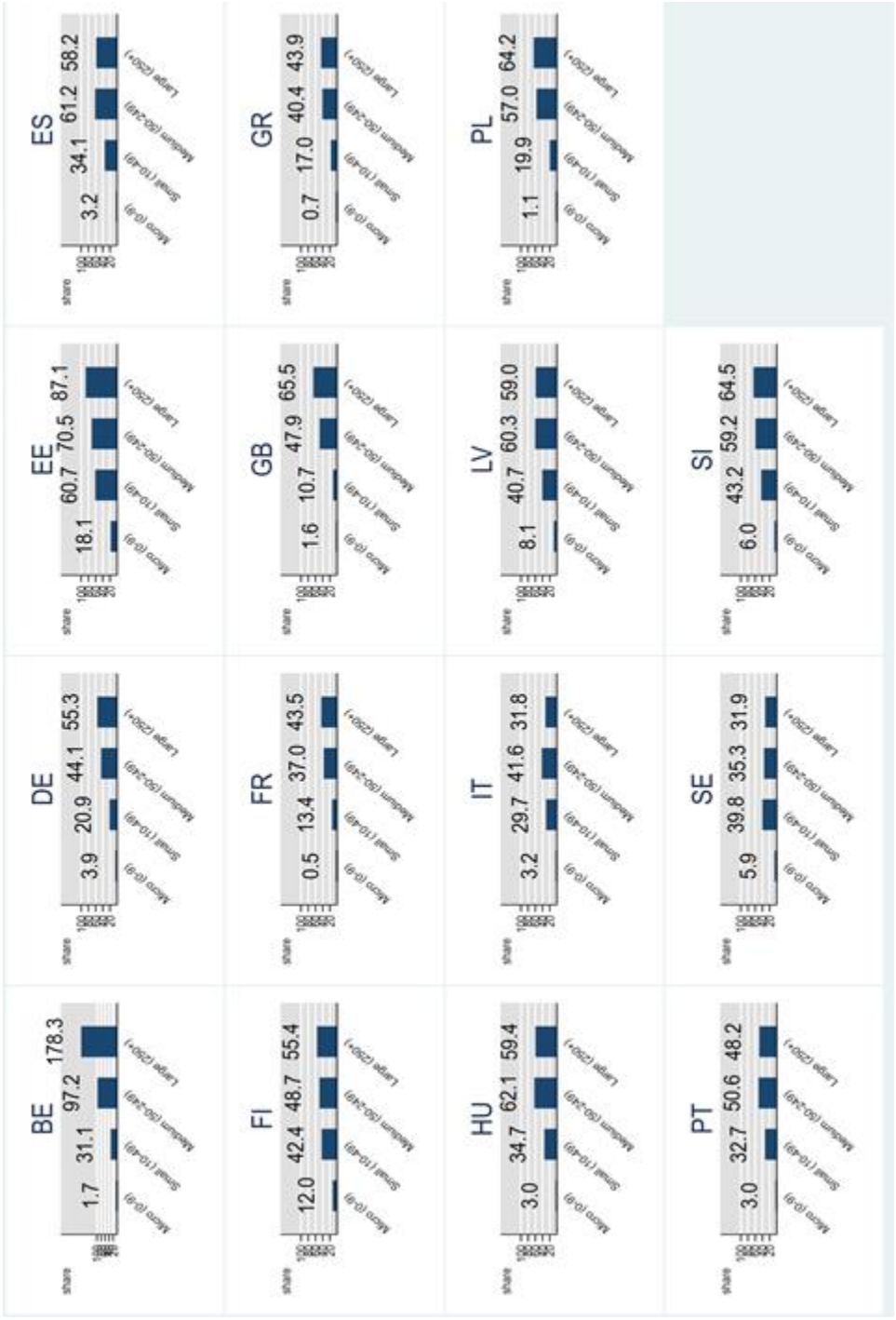
country	Micro firms	Small firms	Medium-sized	Total	Share of firms with a working website in 2022	Share of environmentally-engaged firms
BE	116911	27975	6643	153765	16.1	8.3
DE	1195842	261589	61772	1532426	12.6	4.5
EE	59477	6092	992	66738	26.8	5.5
ES	444396	107641	16871	572010	24.5	9.5
FI	321760	13903	2362	338553	10.2	2.3
FR	71803	44281	14414	134209	31.8	14.7
GB	1237804	158712	35010	1440487	4.8	2.4
GR	12948	10305	2203	25787	48.5	19.1
HU	217398	34837	5992	259431	12.0	3.2
IT	3524982	186692	22483	3737059	4.6	1.6
LV	77454	8572	1434	87658	14.2	3.3
PL	845875	36202	12530	897591	5.5	1.6
PT	274528	39116	6043	320546	13.1	4.2
SE	273517	33005	5165	313188	16.4	5.5
SI	50063	6499	1205	57988	21.2	7.8
Total	8724758	975421	195119	9937436		

Note: The table reports the full sample that is in the data for the year 2019. However, only about one-tenth of this sample is evaluated for the environmental engagement indicator, as the value of the share of working websites reports.
Source: OECD calculations based on the OECD-Orbis database and OECD.dot.stat database.

Overall, one-third of small and one-half of medium-sized firms across 15 OECD countries were screened for environmental engagement (Figure A A.3).

Figure A A.3. The green indicator covers one-third of small and nearly half of medium-sized firms

Share of firms in the economy that are evaluated for environmental engagement by size in 2019



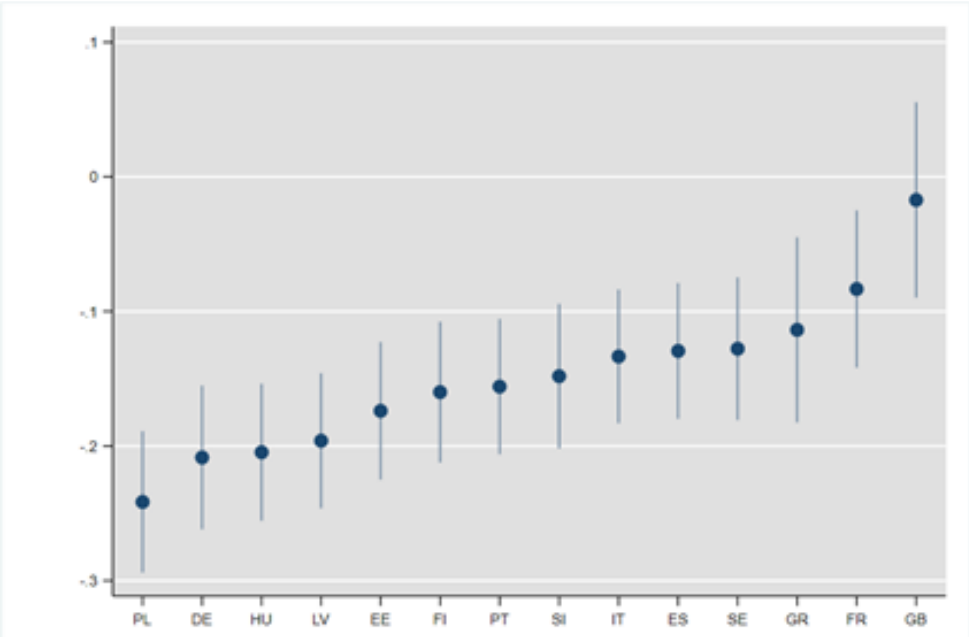
Note: The shares show the coverage of the firms within the size group by the country that had a working website in 2022 and were thus evaluated for environmental engagement. The total number of firms in each size group comes from the official reporting of the national statistics to the OECD, accessible from the OECD.stat database. The shares are based on the 2019 data. The Belgian data display some abnormality in the coverage of large firms. It has 78% more large firms covered by the environmental indicator than the number of actual firms in the economy. Such discrepancies might happen due to the accounting differences.
Source: OECD calculations based on business demography from the OECD.stat (accessed in June 2022) OECD-Orbis database and ISTARI.ai web-scraped data.

Additional results

The composition of micro, small and medium-sized firms in the dataset, as well as sectoral composition, determines the probability of being environmentally engaged. Therefore, controlling for these characteristics in the mean values of the indicator across the countries gives a more across-country comparable picture of how many green firms are present (Figure A A.4).

Figure A A.4. There is a considerable variation of firm greening between countries

Estimated probability that the firm is green in a given country



Note: The outcomes from the probit regression analysis with size group and 2-digit sector control variables indicate the probability to be green as compared to the control group – in this case, firms in Belgium. The average value for Belgium is 0.514, i.e. more than one-half of firms in Belgium are environmentally engaged. The dots can be interpreted as the estimated probability of greening for all countries in the sample besides the control group - Belgium. The vertical line represents a 95% confidence interval within which the results hold. The interpretation is as follows: the estimated value of the probability of greening for UK firms is about 2 percentage points lower than for firms in Belgium. As about 51% of Belgian firms declare greening, it is possible to say that nearly 1 in 2 of the UK firms in the sample is greening, after removing the sector- and size-specific shifts that influence the probability to be green. Controlling for the size group effects means that the probability of greening is considered for firms within the same size groups. Similarly, controlling for the sector effects means that the probability of greening is considered for firms within the same sectors, and the outcomes are averaged across those sectors, removing sector-specific attributes that can influence the probability of greening. The estimations are performed on the values from the year 2019 for all firms that had a functioning website in 2022. See the discussion on the coverage in the section on the robustness of the results.
Source: OECD calculations based on OECD-Orbis database and ISTARI.ai web-scraped data.

Robustness analysis of environmental engagement with EU ETS data

The EU ETS is currently the largest emission trading scheme in the world, covering about 45% of the total EU's greenhouse gas emissions. The scheme was introduced in 2005. Its implementation focused on the subset of the highest polluters as all combustion plants with a thermal input of 20MW and more are obliged to participate. Although the regulation does not require better environmental performance, the participating firms face costs linked to emitting more, so they have also a monetary incentive to reduce their emissions. The evaluation of the scheme often compares the firms that are covered by the regulation to those that missed the threshold of being covered by the regulation but have similar characteristics as the firms in the scheme. The evaluations show that the ETS firms reduced the emissions compared to firms that were

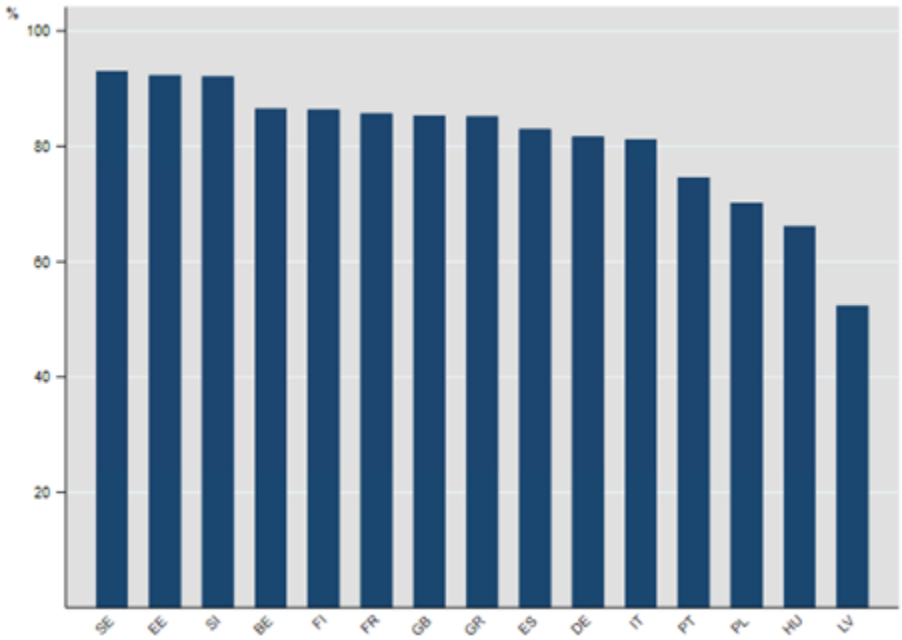
outside of the scheme (see evidence for German firms (Wagner and Petrick, 2014[34]), French firms (Wagner et al., 2014[35]), and some evidence of emission reduction in Norway (Klemetsen, Rosendahl and Jakobsen, 2016[36])). However, there is also no evidence of the positive impact of the scheme on emissions and profitability of Lithuanian firms in the early stages of the scheme (Jaraitė-Kažukauskė and Di Maria, 2016[37]). These results, although partial, are in line with the indicator of environmental engagement developed in this study and indirectly confirm its validity if it is present among participating firms.

Nearly all firms participating in the EU ETS, especially in Sweden, Estonia, Slovenia, and Belgium, are environmentally engaged firms. The notable exception is the firms in Lithuania, where about one-half of firms are environmentally engaged (Figure A A.5). This provides two insights: first, most firms that participated in the emission trading scheme made efforts to improve the environmental impact of their operations. A small share that failed to declare such efforts on their website, likely also failed in attempting any improvements. The results from earlier studies that failed to detect any significant emission reduction in Lithuanian firms are correlated with the low share of environmental engagement among Lithuanian firms in 2022. Such correlation of environmental engagement for firms participating in the emission scheme signifies that the indicator defines at least the *correct* notions if not precise actions.

The firms participating in EU ETS tend to be the largest (the average employment in 2019 across 1 784 firms included in the averages to construct Figure A A.5 is about 2 100). With 80% of them environmentally engaged, they score well above the engagement of 50% among large firms in the whole population of firms evaluated in this study. Firms participating in the ETS but failing to report any related information on their website might continue in their state of affairs without any pollution reduction or might fail to report such information on their website. These firms tend to be smaller (600 employees vs. nearly 2 500 in environmentally engaged firms) and have smaller websites (50 000 characters compared to more than double in environmentally engaged firms).

Figure A A.5. Nearly all firms in the EU Emission Trading Scheme are green

Environmentally-engaged firms as a share in total in 2019



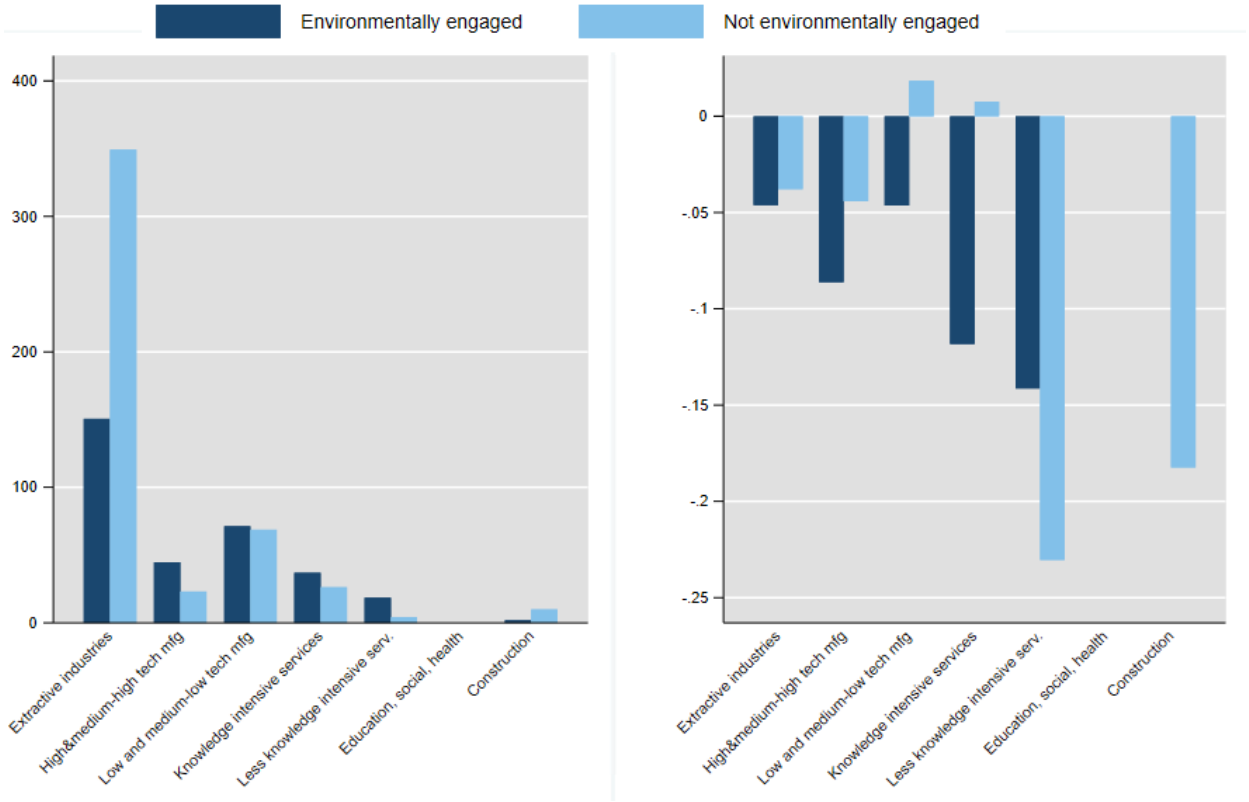
Note: Sample of 1 784 firms that had positive emission values in the ETS dataset in 2019 and had a functioning website in 2022, such that the environmental engagement could be estimated.
Source: Elaborated from the EU-ETS data and OECD-Orbis dataset.

Firm-level pollution changes also prove that environmentally engaged firms tend to decrease the pollution they generate, compared to non-greening firms. Environmentally engaged firms had higher pollution levels per headcount in 2019 in nearly all sectors except for extractive industries and construction. However, in nearly all sector groups with at least 10 observations per group, environmentally engaged firms had lowered their emissions by higher margins than the remaining firms in a median firm. The only sector group where a median non-engaged firm lowered the emissions more was the less knowledge-intensive services.

A median greening firm among low- and medium-low-tech manufacturing industries reduced per-employee pollution levels by nearly 5 per cent, whereas the pollution rose in non-greening firms in these sectors by 2% (Figure A A.6). Only some sectors are represented enough to show the change in pollution, and more observations are necessary for statistical significance. However, the results confirm that the indicator of environmental engagement works well on the set of large firms participating in the ETS. Environmental engagement, moreover, is indicating an actual reduction of pollution, not solely efforts or greenwashing attempts.

Figure A A.6. Green firms have reduced a higher share of the emissions

Per-employee pollution levels (left) in 2019 and change in pollution (right) between 2013 and 2019 in a median firm



Note: The median value of per-employee emissions in 2019 in the group of environmentally engaged firms (the count of not engaged in parenthesis) are calculated on 50 (26) firms in extractive industries, 271 (166) in high- and medium-high-tech manufacturing, 957 (830) in low- and medium-low tech manufacturing, 92 (119) in KIS services, 92 (119) in less-knowledge intensive services, and 17 (21) firms in construction. If the firm count was under 10 firms in 2019, the sector was excluded from consideration for respecting the statistical secret.

The change in pollution is computed as a difference between the 2019 and 2013 values over the 2013 values. Only sectors with at least 10 observations are included. This concerns 38 (15) environmentally-engaged firms in extractive industries, 171 (102) in high- and medium-high-tech manufacturing, 686 (533) in low- and medium-low tech manufacturing, 29 (20) in KIS services, and 49 (43) in less-knowledge intensive services and (13) in Construction.

The end year is chosen as the last year the ETS data is reported. The start year 2013 is chosen as it is the first year with the most plausible values (in the previous years, very low emission values were reported for some firms). The robustness analysis using 2014 and 2015 data yields similar, even if smaller, results.

Source: Elaborated from the EU-ETS data and OECD-Orbis dataset.