Department for
Business, Energy
& Industrial Strategy

Evaluation of second Climate Change Agreements scheme

Micro-econometric report

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Acknowledgements

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Executive Summary

The Climate Change Agreements scheme (CCAs) is a voluntary agreement scheme between UK industrial trade sectors and the Environment Agency (which administers the scheme on behalf of BEIS). CCAs allow participating organisations to benefit from a discount on the Climate Change Levy (CCL, a downstream tax on business energy use), and (where relevant) exemptions from the CRC Energy Efficiency Scheme (CRC), in return for agreeing to meet targets for reduction in energy use or carbon dioxide emissions. The first scheme was introduced in 2001 and the second CCA scheme commenced in 2013.

The dual objectives of the CCA scheme are 1) shielding energy-intensive industries from the CCL (and where relevant CRC) to maintain their international competitiveness; and 2) achieving negotiated energy and CO_2 reduction targets. The CCL discount offered by the CCA scheme has varied over the life of the scheme. For the period covered by this analysis (between 2011 and 2016[1]), the discount was 90% for electricity and 65% for gas, liquefied petroleum gas (LPG), coal and other solid fuels.

Eligibility for CCA was initially defined by a list of processes and facilities covered by the Pollution Prevention and Control (PPC) Regulations (2000). These were later substituted by the Environmental Permitting (England and Wales) Regulations (EPR, 2006, 2007 & 2010). The CCA facilities in sectors which entered the CCA scheme because of eligibility of under EPR regulations are described in this report as the “EPR sample”.

In 2005, eligibility rules for the scheme were expanded beyond sectors covered by the EPR (formerly PPC). Eligibility was also granted to sectors using processes that either had energy intensity of at least 10% or had energy intensity of at least 3% and import penetration (referred to as international trade intensity) of at least 50%. The CCA facilities in sectors that satisfy either of these two criteria are indicated in this report as the Energy Intensive sample (or “EI sample”).

Finally, during 2013/14, the energy consumed by mineralogical and metallurgical (min-met) processes became exempt from both the CCL and the CRC Energy Efficiency scheme (CRC). Some firms chose to leave the CCA scheme because a substantial proportion of their processes were covered by the so-called “min-met exemption”; these are described in this report as the “min-met sample”.

This report provides an econometric assessment of the second CCA scheme with respect to its impact on 1) electricity and gas consumption, 2) energy efficiency (as measured by the electricity and gas intensity of turnover), and 3) economic competitiveness (as measured by changes in turnover). The analysis uses information for the period 2011-2016, comprising two years before the start of the second CCA scheme (2011-2012) and the first four years of scheme operation (2013-2016). The overall effect of the CCA is assessed by considering two separate policy interventions.

The first policy intervention was to offer facilities or firms the option to have a CCA target and related CCL or CRC discount. In this case, the impact of the scheme is assessed by comparing those affected by the CCA (the treated group) against firms which are subject to the

[1] The period 2011-2012 is used in this analysis as the pre-second-CCA scheme period, while 2013-2016 is used as the CCA scheme period.

full CCL (the control group). Hence, this is referred to below as the “CCA membership” scenario.

The other policy intervention consists of introducing the min-met exemption. Facilities made exempt from the CCL and CRC are essentially offered the option of leaving the CCA scheme at no cost to them in relation to the energy consumed by the min-met processes. In this case, the impact of the CCA is assessed by comparing the performance of the facilities that left the scheme as a consequence of the min-met exemption (treated group) against facilities that did not leave the scheme (the control group), including both facilities with min-met processes that elected to stay in the scheme, and facilities within wider CCA sectors. This is referred below as the “min-met leavers” scenario.

Both scenarios are affected by the voluntary nature of the policy interventions, i.e. they can choose whether to enter the CCA in the case of the first scenario, and can decide whether or not to leave the CCA in case of the second scenario, provided that they are eligible. A Difference-in-Difference method with an Instrumental Variable was implemented to take this self-selection component into consideration. This involved a two-step approach, as explained below.

In the first step, the relationship between treated facilities and those eligible for the policy intervention was assessed. The eligibility of each facility, for the CCA and min-met exemption, was captured by ‘Instrumental Variables’ (i.e. variables that were 1 if they were eligible for the relevant policy/exemption and 0 if they were not). This strategy implies that the comparison group for both scenarios should contain facilities which were not eligible for the treatment being assessed, as well as those which were eligible for the treatment but decided not to take it up. For example, the control group for the CCA participation scenario included non-participating facilities that were eligible for the CCA but did not participate, as well others that were not eligible. Similarly, the control group for min-met leavers included CCA participants that were eligible for the min-met exemption but chose not to leave the scheme, as well as other CCA participants that were not eligible for the exemption. This requirement is key to addressing the voluntary nature of the CCA scheme effectively.

In the second step, the impact of the two policy interventions was rigorously estimated using a difference-in-difference regression, with the relevant instrumental variable included in the equations. Analysis of the “CCA membership” scenario was implemented separately for those facilities in sectors that became eligible under environmental criteria (the EPR sample) and those that became eligible though energy and trade intensity criteria (the EI sample). The overall findings of the analysis are summarised in Table 1.

The findings show that the second phase of the CCA had a clear impact on electricity consumption. In the “CCA membership” scenario, there was a statistically significant reduction in electricity consumption for the treated group (i.e. CCA facilities) compared to the control group (i.e. facilities subject to full CCL). As shown in Table 1, a reduction in electricity consumption was found regardless of the eligibility route for the CCA sample (EPR or EI): for facilities in EPR sectors, electricity consumption was 4.1% lower than in comparison sites, while in EI sectors, electricity consumption was 11.4% lower than in comparison sites. In the “min-met leavers” scenario, electricity consumption was also 3.9% higher for min-met sectors that left the scheme, compared to CCA sites that remained in the scheme.

Evidence for gas consumption was less clear. A statistically significant impact was only found for the “CCA membership” scenario for facilities in EI sectors. For these sectors, gas consumption for CCA facilities was 12.6% lower than on comparison sites subject to full CCL (see Table 1). The lack of statistically significant results for the other sample groups might be due to electricity being a much more important fuel in the production process and therefore receiving the bulk of the effort when implementing energy efficiency measures. Alternatively, it might reflect the higher complexity involved in collating gas consumption data, which led to a smaller sample being used in the analysis[2].

The effect of CCA on energy intensity was assessed using the proxy variables of electricity and gas intensity at facility level, using fuel intensity relative to turnover. Turnover data was only available at enterprise-level, although employment data was available at facility level. A proxy for facility-level turnover was therefore estimated by pro-rating enterprise-level turnover on the basis of employment at each facility. Using this methodology, the impact of the CCA scheme on electricity intensity was found to be significant only for the "CCA membership" scenario, and only for facilities in EPR sectors. For this group, the scale of CCA impact on electricity intensity (4.0%) was nearly identical to the estimated impact on electricity consumption. There was no statistically significant impact on gas intensity for any scenario or sample used in the analysis, mirroring the results for gas consumption.

Finally, the impact of the CCA scheme on competitiveness was assessed by looking at CCA impact on turnover at facility level, using the method described above to derive facility-level turnover estimates. Statistically significant changes in turnover were found for both the "CCA membership" scenario (for both EPR and EI samples) and for the "min-met" scenario, suggesting that turnover was markedly affected by the scheme. The findings suggest that facilities within the CCA scheme (which enjoyed CCL discounts but were subject to CCA targets) were more competitive than facilities paying full CCL, with turnover being 5.1% higher for the EPR sample and 5.5% higher for EI sectors. CCA facilities were, however, less competitive than min-met facilities that left the scheme (which were exempt from both CCL and from targets): turnover at min-met facilities that left the scheme was 7.7% higher than at CCA facilities remaining in the scheme.

[2] Matching of gas meters to CCA and non-CCA facilities is complicated by the fact it is unclear how many facilities have a dedicated gas meter. The matching rate for CCA facilities to meters (defined as the number of matches divided by number of facilities) was substantially lower for gas meters (13%) than for electricity meters (43%). However, the matching rates to gas meters showed great variation across CCA sectors. This varied between 64% in the Wallcoverings sector (AWM) to 2% in the case of the Pigs (NFU1) and Bakery (NAMB) sectors. The low matching rates in some sectors might be due to some establishments being in remote areas without access to the gas grid or it is possible that their modest gas consumption may be included in the lease – without the need for a dedicated meter.

Table 1. Estimated coefficients of the effect on outcome variables attributed to membership of the CCA (EPR and EI samples) and to exiting the CCA for min-met facilities (Min-Met).

Outcome variable	Scenario	Treated sample	Comparison group	Estimates
Electricity	CCA membership	EPR	Non-CCA sites in EPR sectors	-0.041***
		EI	Non-CCA sites with similar EI	-0.114**
	Min-met leavers	Min-Met	Remaining CCA sites	0.039***
Gas	CCA membership	EPR	Non-CCA sites	0.038
		EI	Non-CCA sites	-0.126***
	Min-met leavers	Min-Met	Remaining CCA sites	0.031
Electricity Intensity	CCA membership	EPR	Non-CCA sites	-0.040**
		EI	Non-CCA sites	-0.059
	Min-met leavers	Min-Met	Remaining CCA sites	-0.018
Gas Intensity	CCA membership	EPR	Non-CCA sites	0.006
		EI	Non-CCA sites	-0.035
	Min-met leavers	Min-Met	Remaining CCA sites	0.018
Turnover	CCA membership	EPR	Non-CCA sites	0.051***
		EI	Non-CCA sites	0.055**
	Min-met leavers	Min-Met	Remaining CCA sites	0.077**

Note: Statistical significance is expressed with asterisks; *** for 1%, ** for 5% and * for 10%.

1. Introduction

This document reports the results from Quasi-Experimental Analysis (QEA) assessing the micro-econometric impact of the second phase of the Climate Change Agreements (CCAs) scheme, introduced in 2013, on:

- fuel (electricity and gas) consumption
- energy efficiency, measured by fuel (electricity and gas) intensity in relation to turnover
- and competitiveness, measured by turnover.

CCAs are voluntary agreements between UK industry sectors and the Environment Agency (the administrator of the scheme on behalf of BEIS) with the aim of protecting the competitiveness of UK industry while delivering improved energy and/or carbon efficiency. The scheme was first introduced in 2001 to complement the Climate Change Levy (CCL), a downstream tax on energy use consumed by firms above a de minimis size[3] in the industrial, commercial, agricultural and public services sectors. The dual objectives of the CCA scheme are 1) shielding energy-intensive industries from the CCL (and where relevant CRC) to maintain their international competitiveness; and 2) achieving negotiated energy and CO_2 reduction targets (i.e. achieving the energy/carbon reduction objectives of CCL by other means).

By participating in the CCA scheme, firms receive a discount on the CCL, and (where relevant) exemptions from the CRC Energy Efficiency Scheme, in exchange for meeting agreed targets to reduce energy use and carbon emissions over a number of target periods. The CCL discount has varied throughout the scheme but for the period covered by this analysis (2013-2016) it was 90% for electricity and 65% for gas, liquefied petroleum gas (LPG), coal and other solid fuels.

The second CCA scheme runs from 2013 until 2023. It comprises four two-year target periods until end 2020 and a final certification period ending in March 2023. In the second CCA scheme, a buy-out option was introduced allowing participants to pay a fixed fee per unit of emissions if they fall short of their target. This prevents the facility from being excluded from the scheme going forward due to non-compliance, and therefore forgoing the CCL reduction.

Eligibility for CCA was initially defined by a list of processes and facilities covered by the Pollution Prevention and Control (PPC) Regulations (2000). These were later substituted by the Environmental Permitting (England and Wales) Regulations (EPR, 2006, 2007 & 2010). The CCA facilities in sectors which entered the CCA scheme because of eligibility under EPR regulations are described in this report as the “EPR sample”.

Eligibility rules for the scheme were expanded in 2005 beyond sectors covered by the EPR (formerly PPC). Eligibility was granted to sectors using processes that either had energy intensity of at least 10%, or energy intensity of at least 3% and import penetration (referred to as international trade intensity) of at least 50%. The CCA facilities which satisfy either of these two criteria are indicated in this report as the Energy Intensive sample or “EI sample”.

[3] More details can be found in the Excise Notice CCL1/3: Climate Change Levy. Reliefs and special treatments for taxable commodities.

Finally, during 2013/14, the energy consumed by mineralogical and metallurgical (min-met) processes became exempt from CCL and the CRC Energy Efficiency scheme (CRC). Where firms chose to leave the CCA scheme because a substantial proportion of their processes were covered by the so-called “min-met exemption”, they still had to pay the CCL on the energy consumed by processes not listed under the min-met exemptions. Consequently, some firms affected by the min-met exemptions decided to stay in the CCA while others decided to leave the scheme.

This report is structured as follows:

- Section 2 discusses the methodological approach used in the analysis;
- Section 3 presents the data sources and the data matching process which has been used to build the variables of interest affected by the policy, the eligibility of the facilities used in the analysis, and the overlap with other policies;
- Section 4 focuses on the policy scenarios implemented in this analysis, the related treated and control groups and the strategies used to determine eligibility for the policy interventions;
- Section 5 presents the results for both policy scenarios for each of the five variables of interest, electricity and gas consumption, electricity and gas intensity and turnover;
- Section 6 reflects the conclusions of the report.

2. Methodological approach

This report provides an econometric assessment of the second CCA scheme with respect to its impact on several variables of interest: 1) electricity and gas consumption, 2) energy efficiency (as measured by the electricity and gas intensity of turnover), and 3) economic competitiveness (as measured by changes in turnover). The analysis uses information for the period 2011-2016, comprising two years before the start of the second CCA scheme (2011-2012) and the first four years of scheme operation (2013-2016).

2.1 Facility level analysis

The analysis was implemented at facility (i.e. site) level, and the outcomes of interest were electricity and gas consumption, electricity and gas intensity as measure of energy efficiency, and turnover as a measure of competitiveness. As turnover was observed at enterprise but not at facility level, data at the facility level was obtained by scaling down turnover at enterprise level using the ratio between employment at facility and employment at enterprise level, as described below. Turnover at facility level was also used to obtain measures for electricity and gas intensity at facility level. Turnover was used in preference to employment because impact turnover is a better metric for competitiveness than the level of employment. The process used to scale down turnover is discussed further in section 3.2.2 below.

2.2 Removal of outliers

This estimation procedure below was implemented after eliminating outliers in the dataset resulting from measurement error in the electricity and gas meter dataset. Obvious outliers were also eliminated from economic variables contained in the Inter-Departmental Business Register (IDBR).

2.3 Policy interventions

The overall effect of the CCA was assessed by considering two separate policy interventions.

The first policy intervention was to offer facilities or firms the option to have a CCA target and related CCL or CRC discount. In this case, the impact of the scheme is assessed by comparing those affected by the CCA (the treated group) against firms which are subject to the full CCL (the control group). Hence, this is referred below as the “CCA membership” scenario.

The second policy intervention consists of introducing the min-met exemption. Facilities made exempt from the CCL and CRC are essentially offered the option of leaving the CCA scheme at no cost to them in relation to the energy consumed by the min-met processes. In this case, the impact of the CCA is assessed by comparing the performance of the facilities that left the scheme as a consequence of the min-met exemption (treated group) against facilities that did not leave the scheme (the control group), including both facilities with min-met processes that elected to stay in the scheme, and facilities within wider CCA sectors. This is referred to as the “min-met leavers” scenario.

2.4 Difference-in-difference estimation with Instrumental Variables

Both scenarios are affected by the voluntary nature of the policy interventions, i.e. they can choose whether to enter the CCA in the case of the first scenario, and can decide whether or not to leave the CCA in case of the second scenario, provided that they are eligible. A Difference-in-Difference method with an Instrumental Variable was implemented to take this self-selection component into consideration. This involved a two-step approach. In the first step, the relationship between treated facilities and those eligible for the policy intervention was assessed. The eligibility of each facility for the CCA and min-met exemption were captured by 'Instrumental Variables' (i.e. variables that were 1 if they were eligible for the relevant policy/exemption and 0 if they were not). In the second step, the impact of the two policy interventions was rigorously estimated using a difference-in-difference (DiD) regression, with the relevant instrumental variable included in the equations. These steps are described in more detail below.

For the first step of this approach, a treatment indicator is regressed against an eligibility indicator. In the first scenario, the treatment indicator indicates whether a specific facility has taken part in the CCA; in the second scenario, it indicates whether the facility left the scheme as a consequence of the min-met exemption. The eligibility indicator is a dummy variable indicating whether a specific facility was eligible for these two treatments. This strategy implies that the comparison group for both scenarios should contain facilities which were not eligible for the treatment being assessed, as well as those which were eligible for the treatment but decided not to take it up. For example, the control group for the CCA participation scenario included non-participating facilities that were eligible for the CCA but did not participate, as well others that were not eligible. Similarly, the control group for min-met leavers included CCA participants that were eligible for the min-met exemption but chose not to leave the scheme, as well as other CCA participants that were not eligible for the exemption. This requirement is key to addressing the voluntary nature of the CCA scheme effectively.

Specifically, the first stage implies running the following regression

$$T_{it} = \alpha_i + \delta_t + \zeta E_{it} + \boldsymbol{\gamma}\mathbf{X}_{it} + u_{it}, \tag{1}$$

where T_{it} is the treatment indicator, i.e. a dummy defining the treatment status for the facility, $T = 1$ if treated and $T = 0$ if not treated, and E_{it} is the eligibility indicator, i.e. a dummy that equals to 1 for eligible facilities and 0 otherwise. α_i and δ_t are for individual (i) and time (t) fixed effects, respectively, to account for the fact that the panel data spans multiple years. $\mathbf{X}_{it}$ represents a vector of exogenous covariates, so that $\boldsymbol{\gamma}$ is a vector including as many coefficients as there are variables in $\mathbf{X}_{it}$. The variables included in this vector includes indicators flagging a number of policies, i.e. the presence of EU ETS, CRC and ESOS, therefore accounting for potential overlap with CCA facilities, as well the age of the facilities and a set of regional dummies. u_{it} is disturbance term in the regression, which captures residual variations that are not explained by the other variables in the equation. The fitted value of the treatment indicator (($\hat{T}_{it}$) is the 'best fit' estimate derived from the equation above, effectively ignoring the disturbance term.

The second stage uses the fitted values of the first stage ($\hat{T}_{it}$) to estimate the average effect of the policy in the second regression. The coefficient that provides a measure of CCA influence is β:

$$Y_{it} = \alpha_i + \delta_t + \beta\hat{T}_{it} + \boldsymbol{\gamma}\mathbf{X}_{it} + e_{it} , \qquad (2)$$

where Y_{it} is the variable of interest, i.e. fuel (electricity and gas) consumption, fuel (electricity and gas) intensity or turnover. The other variables are the same as those in the first stage equation, except for the error term e_{it}.

Three alternative definitions of the variable of interest are used in the estimation, log-levels ($\ln Y_{it}$), difference between the log levels and the log levels observed in a reference year ($\ln Y_{it} - \ln Y_{iR}$), and the first differences of the log-levels ($\ln Y_{it} - \ln Y_{it-1}$). The selection among these three definitions of the dependent variable is based on satisfying two pre-treatment comparability conditions, as explained below.

The first pre-treatment comparability condition is that the means of the variable of interest are similar between the treated and control groups. This is assessed through t-tests on the means of the variable of interest in the treated and control groups.

The second pre-treatment comparability condition is that there are parallel trends in the variable of interest during the pre-treatment period. Regression-based tests are used to assess the similarity of the trends in the treated and control groups in the pre-treatment period (i.e. 2011 to 2012).

For both of these pre-treatment conditions, the testing procedure starts with the log level specification. If this specification is rejected by either the t-test on the means or those related to the parallel trend assumption, the testing proceeds on the difference between the log levels and the log levels observed in a reference year – from now onwards referred to as '*log differences*'. If this specification is also rejected by the tests, the testing proceeds with the first difference of the log levels, from now onwards referred to as '*log first differences*' variable.

The data used to construct the treatment and eligibility indicators, the variables of interest and the vector of exogenous co-variates, are discussed further in section 3.

2.4 Limitations of the QEA approach

While meeting the standards of established practice from the academic literature and the evaluation work conducted by BEIS, the results arising from the QEA discussed here are affected by a number of limitations.

First of all, matching was particularly problematic for gas meters, perhaps a reflection that only a small share of CCA facilities has a separate gas meter. It would have been helpful for the evaluation team to be aware of which CCA facilities have separate gas and electricity meters and, ideally, unique identifiers for the meters related to a specific facility so that resources could be concentrated on the modelling rather than data collection.

A second limitation is that the changes computed in the QEA are compared to the impact of another policy, full CCL, and in relation to the testable assumption that the impact of the first scheme of the CCA on the treated group was comparable to the effect of the CCL on the control group. Ideally, one would have included treated and control groups not affected by the first phase of the CCA and by the CCL but this was simply not possible due to the considerable degree of intervention of the government on energy consumption in the industrial sector, required to facilitate higher energy efficiency and decarbonisation.

A third limitation is related to the fact that results presented in this report do not consider the trade intensity of those affected by the CCA and those in the control group, an outcome influenced by the two-step matching process required to match trade and turnover data discussed below. Future work could make use of an additional dataset which could allow a robust assessment of the impact of trade intensity.4

A further limitation is that the analysis presented here has focused on the use of CRC Information Declarers as the main source of control units. While this is a sensible and pragmatic control group, the robustness of the results in relation to the choice of the control group and the eligibility mechanism has not been assessed by the QEA. This is a limitation of this study which could be addressed by future evaluations.

Also, the voluntary nature of the CCA has been addressed in this report by adopting a difference-in-differences with instrumental variable method. While this procedure is well established in the literature, future evaluations could assess the robustness of the results in relation to the choice of the methodology used to control for the voluntary nature of the policy; difference-in-difference with propensity score matching would be an obvious alternative choice.

Finally, the work here has made use of the electricity and gas meter datasets and the IDBR datasets. While both are invaluable resources for evaluation studies in the energy sector, the limited set of variables contained in these two datasets and the difficulty in matching CCA facilities, IDBR local units and meter addresses had an impact on the scope of the study in terms of both the CCA impacts being investigated and the samples used in the analysis. As a final limitation of this study, no analysis has been conducted in relation to alternative sources of data such as the ABS which might have allowed a wider exploration of the CCA impacts, perhaps with similarly sized samples to those used here.

4 Commission Decision determining a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage.

3. Data

This section describes the sources from which data used in this study are collected and the process used to match different datasets, largely through the address of facilities in the treated and the control groups.

3.1 Data Sources

Data employed in this analysis originate from a number of sources; some were directly related to the CCA scheme data, while others were sourced from micro datasets (i.e. datasets for individual sites) collected by ONS. CCA scheme data have been used to identify the units which are covered by the CCA ('Target Units'), as well as the facilities which are part of a specific target unit. Further information was obtained on facilities in the scheme by matching facility addresses with other data sets, as described in section 3.2. A similar process has been implemented for the facilities included in the control groups.

Data for electricity and gas consumption are sourced from the BEIS meter dataset. Consumption is recorded annually for each gas and electricity meter. In addition to metered gas and electricity, this analysis also uses electricity and gas consumption reported by scheme participants. This dataset contains biennial consumption figures as reported by the target units with a CCA. Reported consumption excludes fossil fuel use covered by the EU ETS but fuel used to generate electricity on-site is included in the scheme data under the related fuel, therefore increasing comparability between electricity meter and scheme data.

Scheme data are used to build indicator variables to specify the sample used in the analysis, as discussed in section 3.2.1. The scheme dataset is also used to compute the percentage of emissions related to the use of the buy-out. Buy-out payments are a feature of the second phase of the CCA, allowing participants to pay a fixed fee per unit of emissions for the share of their target which has not been met, in order to continue participating in the scheme and retain their CCL discount.

The Inter-Departmental Business Register (IDBR) is used as the main source of economic data, both for firms covered by the CCA and those used as a comparison (control group). In the case of the Energy Intensity (EI) control group, the IDBR is also used as a sampling frame, as discussed in section 4.2 below. The IDBR contains information related to economic firms (enterprises), their parent firms (group) and specific facilities (local units). Different variables are collected at different levels, as mentioned in 3.2.2 in the case of employment and turnover.

Additional economic datasets have been used in the analysis. The Annual Business Survey (ABS), has been employed to identify the four-digit industrial sector codes (SIC) to which controls and CCA target units belong, again as discussed in section 4.2. The Environmental Permitting Regulations (EPR)[5] has been employed to create an indicator for firms eligible to join the CCA because of environmental emission criteria. Datasets related to other specific policies have been used in those cases where there is an interaction between the CCA and any other specific policy. Such policies include 1) EU Emissions Trading Scheme (EU ETS)[6], 2) The Energy Savings Opportunity Scheme (ESOS), and 3) the CRC Energy Efficiency

[5] These were collated from the European Pollutant Release and Transfer register, which can be accessed at this address: https://prtr.eea.europa.eu/#/home
[6] This can be accessed at this address: https://ec.europa.eu/clima/policies/ets/registry_en#tab-0-1

scheme. One would expect these indicators for participation in these policies, which have been included in the estimation below, to have only a small impact as they do not vary much across time, implying that most of their impact is already captured by fixed effects. Table 2 summarises the sources and data used for the variables in this analysis.

Table 2. Source and details on the data to measure the variables used in the QEA.

Variables	Measurement	Granularity	Source
Electricity / Gas consumption	Annual consumption (kWh)	Meter	BEIS meter dataset
	Target Period Consumption (kWh)	Target Unit	CCA scheme data
Buy-out indicator	Flag	Target Unit	CCA scheme data
Turnover	Turnover (£,000)	Firm (enterprise)	IDBR
Employment	Number of employees	Firm (enterprise)	IDBR
	Number of employees	Facility (local unit)	IDBR
Region	NUTS5 indicator suitably grouped to less granular variable	Facility (local unit) and firm (enterprise)	IDBR
Energy intensity[7]	Energy expenditure divided by turnover	4-digit SIC code	ABS
EPR indicator	Flag	Facility	EPR
EU ETS indicator	Flag	Facility	CCA scheme data and EUETS transaction log
CRC indicator	Flag	Meter	CRC Data Scheme
	Flag	Firm	CRC Data Scheme
ESOS indicator	Flag	Facility	ESOS scheme data

[7] This is used as in sectors that qualify for an CCA based on the relative energy intensity, the value of energy used must be 3% or more of production value for the sector. Source: DECC (2008) CCA-B02 Climate Change Agreements Energy Intensive eligibility criteria - guidance for sector associations and participants.

3.2 Data matching processes

The construction of the dataset used in this analysis involved matching the scheme data to a number of data sources, using the addresses of treated and control units.

3.2.1 Scheme data

The CCA scheme dataset contains addresses for approximately 15,000 facilities, including those which exited the scheme and those which applied but were found not eligible. The original intention had been to match CCA facilities to the Ordnance Survey Address Base (OSAB) to provide a Unique Property Reference Number (UPRN) which would then be matched to the gas and electricity meter dataset held by BEIS. However, this two-stage method achieved a low matching rate. In order to achieve higher matching rates, an alternative matching method was implemented which involved matching CCA scheme data (at CCA facility level) directly into electricity and gas meter data, avoiding the intermediate step of matching to UPRNs. In those cases where this one-step matching process did not deliver consumption tracking the pattern in the scheme data, the UPRN-based matching was used. Matched annual data from the meter dataset was compared with those reported in the scheme dataset: the only CCA sectors retained in the analysis were those for which there was enough alignment between the pattern of electricity and gas consumption from matched meters, and consumption reported under the scheme. The acronyms and names of these sectors can be seen in Table 4.

The scheme dataset is also employed to build an indicator which can be used to filter out the facilities unlikely to be suited for the QEA. An indicator was created to flag target units which have made considerable use of the buy-out option. These target units are expected to show relative low levels of energy reduction, according to the rationale that they would have implemented energy efficiency measures if they were available to do them. The analysis reported here has excluded facilities belonging to firms which have achieved more than 20% of the reduction in CO_2 implied by the target by using the buy-out.[8]

3.2.2 Economic indicators

Two variables sourced from the IDBR were used to measure economic activity: employment, which was observed at both the facility and the enterprise level, and turnover, which was only observed at the enterprise level, as indicated in Table 2. These different levels of observations had implications for how electricity and gas intensity were measured. As explained in section 2, the common measure of intensity (defined as fuel consumption divided by turnover) was adapted to reflect the fact that turnover is only available at the enterprise level in the IDBR. An indicator was constructed for electricity and gas intensity by scaling down the turnover observed at the enterprise level ($Turn_e$) based on the share of employment at a certain facility (EMP_f) relative to employment at the enterprise level (EMP_e), or equivalently by multiplying employment at the facility level by the labour productivity of the enterprise.[9]

[8] In the case of the EPR sample this implied reduction in the traded sample of about 30%, although the incidence of this constraint varied across sectors and was largely associated to the NAMB sector – down to 427 units from 835. The FDF1 sector also shown considerable use of the buy-out option with 252 units reduced to 170.

[9] Two other options include 1) aggregating fuel consumption to the firm level and 2) dividing CCA fuel by GVA observed at firm level. Option 1) is not ideal as it would include also fuel from sites not covered by the CCA and therefore covered by CCL instead so that the difference between the treated and control group becomes less clear. In this case, assessing the effect of CCA on energy intensity would be diluted due to incorporating fuel use

$$Turn_f = Turn_e \frac{EMP_f}{EMP_e} = EMP_f \frac{Turn_e}{EMP_e},$$

Fuel intensity at the facility level therefore becomes:

$$\frac{fuel_f}{Turn_f} = \frac{fuel_f}{Turn_e} \frac{EMP_e}{EMP_f}$$

This assumes that the productivity of labour is relatively similar across sites belonging to the same firm. While this assumption is not testable, due to that fact that turnover is not measured at the site level, using a computed measure of turnover was preferable to using employment as a measure of competitiveness, as increased labour force does not necessarily indicate a more competitive firm. In addition, this computation does not affect CCA firms which had only one site, therefore implying equivalence between site and firm turnover.

3.2.3 Eligibility

As explained in sections 1 and 2, indicators were built to reflect the two different eligibility routes to obtain a CCA. In the first phase of the CCA, eligibility was initially determined by whether firms were required to hold a permit under the PPC regulation, which was merged in 2007 with the Waste Management Licensing (WML) regulations to generate the EPR. An indicator can therefore be built for any facility covered by the EPR regulations which are considered eligible to take part into the CCA. As described above, the Environmental Permitting Regulations (EPR) as used to create this indicator, which is 1 or 0 according to whether the facility is covered by the regulation. Consequently, the treated group which became eligible through this route is indicated by the acronym ‘EPR’ in this report.

As explained in sections 1 and 2, the eligibility rules were broadened in 2005 to allow a number of sectors[10] to join the scheme on the condition that they employed a process that had an “energy intensity” of 10% or more, or energy intensity of 3% or more plus 50% import penetration, which is referred to as “trade intensity”. Building an indicator for energy intensity at the four-digit SIC level, after mapping the CCA sectors to four-digit SIC sectors[11], is relatively straightforward as energy expenditure and turnover are both contained in the ABS. Trade intensity is defined by the scheme regulation as imports divided by the sum of net imports and

covered by the CCL rather than the CCA. Option 2) avoids the problem of including energy consumption covered by CCL but suffers from the numerator and denominator being mismatched, as they are related to the part of the firm subject to CCL, and to the whole firm, respectively.

[10] Based on comparison of reports from the 5 target periods in phase 1, this list of sectors includes: 1) Calcium Carbonate (BCCF); 2) Cold storage (CSDF); 3) Geotextiles (BNMA); 4) Heat Treatment (SEHT); 5) Horticulture (NFU4); 6) Industrial Gases (BCGA); 7) Kaolin and Ball Clay (KABC); 8) Laundries (TSA); 9) Packaging and Industrial Films (PIFA); 10) Plastics (BPF); 11) Textiles Energy Intensive (BATE); 12) Data centres (DATC); 13) Sawmills (CONF).

[11] Mapping CCA sectors to four-digit SIC level was not a straightforward task. As an example a spreadsheet (based on the SIC 2003 classification) produced for BEIS by an external consultant which was made available to us presented some inconsistencies especially when the matching of several CCA sectors to the SIC classification was simultaneously assessed. As an example, NAMB is matched to 1581 and 1582 in 2003 SIC, i.e. 1) Manufacture of bread; manufacture of fresh pastry goods and cakes; and 2) Manufacture of rusks and biscuits; manufacture of preserved pastry goods and cakes. In the case of the address matching of CCA facilities to IDBR, NAMB was matched mainly to 47240 in 2007 SIC which reads as “Retail sale of bread, cakes, flour confectionery and sugar confectionery in specialised stores”. Considering that most of the CCA facilities in these sectors are retail bakery shops, the results from the bottom-up matching seem more reliable than those produced by the consultants. In addition, the FDFS sector was also matched in the spreadsheet to 1581 and 1582. This was probably not the best match considering that this comprises facilities of supermarkets.

turnover. To calculate this, import and export data were sourced from the uktradeinfo dataset and turnover was obtained from the ABS. A complicating factor in the matching process was that the dataset used different sector code nomenclature. This meant the Combined Nomenclature (CN) 2017 (used in the uktradeinfo dataset) needed to be mapped into the Statistical Classification of Products by Activity (CPA) 2008 taxonomy, so that it could then be matched to the SIC 2007 taxonomy (which has a one-to-one match with CPA) used by the ABS.

As the characterization of trade intensity proved challenging due to the multi-step matching process, the analysis for the first scenario proceeded only by characterising the potential control group based on the value of energy intensity. Lack of complete overlap between EI sectors and the corresponding SIC sectors implied energy intensity higher in the sector as defined by the CCA than in the corresponding SIC definition.[12] The process used to source control groups assumed that the impact of incomplete overlap between EI sectors and the corresponding SIC sectors on energy intensity manifested itself also in the four-digit SIC sectors used as the sampling frame for control groups. More details related to the construction of the control groups can be found in section 4.3.

Finally, with regard to the min-met exemption[13], an indicator for eligibility is based on firms and facilities belonging to specific CCA sectors, clearly indicated in Table 4. All firms in these "min-met sectors" are considered eligible to exit the scheme.

3.2.4 Overlap with other policies

Facilities have been flagged based on whether they are impacted by the EU ETS, the ESOS, and the CRC. An indicator for facilities covered by the EU ETS was built after identifying facilities through the EU transaction Log which includes details on EU ETS installations throughout the phases of the policy. Installations from this source were matched to the CCA scheme data, as well as facilities used as controls. Potential overlap between the policies is accounted for in the analysis by incorporating a dummy indicator for the facilities affected by the EU ETS. It is worth mentioning that there is no guarantee that all energy consumed at a CCA site is covered by the EU ETS or the other way around. In fact, the exact extent of the overlap between these two policies at a certain site is unobservable, only that some degree of overlap present can be observed and taken into consideration. Energy covered by the EU ETS is not reported to the EA under the CCA.

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[12] A number of factors influence the extent to which one is able to characterize the CCA sector in terms of energy and trade intensity, including 1) no one-to-one match between CCA sectors and SIC four-digit sectors in the Annual Business Survey (ABS); 2) ABS containing only a sample of the firms in any SIC sector; 3) the fact that CCA sectors are essentially a group of facilities not necessarily including all facilities of a firm or in fact all facilities in any industrial subsector, as defined by the SIC taxonomy used in ABS. This implies that only a part of a SIC sector, i.e. the one with a relatively high energy intensity, could be put forward as a CCA sector to meet the required energy intensity threshold contained in the CCA regulation, with the implication that the corresponding SIC sector as whole would not meet the threshold.

[13] A list of firms that left because of the min-met exemption in 2013/14 has been provided by Ricardo-AEA – as presented in the Technical Report for this evaluation. By comparing this list to the firms originally in the scheme, one can assess the percentage of firms in each sector which left, as a consequence of the exemption. It is reported that about 70% of the min-met units which were in the CCA left the scheme while the remaining units decided to stay within the CCA. For metallurgical processes, the exemption applies to energy used in Division 24 of NACE revision 2 including manufacture from scrap and waste, and in Group 25.5 and Group 25.6 of Division 25. For mineralogical processes, the exemption applies to energy used in processes falling in Group DI-26 of NACE revision 1. More details can be found in *HMRC (unknown) Climate change levy: exemption for energy used in metallurgical and mineralogical processes, London: HMRC*. The detailed list of the processes that qualify for an exemption can be found in *UK Government (2019) Excise Notice CCL1/3: Climate Change Levy – reliefs and special treatments for taxable commodities, London: UK Government*.

Overlap between CRC and CCA is avoided by default due to the design of the policy, as CRC was brought in to target emissions not covered by CCAs and the EU ETS.[14] While no specific energy consumption attracts payment of both the CCA/CCL and the CRC, a share of energy consumed by a firm may be reported to the EA as part of the CCA while the remaining share (not covered by CCA) attract CRC rates. The extent of the relative size of these two components is however unobservable, although one can observe that firms are affected by both policies. One can flag CRC firms based on the list of companies affected by the scheme, and the flag assigned to all meters related to those companies.

Firms affected by ESOS are flagged by building indicators from the scheme data collected by the EA.

[14] It is worth mentioning that in Phase 1 organisations qualifying for CRC payments and having more than 25% of their emissions covered by CCAs did not have to pay any CRC charges, so that there was some energy consumption not covered by either the CCA or the CRC, i.e. up to 75% of emissions arising from an organisation meeting the 25% rule. The 25% rule could apply at parent organisation level or could apply to a subsidiary, and in addition full CRC exemptions applied to organisations which did not meet the CRC qualification threshold, once exemptions for subsidiaries were calculated.

4. Control and treated groups employed in the two scenarios

4.1 Modelled scenarios

The definitions of the 'treated' and 'control' groups for the two policy scenarios are summarised in Table 3 below.

Table 3. Counterfactual and treatment scenarios assessed in the QEA.

Scenario	Treatment	Counterfactual
CCA membership	CCA scheme: reduced CCL and CCA target	Non-participant units: full CCL, no CCA targets.[15]
Min-met leavers	Units leaving the CCA as a result of the min-met exemption: no CCL and no CCA target in place	Units remaining in the CCA scheme, across all sectors - reduced CCL and CCA target.[16]

4.2 Treated groups

Table 4 presents details of the treated groups for the first scenario ("CCA membership"), distinguishing between sectors which entered the scheme due to being included in the PPC/EPR list (EPR) and those entering the scheme through the energy and trade intensity route (EI). The table also shows the facilities which were retained for analysis after matching scheme data to the datasets discussed in section 3 and after dropping facilities which did not comply with the description of the two treated groups discussed above.[17] These two treated groups include facilities which were part of Target Period 2 (TP2) on 31/12/2016. Facilities exiting through TP2, for whatever reason, are not a 'treated unit' and were therefore dropped from the analysis. It also excludes facilities which have been given the opportunity to leave the CCA as consequence of the min-met exemption, regardless of whether they accepted this offer or not. As this report assesses the impact of the CCA on energy consumption, those facilities making an excessive use of the buy-out option have been excluded from the treated group, as discussed in 3.2.1.

In the case of the second scenario ("min-met leavers"), the treated group includes min-met facilities which left the CCA because of the min-met exemptions, which are identified as those belonging to the min-met sector and exiting the scheme – either through variation or

[15] This includes both facilities not eligible for CCA and those which were eligible but decided not to take part. Having both of these two groups represented in the control group is essential for the definition of the instrument variable and addresses the issues related to facilities deciding whether they would be part of a negotiated CCA or not.
[16] Similarly, this includes both facilities not eligible for a min-met exemption and those which were eligible but decided not to leave.
[17] As an example, a facility in the min-met sector is not considered in the second treated group if the facility did not leave before the end of TP2 in 2016 or a facility which qualified through EPR is not part of the first treated group above if they have achieved their target by making a significant use of the buy-out facility

termination – any time before the end of target period 2. As explained in section 3, CCA sectors affected by the min-met exemptions were identified based on internal analysis conducted by the EA. They are clearly indicated in Table 4. Table 5 summarises the sectors included in the three treated groups for each level of analysis, i.e. the EPR, EI and MIN-MET samples used for the two scenarios assessed in this study.

Table 4. Details of the CCA sectors incorporated in the analysis, including entry route

Sector	Acronym	Entry Route	Min-Met Sector	Electricity		Gas	
				Included	No. of Units	Included	No. of Units
Aerospace	ADS	EPR	Yes	Yes	12	Yes	2
Aluminium	AFED	EPR	Yes	Yes	19	Yes	8
Agricultural Supply	AIC	EPR	No	Yes	54	No	N/A
Wallcoverings	AWM	EPR	No	Yes	7	Yes	6
Textiles	BATC	EPR	No	Yes	19	Yes	18
Textiles Energy Intensive	BATE	EI	No	No	N/A	No	N/A
Cement	BCA	EPR	Yes	Yes	10	Yes	N/A
Ceramics	BCC	EPR	Yes	Yes	53	Yes	19
Calcium Carbonate	BCCF	EI	No	Yes	7	No	N/A
Compressed Gases	BCGA	EI	No	No	N/A	No	N/A
Egg Processing	BEPA	EPR	No	Yes	1	No	N/A
Glass	BGMC	EPR	Yes	Yes	13	Yes	9
Lime	BLA	EPR	Yes	Yes	9	Yes	5
Brewing	BLRA	EPR	No	Yes	17	Yes	6
Meat	BMPA	EPR	No	Yes	42	Yes	19
Geosynthetics Non-Woven	BNMA	EI	No	No	N/A	No	N/A
Poultry Meat Rearing	BPC1	EPR	No	Yes	118	No	N/A
Poultry Meat Processing	BPC2	EPR	No	No	N/A	No	N/A
Plastics	BPF	EI	No	No	N/A	Yes	73
Printing	BPIF	EPR	No	No	N/A	No	N/A
Tyres	BTMA	EPR	No	Yes	3	No	N/A
Foundries	CAST	EPR	Yes	Yes	100	Yes	54
Metalforming	CBM	EPR	Yes	Yes	98	Yes	11
Chemicals	CIA	EPR	No	Yes	88	Yes	58
Sawmills	CONF	EI	No	No	N/A	No	N/A
Paper	CPI	EPR	No	Yes	17	Yes	10
Cold Storage	CSDF	EI	No	Yes	66	Yes	40
Data Centres	DATC	EI	No	No	N/A	No	N/A
Dairy	DIAL	EPR	No	No	N/A	Yes	13
Mineral Wool	EUR	EPR	Yes	Yes	5	Yes	4

Sector	Acronym	Entry Route	Min-Met Sector	Electricity		Gas	
				Included	No. of Units	Included	No. of Units
Food and Drink	FDF1	EPR	No	Yes	170	No	N/A
Supermarkets	FDFS	EPR	No	Yes	593	No	N/A
Gypsum Products	GPDA	EPR	Yes	Yes	7	Yes	3
Kaolin and Ball Clay	KABC	EI	No	No	N/A	No	N/A
Malting	MAGB	EPR	No	No	N/A	Yes	3
Metal Packaging	MPMA	EPR	No	No	N/A	Yes	6
Bakers	NAMB	EPR	No	Yes	427	Yes	16
Non-Ferrous Metals	NFA	EI	Yes	Yes	47	Yes	26
Pigs	NFU1	EPR	No	Yes	65	Yes	2
Horticulture	NFU4	EI	No	No	N/A	Yes	26
Eggs & Poultry Meat	NFU5	EPR	No	Yes	58	No	N/A
Semiconductors	NMI	EPR	No	Yes	4	No	N/A
Packaging & Industrial Films	PIFA	EI	No	Yes	36	Yes	15
Surface Engineering	SEA	EPR	Yes	Yes	142	Yes	15
Spirits	SEEC	EPR	No	No	N/A	No	N/A
Surface Engineering Heat Treatment	SEHT	EI	Yes	Yes	47	Yes	14
Slag Grinding	SGS	EPR	No	No	N/A	No	N/A
Motor Manufacturing	SMMT	EPR	No	No	N/A	Yes	10
Laundries	TSA	EI	No	Yes	42	Yes	36
Leather	UKLF	EPR	No	Yes	5	Yes	4
Rendering	UKRA	EPR	No	Yes	8	No	N/A
Steel	UKSA	EPR	Yes	Yes	24	Yes	3
Wood Panels	WPIF	EPR	No	No	N/A	No	N/A

Note: Table also indicates whether the treated units are eligible for the min-met exemption, and the number of treated units used when analysing electricity and gas consumption as the outcome variables. The BCCF sector was incorrectly classified as part of the EPR sample, although this is not expected to influence the results of the analysis due to the limited amount of facilities.

Table 5. List of CCA sectors available for the analysis of the two scenarios used in this study.

Scenario and sample	Outcome variable	CCA sectors
CCA membership - EPR sample	Gas	AWM, BATC, BLRA, BMPA, CIA, CPI, DIAL, MAGB, MPMA, NAMB, NFU1, SMMT, UKLF
	Electricity	AIC, AWM, BATC, BCCF, BEPA, BLRA, BMPA, BPC1, BTMA, CIA, CPI, FDF1, FDFS, NAMB(*) , NFU1, NFU5, NMI, UKLF, UKRA
	Gas Intensity	AWM, BATC, BLRA, BLPA, CIA, CPI, DIAL, MAGB, MPMA, NAMB, NFU1, SMMT, UKLF
	Electricity Intensity	AIC, AWM, BATC, BCCF, BEPA, BLRA, BMPA, BPC1, BTMA, CIA, CPI, FDF1, FDFS(*), NAMB(*), NFU1, NFU5, NMI, UKLF, UKRA
	Turnover	AIC, AWM, BATC, BCCF, BEPA, BLRA, BMPA, BPC1, BTMA, CIA, CPI, FDF1(*) , FDFS(*), NAMB(*), NFU1, NFU5, NMI, UKLF, UKRA
Min-met leavers – min-met sample	Gas	ADS, AFED, BCC, BGMC, BLA, CAST, CBM, EUR, GPDA, NFA, SEA, SEHT, UKSA
	Electricity	ADS, AFED, BCA, BCC, BGMC, BLA, CAST, CBM, EUR, GPDA, NFA, SEA, SEHT, UKSA
	Gas Intensity	ADS, AFED, BCC, BGMC, BLA, CAST, CBM, EUR, GPDA, NFA, SEA, SEHT, UKSA
	Electricity Intensity	ADS, AFED, BCA, BCC, BGMC, BLA, CAST, CBM, EUR, GPDA, NFA, SEA, SEHT, UKSA
	Turnover	ADS, AFED, BCA, BCC, BGMC, BLA, CAST, CBM, EUR, GPDA, NFA, SEA, SEHT, UKSA
CCA membership - EI sample	Gas	BPF, CSDF, NFU4, PIFA, TSA
	Electricity	CSDF, PIFA, TSA
	Gas Intensity	BPF, CSDF, NFU4, PIFA, TSA
	Electricity Intensity	CSDF, PIFA, TSA
	Turnover	CSDF, PIFA, TSA

Note: the explanation of abbreviations of the sectors is included in Table 3. Sectors marked with a star (*) indicates sectors dropped from the analysis as a consequence of violation of the assumptions related to comparability of the mean and the trends of the variable of interest.

4.3 Control groups

In the first scenario, information declarers under the CRC scheme are used as the control group when using the EPR sample, i.e. treated firms becoming eligible through the PPC regulations, indicated as EPR in Table 4. Information declarers pay full CCL rates (i.e. only the facilities which do not have a CCA are selected) and have no exposure to CRC.[18] In addition, they include business users with relatively high consumption of energy, implied by the fact that these companies have at least one half-hourly meter[19]. The other strategy to implement the first scenario focuses on the sectors which became eligible through the energy intensity and trade intensity route, EI in Table 4.[20] The control group in this case includes SIC sectors with high levels of energy intensity – measured as the ratio between energy expenditure and turnover both sourced from the ABS – which do not have a negotiated CCA, based on qualitative assessment by the consortium and quantitative analysis of scheme data.

One can deal with self-selection related to the fact that facilities are not mandated to take part in the CCA scheme by including in the control group facilities which are eligible to join but declined to do so, and by implementing the two-step approach described in the methodological section. In the case of the EPR sample, eligibility to participate in the CCA of the information declarers (the control group) has been assessed through the EPR database discussed above. In the case of the other eligibility route into the scheme, the control group is selected to mirror the characteristics of the treated group. As the average energy intensity from the four-digit SIC sector included in this treated group (i.e. those related to the PIFA, TSA and the BPF CCA sectors) is 2.7%, the control group included sectors with a minimum of 4.3% for energy intensity.[21] These control sectors are considered potentially eligible for the CCA as the apparent level of energy intensity is higher than in the sectors that have actually used the energy and trade intensity route to join the CCA. Other control units are sourced from SIC sectors with considerably lower energy expenditure and considered non-eligible for the policy – with a value of energy intensity ranging between 0.8% and 2.5%.[22] SIC sectors 52.101, 52.102 and 52.103 (operation of warehousing for water transport, air transport and land transport) are also considered eligible due to their similarity to the units included in the CSDF sector. Among this pool of control units, those which are used in the analysis are chosen based on their proximity to the value of the quantiles of the distribution of the outcome variable (e.g. electricity consumption, turnover) in the treated group.[23]

[18] Firms classified as Information Declarers were required as part of Phase 1 of the CRC to declare the electricity consumption of their settled half hourly electricity meters but were not covered by the CRC. This essentially include firms that had at least one settled half hourly electricity meter (HHM) in 2008 but with total supplies of qualifying electricity smaller than 6,000 MWh.

[19] Prior to April 2017, half hourly meters were only required for non-domestic premises with relatively high electricity demand (i.e. demand of over 100 kW). Use of half hourly meters has been extended to some other classes of non-domestic consumer since this date, but the change does not affect the current analysis which uses meter data up to 2016.

[20] In the case of electricity this includes only three sectors, although two more CCA sectors are included in the case of gas, as indicated in Table 5.

[21] This is based on SIC sectors 38.22, 23.64, 23.99, 38.21, 37.00, 38.11, 38.12, 36.00, 20.17 and 20.41. These sectors were not part of the CCA scheme based on internal analysis of the scheme data.

[22] This includes sectors 3103, 2821, 2060, 2593, 2219, 3102, 2849, 1624, 2391, 2573, 2530, 3314, 0899, 2512, 1723, 3101, 3109, 3831, 3832, 2894, 2895

[23] The potential set of control units was chosen to incorporate both low and highly energy intensive SIC sectors. In addition, comparability of control units to treated units is increased by including control units with the value of the outcome variable (e.g. electricity consumption or turnover) as close as possible to the 20th, 40th, 60th, 80th and 100th quantiles of the distribution of this outcome variable in the treated group. The maximum number of control units allowed for each quantile was 200.

In the second scenario, min-met sector facilities who left the CCA scheme are the treated units assessed against a control group of facilities which are still part of the CCA. One can deal with self-selection related to the fact that facilities are not mandated to leave the CCA scheme by including in the control group facilities which are eligible to leave but decided to continue their CCA membership. In other words, the control group includes both facilities from the min-met sector which decided to retain their CCA and those from other sectors which were not offered the option to leave – hence, they are not eligible. Among the latter, control units are chosen from the whole pool of non-min-met CCA facilities based on their proximity to the value of the quantiles of the distribution of the outcome variable in the facilities which left the CCA scheme as part of the min-met exemption, using a process similar to that explained in footnote 23.

At this point it is worth reiterating that analysis implemented in this report involves use of logarithms: the analysis uses 'log differences' or 'log first differences' so that the validity of the methodological assumption is carried with regard to those variables. Although marked differences in the levels of any variable of interest in the treated and control groups does not invalidate the methodology implemented in this paper, it is instructive to provide characterisation of the control units with regard to the level of energy use and turnover. For the EPR sample, mean values (based on the initial sample of identified units) for the control and treated groups are provided below. Energy use and turnover are expressed in kWh and £Million respectively.

Table 6a. Mean electricity consumption, gas consumption and turnover for the treated and control units used when assessing the impact of the CCA in the CCA membership scenario (EPR sample).

	Mean electricity consumption (kwh)	Mean gas consumption (kwh)	Mean turnover (million pounds)
Treated	4,112,019	25,500,000	38,115
Control	1,271,405	1,085,371	18,991

Table 6b. Mean electricity consumption, gas consumption and turnover for the treated and control units used when assessing the impact of the CCA in the CCA membership scenario (EI sample) .

	Mean electricity consumption (kwh)	Mean gas consumption (kwh)	Mean turnover (million pounds)
Treated	3,325,213	3,324,162	28,802
Control	974,914	675,986	16,586

5. Results

This section presents the result arising from the estimation of the impact of the CCA scheme on electricity and gas consumption, turnover, and electricity and gas intensity. For each variable of interest, three cases are shown: one based on the first scenario assessed thorough the environmental regulation eligibility avenue ("EPR"), the second based on the energy and trade intensity eligibility route ("EI") and finally the third based on the second scenario centred on the impact of exiting the CCA scheme as a consequence of the min-met exemption ("min-met leavers"). For each case this section presents the results from the impact of the CCA on the variable of interest – through the β coefficient in the second step of the estimation – see section 2 – and the graphs of the variable of interest averaged in the control and treated units. In some cases, the results from the estimation differ from the conclusions that one would draw from the graphs, a reflection of the fact that the latter do not consider self-selection in the sample, as addressed in the estimation.

5.1 Electricity

5.1.1 Results for the CCA membership scenario

The estimated impact of membership of the CCA scheme on electricity consumption is obtained by comparing CCA facilities to those without a CCA which are therefore subject to full CCL. As discussed in Section 4, the analysis has been implemented separately depending on the entry route into CCA: for facilities which acquired eligibility based on pollutant criteria (EPR), and those that joined the scheme based on energy and trade intensity criteria (EI).

The CCA appeared to reduce average electricity consumption by approximately 4% in the EPR sample, as the estimated coefficient provides an approximate percent change due to the model being log-linear.[24] The estimation result based on the EI sample suggested a significant decrease in electricity consumption by about 11%. The results are summarized in Table 7.

Table 7. Estimated coefficients of the effect on electricity consumption attributed to CCA membership

Entry route	Estimates	Sample size	Number of units
EPR	-0.041*** (0.009)	14,548	2,510
EI	-0.114** (0.053)[25]	5,512	981

Note: includes robust standard errors clustered at facility level unless explicitly mentioned. The dependent variable is defined as the difference between the log of the variable and the log of the variable observed in 2012. Asterisks *** and ** indicate 1% and 5% level of statistical significance, respectively.

The selection of the dependent variable was based on the comparability of electricity consumption between the treated and control groups in 2011 and 2012 and the parallel trend assumption, as discussed in the methodological section. Log differences, i.e. the difference

[24] Exact percent changes can be computed using the estimated impact from the log-linear model and applying the transformation, $\left(\exp(\hat{\beta}) - 1\right) * 100$, where $\hat{\beta}$ is the estimated coefficient.

[25] Standard errors are robust to heteroskedasticity in the case of EI.

between the log levels and the log levels observed in a reference year, was selected for both the samples of CCA facilities entering through the EPR and the EI route.

The estimated impact on electricity consumption for the EPR case is the outcome after excluding the NAMB sector. The inclusion of this sector was associated with no pre-treatment comparability between the treated and the control groups, causing violations of the methodology assumptions.[26] Figure 1 shows the average changes in electricity consumption relative to the baseline year 2012 for the treated (EPR and EI) and control groups[27].

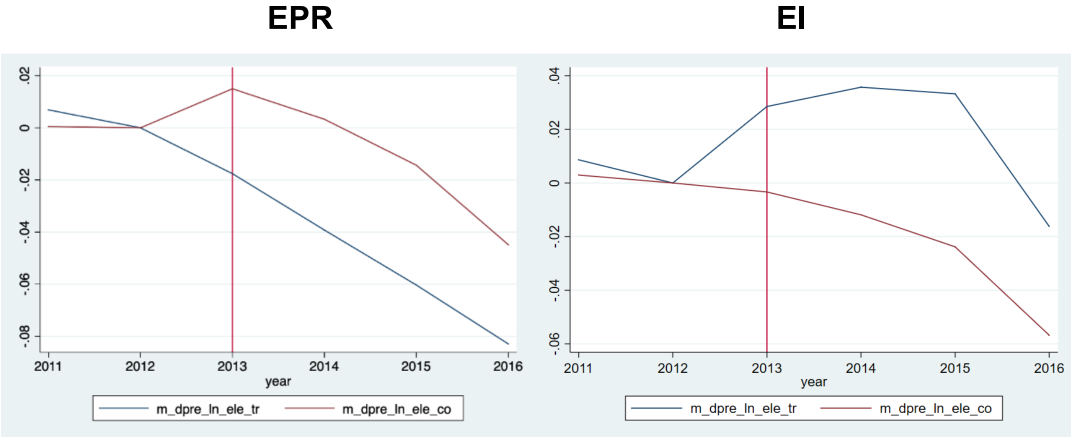


Figure 1. Trends in electricity consumption in the treated (blue) and control groups (red line).

5.1.2 Results for exiting the CCA scenario

This scenario estimates the impact on electricity consumption of facilities leaving the scheme as consequence of the min-met exemptions. The finding suggests a statistically significant increase in electricity consumption by approximately 4% as a consequence of the min-met facilities leaving the CCA. Log differences, i.e. the difference between the log levels and the log levels observed in 2012, was selected in this case, as a consequence of the procedure outlined in section 2.

Table 8. Estimated coefficient of the effect on electricity consumption attributed to leaving the CCA as consequence of the min-met exemption

	Estimates	Sample size	Number of units
MIN-MET	0.039*** (0.015)	5,938	1,025

Note: robust to heteroskedasticity standard errors. The dependent variable is log differences with respect to baseline year 2012. Asterisks *** indicate 1% level of statistical significance.

[26] When including the NAMB sector, the difference in the mean pre-treatment outcome variable and in the pre-treatment trends is significant at all conventional levels of significance.
[27] As noted above, some graphs look counter-intuitive because they do not take account of self-selection.

MIN-MET

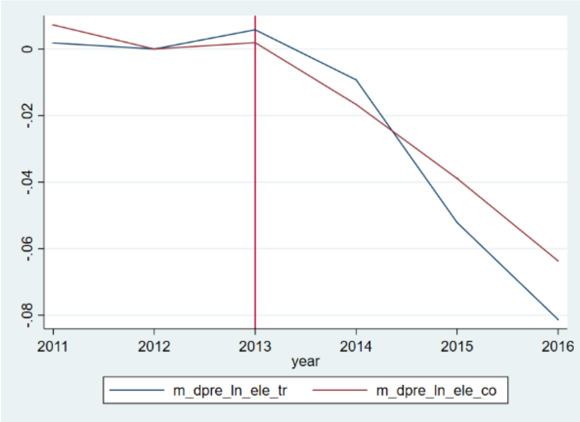


Figure 2. Trends in electricity consumption in the treated (blue) and control groups (red line).

5.2 Gas

5.2.1. Results for the CCA membership scenario

The estimated impact of membership of the CCA scheme on gas consumption is obtained by comparing CCA facilities to those without a CCA and therefore subject to full CCL. As in the case of electricity, the analysis has been implemented separately depending on the entry route into CCA (EPR or EI). Results indicate a statistically significant effect of CCA membership on gas consumption of approximately 12% for the facilities joining via the EI route. The estimated impact for the EPR sample is not statistically significant. The results are summarized in Table 9.

Table 9. Estimated coefficients of the effect on gas consumption attributed to CCA membership

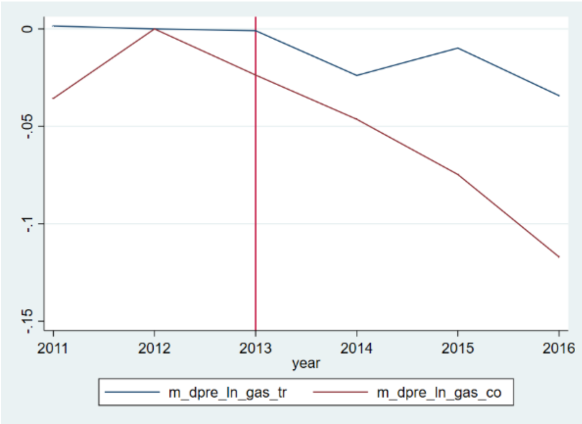
Entry route	Estimates	Sample size	Number of units
EPR	0.038 (0.032)	2,468	434
EI	-0.126*** (0.048)[28]	4,494	799

Note: robust standard errors clustered at facility level unless explicitly mentioned. The dependent variable is log differences with respect to 2012. Asterisks *** indicate 1% level of statistical significance.

Log differences was selected for both the samples of CCA facilities entering through the EPR and the EI route. Unlike the case of electricity, none of the CCA sectors in the EPR sample as excluded from the analysis due to violation of the assumptions required by the methodology. Figure 3 exhibits the average changes in the outcome variable with respect to the year 2012 for the EPR and EI samples.

[28] Standard errors are robust to heteroskedasticity in the case of EI.

EPR



EI

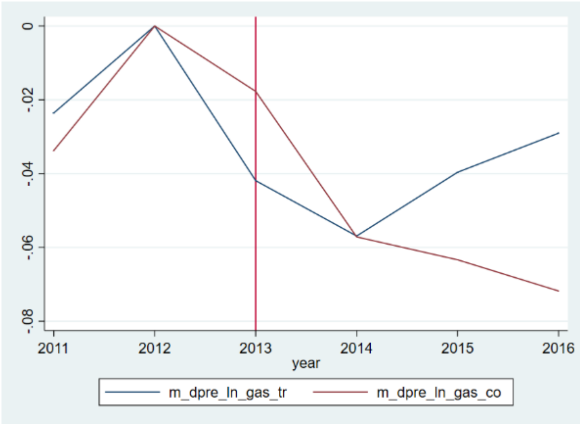


Figure 3. Trends in gas consumption in the treated (blue) and control groups (red line).

5.2.2 Results for exiting the CCA scenario

The finding from this estimation does not suggest any statistically significant changes in the gas consumption of the facilities leaving the CCA as a consequence of the min-met exemption; the estimated coefficient is shown in Table 10. Log difference of gas consumption was selected as the dependent variable. Figure 4 exhibits the average changes in the outcome variable with respect to the level observed in 2012.

Table 10. Estimated coefficient of the effect on gas consumption attributed to leaving the CCA as consequence of the min-met exemption

	Estimates	Sample size	Number of units
MIN-MET	0.031 (0.044)	2,846	497

Note: Robust standard errors clustered at facility level. The dependent variable is log differences with respect to 2012.

Figure 4 shows a trend assumption line chart showing the gas consumption of the treated and control groups from the MIN-MET sample groups. The trends seem to be divergent

MIN-MET

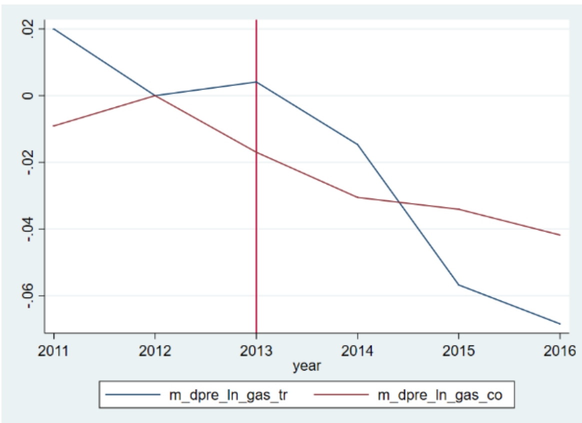


Figure 4. Trends in gas consumption in the treated (blue) and control groups (red line).

5.3 Electricity Intensity

5.3.1. Results for the CCA membership scenario

Results for electricity intensity point at a statistically significant effect of CCA membership on electricity consumption in the EPR sample, namely a 4% reduction. No statistically significant change could be estimated in the case of the EI sample. The results are summarized in Table 11. Figure 5 depicts average changes in the log of electricity intensity with respect to the value observed in 2012 and in the first difference of the logs for the EPR and EI sample, respectively.

Based on the selection procedure described in section 4, log differences with respect to 2012 has been selected to represent the dependent variable in the EPR sample, while in the case of the EI sample, log first differences were used. The analysis of the estimated impact in the EPR sample excludes the NAMB and FDFS sectors, as the inclusion of these sectors was associated with no pre-treatment comparability between the treated and the control groups, causing violations of the methodology assumptions.

Table 11. Estimated coefficients of the effect on electricity intensity attributed to CCA

Entry route	Estimates	Sample size	Number of units
EPR	-0.040** (0.016)[29]	9,327	1,628
EI	-0.059 (0.058)	6,364	1,085

Note: robust standard errors clustered at facility level unless explicitly mentioned. Dependent variable is in log differences with respect to 2012 for EPR and log first differences for EI. Asterisks ** indicate 5% level of statistical significance.

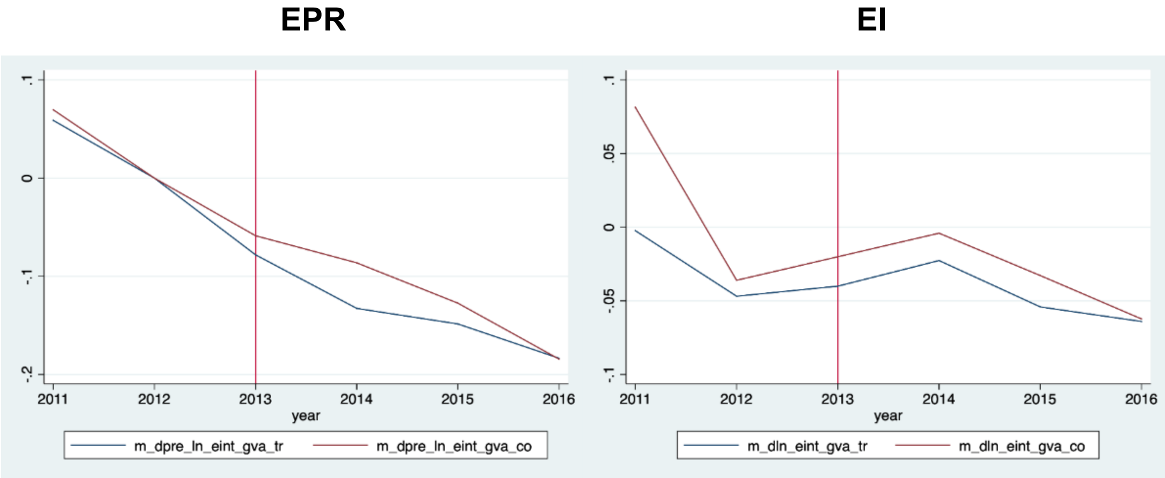


Figure 5. Trends in electricity intensity in the treated (blue) and control groups (red line).

[29] Standard errors are robust to heteroskedasticity in the case of EPR.

5.3.2 Results for exiting the CCA scenario

The findings from this estimation do not suggest any statistically significant changes in the electricity intensity of the facilities leaving the CCA as a consequence of the min-met exemption. The estimated coefficient is shown in Table 12. Log difference of electricity intensity was selected as the dependent variable. Figure 6 plots the average change in electricity intensity for the treated group and the control group. In order to achieve pre-treatment comparability between the treated and control groups, NAMB, FDFS and FDF1 sectors were excluded from the control group.

Table 12. Estimated coefficient of the effect on electricity intensity attributed to leaving the CCA as consequence of the min-met exemption

	Estimates	Sample size	Number of units
MIN-MET	-0.018 (0.055)	2,705	467

Note: robust standard errors clustered at facility level. Dependent variable is in log differences with respect to 2012.

MIN-MET

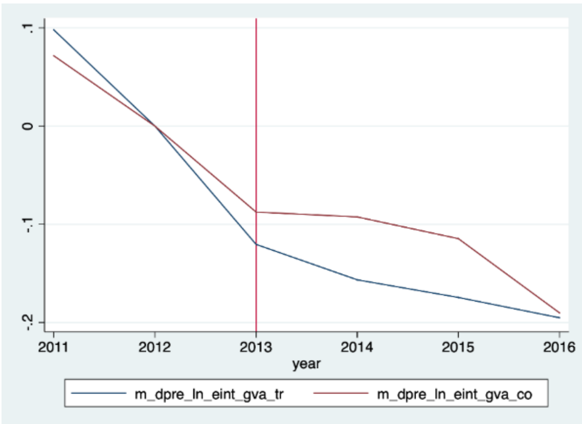


Figure 6 Trends in electricity intensity in the treated (blue) and control groups (red line).

5.4 Gas Intensity

5.4.1. Results for the CCA membership scenario

Results for gas intensity found no statistically significant effect of CCA membership on gas intensity in either the EPR sample or EI sample. The results are summarized in Table 13. Log differences of gas intensity with respect to the baseline year is used as the dependent variable. The average changes in gas intensity with respect to the year 2012 are shown in Figure 7 for the EPR and EI samples.

Table 13. Estimated coefficients of the effect on gas intensity attributed to CCA membership

Entry route	Estimates	Sample size	Number of units
EPR	0.006 (0.045)	2,187	374
EI	-0.035 (0.093)	3,420	587

Note: robust standard errors clustered at facility level. Dependent variable is in log differences with respect to 2012.

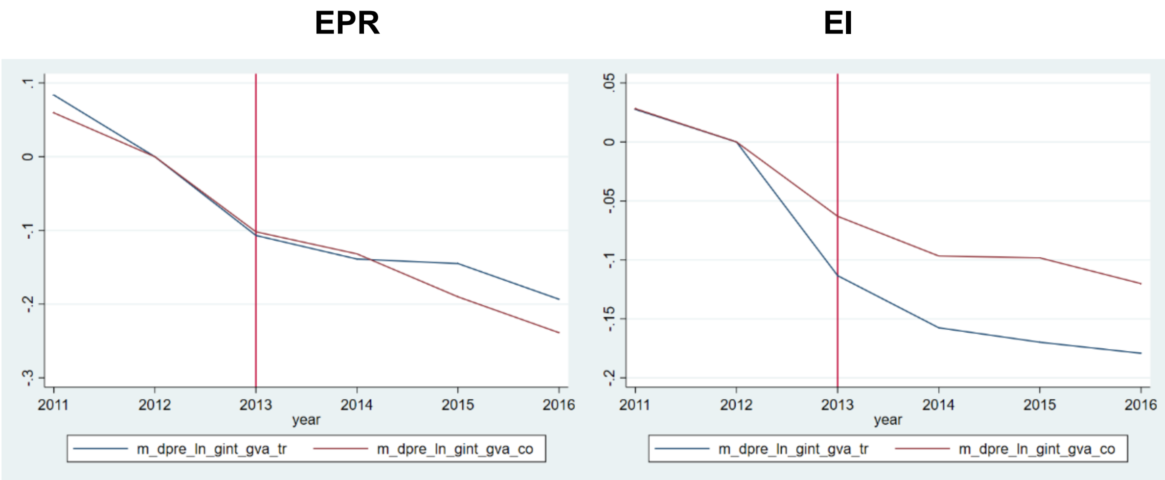


Figure 7. Trends in gas intensity of the treated (blue) and control groups (red line).

5.4.2 Results for exiting the CCA scenario

The findings do not suggest any statistically significant changes in the gas intensity of facilities leaving the CCA as a consequence of the min-met exemption. The estimated coefficient is shown in Table 14. Log difference of gas intensity was selected as the dependent variable. Figure 8 plots the average change in gas intensity for the treated and the control groups.

Table 14. Estimated coefficient of the effect on gas intensity attributed to leaving the CCA as consequence of the min-met exemption

	Estimates	Sample size	Number of units
MIN-MET	0.018 (0.061)	2,484	431

Note: robust standard errors clustered at facility level. Dependent variable is in log differences with respect to 2012.

MIN-MET

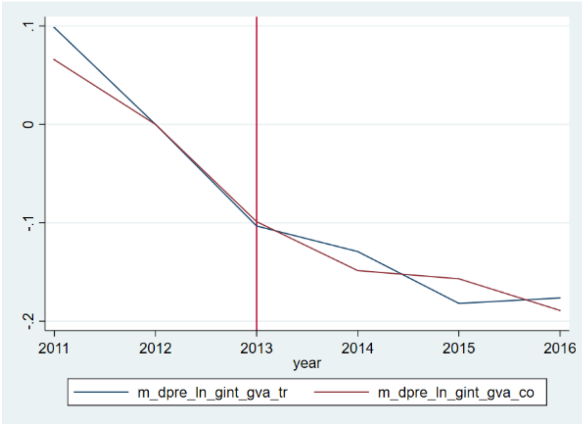


Figure 8. Trends in gas intensity of the treated in the treated (blue) and control groups (red line).

5.5 Turnover

5.5.1. Results for the CCA membership scenario

Results point at a statistically significant effect of CCA membership on turnover for both the facilities which acquired eligibility based on environmental criteria (EPR) and those which gained access to the scheme using energy and trade intensity route(EI). In both cases, the CCA effect was approximately a five per cent increase in turnover. The selection of the dependent variable based on the comparability of turnover between the treated and control groups in the period before the treatment, as discussed in section 4, led to the choice of the log difference with respect to a baseline year in the case of the EPR sample, and to the log first difference specification in the case of the EI sample. Figure 9 depicts average changes in the log of turnover with respect to the value observed in 2012 and in the first difference of the logs, for the EPR and EI sample, respectively

Results for the EPR sample are obtained after dropping facilities belonging to the NAMB, FDFS and FDF1 sectors (indicated as sample 1 below), as their inclusions resulted in the violations of the assumption required by the methodology. As a robustness check, the analysis has also been implemented based on a sample which excludes NAMB and FDFS but retains FDF1 (sample 2). In this case, the assumptions of parallel trend and the equality of the means are rejected at 10%, the estimated effect is robust compared to the estimate based on sample 1, and turnover still appears to significantly increase by about 5%. The estimated coefficients are provided in Table 15.

A robustness check was also implemented for the EI sample, as the “mean equality” condition is accepted only at the 1% level, by estimating the impact of the CCA on the CSDF sector, i.e. the biggest CCA sector contained in the sample, The estimated coefficients are shown in Table 15 – see EI (sample 2). The dependent variable in the case of sample 2 is expressed in log first difference, although the t-test is accepted only at the 1%, like in sample 1. The effect for EI Sample 2 turnover growth is approximately 8% faster compared to the control group, a figure comparable to the estimate based on EI sample 1.

Table 15. Estimated coefficients of the effect on turnover attributed to CCA membership

	Estimates	Sample size	Number of units
EPR (sample 1)	0.051*** (0.017)	18,962	3,243
EPR (sample 2)	0.048*** (0.013)	20,924	3,578
EI (sample 1)	0.055** (0.022)	8,800	1,503
EI (sample 2)	0.084** (0.037)	8,206	1,401

Note: robust standard errors clustered at facility level. Dependent variable is in log differences with respect to 2012 for EPR and in log first differences for EI. Asterisks ***, ** and * indicate 1%, 5% and 10% level of statistical significance, respectively.

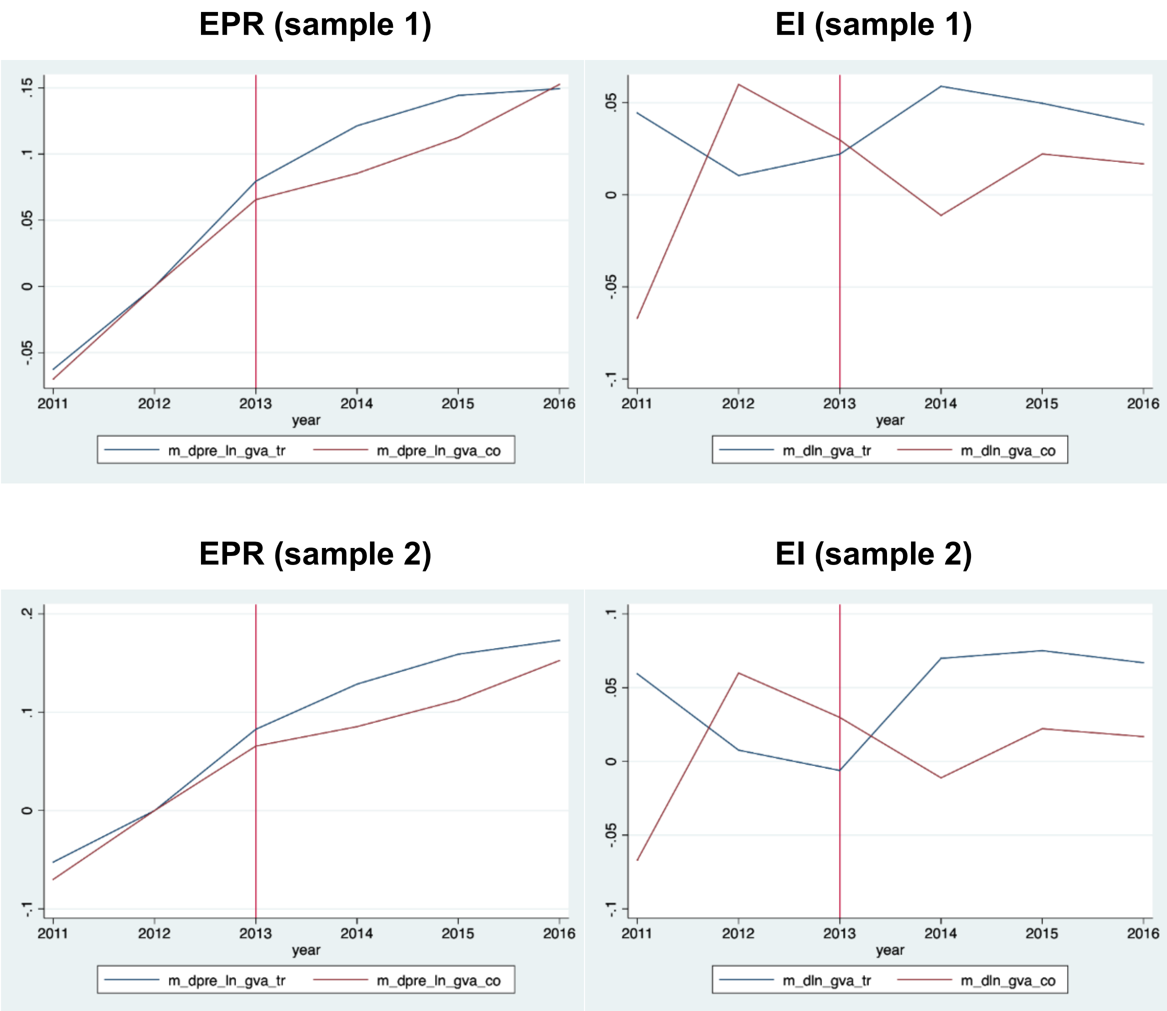


Figure 9. Trends in turnover of the treated in the treated (blue) and control groups (red line).

5.5.2 Results for exiting the CCA scenario

The findings from this estimation suggest a statistically significant increase in the turnover of the facilities leaving the CCA as a consequence of the min-met exemption. The estimated coefficient is shown in Table 16. The results provide significant evidence that turnover increases by about 8% due to leaving the scheme (given the exemption from CCL and CRC, and lack of CCA targets). Log difference of turnover was selected as dependent variable. Figure 10 plots the average change in the variable of interest for the treated group and the control group.

In order to achieve pre-treatment comparability between the treated and control groups, the analysis is implemented with a control group excluding NAMB, FDFS, FDF1 and CAST as the incorporation of these sectors induced violations with regard to pre-treatment similarity in the control and treated group.

Table 16. Estimated coefficient of the effect on turnover attributed to leaving the CCA as consequence of the min-met exemption

	Estimates	Sample size	Number of units
MIN-MET	0.077** (0.039)	5,240	892

Note: robust standard errors clustered at facility level. Dependent variable is in log differences with respect to 2012. Asterisks ** indicate 5% level of statistical significance.

MIN-MET

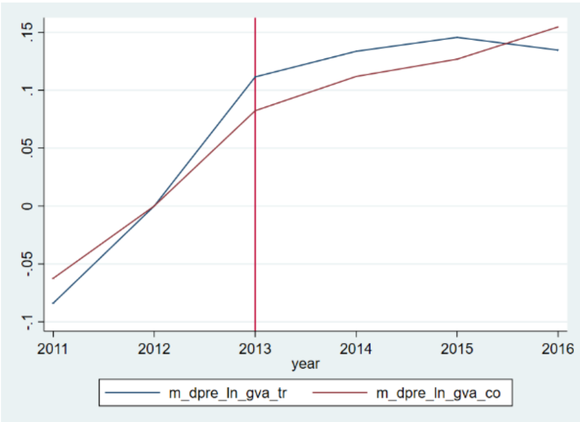


Figure 10. Trends in turnover of the in the treated (blue) and control groups (red line).

6. Heterogeneous impact of the CCA

6.1 Rationale

Considering the results reported in section 5, it is interesting to explore whether the CCA had a uniform impact across the facilities subject to this policy.

This analysis investigates electricity consumption. An analysis of the heterogeneous impact of the CCA was also undertaken for employment but this was not statistically significant, so no employment effect related to the CCA could be identified.

6.2 Approach

One can deliver an analysis of the heterogeneous impact of the CCA by using use the Changes-in-Changes (CIC) estimator developed in Athey and Imbens (2006) [30]. CIC is a generalisation of the DiD estimator, where the treatment effect for those affected by a specific policy can be evaluated at any arbitrary point in the distribution of a variable of interest. Therefore, any possible heterogeneity in responses to the treatment is explicitly accounted for. One caveat is that the method requires overlapping distributions in outcomes; that is, the range in outcomes of the control group needs to cover the range in outcomes of the treatment group. Where this is not the case, the treatment effect can be estimated only up to the maximum value covered by the control group. The estimation procedure involves finding a counter-factual distribution of outcomes for the treatment group. i.e. what would have occurred if they had not participated in the treatment. In the CCA context, it allows the evaluation of how CCA participants would have fared if they were not in CCA. The two counterfactual distributions estimated are electricity consumption in kWh and employment using a combination of the EPR and EI sectors without logarithmic transformation.

6.3 Findings

Table 17 shows the results for the impact of CCA on electricity consumption, which can be identified up to the 80th percentile. The treatment effect for almost all quantiles is negative, e.g. participation in CCA reduced electricity consumption for the treated regardless of pre-CCA levels of consumption. The 10th percentile diverges from this trend, as the estimated treatment effect is positive, however, the results are not statistically significantly different from 0. The results for the 20th and 30th percentiles are similarly not significant, although negative. Given the results, it appears that CCA participation encouraged big consumers of electricity consumption, i.e. those above the 40th percentile of the distribution of electricity consumption, to significantly reduce consumption. Note that the treatment effects are larger in absolute terms for higher percentiles but may not necessarily be bigger as a proportion of consumption.

[30] Athey, S. and Imbens G. W. (2006). “Identification and inference in nonlinear difference-in-differences models”, Econometrica, 431-497.

Table 17. CIC Estimates for electricity consumption.

Percentile	Treatment Effect (KWh)	Standard Error	Significance
10th	2,191.24	6,804.36	
20th	-3,057.92	13,883.65	
30th	-2,082.62	32,056.44	
40th	-56,811.60	32,003.46	*
50th	-57,131.75	25,190.33	**
60th	-277,481.05	92,644.76	***
70th	-337,369.96	162,808.74	**
80th	-288,466.39	100,777.45	***
Average	-129,394.19	45,599.26	***

Note: Significance values: *** = 1%, ** = 5%, * = 10%.

7. Conclusions

This study has implemented two scenarios to estimate the average effect of the second phase of the CCA scheme on electricity and gas consumption, electricity and gas intensity, and turnover. The first scenario involves a comparison between CCA facilities and those subject to the full CCL, the second a comparison between facilities which left the CCA as a consequence of the min-met exemption, and units covered by the CCA scheme. The first scenario was implemented separately for CCA sectors entering the scheme through environmental/pollutant criteria (the EPR sample) and for those qualifying via energy and trade intensity criteria, (the EI sample).

A statistically significant decrease in electricity consumption caused by the CCA is observed for facilities entering either through the environmental or the energy and trade intensity route, which is confirmed by a statistically significant increase in electricity consumption in the facilities leaving the CCA as consequence of the min-met exemption in the second scenario. The analysis for gas consumption does not provide evidence of a statistically significant difference between the CCA and the counterfactual in the second scenario. However, a significant decrease in gas consumption is suggested for CCA facilities in the EI sample. Electricity intensity appears to significantly decrease only in the EPR sample while it does not suggest any significant effects in all other cases. The analysis for turnover provides evidence on there being a statistically significant difference between the CCA and the counterfactuals in both scenarios, with gains in turnovers in both cases.

A separate analysis of the distribution of CCA effects showed that the absolute scale of CCA influence on electricity consumption was greater for sites with higher electricity consumption.

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