US, UK and EU Firms Reporting to The Carbon Disclosure Project: The Effect on their CO2 emissions

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The European Conference on Sustainability, Energy & the Environment 2016
Official Conference Proceedings

Abstract
Carbon Disclosure Project is a non-profit organization allowing companies to report and manage their emissions, climate risk and reduction goals. In the last few years, firms are under increasing pressure from their investors to participate to the Carbon Disclosure Project and improve their yearly ranking. In this article we investigate the impact of this program on a firms' emissions, and in particular we focus on three geographic regions: United States, United Kingdom and the rest of European Union. To measure the impact of the Carbon Disclosure Project we use a relatively new method called "synthetic control approach", which allows us to estimate the treatment effect and to evaluate the significance of our estimates. Based on a unique database we constructed, we found no significant difference between the three geographic regions in term of reduction of CO2 emissions. However, we approve with the inference tests highly significant positive effect of the Carbon Disclosure Project for eight companies from our sample.

Keywords: Carbon Disclosure Project, CO2 emissions, Program evaluation, Synthetic control methods, Treatment effect.

Introduction

Whoever is not "green" is not "in". That's the latest trend of the market. This environmental movement pushes the companies to review their policies and assure a sustainable development by reducing their carbon dioxide (CO2) emissions and use of natural resources or in general show eco-friendly behaviour.

The main purpose of this paper is to evaluate the pertinence of environmental policy introduction at the business level. In particular, we analyse whether there is a positive effect of signing up to the Carbon Disclosure Project (CDP)[1], as one of the binding reporting standards, on the firm's emissions. These results are then compared on an international level. In particular, we concentrate our attention on the companies from United States (US), United Kingdom (UK) and the rest of the European Union (EU) that started to report in years 2009 and 2010. We employ a unique database that we built with contribution from South Pole Group[2]. For normalisation purposes we consider the CO2 emissions per employee as a main outcome variable to be studied.

In order to assess the treatment effect of the policy, we use a relatively new program evaluation method called "synthetic control method" (SCM) introduced by Abadie and Gardeazabal (2003). Almer and Winkler (2012) used this method in environmental problematic, but to our knowledge it has not been applied to evaluate a firms' policy such as environmental programme at a company level.

We have chosen the synthetic control method for different reasons. First of all, it allows researchers to analyse phenomena that occur in a limited population or that apply to only a small number of firms, which is perfectly suited to our problematic. Additionally, this method allows performing inference analysis and supporting quantitatively the results.

We are not the first to evaluate the firm's environmental disclosures, but other studies have slightly different emphasis on the problematic. Already in early 90's Wiseman (1982) assesses the environmental disclosures made in corporate annual reports, and reveals the poor quality of reported data. Other studies focusing on the quality of disclosed data, as for example Dragomir (2012) or Andrew and Cortese (2011), found similar deceiving features of disclosed environmental information.

Different categories of findings in environmental accounting are for example due to Al-Tuwaujri et al. (2004) or Clarkson et al. (2008). These studies found a positive association between environmental performance and the level of environmental disclosure. Nevertheless these articles centre more on building and evaluating the so-called disclosure index and less on the actual policy evaluation.

Luo and Tang (2014) is the closest study to ours, since they evaluate the Carbon Disclosure Project. But again, their focus is on the relationship between the degree of disclosure and carbon performance, rather than on the program evaluation itself. They

[1] www.cdp.net

[2] South Pole Group is a specialist provider of climate action solutions that is, among other solutions, offering consulting services, data and products for investors in the area of assessing investment climate impact.

conclude that the firms' voluntary carbon disclosure in the CDP is indicative of their underlying actual carbon performance, and that the firms with good performance are likely to disclose more to distinguish themselves for investors and other stakeholders. The limit of their research is that the analysis is merely a snapshot of reporting practice over a single year.

Finally, Abrell et al. (2011) assess the impact of the EU Emission Trading System (ETS) using firm level data. This study is very close to our analysis, with the difference being they focus on a different program and use another method to evaluate the effect. Even though they found positive results of the program on firm's emissions, they conclude that the result has to be interpreted with caution, as the counterfactual build (similar companies that are not part of EU ETS) is not of very good quality.

Comparing to all these studies, we bring a new light to the evaluation of the CDP over a longer period of time with a more reliable method to assess the effect of the program.

Carbon Disclosure Project

Carbon Disclosure Project is an international non-profit organisation founded in 2003 and based in the United Kingdom. The CDP collaborate with investors, companies, cities, government and policymakers from all over the world. From the firm's perspective, CDP's main objective is to help companies to take an action toward a more sustainable world. Reporting companies get help in building environmental strategies that improve the management of environmental risk. That is, the focus is on reduction of CO2 emissions, use of energy, investment in new lower pollution production, improvement of supply chain and many other pro-environmental tactics.

If we compare CDP to the Kyoto protocol, CDP concentrates on individual companies rather than nations, with the same objective of driving sustainable economies. Today, CDP works with 827 institutional investors, government and policymakers holding US$95 trillion in assets. In 2003, CDP included only 253 reporting institutions, and this number increased to 5600 in 2015, including companies and cities.

CDP proposes four main programs, focusing on firms: climate change, water, supply chain and forest. These programs have different objective. *CDP's climate change program's* target is the reduction of companies' greenhouse gases emissions and the mitigation of the climate change risk. The *CDP's water program* main objective is to mobilise action on corporate water management in order to secure water resources and alleviate the global water crises. *CDP's supply chain program* objective is to achieve sustainable supply chain management for firms and their suppliers by optimising the risks and opportunities that climate change pose to the globalised supply chain. And finally, *CDP's forest program* intends to manage companies' impact on the deforestation risk and as a consequence regulate the land use change for agriculture as being the main driver of deforestation.

CDP believes that companies that are aware about the scope of their environmental risk can better manage the environmental strategies and improve their "green" footprint. CDP is convinced of crucial importance of firm's carbon disclosure

transparency and the necessity to provide the environmental information to the decision makers in order to drive the appropriate action in sustainable development.

Moreover, since October 2010, CDP ranks companies with high-quality disclosure as top scoring companies in the Climate Disclosure Leadership Index (CDLI). The leading firms with high performance score figure on the "Climate or Water A list". These companies are gaining competitive advantage and commercial benefits over their competitors and can potentially count on more investors or government help. For many investors, the CDLI has become a standard and they may expect the companies not only be reporting to the CDP, but also to have a certain index position.

Data

As we mentioned, our database is unique. It contains personally collected panel data with contribution from South Pole Group[3]. We added different firm's characteristics to the initial database that was provided by them[4]. We present the main quantitative information concerning our databases in table 1.

Number of companies: 135
Number of participating companies: 73
Number of non-participating companies: 62
Period: 2005 - 2013
Regions: EU (48, 29, 19), US (53, 28, 25), UK (34, 16, 18)
Sectors: Consumer Discretionary (22, 10, 12), Consumer Staples (16, 12, 4), Industrials (36, 18, 18), IT & Telecommunications (14, 12, 2), Energy (8, 3, 5), Materials (11, 5, 6), Financials (12, 3, 9), Health Care (10, 7, 3), Utilities (6, 3, 3)
Note: In parenthesis you find number of observations for total, participating companies and non-participating companies respectively.

Table 1 Main database characteristics

In total, the database contains 135 companies observed over a period of 9 years, from 2005 to 2013. Unfortunately we were not able to get the information on longer longitudinal scale as the provided data by South Pole Group contains information for these years only. Moreover, our main study variable, which is a company's greenhouse gas emission, could not be tracked for additional years. Even though we can easily find this information for the majority of the countries - for example World Bank provide the data going to 1960, the firm's level emissions are not so easily attainable.

The sustainable behaviour of firms received closer attention only in the last two decades and since then the companies started slowly reporting their CO2 emissions. At the beginning, the reported values were highly inaccurate and the firms needed a better guidance in how to collect and disclose the data. The companies did not have to wait long for this help and many governments and private companies are now proposing a multitude of programs to this effect.

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[4] As the primary database had missing data, we needed to complete the missing values via verified sources as CDP database, Thomson Reuters, Statista, YCharts, companies' annual reports or corporate social and sustainability responsibility report.

Nevertheless, the fact is that to our knowledge there is no existing publically reachable database containing firms' CO2 emissions for a longer period of time. Even the individual survey would not help, because the companies are usually not holding past data on their emissions, as it is to some degree a fairly new measurement. We believe that this fact is not due to the companies' intention to purposely hide the correct numbers, but because of lack of interest in the past.

Our database contains 22 variables capturing company's characteristics for each of nine periods. We describe the main variables in the table 2. Moreover, our data are classified as balanced panel data, which means that no missing value is observed for any of the variables.

Variables	Description
NAME	Name (nominal);
CDP	Reporting to the CDP (binary)
COUNTRY	Headquarter (nominal);
SECTOR	Sector (nominal);
GHG	CO2 emissions in metric tons (digital);
R	Revenue in mio CHF (digital);
GP	Gross profit in mio CHF (digital);
COGS	Cost of goods sold in mio CHF (digital);
FA	Fixed assets in mio CHF (digital);
EMP	Number of employees (digital);
P	Share price (digital);
RI	Return on investment (digital);
KL	Capital labor ratio (digital);
GHG_EMP	CO2 emissions in metric tons per employee (digital);

Table 2 Main variables

The data comprehend two big categories of companies. The first group contains the firms that started to report to the CDP in 2009 and the second group contains only companies that don't report to the CDP.

Additionally, the data covers three geographic regions: United States, United Kingdom and the rest of European Union. The regions were defined with respect to the company's headquarters, being primarily responsible for company policy, including sustainability. We have selected these regions not only because of their similarities in economic development, but also and especially because of the similarities in corporate social responsibility policy. We can name the most common regulations in these regions, which are the EU Emission Trading System, the UK Carbon Reduction Commitment Energy Efficiency Scheme and the US Environmental Protection Agency's Mandatory GHG Reporting Rule. UK is not purposely included in the EU, because of its specificity in sustainable development strategy.

Moreover, we used the Global Industry Classification Standard to categorise companies in nine sectors: consumer discretionary (CD), consumer staples (CS), energy (ENGY), financials (FINA), health care (HC), industrials (INDU), information technology and telecommunications (ITTE), materials (MATR), utilities (UTIL). As for the geographic region, this firm's characteristic will be one of the decisive factors in the level of the carbon emissions. For example companies belonging to the energy sector will have most likely higher emissions than the one from health care sector.

As previously mentioned, the main study variable is the company's greenhouse gas (GHG) emission. Collecting the data on all of these gasses would be very difficult, that's why we used as proxy the carbon dioxide, i.e. the major greenhouse gas. Moreover, the reported values contain SCOPE 1[5] and SCOPE 2[6] emissions.

CDP report (2014) recognises a positive effect of return on investment and stock price on the level of CO2 emissions. This finding is approved by Matsamura et al. (2011). In their study, they found a negative association between carbon emission level and firms' value. Besides Cole (2012) suggests that the capital labour ratio and firm size are key determinants of CO2 emissions. South Pole Group proposes revenue and cost of goods sold as one of the elements to use for normalising purposes. All theses suggestions motivated our choice of the variables with highly predictive power of the firm's CO2 emissions. Notice then, the variables revenue and number of employee describe the size of the company.

Predictors	GHG	GHG_EMP
R	0.18****	0.62****
COGS	0.17****	0.14****
EMP	0.25****	−0.12****
P	0.65****	0.24
RI	−0.01	−0.01
KL	0.19****	0.06*

Note: non significant $p>0.05$, *$p\leq0.05$, ****$p\leq0.0001$

Table 3 Correlation and significance of the variables

Table 3 shows results that confirm the choice of the predictors. We found positive and significant relations between CO2 emissions (GHG) and revenue, cost of goods sold, share price and capital-labour ratio. The first two results suggest that a bigger firm usually has higher emissions. The positive relation between CO2 emissions and share price seems unexpected, as we would anticipate that the market would punish firms with increasing emissions. This result could be due to the strong positive correlation that we found between share price and revenue. And as the market reflects immediately the financial result to the share price, this relation could be potentially stronger that the one with the emissions. Furthermore, the positive relationship of CO2 emissions with the capital-labour ratio advocates that the firms that are heavily dependent on machinery and equipment tend to be more polluting than those that are labour intensive.

Still, based on table 3, a negative correlation was found between CO2 emissions and return on investment. This result was expected, but not significant. The number of employees showed a positive correlation with the CO2 emissions. Again, this approves the theory that emissions are generally growing with the size of the firm. Although we found that the large firms try to be less pollution intensive than smaller firms, which can be associated to the economics of scale. That is, we detect negative

[5] GHG emissions from sources that are owned or controlled by the reporting entity.
[6] GHG emissions from consumption of purchased electricity, heat or steam, that are a consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity.

and significant relationship between number of employee and CO2 emissions per employee (GHG_EMP), and the relationship was even more evident in each sector. Our results support most of the previous research.

Methodology: Synthetic control method

Synthetic control method is one of the program evaluation methods that intend to assess the causal effect of exposure of a set of units to a program or treatment on some outcome. By the term "unit", we generally mean "economic agents" such as individuals, household, schools, firms or countries. The term "treatment" refers for example to laws, regulations, environmental or technology exposure. And finally, the term "causal effect" denotes the comparisons of so-called potential outcomes, pairs of outcomes defined for the same unit given different levels of exposure to the treatment (see figure 1).

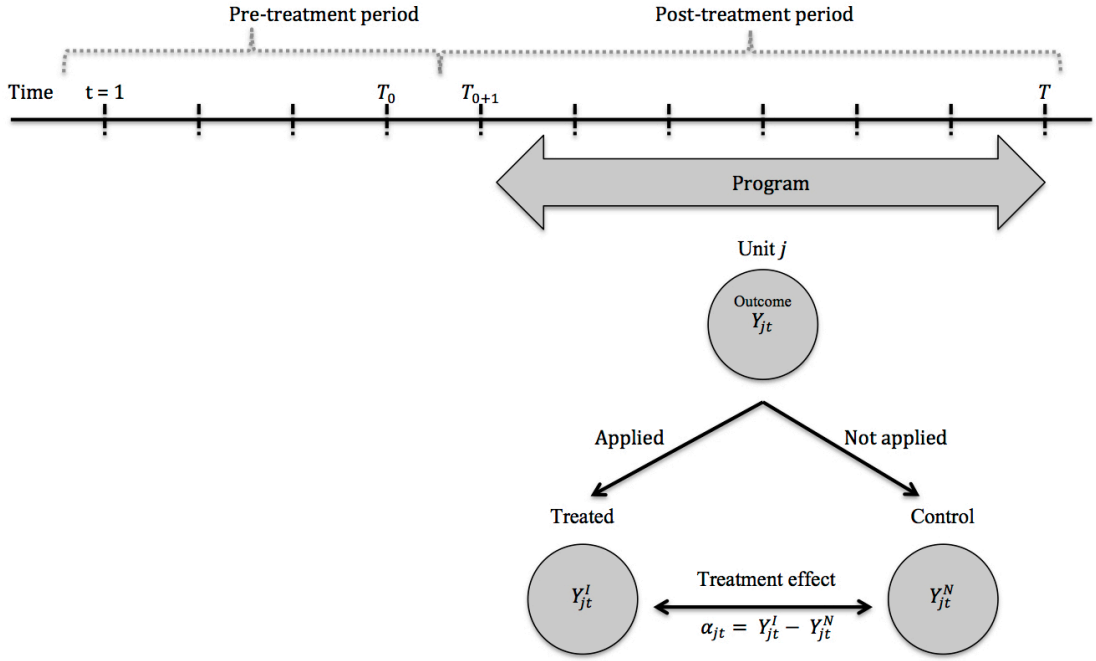

Figure 1 Treatment effect

As we cannot observe the same unit exposed and not exposed to the treatment, only one of the potential outcomes is realisable. In order to evaluate the treatment effect we have to make use of the counterfactual outcome, which is the non-realised potential outcome that has to be estimated.

To motivate our model, we suppose balanced sample of $J + 1$ companies, indexed by $j = 1, \dots, J + 1$, that are observed at time periods, $t = 1, \dots, T$. We suppose a positive number of pre-treatment periods T_0 and of post-treatment periods T_1, with $T_0 + T_1 = T$ and $1 < T_0 < T$. In our case we observe the companies between years 2005-2013, where the treatment year is 2009. The variable Y_{it} is so-called "potential outcome" and measure the impact of the CDP. We denote by Y_{jt}^N the CO2 emissions per employee of company j at time t without treatment, and similarly Y_{jt}^I with treatment. Without lost of generality, we assume that only the first company is exposed to the

CDP and the rest of companies, that are not exposed, constitute the so-called "donor pool" of J control companies. That is, the actual emissions path Y_{1t}^{I} is observed only for the treated company and we do not have any observations for the same company in absence of the CDP program after the treatment. Thus, we have to estimate the Y_{1t}^{N} and find the effect α_{1t} of the CDP for company j at time t:

$$\alpha_{1t} = Y_{1t} - Y_{1t}^{N}.$$

Our method intends to construct a synthetic control group providing an estimate for this missing potential outcome. Abadie and Gardezabal (2003), Abadie et al. (2010) propose to make use of the observed characteristics of the units from the donor pool. The idea is to find weights associated to each control unit, $W = (w_2, \dots, w_{J+1})'$, with $w_j \geq 0$, for $j = 2, \dots, J+1$, and $\sum_{j=2}^{J+1} w_j = 1$, such that the weighted average of all companies from the donor pool resembles the treated company with respect to CO2 emissions per employee in the pre-treatment period and all other relevant characteristic $Z = (R, COGS, EMP, P, RI, KL)$. These weights are obtained by a constrained quadratic optimisation that minimises the difference between the pre-treatment characteristics of the treated unit and a synthetic control. That is, the synthetic control, $W^* = (w_2^*, \dots, w_{J+1}^*)'$, is chosen to minimise the size of the distance measured in terms of the mean squared prediction error:

$$(X_1 - X_0 W)' V (X_1 - X_0 W),$$

where the X_0 denotes a $(k \times 1)$ vector of pre-treatment characteristics of the treated unit, which may include the pre-treatment emission path, and X_0 denotes $(k \times J)$ matrix of the same variables for the J companies in the donor pool and V is a diagonal matrix reflecting the relative importance of the different pre-treatment characteristics (for more details see Turková and Donzé (2016)). The figure 2 represents the treatment effect estimation.

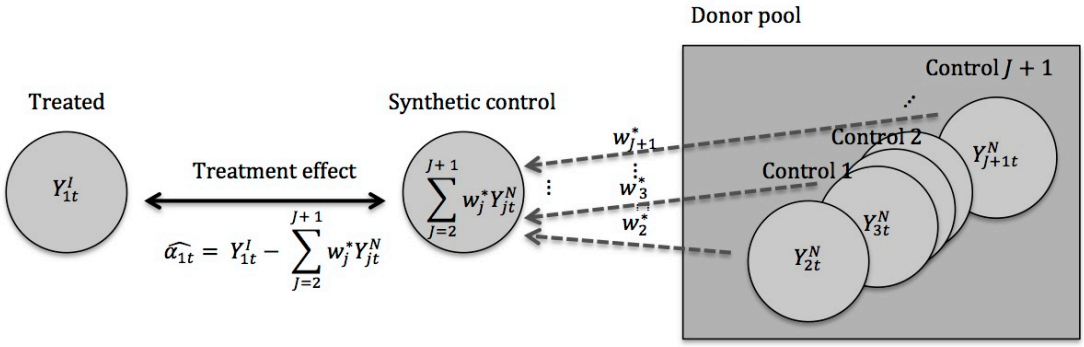

Figure 2 Treatment effect estimation

Synthetic control method provides an alternative mode of qualitative and quantitative inferences. The systemised process of estimating the counterfactuals in SCM enables us to conduct falsification exercises, so called "placebo studies". One more way to measure and test the misspecification of the model is to use the root mean squared prediction error (RMSPE). Both methods are explained in Turková and Donzé (2016).

Firstly, the idea of placebo studies is to predict the counterfactual outcome path for the units in the donor pool. We suppose that the treatment effect estimated for the company that participate to the CDP reflects the impact of the program. Replication of synthetic control analysis for the companies that did not participate to the CDP should not generate a significant divergence between synthetic and actual outcome. In our study, we apply so-called in-space multiple placebo tests, where we implement synthetic control methods to all controls in the donor pool. The pseudo p-value, constructed for placebo test, represents the probability of obtaining an estimate at least as large as the one obtained for the unit of interest when the intervention is reassigned at random in the data set. Smaller is the pseudo p-value, more significant is the treatment effect.

The second types of measures to evaluate the estimates are the RMSPE and RMSPE-ratio. The second calculates a ratio of the post-treatment prediction errors to the pre-treatment prediction errors and provides a scale-free measure of the extremity of the hypothetical treatment on each control unit. Its p-value gives us proportion of units with higher RMSPE-ratio to total number of tested units. We search for results with small RMSPE, high RMSPE-ration with small p-value.

The three measures together, pseudo p-value, RMSPE and RMSPE-ratios, will imply highly significant treatment effect. For inference analyses Abadie et al. (2015) recommend to use the units from the donor pool with RMSPE that is smaller than three times RMSPE of the unit under investigation. In our study, we used five times RMSPE rule.

Results

Table 4 reports the key descriptive statistics for our sample. We observe different values of the variable GHG for both CDP and Non-CDP companies, with high average CO2 emissions and associated extremely big range. On the other side, the CO2 emissions per employee have much lower values and relatively to absolute emissions, this intensity measure consider the size of the firm and thus is more comparable across firms and also between different reporting periods. We suggest thus considering the variable GHG_EMP as the measurement of carbon performance.

Variables	Mean	Median	Std. Dev.	Min.	Max.	N
CDP companies						
GHG	2055589	192362	6888017	1910	56739464	657
R	8290	3714	15061	86	108000	657
COGS	5337	2058	12261	0.16	103000	657
EMP	26785	9590	35561	67	171400	657
P	56	23	234	0.04	3117	657
RI	37559	1148	164030	7	1389152	657
KL	756718	145336	1910218	1376	11384492	657
GHG_EMP	168	13	587	1	7432	657
Non-CDP companies						
GHG	887478	96676	1727858	228	9842151	558
R	16013	2395	84223	15	6950000	558
COGS	4599	1248	11226	4	88012	558
EMP	14884	6206	29635	6	2470000	558
P	39	16	78	0.08	932	558
RI	3889	505	15652	6	193627	558
KL	1877658	129950	6505555	2370	58158299	558
GHG_EMP	217	15	673	1	6030	558

Table 4 Summary statistics (panel data on 9 years)

Figure 3 presents the average emissions per employee without extreme values. The four quadrants show the nine years path not only for all companies, but also per region. The green line denotes the Non-CDP companies, the blue one all companies and the red one the participating companies. These graphs represent only tendencies in evolution of emissions per employee and cannot be used for final conclusion to approve that there is a positive effect from the CDP program, even if the graphs would suggest otherwise.

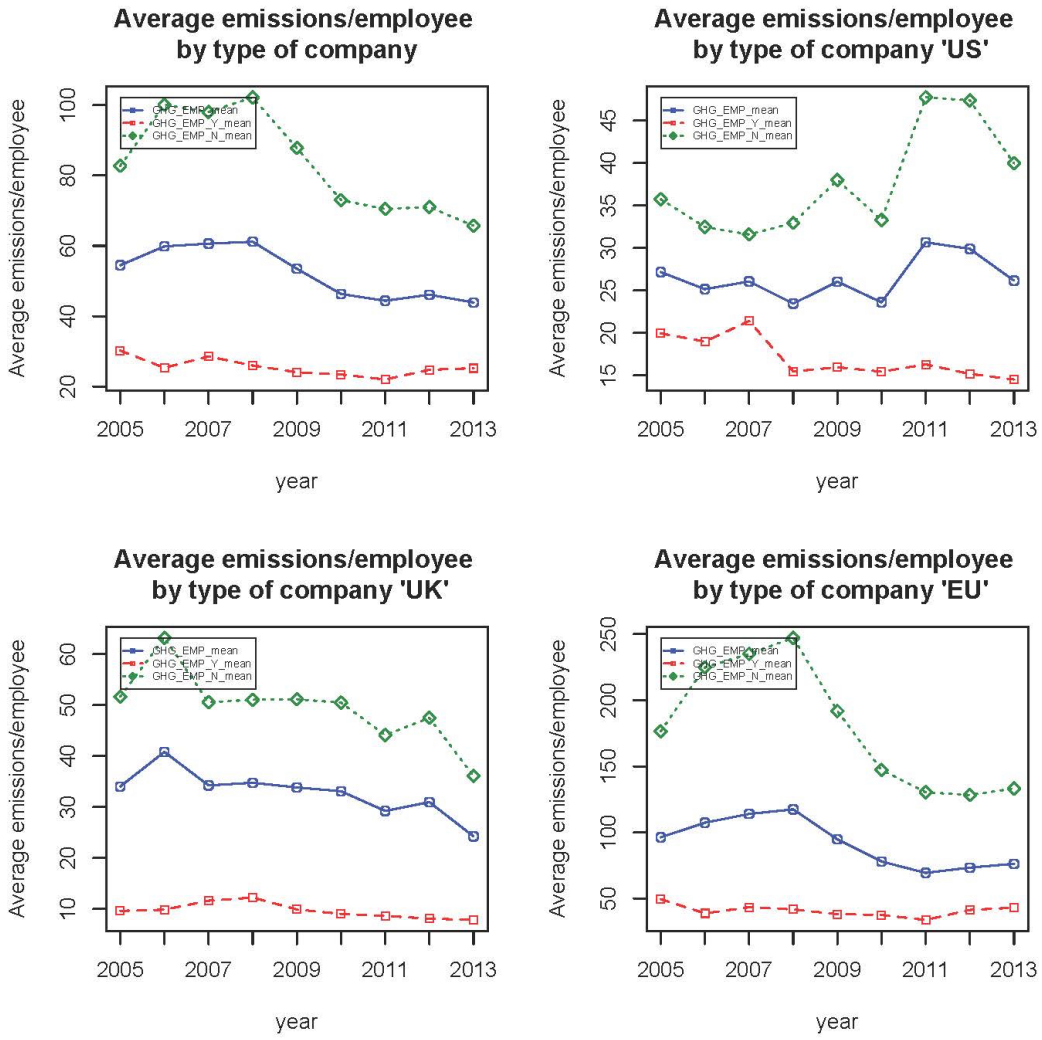

Figure 3 Average emissions per employee (company and regions)

In order to evaluate the treatment effect, we run individual analyses for each company. To find the best counterfactual unit for a specific treated unit, we restricted the control group to Non-CDP firms that belong to the same sector as the respective treated company. This analysis by sector takes into account the potential shock effects and the heterogeneity in CO2 emissions intensity, for example the health care sector will be less polluting than the energy sector.

Our data contains 73 treated and 62 potential control companies, divided into 9 sectors. We have observed 6 extremely large treated companies that did find any matching synthetic control. Their pre-treatment RMSPE was higher than 200 and so

we removed these firms from our analysis. The rest of the companies performed relatively well and, with exception of two firms, their pre-treatment RMSPE was lower than 10. This shows the good matching results between the treated and its synthetic control. Out of the remaining 67 companies, 49 companies show decrease of CO2 emissions per employee after signing to the CDP. This result would suggest the 73% success rate of the program. Table 5 shows the summary results of our analysis distributed by region.

EU	UK	US	
29	28	16	Companies
-1	-3	-2	Extreme
28	25	14	Treated
-7	-7	-4	No effect
21	18	10	Decline in CO2
(75%)	(72%)	(71%)	Success in decrease of CO2 per employee

Table 5 Summary results by region

Table 6 presents overall results after the tests. And table 7 shows detailed inference test results for all companies with a positive average treatment effect.

Total	49	companies with decrease in CO2 emissions per employee
(−)	9	without significant change with respect to pre-treatment period
(+)	12	with at least 10% decrease of CO2 with respect to the pre-treatment period
(∗)	20	with at least 10% decrease of CO2 with respect to the pre-treatment period and significant placebo test results
(∗∗)	8	with at least 100% decrease of CO2 with respect to the pre-treatment period, and highly significant placebo test and RMSPE test results

Table 6 Summary of significant treatment effects

Out of the 49 companies with evident decline in CO2 emissions per employee, 9 have RMSPE-ratios lower than one. This means that their CO2 emissions per employee were no different from before the company signed to the CDP. Thus for these companies we cannot approve the improvement in carbon performance regardless of the decrease in emissions. This result leaves us with 40 companies showing positive change in the post-treatment period.

Out of the 40 companies about 70% have relatively small pseudo p-value, which indicates the significant improvement from the pre-treatment period. The remaining 12 companies are considered as non-significant.

20 companies have relatively small RMSPE-ratios, with high RMSPE-ratios p-values indicating no significant improvement from the pre-treatment period. For these 20 companies we couldn't approve with placebo tests and RMSPE-ratios a significant and positive treatment effect, so we classify them as low significant.

On the other side, 8 companies outperform the other ones in the values of the tests. They all have relatively high RMSPE-ratio with respect to the rest of the firms. This high ratio shows large decrease in CO2 emissions per employee. The results are supported by both low placebo and RMSPE p-values for all eight companies, showing that other placebo treated companies did not perform as well as the treated companies under investigation.

Region	Sector	Tr.effect	RMSPE	RMSPE-ratio	RMSPE-ratio p-value	Placebo p-value
United States	CD	−14.15*	8.53	1.84	0.84	0.08
	CD	−0.93−	3.24	1.06	1.00	0.41
	CD	−0.68−	0.87	1.04	0.92	0.40
	CS	−4.87**	0.62	14.13	0.18	0.07
	CS	−0.61**	0.14	15.71	0.06	0.25
	CS	−7.32*	4.87	1.61	0.82	0.06
	CS	−4.12*	1.73	2.41	0.64	0.15
	INDU	−0.24+	0.05	6.67	0.11	0.50
	HC	−0.32+	0.67	4.76	0.20	0.75
	HC	−4.16**	0.36	12.26	0.20	0.17
	ITTE	−9.17*	5.56	2.18	0.56	0.07
	ITTE	−1.02*	0.02	8.95	0.47	0.23
	ITTE	−1.95*	0.23	8.48	0.60	0.10
	ITTE	−17.25**	0.45	50.18	0.14	0.13
	ITTE	−0.79−	2.09	0.89	1.00	0.76
	MATR	−6.05−	11.80	1.00	0.91	0.36
	ENGY	−6.24*	3.10	6.93	0.50	0.12
	UTIL	−2.25+	0.80	2.56	0.64	0.70
United Kingdom	CD	−0.72*	0.16	5.47	0.46	0.28
	CD	−0.62−	0.36	0.61	0.62	0.52
	CS	−4.47**	0.03	23.03	0.11	0.15
	INDU	−0.06+	0.33	3.36	0.57	0.42
	INDU	−1.57**	0.08	19.19	0.10	0.18
	HC	−13.85*	7.41	1.87	0.30	0.11
	HC	−3.28*	2.21	2.34	0.40	0.12
	ITTE	−0.39+	0.38	1.26	0.92	0.77
	ITTE	−1.15+	1.15	1.33	0.78	0.67
	FINA	−1.66−	4.25	0.80	0.90	0.54
European Union	CD	−0.41−	0.73	0.83	1.00	0.43
	CD	−28.75*	24.86	6.24	0.38	0.08
	CD	−2.10*	0.25	3.77	0.54	0.23
	CS	−6.14*	2.57	2.65	0.64	0.09
	CS	−0.56+	0.10	4.77	0.41	0.55
	CS	−2.85*	2.44	1.44	0.82	0.08
	INDU	−4.18**	0.45	11.59	0.26	0.07
	INDU	−0.76−	2.97	0.25	1.00	0.31
	INDU	−1.07+	0.37	4.75	0.47	0.81
	INDU	−2.13*	1.24	1.77	0.79	0.11
	INDU	−3.59*	1.62	2.22	0.47	0.05
	INDU	−1.09*	0.04	2.30	0.74	0.36
	INDU	−3.72**	0.33	14.57	0.21	0.06
	HC	−2.29*	1.09	2.10	0.60	0.20
	ITTE	−0.82*	0.14	6.55	0.21	0.38
	ITTE	−8.18*	1.22	7.96	0.42	0.09
	ITTE	−1.09+	0.56	2.45	0.78	0.45
	FINA	−0.43+	0.41	1.24	0.70	0.54
	FINA	−3.34−	0.56	0.88	0.90	0.54
	ENGY	−3.96+	0.44	4.80	0.64	0.66
	UTIL	−4.30+	1.67	1.47	0.88	0.61

Note: (−) rmspe-ratio <1.1,,(+) rmspe.ratio >1.1, (*) rmspe-ratio >1.1 and placebo p-value <0.3, (**) rmspe.ratio >10 and rmspe-ration <0.2 and placebo p-value <0.2.

Table 7 Placebo test results

The Figure 4 presents the examples of synthetic matching and permutation tests for three companies from consumer staples sector. These companies are from US, UK and EU respectively[7].

The first column of figure 4 shows the graphs of the gaps of the CO2 emissions per employee for three treated companies and their synthetic controls. The almost parallel lines in pre-treatment period, before the vertical line, for the first two companies indicate a good match between the treated company and its synthetic control with respect to the CO2 emissions per employee. This result is approved by small pre-treatment RMSPE for the two companies. The third company has a relatively bigger gap that is also reflected in relatively higher RMSPE. The gap between the treated and synthetic control in post-treatment period indicates treatment effect: the bigger is the gap, the larger is the effect. We observe positive treatment effects, supported by high RMSPE-ratios, indicating large decreases in CO2 emissions per employee in the post-treatment period for the first two companies. Moreover, we detect smaller RMSPE-ratio for the third company, as the pre-treatment RMSPE is higher.

The second column of figure 4 shows the treated units and their relative placebo treated units. We can see almost all placebo treated units sitting above the treated units under investigation. This means that the positive treatment effect of the treated unit is not random. The results for the first two companies are approved by low placebo and RMSPE p-values, this means that rest of the placebo treated companies did not do as well as the treated companies under investigation. The last company has higher p-values, but again, this is due to the higher RMSPE in pre-treatment period.

Conclusion

The objective of our study was to assess the effect of the CDP on the companies' emissions. To do so, we made use of the synthetic control methods that allowed us to generate the treatment effect for each of the studied companies, and perform statistical inferences. This method is highly appropriate to our study and can be used for further similar research, for example to analyse introduction of other green policies or evaluation of the disclosure methods.

We found that out of the 67 companies evaluated over 5 years and covering 9 sectors, 49 show decrease in CO2 emissions per employee after starting to report to the CDP. Only 28 show significant and positive treatment effects. This result could be due to the fact that other non-participating companies are also under another strong institutional regulation of CO2 emissions.

We did not find a significant difference between US, UK and EU. In all three regions, the firms show about 70% success rate in reduction of CO2 emissions, but in the majority of cases they are not highly significant. Indeed, our statistical inferences put into evidence a low-significant positive treatment effect for 20 companies. It is worth mentioning that 8 firms prove highly significant treatment effect on emissions of reporting companies to the Carbon Disclosure Project.

[7] In table 7, US observation 4, UK observation 3 and EU observation 4.

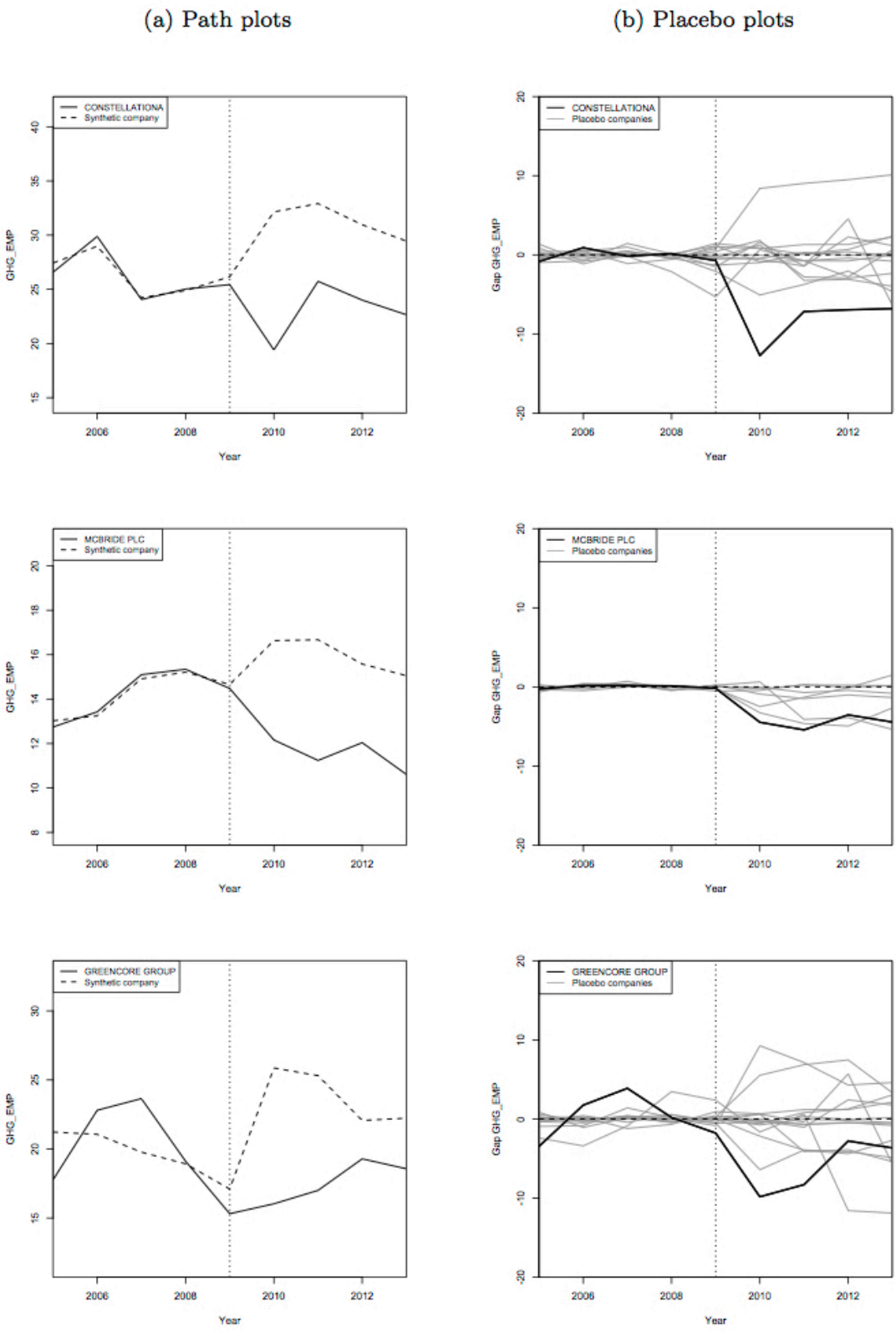

Figure 4 a) Synthetic matching and b) permutation tests for companies from consumer staples sector and US, UK, EU respectively

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