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# Working Paper Corporate CO<sub>2</sub> offsetting in small- and medium-seized firms in Germany

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# Corporate CO<sub>2</sub> offsetting in small- and medium-sized firms in Germany

October 2021

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# Corporate CO<sub>2</sub> offsetting in small- and medium-sized firms in Germany

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#### Abstract

Voluntary CO<sub>2</sub> offsetting by individuals, firms, and organizations is increasingly considered as a direction of climate policy that is complementary to traditional approaches such as subsidies or CO<sub>2</sub> taxes. Based on data from a large-scale survey among corporate decision makers, this paper empirically examines corporate CO<sub>2</sub> offsetting and its determinants in smalland medium-sized firms in Germany. Our descriptive analysis shows both a rather limited engagement in corporate CO<sub>2</sub> offsetting as well as a strong lack of knowledge about its mechanism. The econometric analysis reveals that some firm-specific characteristics like the average age of the employees, firm size, and firm age matter for CO<sub>2</sub> offsetting. However, the main estimation results refer to the relevance of general environment-related variables like the implementation of environmental product and service innovations or the share of employees that carry out environment-related tasks and especially of climate-related factors and activities. In particular, the implementation of climate targets and the participation in the EU Emissions Trading System (EU ETS) are strongly significantly positively correlated with CO<sub>2</sub> offsetting. In line with similar findings at the individual level, these estimation results imply that corporate CO<sub>2</sub> offsetting also does not substitute or crowd out other climate protection and further pro-environmental activities, but rather complements them.

#### **Keywords:**

Corporate  $CO_2$  offsetting, corporate climate protection and pro-environmental activities, small- and medium-sized firms

#### **1. Introduction**

According to the Paris Agreement, each country sets a target for the reduction of greenhouse gas (GHG) emissions. But even if countries are willing to achieve ambitious targets, it is not clear how they are implemented at the national level. A key challenge for national governments is the translation of targets into regulations. Previous climate policy measures such as subsidies, emission trading systems, or  $CO_2$  taxes show that their success, among others, strongly depends on the acceptance of citizens in the respective countries (e.g. Attari et al., 2009; Lee et al., 2015; Drews and van den Bergh, 2016; Rhodes et al., 2017; Ziegler, 2019; Engler et al., 2021). However, due to the limited support and enforceability of effective and efficient climate policy measures in many countries, voluntary climate protection activities by individuals, firms, and organizations are increasingly considered as an important complementary direction of climate policy. Examples of individual or corporate activities are saving energies, reducing car use and flights, or the use of climate-friendly means of transportation such as public transportation. An additional increasingly popular direction of voluntary climate protection activities is  $CO_2$  offsetting.

CO<sub>2</sub> offsetting describes the financial compensation of CO<sub>2</sub> emissions caused by individuals or firms through, for example, vehicle use, (business) travel activities, logistics services, or energy consumption (e.g. Ziegler et al., 2012; Blasch and Farsi, 2014; Lange and Ziegler, 2017; Lange et al., 2017). There are various ways to offset CO<sub>2</sub> emissions. In some cases, it is possible to directly compensate CO<sub>2</sub> emissions, for example, when booking a flight. In this case, an additional amount must be paid depending on the CO<sub>2</sub> emissions incurred. Alternatively, one can seek the services of a specialized provider to offset activities that have already been carried out or will be carried out in the future. The corresponding compensation payments are typically used to financially support climate protection projects for reforestation, increasing energy efficiency, or the expansion of renewable energies in developing countries (e.g. Brouwer et al., 2008; Akter et al., 2009; MacKerron et al., 2009). Therefore, such projects can entail additional positive (local) co-benefits in terms of promoting biodiversity, reducing poverty, or enabling innovations in low-carbon sectors (e.g. MacKerron et al., 2009).

Many previous studies empirically examine  $CO_2$  offsetting at the individual level. These studies, for example, show that many individuals are generally interested in this direction of climate protection (e.g. Schwirplies and Ziegler, 2016). However, the direct engagement in  $CO_2$ offsetting is still rather low, which might be caused by the low level of knowledge about its mechanism (e.g. Ziegler et al., 2012). Previous studies reveal that individual  $CO_2$  offsetting additionally depends on several other factors such as trust in the voluntary carbon market (e.g. Akter et al., 2009), co-benefits of climate protection projects (e.g. MacKerron et al., 2009), climate change awareness (e.g. Ziegler et al., 2012), environmental values and identity (e.g. Schwirplies and Ziegler, 2016; Schwirplies et al., 2019), or further individual characteristics such as income, education, and age (e.g. Blasch and Farsi, 2014; Lange and Ziegler, 2017). Previous studies specifically suggest a complementary relationship between  $CO_2$  offsetting and other voluntary climate protection activities (e.g. Lange et al., 2017) as well as mandatory government climate policies (e.g. Schleich et al., 2018).

In contrast to individual CO<sub>2</sub> offsetting, corporate CO<sub>2</sub> offsetting has not been extensively analyzed so far. Previous studies at the firm level instead consider, for example, general sustainability initiatives and environmental management strategies (e.g. Arimura et al., 2008; Ziegler and Seijas Nogareda, 2009; Arimura et al., 2011; Leonidou et al., 2017; Testa et al., 2018; Boiral et al., 2019) or general environmental activities like conducting environmental product and process innovations (e.g. Ziegler, 2015) without focus on climate protection. In addition, some previous studies specifically examine voluntary corporate climate protection activities beyond CO<sub>2</sub> offsetting (e.g. Dawkins and Fraas, 2011; Böttcher and Müller, 2016). Due to the high potential in implementing voluntary climate protection activities among firms (e.g. Fischedick et al., 2014; Kornelis et al., 2020), the analysis of the experience and motives of corporate CO<sub>2</sub> offsetting is certainly interesting for both small and large firms. From a policy perspective, however, the analysis of small- and medium-sized firms is especially crucial for quantifying the extent of their contribution in achieving the climate targets set in the Paris Agreement. Furthermore, the impact of small- and medium-sized firms may be multiplicative if considering the effects that corporate climate protection activities have on employees and communities around them (e.g. Norton et al., 2014; Haski-Leventhal et al., 2017; Paillé et al., 2019).

Against this background, this paper examines the extent of engagement in as well as determinants of voluntary  $CO_2$  offsetting in small- and medium-sized firms. The contribution of our study is threefold: First, we contribute to the specific literature on  $CO_2$  offsetting by analyzing its determinants at the firm level instead of the individual level as in many previous studies. Second, we contribute to the more general literature on corporate climate protection and other pro-environmental activities by analyzing small- and medium-sized firms instead of large firms and especially stock corporations as in previous studies. Third, our econometric analysis is based on a unique data set from a survey among decision makers in German small- and medium-sized firms. As such, it includes a comprehensive set of explanatory factors. Besides controlling for firm-specific characteristics like firm size or firm age, we focus on climate-related variables such as the implementation of climate targets and further environment-related variables like certified environmental management systems or the implementation of environmental measures. To address a major criticism of CO<sub>2</sub> offsetting that it can crowd out pro-environmental activities (some critics even compare the concept of CO<sub>2</sub> offsetting to the old practice of buying indulgences from the Catholic Church, e.g. Kotchen, 2009; Lange and Ziegler, 2017) and can thus have a negative net impact on environmental activities (including climate protection activities) and corporate CO<sub>2</sub> offsetting are indeed substitutes or rather complements.

Our descriptive analysis shows that  $CO_2$  offsetting as a topic has only reached a small proportion of small- and medium-sized firms in Germany, which is also reflected in the limited number of firms that have conducted voluntary  $CO_2$  offsetting so far. The econometric analysis reveals that some firm-specific characteristics such as the average age of the employees, firm size, and firm age matter for  $CO_2$  offsetting. However, the main estimation results refer to the relevance of climate- and further environment-related factors and activities. For example, we find a significantly positive correlation of  $CO_2$  offsetting with the implementation of climate targets and the participation in the EU Emissions Trading System (EU ETS). With respect to environmental innovations, our analysis shows a strong significantly positive correlation between environment-related employees in the firm is also significantly positively correlated with the probability of  $CO_2$  offsetting. Therefore, our estimation results suggest that corporate  $CO_2$  offsetting does not substitute or crowd out corporate climate protection and further proenvironmental activities, but rather complements them.

The remainder of the paper is organized as follows: Section 2 presents the data used in our empirical analysis. Section 3 reports the results of our descriptive and econometric analysis. Section 4 concludes and provides some policy implications.

# 2. Data

Our empirical analysis is based on data collected in a large-scale web survey among decision makers in small- and medium-sized firms in Germany, which were founded before 2019. The

survey was carried out in cooperation with the German market research company Psyma+Consultic GmbH (Psyma) in February and March 2021. The respondents were recruited from an online panel of decision makers in firms with headquarters in Germany. On the basis of information available to the online panel provider, invitations to participate in the survey were sent to decision makers from firms that meet the criteria for small- and mediumsized firms as defined by the European Commission (2021), i.e. less than 250 employees and a turnover between two and 50 million euros. Due to the focus of the survey on CO<sub>2</sub> offsetting, only decision makers informed about important environmental or sustainability-related measures in their firm (e.g. the development of environmental and sustainability strategies, general energy efficiency measures, or environmental management) were interviewed. A total of 991 people participated in the survey, with 700 interviews completed and a median interview time of about 28 minutes. For our empirical analysis, we exclude 120 of these 700 interviews because the corresponding firms are too large in terms of turnover or the number of employees according to the aforementioned definition.<sup>1</sup> Accordingly, we only include firms between ten and 249 employees<sup>2</sup> and a turnover of less or equal to 50 million euros in 2020.<sup>3</sup> In addition, three other firms are excluded due to invalid answers, where, for example, decision makers did not make realistic numerical entries when asked for the number of women in the firm or reported a total number of employees engaged in environment-related jobs that exceed the total number of employees in the firm. As a result, our empirical analysis is based on data from 577 firms.

#### 3. Empirical analysis

#### 3.1 Descriptive analysis of corporate CO<sub>2</sub> offsetting

We first consider the awareness and knowledge of  $CO_2$  offsetting. Table 1 shows that 57.71% of the surveyed decision makers have already heard of  $CO_2$  offsetting prior to the survey.<sup>4</sup> Of these 333 respondents, 34.84% rate their knowledge of  $CO_2$  offsetting as rather high or very high, 32.73% as rather low or very low, and 32.43% are undecided (see Table 2). Thus, about

<sup>&</sup>lt;sup>1</sup> Although only firms with less than 250 employees and a turnover between two and 50 million euros according to the information of the online panel provider were invited, this information is outdated for some firms, which now exceed at least one of the size thresholds for small- and medium-sized firms.

 $<sup>^{2}</sup>$  Micro-sized firms with less than ten employees are not considered in this study since we assume that these firms compensate CO<sub>2</sub> emissions to a significantly lower extent due to limited financial and staff capacities.

<sup>&</sup>lt;sup>3</sup> Among the firms included, 42 reported turnovers of zero euros for 2020. One possible reason for this response behavior is that the respondents did not want to disclose this information. To not further reduce the sample size, we do not exclude these firms at this point, but address this point in the econometric analysis to avoid any selection bias.

<sup>&</sup>lt;sup>4</sup> All survey questions analyzed in this study are reported in the online appendix.

 $61.18\%^5$  of all respondents have no or only little knowledge of CO<sub>2</sub> offsetting. These results suggest that so far the topic of CO<sub>2</sub> offsetting has only reached a rather small share of decision makers in small- and medium-sized firms in Germany. The observed low level of knowledge about CO<sub>2</sub> offsetting is also reflected in the past CO<sub>2</sub> offsetting activities: According to Table 3, only 14.90% of the firms have already compensated CO<sub>2</sub> emissions before 2018, while 22.01% have conducted offsetting activities between 2018 and 2020. In total, only 139 firms, and thus less than one quarter (24.09%), have started conducting CO<sub>2</sub> offsetting by 2020, although we observe a slight increase in the number of firms conducting CO<sub>2</sub> offsetting within the last few years.

Decision makers of firms with CO<sub>2</sub> offsetting activities in the last three years from 2018 to 2020 were also asked which types of self-generated CO<sub>2</sub> emissions their firm has previously offset (the selection of multiple types was possible).<sup>6</sup> Accordingly, most of these firms have compensated emissions from their energy consumption (48.03%), followed by emissions from car travel for business trips (45.67%), logistics services for the firm (45.67%), flights for business trips (38.58%), stays in hotels or other overnight accommodation during business trips (37.01%), and long-distance bus travel for business trips (31.50%). 10.24% have compensated all emissions from the firm within a given time period and only 2.36% have compensated further emissions not listed before. The vast majority of firms (70.08%) has used a provider for CO<sub>2</sub> offsets (e.g. atmosfair, myclimate) to conduct their offsetting activities. A smaller share of firms has conducted direct payments to a climate protection project (41.73%) and 31.50% have compensated emissions by directly paying extra when booking a specific activity (e.g. when booking a flight).<sup>7</sup>

We also asked all respondents about their firm's future willingness to conduct  $CO_2$  offsetting. Table 4 shows that a clear majority (89.93%) of the 139 firms that have already conducted  $CO_2$  offsetting in the past is also willing to offset  $CO_2$  emissions in the future. Only 6.47% are no longer willing to carry out  $CO_2$  offsetting in the future and the remaining 3.60% are unsure. Considering firms that have not conducted any  $CO_2$  offsetting so far, 32.02% are willing to offset  $CO_2$  emissions in the future, while 30.06% are not willing to do so and the largest share

<sup>&</sup>lt;sup>5</sup> Here, we consider all respondents that have never heard of  $CO_2$  offsetting before and those with rather or very low knowledge: (244+94+15)/577 = 0.6118 (or 61.18%).

<sup>&</sup>lt;sup>6</sup> The categories presented to the respondents were as follows: 1) emissions from flights for business trips, 2) emissions from stays in hotels or other overnight accommodation during business trips, 3) emissions from car travel (incl. rental car travel) for business trips, 4) emissions from long-distance bus travel for business trips, 5) emissions from logistics services (shipping) for your firm, 6) emissions from the energy consumption of your firm, 7) all emissions from your firm within a period of time, and 8) other.

<sup>&</sup>lt;sup>7</sup> Again, respondents could indicate multiple categories.

of 37.92% is not sure about this point. Thus, we find a moderate willingness for  $CO_2$  offsetting among firms that have not yet carried out such activities. However, these figures also imply a considerable potential for future corporate  $CO_2$  offsetting, as the vast majority (i.e. 32.02% +37.92% = 69.94%) of all firms that have not yet carried out any  $CO_2$  compensations do not categorically rule out such activities in the future.

#### 3.2 Econometric analysis

#### 3.2.1 Dependent variables

To analyze the determinants of corporate CO<sub>2</sub> offsetting, we consider two of the answers respondents gave in the survey about their firm's CO<sub>2</sub> compensations in the past (see Table 3). The dummy variable 'CO<sub>2</sub> offsetting in the past' takes the value one if the respondents indicated that their firm has conducted CO<sub>2</sub> offsetting either before 2018 and/or between 2018 and 2020. The variable takes the value zero if the respondent answered "no" both times, "no" and "don't know," or "don't know" and "no," respectively. As treating "don't know" answers in the same way as "no" answers could influence the results of our econometric analysis, we also construct a second dummy variable 'CO<sub>2</sub> offsetting in the past (without don't know answers).' This variable is identical to the previous variable except that those respondents who did not know whether their firm has conducted CO<sub>2</sub> offsetting in the past are treated as missing data.<sup>8</sup> The upper part of Table 5 reports selected descriptive statistics for these two dependent variables. In line with our description in the previous section, the mean of 'CO<sub>2</sub> offsetting in the past' is 0.2409, which indicates that less than one quarter of all firms in the sample has offset some CO<sub>2</sub> emissions yet. The mean of 'CO<sub>2</sub> offsetting in the past (without don't know answers)' is calculated with only 495 observations and therefore slightly higher (0.2808) than for the previous case, where all observations are considered.

#### 3.2.2 Explanatory variables

Our selection of potential explanatory factors for corporate CO<sub>2</sub> offsetting is based on previous empirical findings in the field of corporate environmental management, but also on studies

<sup>&</sup>lt;sup>8</sup> The dummy variable 'CO<sub>2</sub> offsetting in the past (without don't know answers)' takes the value one if the firm has ever conducted CO<sub>2</sub> offsetting before 2018 and/or between 2018 and 2020, and the value zero if CO<sub>2</sub> offsetting has not been carried out in either of the two periods. Cases in which respondents indicated either "don't know" both times, "no" and "don't know," or "don't know" and "no" are treated as missing values.

analyzing CO<sub>2</sub> offsetting among individuals. For a better overview, we distinguish in the following between a) climate-related variables, b) further environment-related variables, and c) firm-specific characteristics.

#### Climate-related variables

We first aim to capture the vulnerability of firms due to climate change. We thereby address findings showing that an exposure to climate change affects corporate climate activities (e.g. Chrischilles and Mahammadzadeh, 2014). To this end, we asked the respondents to indicate the extent to which their firm's business has been affected by climate change over the last ten years since 2010. The five ordered response categories were 'not at all affected,' 'rather little affected,' 'undecided,' 'rather strongly affected,' and 'very strongly affected.' The dummy variable 'affected by climate change' takes the value one if the decision makers selected 'rather strongly affected' or 'very strongly affected,' and zero otherwise. We further take into account results showing that (some) corporate climate change targets are correlated with reductions in GHG emissions (e.g. Dahlmann et al., 2019) or that the commitment to climate change action is positively related to corporate GHG performance (e.g. Littlewood et al., 2018). The corresponding dummy variable 'climate targets' takes the value one if the firm has formulated specific goals for its own climate protection activities, and zero otherwise. Finally, we also consider the role of climate-related regulatory measures by constructing the dummy variable 'EU ETS' that takes the value one if the firm participates in the EU ETS, and zero otherwise. The second part of Table 5 shows that almost 17% of the decisions makers indicated that their firm has been rather or very strongly affected by climate change over the last ten years. More than 28% of the firms have formulated specific targets for climate protection activities and about one eighth of firms participates in the EU ETS.

#### Further environment-related variables

In addition to variables specifically related to climate change, we also consider further environment-related variables. Previous studies show that organizational environmental measures and specifically the implementation of environmental management systems (e.g. ISO 14001) are positively related to a firm's commitment to reduce their GHG emissions (e.g. Böttcher and Müller, 2016), to reduce other environmental impacts (e.g. Arimura et al., 2008), or to conduct voluntary environmental activities (e.g. Arimura et al., 2011). We consider three different variables to capture organizational environmental measures: The dummy variable 'EMAS or ISO 14001' takes the value one if the firm or (at least) one site of the firm has implemented a certified environmental management system according to EMAS or ISO

14001, and zero otherwise. The dummy variable 'uncertified environmental management system' takes the value one if the firm or (at least) one site of the firm has implemented an environmental management system that has not been certified according to EMAS or ISO 14001, and zero otherwise. We additionally asked the decision makers to indicate those of the following five types of environment-related non-financial matters on which their firm regularly collects information: a) emissions of CO<sub>2</sub>, b) emissions of other pollutants (e.g. nitrogen oxides), c) share of renewable energies in the total energy consumption, d) total water consumption, and e) amount of waste. The variable 'number registered environmental indicators' indicates how many of these different indicators are registered in each firm and thus can range between zero and five.

Previous studies also suggest a positive correlation between corporate environmental and social motivations and the commitment to reduce GHG emissions (e.g. Boiral et al., 2012) or between corporate environmental performance and voluntary climate change disclosure (e.g. Dawkins and Fraas, 2011). Likewise, at the individual level, environmental awareness and identity (e.g. Schwirplies and Ziegler, 2016; Schwirplies et al., 2019) and some pro-environmental activities (e.g. Lange et al., 2017) tend to be positively correlated with individual CO<sub>2</sub> offsetting. Therefore, we additionally take specific voluntary corporate environmental activities into account. To this end, we asked the decision makers to indicate which of the following environmental protection measures are regularly carried out in their firm: a) environmental audits, b) reporting of emissions (e.g. CO<sub>2</sub>), c) environmental training for employees, d) use of renewable energies, e) use of environmentally friendly office materials (e.g. use of recycled paper), e) supporting the use of environmentally friendly means of transportation by employees (e.g. promoting the use of public transport and rail via job tickets or for business trips), and f) other measures. The variable 'number environmental measures' indicates the total number of different voluntary environmental protection measures regularly carried out in the firm and can thus range between zero and six.

Additionally, we refer to previous studies finding a positive relationship between environmental innovations and other corporate environmental activities (e.g. Rehfeld et al., 2007; Ziegler and Seijas Nogareda, 2009; Ziegler, 2015) and include two corresponding variables in our econometric analysis. The dummy variable 'environmental product and service innovations' takes the value one if the firm has carried out at least one environmental product and/or service innovation in the last three years between 2018 and 2020, and zero otherwise. In the same manner, the dummy variable 'environmental process and procedure innovations' takes the value one if the firm has implemented at least one environmental process and/or procedure innovation in the past, and zero otherwise. Finally, we also include the variable 'share environment-related employees,' which measures the ratio between the number of employees that deals directly with information, technologies, or materials that maintain or restore environmental quality and the total number of employees in the firm. We thereby address empirical evidence of a positive relationship between employees' awareness of environmental issues and corporate climate protection activities (e.g. Damert and Baumgartner, 2018a).

The third part of Table 5 shows that 31.02% of the firms have a certified environmental management system, while 6.41% have an uncertified environmental management system. On average, firms register about 1.8 of the five environmental indicators<sup>9</sup> and conduct about 2.2 of the six environmental measures<sup>10</sup> listed above. Moreover, almost one third has conducted environmental product and/or service innovations in the last three years from 2018 to 2020, and a slightly lower share (29.46%) has conducted environmental process and/or procedure innovations. The average share of environment-related employees among all employees is 15.93%.

#### Firm-specific characteristics

We also consider a variety of firm-specific characteristics. Previous studies consider the share of women and younger employees in firms with respect to corporate climate issues (e.g. Ciocirlan and Pettersson, 2012). We thus include the variable 'share female employees,' which is the ratio between the number of female employees and the total number of employees. The dummy variable 'average age employees up to 34 years' takes the value one if the average age of employees in the firm does not exceed 34 years.<sup>11</sup> Previous findings further suggest that firm size is correlated with the engagement in environmental management practices (e.g. Uhlaner et al., 2012) and the implementation of low-carbon practices and climate change strategies (e.g. Böttcher and Müller, 2015; Damert and Baumgartner, 2018b). This is attributed to the availability of resources, including knowledge and financial funds, which tend to increase not only with firm size, but also with the years of existence in the market.

<sup>&</sup>lt;sup>9</sup> Most firms collect information on their total water consumption and amount of waste (53.25% and 53.90% respectively), followed by information on the share of renewable energies, emissions of  $CO_2$ , and emissions of other pollutants (e.g. nitrogen oxides), which are collected by 31.02%, 25.65%, and 17.50% of the firms, respectively.

<sup>&</sup>lt;sup>10</sup> Most firms (62.91%) use environmentally friendly office materials, followed by the use of renewable energies (48.53%), the support of environmentally friendly means of transportation by employees (35.36%), and the provision of environmental training for employees (31.20%). The other measures are negligible.

<sup>&</sup>lt;sup>11</sup> We use the threshold of 34 years of age for differentiating between young and old employees. This approach is in line with a report on this topic from the German Statistical Agency (e.g. Günther und Gawronski, 2018).

Against this background, the dummy variable 'number employees over 49' takes the value one if the firm has more than 49 employees, which corresponds to the threshold of small- to medium-sized firms. In addition, the dummy variable 'average turnover over ten million euros' takes the value one if the average annual turnover for the years between 2018 and 2020 exceeds 10 million euros (again, in line with the threshold of small- to medium-sized firms), and the variable 'log firm age' is the natural logarithm of the years of activity.<sup>12</sup>

Finally, we aim to capture regional and sector-specific differences. The dummy variable 'Eastern Germany' takes the value one if the headquarter or head office of the firm is located in one of the Eastern German federal states. We also asked the decision makers to indicate to which sector<sup>13</sup> their firm belongs. We construct dummy variables for the four sectors with the highest number of firms in our sample, namely "manufacturing or production of goods," "constructions," "health and social care," and "information and communication." Accordingly, the dummy variables 'manufacturing sector,' 'construction sector,' 'health sector,' and 'information communication sector' take the value one if the firm belongs to the corresponding sector, and zero otherwise, respectively. The bottom part of Table 5 shows that on average 41.82% of the employees are female and that in 16.12% of the firms the average age of employees does not exceed 34 years. Moreover, almost 56% of the firms have more than 49 employees, while 32.41% have an average annual turnover of over 10 million euros for the years between 2018 and 2020. The average firm age is about 35 years. In addition, about one quarter of the firms is based in Eastern Germany and 14.38%, 9.18%, 8.66%, and 8.32% are active in the manufacturing, construction, health, and information and communication sectors, respectively.

#### 3.3 Results

To address the binary nature of our two dependent variables, we use binary probit models in our econometric analysis.<sup>14</sup> Table 6 reports the estimates of average marginal and discrete probability effects<sup>15</sup> in binary probit models based on two different model and sample specifications for both dependent variables.<sup>16</sup> The estimation results for models (1) and (2) are

 $<sup>^{12}</sup>$  Firms founded after 2018 are excluded from our analysis since they cannot provide information on CO<sub>2</sub> offsetting conducted before 2018, which is a crucial component for constructing our dependent variables.

<sup>&</sup>lt;sup>13</sup> According to the classification of the German Federal Statistical Office (Statistisches Bundesamt, 2008).

<sup>&</sup>lt;sup>14</sup> We use the statistical software package Stata 15 for our econometric analysis.

<sup>&</sup>lt;sup>15</sup> We use the term "effect" as it is common in econometric analyses. However, some relationships between the dependent and explanatory variables should rather be interpreted as correlations instead of causal effects.

 $<sup>^{16}</sup>$  'CO<sub>2</sub> offsetting in the past' is the dependent variable in models (1) and (3), while 'CO<sub>2</sub> offsetting in the past (without don't know answers)' is the dependent variable in models (2) and (4).

based on the same (full) sample as considered in the descriptive analysis.<sup>17</sup> In both specifications, we include all previously mentioned explanatory variables, except 'average turnover over ten million euros' since this sample comprises firms indicating no turnover for 2020. To test the robustness of the estimation results, we omit the firms with indicated zero turnover in 2020 (see Section 2) in models (3) and (4), reducing the sample sizes to 535 and 459, respectively. In these models we consider the explanatory variable 'average turnover over ten million euros' as alternative indicator for firm size (and exclude 'number employees over 49').<sup>18</sup> Overall, comparing the estimation results across the different model specifications reveals that most of the estimated average marginal and discrete probability effects are very similar in terms of their direction and statistical significance. Differences in the estimation results between the model specifications are discussed in the following.

#### Climate-related variables

Concerning our climate-related variables, we find no evidence that the vulnerability of firms by climate change in the past is correlated with  $CO_2$  offsetting. Instead, we find that both the implementation of climate targets and the participation in the EU ETS are significantly positively correlated with  $CO_2$  offsetting. In terms of economic significance, the estimation results in model (1) imply that firms having formulated specific goals for their own climate protection activities are on average 13.37 percentage points more likely to conduct  $CO_2$  offsetting than their counterparts. This finding is in line with previous studies revealing a positive correlation between (some) corporate climate change targets or the commitment to climate change action (which includes specific goals and targeted measures to reduce GHG emissions) and corporate GHG performance (e.g. Littlewood et al., 2018; Dahlmann et al., 2019). Remarkably, the estimated probability effect of 'EU ETS' is even higher: The estimation results in model (1) imply that firms participating in the EU ETS are on average 26.80 percentage points more likely to conduct  $CO_2$  offsetting than non-EU ETS firms.<sup>19</sup> In sum, the estimation results thus suggest that corporate  $CO_2$  offsetting does not substitute corporate climate protection activities, but rather complements them.

<sup>&</sup>lt;sup>17</sup> That is, we consider all firms with less than or equal to 50 million euros turnover in 2020.

<sup>&</sup>lt;sup>18</sup> To test the robustness of our econometric results, we have also considered a model specification with both explanatory variables 'number employees over 49' and 'average turnover over ten million euros' besides all other explanatory variables. While the corresponding estimation results (which are available upon request) are qualitatively very similar to the case of exclusively including one variable for firm size, it should be noted that 'number employees over 49' and 'average turnover over ten million euros' are highly correlated with a correlation coefficient of 0.54 so that multicollinearity problems occur in this case.

<sup>&</sup>lt;sup>19</sup> Further estimations reveal that EU ETS firms which have formulated climate targets are on average even about 47 percentage points more likely to conduct CO<sub>2</sub> offsetting than non-EU ETS firms without climate targets.

#### Further environment-related variables

With respect to organizational environmental measures, we find no significant correlation between 'number registered environmental indicators' or 'uncertified environmental management system' and CO<sub>2</sub> offsetting. Instead, the estimated probability of CO<sub>2</sub> offsetting is slightly higher for firms with a certified environmental management system (i.e. EMAS or ISO 14001) compared to firms without any environmental management system. However, the corresponding parameter is only different from zero at the 10% significance level when we consider 'CO<sub>2</sub> offsetting in the past' as dependent variable. Thus, these results do not unequivocally support previous studies showing a positive correlation between the implementation of environmental management systems and corporate GHG reduction or environmental activities (e.g. Arimura et al., 2008; Ziegler and Seijas Nogareda, 2009; Arimura et al., 2011; Ziegler, 2015; Böttcher and Müller, 2016). However, in no model organizational environmental measures are negatively correlated with the estimated probability of CO<sub>2</sub> offsetting.

Concerning environmental activities beyond organizational measures, only environmental process and/or procedure innovations are negatively correlated with the estimated probability of CO<sub>2</sub> offsetting. However, the correlation is only weakly significant in model (3). In contrast, the implementation of environmental product and/or service innovations is significantly positively correlated with the probability of CO<sub>2</sub> offsetting in all four models. In terms of economic significance, the estimated average discrete probability effects vary between 8.35 percentage points in model (3) and 14.71 percentage points in model (2), which are not negligible. Furthermore, the number of environmental measures is weakly significantly positively correlated with CO<sub>2</sub> offsetting in models (3) and (4). Finally, and in line with evidence of a positive correlation between employees' awareness of environmental issues and corporate climate activities (e.g. Damert and Baumgartner, 2018a), we find a significantly positive correlation between the share of environment-related employees and CO<sub>2</sub> offsetting. An increase of the share by 0.01 (i.e. one percentage point) is associated with an increase of the estimated average probability of CO<sub>2</sub> offsetting by values between 0.12 and 0.18 percentage points. Therefore, with the exception of environmental process and/or procedure innovations, our estimation results suggest that corporate CO<sub>2</sub> offsetting also seems to be a complement rather than a substitute to our other environment-related variables.

In sum, the estimation results for the climate- and further environment-related variables are strongly in line with findings of previous studies at the individual level. For example, Schwirplies and Ziegler (2016) and Schwirplies et al. (2019) reveal a positive correlation between

environmental values (measured by a scale according to the New Ecological Paradigm, see e.g. Ziegler, 2021) or environmental identity and individual CO<sub>2</sub> offsetting. In particular, Lange et al. (2017) show a complementary relationship between individual CO<sub>2</sub> offsetting and other pro-environmental activities including climate protection activities in Germany and the USA. Therefore, it seems that neither individual nor corporate CO<sub>2</sub> offsetting crowd out individual or corporate pro-environmental activities including climate protection activities.

#### Firm-specific characteristics

Concerning further firm-specific characteristics, we find a significantly positive correlation between corporate  $CO_2$  offsetting and firm size in terms of employees, younger firms, and younger employees in the firm, respectively. The estimation result for firm size suggests that larger firms have more resources for financing  $CO_2$  offsetting. Furthermore, it might be speculated that younger firms and firms with more young employees may have a corporate culture with a stronger focus on environmental issues. In contrast, we find no significant correlation between any of the remaining firm-specific characteristics such as the share of females in the firm and the probability of  $CO_2$  offsetting. The only exception refers to the estimated effect for our regional dummy variable 'Eastern Germany,' which is significant in models (3) and (4), albeit only at the 10% significance level.

#### 4. Conclusions and climate policy implications

Based on data from a large-scale survey among corporate decision makers in small- and medium-sized firms in Germany, this paper empirically examines corporate  $CO_2$  offsetting and its determinants. Our descriptive analysis shows a limited number of firms in our sample that have conducted voluntary  $CO_2$  offsetting so far. Concerning future  $CO_2$  offsetting, most firms that have already conducted  $CO_2$  offsetting in the past are also willing to compensate  $CO_2$ emissions in the future. In contrast, we only find a moderate willingness to offset  $CO_2$  emissions among firms that have not yet carried out such activities. Importantly, the limited engagement in corporate  $CO_2$  offsetting is associated with a strong lack of knowledge about its mechanism. An important direction for climate policy to increase the extent of corporate  $CO_2$ offsetting is therefore the promotion of systematic information campaigns on this topic. It can be expected that the provision of fundamental knowledge may reduce uncertainties and eliminate possible reservations towards  $CO_2$  offsetting. The results of our econometric analysis, especially with respect to firm-specific characteristics like firm size, average age of the employees, and years of activity provide a good basis for targeted information allocation. The main estimation results of our econometric analysis refer to the relevance of climate- and further environment-related factors and activities. In particular, the implementation of climate targets and the participation in the EU ETS are strongly significantly positively correlated with  $CO_2$  offsetting. Furthermore, our econometric analysis reveals a strong positive correlation between  $CO_2$  offsetting and environmental product and/or service innovations as well as the share of environment-related employees in the firm. In line with similar findings at the individual level, these estimation results thus imply that corporate  $CO_2$  offsetting also does not substitute or crowd out other climate protection and further pro-environmental activities, but rather complements them. Therefore, our empirical findings do not support concerns that the availability of  $CO_2$  offsetting has a negative net impact on environmental quality. With respect to climate policy, these estimation results suggest combined public campaigns addressing both voluntary direct corporate climate protection and further pro-environmental activities as well as corporate  $CO_2$  offsetting to increase general corporate environmental and climate performance.

While our empirical study is, to the best of our knowledge, the first systematic empirical analysis of corporate  $CO_2$  offsetting and its determinants based on a unique data set, we cannot clearly establish causal effects between climate protection and further pro-environmental activities on the one hand and  $CO_2$  offsetting on the other hand. An important direction for further research is therefore to analyze the causality of this relationship based on panel data, which are not available so far, as well as on the basis of revealed instead of stated activities.

#### References

Akter, S., R. Brouwer, L. Brander, and P. van Beukering (2009), Respondent uncertainty in a contingent market for carbon offsets, *Ecological Economics* 68 (6), 1858-1863.

Arimura, T.H., A. Hibiki, and H. Katayama (2008), Is a voluntary approach an effective environmental policy instrument? A case for environmental management systems, *Journal of Environmental Economics and Management* 55 (3), 281-295.

Arimura, T.H., N. Darnall, and H. Katayama (2011), Is ISO 14001 a gateway to more advanced voluntary action?: The case of green supply chain management, *Journal of Environmental Economics and Management* 61 (2), 170-182.

Attari, S.Z., M. Schoen, C.I. Davidson, M.L. DeKay, W.B. de Bruin, R. Dawes, and M.J. Small (2009), Preferences for change: Do individuals prefer voluntary actions, soft regulations, or hard regulations to decrease fossil fuel consumption?, *Ecological Economics* 68 (6), 1701-1710.

Blasch, J. and M. Farsi (2014), Context effects and heterogeneity in voluntary carbon offsetting – A choice experiment in Switzerland, *Journal of Environmental Economics and Policy* 3 (1), 1-24.

Boiral,O., J.-F. Henri, and D. Talbot (2012), Modeling the impacts of corporate commitment on climate change, *Business Strategy and the Environment* 21 (8), 495–516.

Boiral, O., M. Ebrahimi, K. Kuyken, and D. Talbot (2019), Greening remote SMEs: The case of small regional airports, *Journal of Business Ethics* 154, 813-827.

Böttcher, C. and M. Müller (2015), Drivers, practices and outcomes of low-carbon operations: Approaches of German automotive suppliers to cutting carbon emissions, *Business Strategy and the Environment* 24, 477-498.

Böttcher, C. and M. Müller (2016), Insights on the impact of energy management systems on carbon and corporate performance. An empirical analysis with data from German automotive suppliers, *Journal of Cleaner Productions* 137, 1449-1457.

Brouwer, R., L. Brander, L., and P. Beukering (2008), "A convenient truth": Air travel passengers' willingness to pay to offset their CO2 emissions, *Climatic Change* 90 (3), 299-313.

Chrischilles, E. and M. Mahammadzadeh (2014), Wahrnehmung des Klimawandels in deutschen Großunternehmen: Erkenntnisse aus dem Carbon Disclosure Project, *IW-Trends - Vierteljahresschrift zur empirischen Wirtschaftsforschung* 41 (1), 3-16.

Ciocirlan, C. and C. Pettersson (2012), Does workforce diversity matter in the fight against climate change? An analysis of fortune 500 companies, *Corporate Social Responsibility and Environmental Management* 19, 47-62.

Dahlmann, F., L. Branicki, and S. Brammer (2019), Managing carbon aspirations: The influence of corporate climate change targets on environmental performance, *Journal of Business Ethics* 158, 1-24.

Damert, M. and R.J. Baumgartner (2018a), External pressures or internal governance – What determines the extent of corporate responses to climate change?, *Corporate Social Responsibility and Environmental Management* 25, 473-488.

Damert, M. and R.J. Baumgartner (2018b), Intra-sectoral differences in climate change strategies: Evidence from the global automotive industry, *Business Strategy and the Environment* 27 (3), 265-281.

Dawkins, C. and J.W. Fraas (2011), Coming clean: The impact of environmental performance and visibility on corporate climate change disclosure, *Journal of Business Ethics* 100, 303-322.

Drews, S. and J.C.J.M. van den Bergh (2016), What explains public support for climate policies? A review of empirical and experimental studies, *Climate Policy* 16 (7), 855-876.

Engler, D., E.D. Groh, G. Gutsche, and A. Ziegler (2021), Acceptance of climate-oriented policy measures under the COVID-19 crisis: An empirical analysis for Germany, *Climate Policy*, forthcoming.

European Commission (2021), SME definition, *https://ec.europa.eu/growth/smes/sme-defini-tion\_en*, last accessed on October 4<sup>th</sup>, 2021.

Fischedick M., J. Roy, A. Abdel-Aziz, A. Acquaye, J. M. Allwood, J.-P. Ceron, Y. Geng, H.
Kheshgi, A. Lanza, D. Perczyk, L. Price, E. Santalla, C. Sheinbaum, and K. Tanaka (2014),
Industry. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*[Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler,
I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von
Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United
Kingdom and New York, NY, USA.

Günther, L. and K. Gawronski (2018), Junge Menschen auf dem Arbeitsmarkt: Ergebnisse des Ad-hoc-Moduls zur Arbeitskräfteerhebung 2016, Destatis (Statistisches Bundesamt).

Haski-Leventhal, D., L. Roza, and L. Meijs (2017), Congruence in corporate social responsibility: Connecting the identity and behavior of employers and employees, *Journal of Business Ethics* 143, 35-51.

Kornelis, B., A. Afanador, I. van der Hoorn, T. Berg, O. Edelenbosch, and D. van Vuuren (2020), Assessment of sectoral greenhouse gas emission reduction potentials for 2030, *Energies* 13 (943), 1-24.

Kotchen, M.J. (2009), Voluntary provision of public goods for bads: A theory of environmental offsets, *Economic Journal* 119, 883-899. Lange, A. and A. Ziegler (2017), Offsetting versus mitigation activities to reduce CO<sub>2</sub> emissions: A theoretical and empirical analysis for the U.S. and Germany, *Environmental and Resource Economics* 66 (1), 113-133.

Lange, A., C. Schwirplies, and A. Ziegler (2017), On the interrelation between the consumption of impure public goods and the provision of direct donations: Theory and empirical evidence, *Resource and Energy Economics* 47, 72-88.

Lee, T. M., E.M. Markowitz, P.D. Howe, C.-Y. Ko, and A.A. Leiserowitz (2015), Predictors of public climate change awareness and risk perception around the world, *Nature Climate Change* 5, 1014-1020.

Leonidou, L., P. Christodoulides, L. Kyrgidou, and D. Palihawadana (2017), Internal drivers and performance consequences of small firm green business strategy: The moderating role of external forces, *Journal of Business Ethics* 140, 585-606.

Littlewood, D., R. Decelis, C. Hillenbrand, and D. Holt (2018), Examining the drivers and outcomes of corporate commitment to climate change action in European high emitting industry, *Business Strategy and the Environment* 27 (8), 1437-1449.

MacKerron, G.J., C. Egerton, C. Gaskell, A. Parpia, and S. Mourato. (2009), Willingness to pay for carbon offset certification and co-benefits among (high-)flying young adults in the UK, *Energy Policy* 37 (4), 1372-1381.

Norton, T., H. Zacher, and N. Ashkanasy (2014), Organisational sustainability policies and employee green behaviour: The mediating role of work climate perceptions, *Journal of Environmental Psychology* 38, 49-54.

Paillé, P., N. Raineri, and O. Boiral (2019), Environmental behavior on and off the job: A configurational approach, *Journal of Business Ethics* 158, 253-268.

Rehfeld, K.-M., K. Rennings, and A. Ziegler (2007), Integrated product policy and environmental product innovations: An empirical analysis, *Ecological Economics* 61 (1), 91-100.

Rhodes, E., J. Axsen, and M. Jaccard (2017), Exploring citizen support for different types of climate policy, *Ecological Economics* 137, 56-69.

Schleich, J., C. Schwirplies, and A. Ziegler (2018), Do perceptions of international climate policy stimulate or discourage voluntary climate protection activities? A study of German and US households, *Climate Policy* 18 (5), 568-580.

Schwirplies, C. and A. Ziegler (2016), Offset carbon emissions or pay a price premium for avoiding them? A cross-country analysis of motives for climate protection, *Applied Economics* 48 (9), 746-758.

Schwirplies, C., E. Dütschke, J. Schleich, and A. Ziegler (2019), The willingness to offset CO2 emissions from traveling: Findings from discrete choice experiments with different framings, *Ecological Economics* 165, 106384

Statistisches Bundesamt (2008), Klassifikation der Wirtschaftszweige, *https://www.desta-tis.de/static/DE/dokumente/klassifikation-wz-2008-3100100089004.pdf*, last accessed on July 31st, 2021.

Testa, F., O. Boiral, and F. Iraldo (2018), Internalization of environmental practices and institutional complexity: Can stakeholders pressures encourage greenwashing?, *Journal of Business Ethics* 147 (2), 287-307.

Uhlaner, L., M. Berent-Braun, R. Jeurissen, and G. de Wit (2012), Beyond size: predicting engagement in environmental management practices of Dutch SMEs, *Journal of Business Ethics* 109, 411-429.

Umwelbundesamt (2019), Freiwillige CO<sub>2</sub>-Kompensation, April 19, 2021, from *https://www.umweltbundesamt.de/themen/freiwillige-co2-kompensation*.

Ziegler, A. (2015), Disentangling technological innovations: A micro-econometric analysis of their determinants, *Journal of Environmental Planning and Management* 58 (2), 315-335.

Ziegler, A. (2019), The relevance of attitudinal factors for the acceptance of energy policy measures: A micro-econometric analysis, *Ecological Economics* 157, 129-140.

Ziegler, A. (2021), New Environmental Paradigm meets behavioral economics: On the relationship between environmental values and economic preferences, *Journal of Environmental Economics and Management* 109, 102516.

Ziegler, A., J. Schwarzkopf, and V.H. Hoffmann (2012), Stated versus revealed knowledge: Determinants of offsetting CO<sub>2</sub> emissions from fuel consumption in vehicle use, *Energy Policy* 40, 422-431.

Ziegler, A. and J. Seijas Nogareda (2009), Environmental management systems and technological environmental innovations: Exploring the causal relationship, *Research Policy* 38 (5), 885-893.

# Tables

## Table 1: Awareness of CO<sub>2</sub> offsetting

	Yes	No
Have you ever heard anything of CO <sub>2</sub> compensations (or CO <sub>2</sub> offsetting)?	333 (57.71%)	244 (42.29%)

## Table 2: Self-assessed knowledge of CO<sub>2</sub> offsetting

	Very high	Rather high	Undecided	Rather low	Very low
According to your assessment, how high is your knowledge of how CO <sub>2</sub> compen- sations work?	21 (6.31%)	95 (28.53%)	108 (32.43%)	94 (28.23%)	15 (4.50%)

Note: The table only contains answers of the 333 decision makers who have already heard anything of  $\rm CO_2$  compensations.

# Table 3: CO<sub>2</sub> offsetting in the past

		Has your firm conducted CO <sub>2</sub> compensations for self- generated emissions before 2018?			
		Yes	No	Don't know	Total
Has your firm conducted $CO_2$ compensations for self-generated emissions in the last three years from 2018 to 2020?	Yes	74 (12.82%)	50 (8.67%)	3 (0.52%)	127 (22.01%)
	No	9 (1.56%)	356 (61.70%)	11 (1.91%)	376 (65.16%)
	Don't know	3 (0.52%)	18 (3.12%)	53 (9.19%)	74 (12.82%)
	Total	86 (14.90%)	424 (73.48%)	67 (11.61%)	577 (100.00%)

# Table 4: Willingness to conduct CO<sub>2</sub> offsetting in the future

	Yes	No	Don't know	Number of firms
In the future, is your firm still willing to conduct CO <sub>2</sub> compensations?	125 (89.93%)	9 (6.47%)	5 (3.60%)	139
In the future, would your firm be willing to conduct CO <sub>2</sub> compensations?	114 (32.02%)	107 (30.06%)	135 (37.92%)	356

Variables	Number of firms	Mean	Standard deviation	Minimum	Maxi- mum
Dependent variables			·		
CO <sub>2</sub> offsetting in the past	577	0.2409	0.4280	0	1
CO <sub>2</sub> offsetting in the past (without don't know answers)	495	0.2808	0.4498	0	1
Climate-related variables					
Affected by climate change	577	0.1698	0.3758	0	1
Climate targets	577	0.2825	0.4506	0	1
EU ETS	577	0.1265	0.3327	0	1
Further environment-related variables	·	·		·	
EMAS or ISO 14001	577	0.3102	0.4630	0	1
Uncertified environmental management system	577	0.0641	0.2452	0	1
Number registered environmental indicators	577	1.8232	1.4482	0	5
Number environmental measures	577	2.2114	1.5059	1	6
Environmental product and service innovations	577	0.3137	0.4644	0	1
Environmental process and procedure innovations	577	0.2946	0.4563	0	1
Share environment-related employees	577	0.1593	0.2629	0	1
Firm-specific characteristics					
Share female employees	577	0.4182	0.2329	0	1
Average age employees up to 34 years	577	0.1612	0.3680	0	1
Number employees over 49	577	0.5581	0.4970	0	1
Average turnover over ten million euros	577	0.3241	0.4684	0	1
Firm age	577	35.0208	29.1934	3	171
Eastern Germany	577	0.2582	0.4380	0	1
Manufacturing sector	577	0.1438	0.3512	0	1
Construction sector	577	0.0919	0.2891	0	1
Health sector	577	0.0867	0.2816	0	1
Information communication sector	577	0.0832	0.2764	0	1

Table 5: Descriptive statistics of the dependent and explanatory variables in the econometric analysis

# Table 6: Estimates (robust z-statistics) of average marginal and discrete probability effects in binary probit models

	All firms with less than or equal to 50 million euros turnover in the year 2020		All firms with less million euros turno (excluding firms ind for 2	than or equal to 50 ver in the year 2020 dicating no turnover (020)
	(1)	(2)	(3)	(4)
Explanatory variables	CO <sub>2</sub> offsetting in the past	CO <sub>2</sub> offsetting in the past (without don't know answers)	CO2 offsetting in the past	CO <sub>2</sub> offsetting in the past (without don't know answers)
Climate-related variables				
Affected by climate change	0.0270	-0.0022	0.0370	0.0068
	(0.69)	(-0.05)	(0.93)	(0.16)
Climate targets	0.1337***	0.1841***	0.1407***	0.1889***
	(3.00)	(3.40)	(2.89)	(3.13)
EU ETS	0.2680***	0.3413***	0.2810***	0.3525***
	(3.74)	(3.81)	(3.81)	(3.79)
Further environment-related variabl	es			
Number registered environmental indicators	0.0127	0.0058	0.0113	0.0052
	(1.05)	(0.43)	(0.89)	(0.36)
EMAS or ISO 14001	0.0773*	0.0680	0.0744*	0.0715
	(1.83)	(1.54)	(1.69)	(1.52)
Uncertified environmental	0.0742	0.0470	0.0719	0.0494
management system	(1.23)	(0.80)	(1.13)	(0.79)
Number environmental measures	0.0169	0.0146	0.0246*	0.0235*
	(1.34)	(1.09)	(1.87)	(1.67)
Environmental product and service innovations	0.1121**	0.1471***	0.0835*	0.1172**
	(2.46)	(2.90)	(1.88)	(2.34)
Environmental process and procedure innovations	-0.0513	-0.0362	-0.0614*	-0.0472
	(-1.61)	(-1.07)	(-1.90)	(-1.38)
Share environment-related	0.1535***	0.1755***	0.1199***	0.1267***
employees	(3.32)	(3.53)	(2.81)	(2.76)
Firm-specific characteristics				
Share female employees	-0.0191	-0.0597	-0.0755	-0.1132
	(-0.30)	(-0.86)	(-1.15)	(-1.56)
Average age employees up to 34 years	0.0939**	0.1040**	0.1003**	0.1083**
	(2.41)	(2.35)	(2.48)	(2.33)
Number employees over 49	0.0621** (2.25)	0.0867*** (2.94)	-	-
Average turnover over ten million euros	-	-	0.0220 (0.71)	0.0101 (0.31)
Log firm age	-0.0540***	-0.0422**	-0.0520***	-0.0339
	(-2.85)	(-2.10)	(-2.70)	(-1.63)
Eastern Germany	0.0291	0.0306	0.0560*	0.0610*
	(0.92)	(0.94)	(1.69)	(1.77)
Manufacturing sector	-0.0418	-0.0344	-0.0335	-0.0185
	(-1.26)	(-1.00)	(-0.95)	(-0.49)
Construction sector	-0.0320	-0.0233	-0.0353	-0.0382
	(-0.72)	(-0.50)	(-0.85)	(-0.88)
Health sector	-0.0241	-0.0314	-0.0067	-0.0147
	(-0.53)	(-0.65)	(-0.13)	(-0.27)
Information communication sector	0.0058 (0.12)	-0.0007 (-0.01)	0.0155 (0.31)	0.0082 (0.15)
Number of firms	577	495	535	459

Notes: \* (\*\*, \*\*\*) means that the appropriate effect is different from zero at the 10% (5%, 1%) significance level, respectively.

# Online appendix: Survey questions used in the empirical analysis (translated into English)

Have you ever heard anything of CO<sub>2</sub> compensations (or CO<sub>2</sub> offsetting)?

No	
Yes	

According to your assessment, how high is your knowledge of how CO<sub>2</sub> compensations work?

Very low	Rather low	Undecided	Rather high	Very high

The following two questions were used to construct the variables ' $CO_2$  offsetting in the past' and ' $CO_2$  offsetting in the past (without don't know answers)':

Has your firm conducted  $CO_2$  compensations for self-generated emissions in the last three years from 2018 to 2020?

No	
Yes	
Don't know	

Has your firm conducted CO<sub>2</sub> compensations for self-generated emissions before 2018?

No	
Yes	
Don't know	

In the future, is your firm still willing to conduct CO<sub>2</sub> compensations?

No	
Yes	
Don't know	

In the future, would your firm be willing to conduct CO<sub>2</sub> compensations?

No	
Yes	
Don't know	

# *The first item of the following question was used to construct the variable 'affected by climate change':*

In your opinion, to what extent was or is your firm's business affected by climate change during the following periods?

Period	Not at all affected	Rather little affected	Unde- cided	Rather strongly affected	Very strongly affected
Over the last ten years since 2010					
In the next ten years until 2030					
In the time period after 2030					

*The following question was used to construct the variable 'climate targets':* 

Has your firm formulated concrete goals for its own climate protection measures?

Info: Such targets can include, for example, reduction targets for greenhouse gas emissions or targeted shares of renewable energy in the firm's total energy consumption.

No	
Yes	

The following question was used to construct the variable 'EU ETS':

Does your firm participate in the European Emissions Trading Scheme (EU ETS)?

Info: In the European Union, the EU ETS sets a certain amount of greenhouse gas emissions that firms from the energy and other industry sectors are allowed to emit in total for a certain period of time. From this amount, the firms receive or purchase emission rights that they can trade among themselves on a market. After the purchase, these rights are no longer available to other firms.

No	
Yes	

The following questions were used to construct the variables 'EMAS or ISO 14001' and 'uncertified environmental management system':

Decision makers from firms with one site:

Do you currently have an environmental management system implemented in your firm?

No	
Yes	

Is this environmental management system certified according to EMAS or ISO 14001? (Multiple selection possible)

No	
Yes, according to EMAS (Eco-Management and Audit Scheme)	
Yes, according to ISO 14001	

# Decision makers from firms with more than one site:

Do you currently have (at least) one environmental management system implemented in your firm or in one of your firm's sites?

No	
Yes	

Is (at least) one environmental management system certified according to EMAS or ISO 14001? (Multiple selection possible)

No	
Yes, according to EMAS (Eco-Management and Audit Scheme)	
Yes, according to ISO 14001	

The following question was used to construct the variable 'number registered environmental indicators':

About which of the following non-financial matters does your firm regularly collect information? (Multiple selection possible)

Emissions of carbon dioxide (CO <sub>2</sub> )	
Emissions of other pollutants (e.g. nitrogen oxides)	
Share of renewable energies in total energy consumption	
Total water consumption	
Amount of waste	

# The following question was used to construct the variable 'number environmental measures':

Which of the following environmental protection measures does your firm regularly carry out voluntarily (i.e. not required by law)? (Multiple selection possible)

Environmental audits	
Reporting on emissions, e.g. of CO <sub>2</sub>	
Environmental training for employees	
Use of renewable energies	
Use of environmentally friendly office materials (e.g. use of recycled pa-	
per)	
Supporting the use of environmentally friendly means of transportation	
by employees (e.g. promoting the use of public transport and rail via job	
tickets or for business trips)	
None of these measures	
Other measures, namely	

The following questions were used to construct the variables 'environmental product and service innovations' and 'environmental process and procedure innovations':

Decisions makers indicating that their firm conducted product and service and/or process and procedure innovations in the last three years from 2018 to 2020 were asked the following questions. Product and service innovations were defined as follows: Product and service innovations are new or improved products or services whose components or basic characteristics (technical features, integrated software, application properties, user-friendliness, availability, customer benefits, design) differ noticeably from the products and services previously offered by your firm. The innovation must be new for your firm, but it does not necessarily have to be a market novelty. It is irrelevant who developed the innovation. The mere sale of innovations produced by other firms is not a product innovation. Moreover, we defined process and procedure innovations as follows: Process and procedure innovations are new or improved procedures and methods that have a noticeably positive effect on costs or quality. Process and method innovations can relate to manufacturing or process technologies, service delivery methods, logistics and distribution methods, information technology, support activities (e.g. office technology, administrative procedures), organizational and management methods and marketing methods. The innovation must be new to your firm, but it does not necessarily have to have been introduced by your firm first. It does not matter who developed the innovation.

By environmental innovations, we mean product and service innovations or process and procedure innovations that lead to a noticeable reduction in environmental impact. The positive environmental effects can be both an explicit goal or a side effect of the innovation. The positive environmental effects can occur either in your firm (including in sales) or in the use of the products or services by your customers or end users.

Was at least one of the product or service innovations carried out by your firm in the last three years from 2018 to 2020 an environmental innovation?

No	
Yes	

Was at least one of the process or procedure innovations carried out by your firm in the last three years from 2018 to 2020 an environmental innovation?

No	
Yes	

The following questions were used to construct the variables 'number employees over 49,' 'share environment-related employees,' and 'share female employees':

Please indicate how many people (including yourself) are currently employed in your firm (if you are not sure, please estimate):

Info: Full-time, part-time, temporary and seasonal employees are included here. Apprentices or students who are in vocational formation and have an apprenticeship or training contract, as well as employees on maternity or parental leave are not counted as employees.

Number: \_

Please indicate how many employees (including yourself) are currently engaged in environment-related jobs in your firm, either partially or fully (if you are not sure, please estimate):

Info: An environment-related job is one that deals directly with information, technologies, or materials that maintain or restore environmental quality. This requires specific skills, knowledge, training, or experience (e.g. checking compliance with environmental legislation, monitoring resource efficiency within the firm, promoting and selling green products and services).

#### Number:

Please indicate how many women *[if the respondent is a woman, we added "including your-self"]* are currently employed in your firm. You can refer here to the absolute number of women or to their share of all employees. Which value would you like to indicate?

Absolute number of women	
Share of women in all employees	

# If decision maker selected "absolute number of women":

Please now indicate the current absolute number of women in your firm (if you are not sure, please estimate):

Info: Again, full-time, part-time, temporary and seasonal staff are included. Apprentices or students who are in vocational training and have an apprenticeship or training contract, as well as employees on maternity or parental leave are not counted as employees.

Number:

If decision maker selected "share of women in all employees":

Please now indicate the current share of women in all employees in your firm (if you are not sure, please estimate):

Info: Again, full-time, part-time, temporary and seasonal staff are included. Apprentices or students who are in vocational training and have an apprenticeship or training contract, as well as employees on maternity or parental leave are not counted as employees.

Share in %:

The following question was used to construct the variable 'average age employees up to 34 years':

Please indicate the average age of all employees in your firm. Please use the following age groups for a rough estimate:

Up to 34 years	
Over 34 years up to 49 years	
Over 49 years	

The following question was used to construct the variable 'log firm age':

Please indicate when your firm was founded?

In the year: \_

The following question was used to construct the variable 'average turnover over ten million euros':

Please indicate the annual turnover (in million euros) of your firm for the last three years from 2018 to 2020 (if you are not sure, please estimate):

Annual turnover 2018 in million euros:
Annual turnover 2019 in million euros:
Annual turnover 2020 in million euros:

The following question was used to construct the variable 'Eastern Germany':

In which federal state is your firm's headquarters or head office located?

Baden-Wurttemberg	
Bavaria	
Berlin	
Brandenburg	
Bremen	
Hamburg	
Hesse	
Mecklenburg-Western Pomerania	
Lower Saxony	
North Rhine-Westphalia	
Rhineland-Palatinate	
Saarland	
Saxony	
Saxony-Anhalt	
Schleswig-Holstein	
Thuringia	

The following question was used to construct the variables 'manufacturing sector,' 'construction sector,' 'information communication sector,' and 'health sector':

Agriculture, forestry and fishing	
Mining and quarrying	
Manufacturing or production of goods	
Energy supply	
Water supply, sewerage, waste management and remediation activities	
Construction	
Wholesale and retail trade, repair of motor vehicles and motorcycles	
Transport and storage	
Accommodation and food service activities	
Information and communication	
Financial and insurance activities	
Real estate activities	
Professional, scientific and technical activities	
Other business services	
Public administration and defense, compulsory social security (public service)	
Education	
Health and social work activities	
Arts, entertainment and recreation	
Other service activities	
Extraterritorial organizations and bodies	
Other sector, namely:	

To which sector does your firm belong?