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Free allocations in EU ETS Phase 3: The impact of emissions-performance benchmarking for carbon-intensive industry

S. Lecourt, Chaire Economie du Climat and Université Paris Dauphine,
stephen.lecourt@chaireeconomieduclimat.org

C. Pallière, CDC Climat Research, Sciences Po.
clementpalliere@gmail.com

O. Sartor, CDC Climat Research and Université Paris 1,
oliver.sartor@cdcclimat.com

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Abstract

From Phase 3 (2013-20) of the European Union Emissions Trading Scheme, carbon-intensive industrial emitters will receive free allocations based on harmonised, EU-wide benchmarks. This paper analyses the impacts of these new rules on allocations to key energy-intensive sectors across Europe. It explores an original dataset that combines recent data from the National Implementing Measures of 20 EU Member States with the Community Independent Transaction Log and other EU documents. The analysis reveals that free allocations to benchmarked sectors will be reduced significantly compared to Phase 2 (2008-12). This reduction should both increase public revenues from carbon auctions and has the potential to enhance the economic efficiency of the carbon market. The analysis also shows that changes in allocation vary mostly across installations within countries, raising the possibility that the carbon-cost competitiveness impacts may be more intense within rather than across countries. Lastly, the analysis finds evidence that the new benchmarking rules will, as intended, reward installations with better emissions performance and will improve harmonisation of free allocations in the EU ETS by reducing differences in allocation levels across countries with similar carbon intensities of production.

Keywords: European Union Emissions Trading Scheme (EU ETS), CO_2 allowance allocation, Emissions-performance benchmarking

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1 Introduction

As the world's first international carbon market for controlling greenhouse gas emissions, the European Union Emissions Trading Scheme (EU ETS) continues to be an important policy experiment. However, after eight years of operation, certain aspects of the scheme remain controversial. One of the most controversial issues has been the allocation of free emissions allowances to carbon-intensive industry.

In Phases 1 (2005-07) and 2 (2008-12) of the EU ETS, over 90% of the initial allocation of European Emissions Allowances (EUAs) were allocated to installations free of charge, with allocation rates based on historical emissions (EC, 2003). These allocations were determined by each EU Member State under its own National Allocation Plan (NAP). Given Europe's politics, the complexity of the task, and the short time-frame available, it can be argued that such a decentralised approach made practical sense in the early phases of the EU ETS (Ellerman et al., 2010).

But this approach nevertheless led to controversial outcomes. Firstly, it allowed for the possibility of competitiveness distortions, since the flexibility granted by the ETS Directive led to different allocation rules being used in different Member States (Betz et al, 2004; Betz et al, 2006). Secondly, the NAP system led to significant over-allocations. For example, during Phase 1, non-combustion sectors of the EU ETS saw their average allocation range from 104.2% of actual emissions in the cement sector to 120.3% in the pulp and paper sector (Trotignon & Delbosc, 2008). The pre-recession allocations and emissions of Phase 2 in 2008 also saw a continuation of substantial over-allocations in key sectors (Pearson, 2010). This phenomenon gave rise to a number of questions being raised about the distributional equity, environmental effectiveness and economic efficiency of the NAP system of allocation (Betz et al, 2006; del Rio Gonzalez, 2006; Neuhoff et al, 2006; Burtaw et al, 2006). Indeed, Abrell et al (2011) produced econometric evidence suggesting that the marginal carbon price incentives to reduce emissions in the non-electricity sector had been weakened by the amounts of free allocation, thus reducing the economic efficiency of the scheme. While Pahle et al (2011) have presented evidence of distortionary effects of non-performance-based free allocation in the electricity sector.

This paper therefore seeks to provide a first, detailed analysis of the changes in allocation induced by the new benchmark-based allocation rules, which have been put in place to address these concerns. A new dataset, which matches preliminary Phase 3 installation-level allocation data for 20 EU countries with CITL and sectoral NACE code data, is thus exploited to answer three questions which are directly relevant for evaluating the new allocation policy: How will the new rules affect the amount of free allocation that different industrial sectors and Member States will receive in Phase 3? To what extent does benchmarking change the distribution of allowance allocations and thus ETS compliance costs, both across and within Member States and across and within economic sectors?

Thirdly, do these observed changes in free allocation reflect an improved harmonisation of allocations, based on the principles outlined in the revised ETS Directive (EC, 2009)? To our knowledge, only Clò (2010), Dröge & Cooper (2010) and Martin et al (2012) have attempted an empirical evaluation of the new benchmarking rules. This paper goes further than these previous papers, however, which focused on evaluating the decision rules for determining which sectors were deemed exposed to carbon leakage and therefore to higher free allocations.

Section 2 begins with a brief explanation of some key features of the benchmarking rules. Section 3 summarises several of the key features of the changes in allocations induced by benchmarking, and estimates several measures of their impacts on compliance costs in Phase 3. Section 4 then provides an econometric analysis in search of evidence that the observed changes in allocations described in the preceding section are consistent with the stated policy aims of benchmarking. Section 5 concludes.

2 The new benchmarking rules

To address concerns over the method of allocation of EUAs in Phases 1 and 2 of the EU ETS, the revised ETS Directive of 2009 laid out new principles governing initial allocations from Phase 3 onwards. The majority of allowances would be allocated by auction, with 100% auctioning for electricity for all but the 10 "new" EU Member States, while free allocation to other sectors would be determined by harmonised Community-wide rules, using emissions performance benchmarks. The stated aims of the new benchmarking rules were two-fold: "to minimise distortions of competition within the Community" and "to ensure that allocation takes place in a manner that provides incentives for reductions in greenhouse gas emissions and energy efficient techniques" (EC, 2009a).

The basic formula that determines each installation's allocation for each of its eligible products can be summarized as follows (EC, 2011) [1]:

$$FA_{i,p,t} = BM_p \times HAL_{i,p} \times CLEF_{p,t} \times CSCF_t \qquad (1)$$

where $FA_{i,p,t}$ is the total free allocation that installation i receives for its product p in year t. BM_p is the product emissions-intensity benchmark of product p. It is generally measured in tonnes of CO_2e/unit of output, and is based on the average emissions intensity of the 10% most efficient installations in the EU ETS in 2007-08 [2]. $HAL_{i,p}$ is the reference historical activity (production) level of product p by installation i, with installations' operators allowed to choose the highest value of the 2005-08 and 2009-10 medians. The new free allocation formula thus seeks to compensate emissions

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[1] In some cases benchmarks for specific products cannot easily or practically be used and so hierarchy of fallback approaches is used, based firstly on heat and then fuel consumption benchmarks and, if these are not possible, historical process emissions x 0.97 are used.

[2] Where the best 10% of installations emissions intensity could not be gauged, fallback approaches were used based on best available technology literature.

compliance costs for industry only to the level of emissions consistent with the "best available technology". It is in this way that the European Commission seeks to "provide incentives for reductions in greenhouse gas emissions and energy efficient techniques", while also harmonising free allocation rules.

However, several additional complexities can affect the amount ultimately allocated to each installation and these are relevant to the analysis and interpretation of the results presented here. First, $CLEF_{p,t}$ in formula (1) is an allocation reduction factor that is applied to a small minority of products that are not considered to be at risk of carbon leakage (cf. EC, 2010a). These products will see their free allocations reduced by a multiplier of 0.8 in 2013, which declines linearly to 0.3 in 2020. Second, $CSCF_t$ in formula (1) is a uniform, cross-sectoral correction factor that can be applied to ensure that the total free allocation will not exceed the maximum annual amount of free allocation as defined in Article 10a(5) of the ETS directive[3]. Third, where heat exchanges occur between two ETS installations, related emission allowances will now be allocated free of charge to the heat consumer, while allowances are allocated to the heat producer when the heat consumer only is not covered by the EU ETS. Fourth, with the exception of where waste gases are recaptured from steel production, or where there is highly efficient cogeneration of heat and electricity, the emissions for electricity that is auto-produced by an installation should be deducted from the amount of free allocation to reflect the principle of no free allocation for electricity production. Similarly, where electricity consumption and other fuel use is considered substitutable, a correction is made to the amount of free allocation. Finally, regardless of an installation's original historical activity level (HAL), large changes to its production capacity accompanied by "significant" changes in activity can trigger changes in free allocation[4]..

3 Free allocation changes from Phase 2: evidence from the Phase 3 NIMs

3.1 Data description

This analysis uses EU ETS installations compliance data from the CITL for the period 2008-11. These data were matched with the preliminary annual free allocation data for each installation for the period 2013-20 as reported in the National Implementation Measures (NIM) of 20 Member States. Missing are Belgium, Hungary, Malta, Lithuania, Slovenia, Czech Republic and Latvia.

Since the changes in allocation levels to new entrants in Phase 3 were not able to be calculated, this paper ignores the effects of the benchmarking rules on new entrants. Excluding new entrants, the aviation sector, installations which had left the EU ETS in Phase 3, and installations which could not

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[3] For more details on these factors, see (Lecourt, 2012).

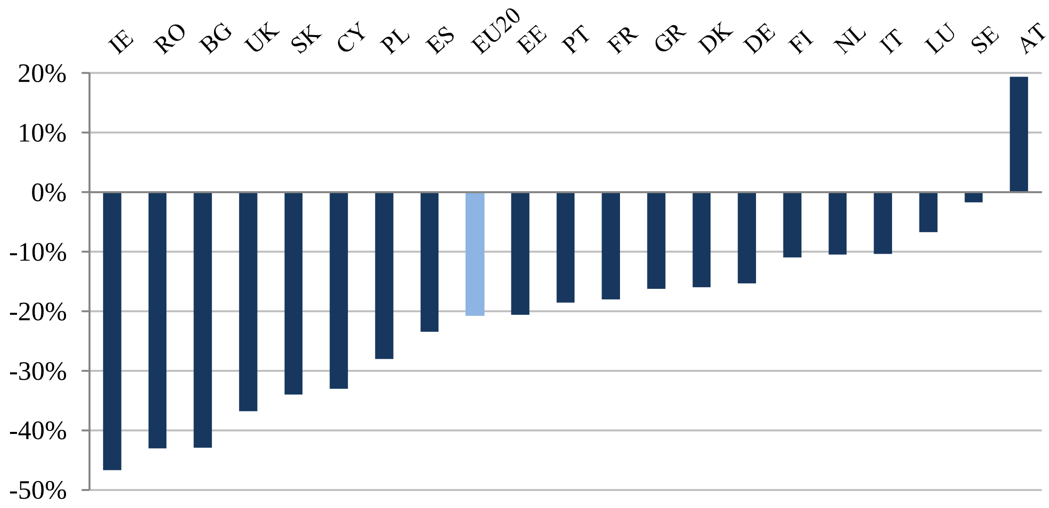
[4] Increases in production capacity greater than 15% are eligible for consideration of an adjustment in the installation's HAL. If production activity drops by 50-75% compared to the initial activity level, the baseline HAL used to calculate future free allocations will fall by 50%. If activity falls below 90%, free allocation will be ceased. This too can affect the change in allocation of some installations between Phases 1, 2 and 3.

be matched with either a CITL installation code or a NACE code, left a sample of 7149 installations which together accounted for 1.46 billion tonnes of CO_2 or approximately 80% of EU ETS emissions in 2010 (CITL, 2011). Of these, 4174 installations were identified by their NACE code as non-electricity installations and thus subject directly to benchmarking. Of these 4174 installations, 329 specializing in the chemicals and non-ferrous metals sector were not included in the analysis since these sectors have had their EU ETS perimeter change significantly between Phases 2 and 3 and hence changes in allocation could not be attributed to benchmarking alone.

3.2 Aggregate Phase 3 free allocation changes across Member States and economic activities

Free allocations to benchmarked sectors will fall significantly in Phase 3. For our sample of over 4000 benchmarked installations passing from Phase 2 into Phase 3, the aggregate decline in free allocation will be 20.6% on average over Phase 3 (Figure 1), before taking account of the possible uniform linear adjustment factor (it was yet to be announced at the time of writing).

Figure 1. Free allocation changes in benchmarked sectors in Phase 3 by Member State



Note: Figures exclude the chemicals and non-ferrous metals sectors since the perimeter of the ETS has changed for these activities in Phase 3.

The changes in allocation will also vary across Member States, with some countries seeing relatively small declines or increases, while others see falls of between -30 to -47% (cf. Figure 1). However, one must be careful about jumping to the conclusion that this illustrates the relative “winners” and “losers” under the new system, since a number of factors are ignored here. For example, these allocation changes are based on the difference between the average annual free allocation in Phase 2 versus that of Phase 3. So countries which tended to be more generous with their allocations to industry in Phase 2 might therefore be expected to witness bigger declines under the harmonised rules and vice-versa. Nevertheless, there is evidence of significantly declines across almost all 20 Member States[5].

The declines in free allocation are generally quite uniform across sectors (Table 1). With the exception of what we define here as "other sectors", which includes a large number of sub-sectors not deemed exposed to carbon leakage and therefore facing a larger reduction factor on average, all of the declines fall in the relatively narrow range of -13 to -24%. Since many sectors were over-allocated allowances at the beginning of Phase 2, a large share of the decline appears to offset excess historical allocations. For example, the pulp and paper sector sees a 22% surplus largely offset by a 21% decline in allocation. The reductions in aggregate sectoral allocations induced by benchmarking therefore do not seem to be "excessive" for these sectors, although they will certainly reduce over-allocations and increase net compliance costs at the margin for several sectors. The dispersion of installations' allocation changes around the median installation's decline is generally quite wide, which implies that, as expected, benchmarking will redistribute allowances significantly within sectors.

Table 1. Percentage change in allocation by sector

	Cokery	Refined petrol products	Glass	Ceramics and brick	Cement	Lime	Pulp and paper	Iron and Steel	Other sectors
Aggregate Net Position 2008µ	-16	-1	+9	+35	+11	+15	+22	+29	+13
Aggregate allocation change†	-17	-24	-24	-16	-13	-19	-21	-13	-37
Median allocation change*	-6	-14	-21	-17	-11	-18	-22	-11	-33
Dispersion of allocation changes^	25	26	19	28	9	18	1331	82	99

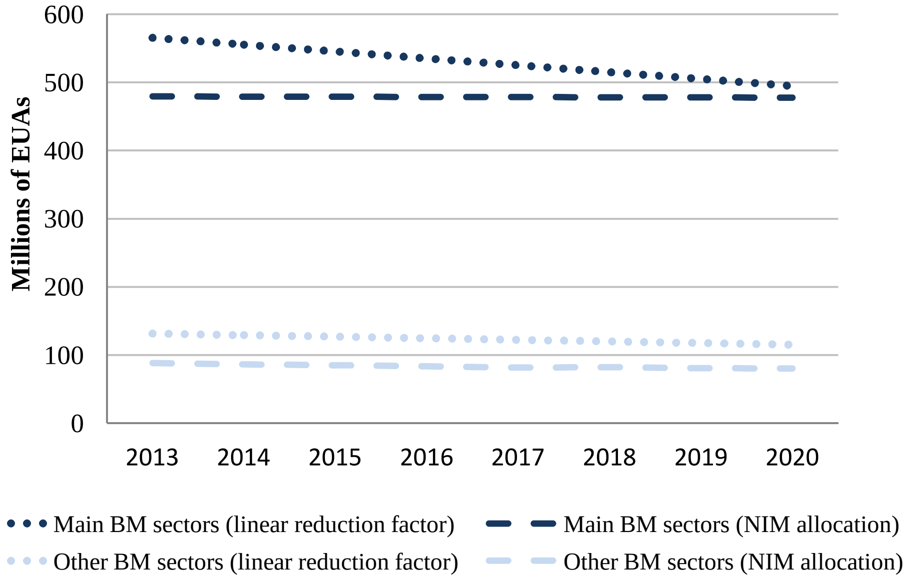
µCalculated as (allocation – emissions)/emissions in 2008 in the sector, †Refers to the total aggregate reduction in allocation in the sector, *Refers to the median reduction in allocation of installations in the sector, ^Refers to the average distance from the median allocation reduction of installations in the sector

Table 1 also indicates that declines in allocations for most sectors are larger than the 14% decline in the emissions cap from the beginning to the end of Phase 3. This implies that the introduction of benchmarking leads to larger reductions in initial free allocations than if the European Commission had simply decided to reduce allocations according to a linear reduction factor equivalent to the cap on emissions. Figure 2 shows that, especially at the front

[5] Sweden's unusual outcome is a result of now Union-wide allocation rules that has forced Sweden to allocate free allowances to installations of the electricity, gas, steam and hot water sector that were not allocated in Phase 2 under Sweden's Phase 2 NAP, while Austria's result appears to reflect capacity changes for installations taking effect in Phase 3.

end of Phase 3, the benchmarks allocations will be significantly stricter on aggregate than such a baseline scenario. On average the difference between the two scenarios is 8.7% of the baseline allocation. This suggests that the benchmarks generate a significantly more stringent amount of allocation to the main benchmarked sectors than if free allocation had continued on a pathway extrapolated from the Phase 2 NAP allocations. Under benchmarking, an additional 670 million EUAs would be auctioned rather than allocated for free.

Figure 2. Number of allowances allocated to main benchmarked sectors* under Benchmarking vs. a hypothetical linear allocation reduction scenario from NAP2s



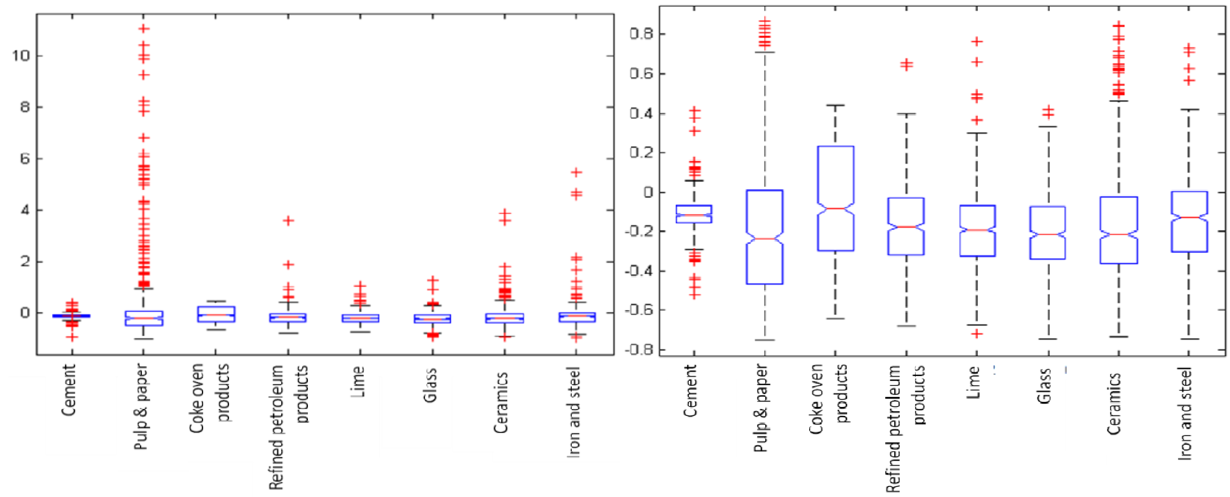
Main BM sectors: Pulp and paper, steel, coke, refining, cement, lime, ceramics, glass, and ferrous metals production.

3.3 The distribution of allocation changes

The preceding sub-section showed that changes in allocations from Phase 2 to Phase 3 are found to vary substantially within individual sectors. Figure 3a provides further detail on this aspect of benchmarking's impact. The flat line inside each box represents the median installation's allocation change, the outer limits of the boxes represent the second and third quartiles, the black moustache-lines show the portion of installations falling inside 1.5 standard deviations of the median, while the crosses represent those installations lying outside these ranges. Figure 3b removes the first and last vigintiles (10% of the sample is withdrawn) to more clearly see the distribution for the majority of installations.

The sectoral distributions show that, for each of the main benchmarked sectors, the installations in the first three quartiles (75% of installations) generally undergo an allocation reduction. Upper quartiles have a larger range in allocation changes, mostly due to a large number of installations with small levels of allocation in Phase 2. Overall, it can be seen that that the benchmarking rules will lead to a substantial redistribution of allowance allocations within sectors.

Figure 3 (a: left, b: right). Distribution of inter-phase allocation changes at the installation level (allocation change expressed as a fraction of Phase 2 allocation on y axis)



These redistributions across installations raise the question of whether the variance is mostly due to differences *across* or *within* individual Member States. Comparing both inter- and intra-Member State distributions in allocation changes shows that intra-Member State variance accounts for most of the total variance across installations. Table 2 decomposes the spread between each installation and the sectoral average into a spread between the installation and its national average and the remaining spread between the installation and the sectoral average. The results indicate that while some redistribution of allowances will occur *across* Member States, this redistribution is generally small compared to redistributions *within* Member States in most sectors. This result makes intuitive sense when one considers that allocations in Phase 2 were often based on a range of different fuel-emissions benchmarks- and load-factors, which sought to reduce the dispersion of cost impacts across installations within countries and that these rules have now been replaced with common rules for all installations in each sector. Interestingly, this raises the possibility that carbon-cost competitiveness impacts induced by the new allocations could be felt more intensely in terms of intra-country competition than inter-country competition.

Table 2. Decomposition of the installation allocation change variance of benchmarked sectors

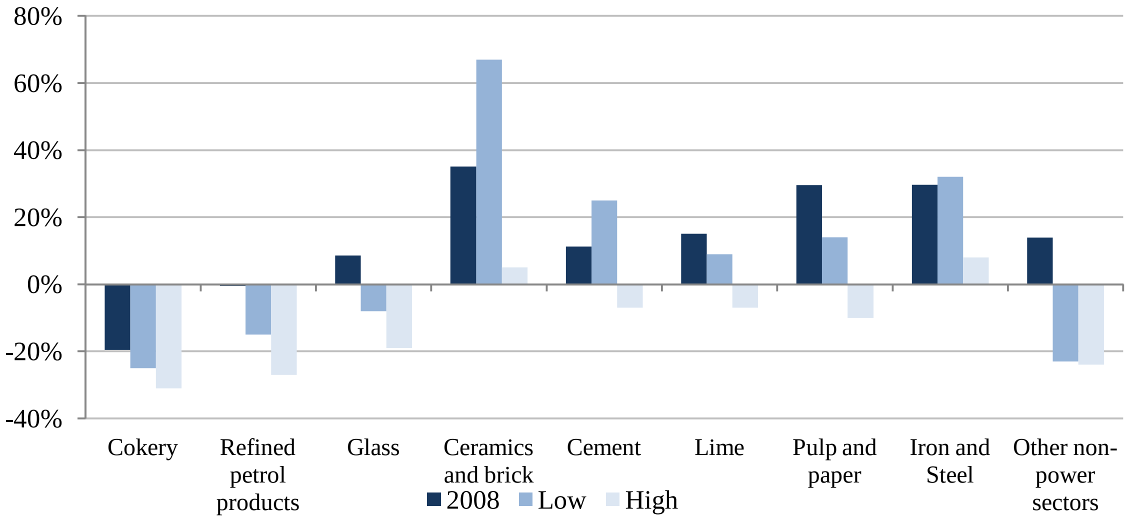
	Pulp and paper	Cokery	Refined petroleum products	Glass	Ceramics and bricks	Cement	Lime	Iron and steel
Inter-country	11%	44%	27%	9%	16%	26%	26%	10%
Intra-country	89%	56%	73%	91%	84%	74%	74%	90%

3.4 Estimating net compliance cost changes

The analysis provided in Figure 4 offers estimates of EU sectoral expected net positions based on the NIM allocations under two hypothetical scenarios. The "High emissions" scenario refers to a situation in which each installations average annual Phase 3 emissions are equivalent to the reference historical activity level (HAL) as defined by the benchmarking rules. Equivalently, we define a "Low emissions" scenario in which we assume that average annual emissions remain at their 2011 levels for all installations Phase 3, since 2011 represents a low point in EU ETS emissions. For simplicity the effects of Phase 2 allowances banked into Phase 3 are ignored.

If the HAL-year emissions are a reliable guide to average annual Phase 3 emissions, then the sectors listed in Figure 4 would hold a net deficit position, with the exception of iron and steel and ceramics and brick. Hence the benchmarking rules would imply a small to medium level of "ambition" for most of the main benchmarked sectors.

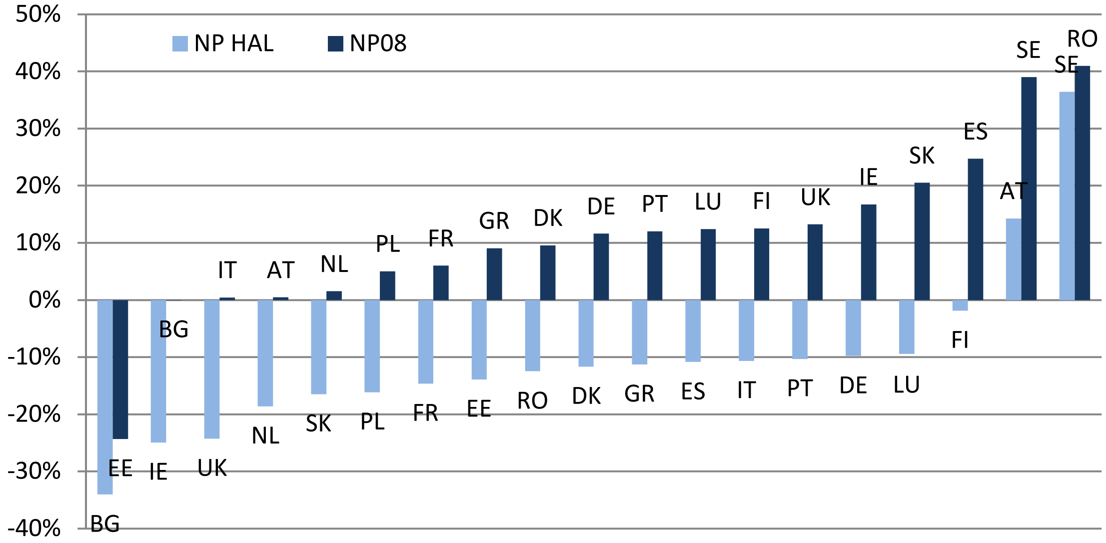
Figure 4. Sectoral net positions in 2008 vs. benchmarking under two emissions scenarios



^Refers to the total EU20-wide sectoral net compliance position.

Furthermore, for many sectors benchmarking would, under the HAL emissions scenario, reduce the average differences in net positions across countries in several sectors. The average distance of countries from the sectoral median across all of these sectors would be 8.5% in Phase 3 versus 9.7% in 2008 (see Figure 5). This suggests that rather than increasing the gaps in the degree of free allocation compensation levels to different countries within sectors, benchmarking could potentially reduce them.

Figure 5. Comparison of aggregate net compliance positions in 2008 vs HAL scenario



Note: percentages refer to aggregate net position in 8 key sectors identified above.

A change from the High emissions scenario to the Low emissions scenario makes a significant difference to the expected sectoral net positions. This reflects the strong impact of the deterioration in European manufacturing production since 2009 and hence beyond the period which most installations use to determine their HALs. However, the fact that depressed industry emissions levels may lead some sectors as a whole to have a net neutral or even positive compliance position during Phase 3 does not mean that benchmarking will impact all installations in these sectors the way. Table 3 shows that even under the low emissions scenario, eight of the nine key sectors would see a higher share of installations needing to either purchase or draw down on banked allowances to be in compliance than in 2008. This share also rises by 11% or more for four out of the nine sectors. Thus, despite the economic downturn having reduced emissions, the benchmarks nevertheless impose a greater degree of compliance stringency on installations in these sectors than the NAP2s did.

Table 3. Summary of installation level expected net positions under two emissions scenarios.

	2008	LOW	HIGH	2008	LOW	HIGH	2008	LOW	HIGH
		Pulp and paper			Coke			Refined petrol. products	
Percentage < 0^	31%	56%	65%	24%	25%	63%	41%	59%	77%
Median installation*	10%	-7%	-15%	9%	29%	-5%	2%	-12%	-20%
		Glass			Ceramic and brick			Cement	
Percentage < 0	37%	67%	81%	14%	17%	64%	22%	24%	83%
Median installation	5%	-8%	-15%	27%	49%	-6%	8%	17%	-8%
		Lime			Iron and steel			Other sectors	
Percentage < 0	22%	33%	66%	29%	28%	50%	24%	68%	78%
Median installation	15%	10%	-6%	8%	16%	-1%	15%	-33%	-43%

^Percentage < 0 refers to the percentage of sampled installations in the sector whose emissions either were or would be greater than their free allocation under the relevant scenario.

*Median installation refers to the median (estimated) net position of the sampled installations in that sector.

4 Explaining differences in changes in allocations across Member States

This section estimates a simple econometric model that seeks to identify whether the observed changes in allowance allocations can be explained by the factors which one would expect if allocations are being made consistently with benchmarking's main policy objectives (i.e. rewarding improved performance and improving harmonization). Encouragingly, there is evidence in the NIMs of an improved harmonization of allocations across the EU based on observable proxies for emissions performance.

4.1 Data and econometric specification

Before attempting to evaluate the role of different variables in explaining the observed variations in free allocation changes, a decision is required about what level of aggregation to examine. Unfortunately, pan-European data on individual installation characteristics which could explain installation-level changes in allocation (e.g. measures of installation energy efficiency, carbon intensity of production, electricity consumption, etc) were not available at such a disaggregated level. Nevertheless, these data could only be constructed from available sources at the country and sector level. Combining these data with allocation aggregates provided by the NIM and CITL databases allowed for the estimation of the impact of country-sectoral level factors on allocation changes for three sectors: steel, cement and pulp and paper production. Despite their limitations, these data still provide preliminary evidence that the benchmarking rules are (re)allocating allowances in a way that appears to be consistent with the primary goals of the policy.

To identify the role of individual factors, the following fixed-effects regression model was specified:

$$\Delta ALLOCij = \beta_1 CO2IntFuel_{ij} + \beta_2 CO2IntProc_{ij} + \beta_3 NetPos08_{ij} + \beta_4 ElecCons_{ij} + \beta_5 CLExp_{ij} + \beta_6 EI_{ij} + FE_i + \varepsilon_{ij}$$

$\Delta ALLOC_{ij}$ is the percentage change in average annual free allocation to sector *i* in country *j* ("country-sector pair *ij*") in moving from Phase 2 to Phase 3. All else equal, country-sector pairs with higher (lower) CO_2 intensities should see their free allocations decline more than others if the benchmarking rules are genuinely encouraging emissions performance through higher relative allocations, as intended. Thus, the variable $CO2IntFuel_{ij}$ is included as a measure of the relative carbon dioxide-intensity of the primary fuel mix consumed by country-sector pair *ij* in tCO_2/toe. Similarly, $CO2IntProc_{ij}$ represents the relative carbon emissions-intensity of country-sector pair ij's process (non-energy-related) emissions, in tCO_2e/tonne of production; while EI_{ij} is the energy intensity, in toe/tonne of output, of the country-sector pair *ij*. These data were constructed based on Enerdata's ODYSSEE Energy Indicators database and the IEA's *WDS World Energy Statistics* database.

In addition several control variables are included. $NetPos08_{ij}$ is a proxy for the extent to which country-sector pair *ij* can be considered to have been over- or under-allocated in Phase 2. To control for the effects of the severe drop in industrial production in 2009 and thereafter, we use the ratio of allocation to verified emissions in 2008 as reported in the CITL. $ElecCons_{ij}$ represents the extent to which country-sector pair *ij* consumes electricity instead of other fuels in its primary energy supply. This is included to control for the effect of benchmarking rules on allocations for electricity production and consumption, as explained above. The data are also based data from the IEA Energy Statistics *WDS Energy Statistics* database. $CLExp_{ij}$ is a measure of the extent to which country-sector pair *ij* is composed of installations which produce products that are considered to be exposed to carbon leakage (and hence eligible for 100% allocation of the benchmarked amount). It is calculated from the NIMs data by observing the extent to which a given installation's free allocation diminishes over Phase 3.

To control for sector-specific differences in allocations, which were identified using a Breusch-Pagan test, sectoral fixed effects were included (FE_i). A Hausman test also indicated that since these effects were correlated with the explanatory variables, fixed effects was the most conservative estimation option for ensuring robustness of our estimates (cf. Annex).

Compiling a panel dataset using three data sources meant that data for some variables were missing for some countries. Three observations were also identified as being "influential" outliers using Dfbeta tests and were removed from the final estimations (cf. Annex). This left a final unbalanced panel of 41 observations which was used for estimation.

Post-estimation analysis of the model errors showed that the estimated residuals were approximately normally distributed and provided little evidence of heteroskedasticity (cf. Annex).

4.2 Regression results

Encouragingly, the results generally correspond with what should be expected if the benchmarks were being implemented consistently with the stated aims of the Benchmarking Decision. The coefficient estimates for $CO2IntFuel_{ij}$ are negative and statistically significant at conventional levels across all five estimated specifications. The coefficient estimates for $CO2IntProc_{ij}$ are both negative and statistically significant at a 90% in the central specification (i.e. model 4) and seemed to be robust to alternative specifications. Even when the model is expanded to include further variables, the coefficient estimates remain statistically significant at >90% on the one-sided test[6].

[6] It can be safely assumed *a priori* that $CO2IntProc_{ij}$ is not positively correlated with changes in allocation. Moreover, the fact that this variable is not as strongly statically significant as those for CO2IntFuel seems likely

These two results imply that, all else equal and across the cement, steel and pulp and paper sectors, the more CO_2-intensive is a Member State's primary fuel mix or its (chemical) production processes, the more it tends to see its free allocation for that sector reduced in Phase 3. This is consistent with the qualitative result that benchmarking was intended to deliver since it implies that Phase 3 allocations are "correcting" the allocations in Phase 2 for excess allocations not related to emissions performance. This is therefore evidence that the Benchmarking process does appear to be rewarding (penalizing) better (poorer) emissions performers on average throughout the EU more than the NAP2s did.

Table 4. Regression results

Coefficient	1.	2.	3.	4.	5.
CO2IntFuel	-0.060[b] (0.034)	-0.086[a] (0.034)	-0.094[a] (0.037)	-0.084[a] (0.036)	-0.090[a] (0.039)
CO2IntProc				-0.231[b] (0.123)	-0.185[c] (0.140)
NetPos08		-0.22[a] (0.087)	-0.241[a] (0.093)	-0.285[a] (0.093)	-0.250[a] (0.108)
ElecCons			-0.129 (0.239)	-0.291[c] (0.247)	-0.431[c] (0.318)
EI					-0.278 (0.364)
CLExp					-0.325 (1.660)
Descriptive Statistics					
R^2 (within)	0.08	0.22	0.23	0.30	0.31
F-statistic	3.02	5.04	3.39	3.60	2.40
Prob > F	0.09	0.01	0.03	0.02	0.05
Observations	41	41	41	41	41

[a]Statistically significant at 95% level, [b]Statistically significant at 90% level [c]Statistically significant at 90% level based on a one-sided test only.

Moreover, the *NetPos08*$_{ij}$ variable was statistically significant at high levels and negatively signed. This implies that, all else equal, a country-sector pair with a higher allocation level relative to its actual emissions in 2008 tended to see a bigger drop in free allocation in Phase 3 under benchmarking. This result is interesting for what it says about the behavior of Member States in

to be explained by the fact that all the CO2IntProc observations for pulp and paper are zeros, which implies less variation to enable parameter identification.

allocating allowances in Phase 2 compared to what they are required to do now under benchmarking. Specifically, it indicates that aggregate sectoral allocations in Phase 2 were not simply based on historical emissions but rather included some degree of country-specific heterogeneity. Indeed, the regressions performed above effectively controlled for both emissions intensity and production levels [7] – as well as other potential biases such as electricity production and sectoral effects. Yet they still found that some *additional* free allocation decline from Phase 2 to Phase 3 was left to be explained by the $NetPos08_{ij}$ variable. This implies that Phase 2 saw excess allocation in the sampled sectors over and above what was due on a historical emissions basis and that the benchmarking rules correct for this (by subjecting all countries to the same rules) in Phase 3. This is evidence that the benchmarking system appears to be achieving one of its key goals of reducing differences in free allocation and thus possible competitiveness distortions that are *not* related to differences in emissions performance by harmonising EU allocations according to the benchmarks.

The regression results also provide some weak evidence that sectoral electricity consumption to total energy consumption rates are negatively correlated with cross-country sectoral declines in free allocation. This could plausibly reflect the fact that countries with higher electricity use in these industries see bigger declines in free allocation on average, as per the benchmarking rules which insist on no free allocation where electricity consumption and combustion fuel use are substitutes. However, more data would be required to obtain greater certainty concerning this hypothesis.

Insufficient statistical evidence was found to conclude that the energy intensity (EI_{ij}) variable is a significant explanator of differences in free allocation changes across Member States. While this may seem counter-intuitive, benchmarks are based on CO_2-intensity of production rather than energy intensity of production, so *a priori* one should not necessarily expect as strong a correlation between emissions performance and energy intensity. Moreover, to the extent that the two are correlated, it seems plausible that relative energy intensity may not matter as much in explaining relative performance *across* Member States, which is the limitation of this analysis which the current data restrict us to. Analysis with a richer intra-country dataset would be required, however, to be confident of such conclusions.

Insufficient evidence was also found to conclude that the relative exposure to carbon leakage of each country's sector-specific product mix is a statistically significant factor in explaining differences in changes in free allocation across Member States. This result was believed to follow from a lack of variation in the sample, since the vast majority of observations for the three examined sectors contained a value of 100%-exposed to carbon leakage, with others very close to 100%.

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[7] Historical production is controlled for implicitly since historical activity is used to calculate Phase 3 allocation, which is in turn used to calculate the dependent variable.

4.3 Robustness and data limitations

A few caveats are required on the interpretation of these regression results. Firstly, the estimates refer to *cross-country* estimations (for three specific sectors). Consequently, the coefficient estimates cannot therefore be interpreted as explaining the impact of the observed variables on intra-country differences in allocation changes across installations or sectors.

Secondly, there is a likelihood of some measurement error. The best that could be done with the available data was to match country-sector pair allocation data (constructed based on very specific products produced by each installation) with a more aggregated measures of national-sectoral energy and CO_2 consumption. However this measurement error reduces the precision of the estimation (this helps to explain the relatively low R-squared (0.30) of the model).

Thirdly, at least three interesting variables could not be controlled for due to data availability problems. Country-specific effects could not be robustly for due to the small sample size, while two other variables – namely the level of cross-installation-boundary heat flows and capacity changes – could not be controlled for due to lack of data. While there is not a strong reason to believe that the absence of these two variables biases the estimates, these variables might be expected to help explain a significant share of the variation in allocations across countries' sectors and thus increase the precision of the estimates. Their absence is thus another caveat on these results (and also helps to explain the low R-squared of the model).

5 Conclusions

The introduction of emissions performance benchmark-based allocations in Phase 3 of the EU ETS will significantly change the manner in which free CO_2 allowances are allocated to emissions-intensive industry in Europe. The move to benchmarking implies a significant fall in free allocations to benchmarked sectors compared to allocations of Phase 2 and compared to the decline in the ETS-wide emissions cap. The estimates presented here indicate that the overall reductions in allocations will leave at least an additional 670 million allowances available to be auctioned by public authorities compared to a hypothetical continuation of the NAP allocations. If previous empirical literature (cf. Abrell et al, 2011) is correct, these reductions in free allocations could potentially improve the environmental effectiveness and efficiency of the EU ETS – although this remains to be confirmed by further research.

The above analysis shows that benchmarking entails substantial redistributions of emissions allowances and relative compensation levels across installations, with some receiving more but with most receiving less than in Phase 2. The vast majority of this redistribution is found to be between installations within the same sectors and Member States. This suggests that any resulting carbon-cost competitiveness effects from benchmarking could potentially be stronger across different installations within countries, than across different countries.

Lastly, a simple regression analysis also indicates that a significant portion (at least 30%) of the cross-country differences in the changes in sectoral free allocation in Phase 3 is consistent with the two main stated aims of the benchmarking approach in the revised ETS Directive (EC, 2009a): firstly, to reward more efficient emissions performance through higher allocations; and secondly to improve EU-wide harmonisation of allocations.

Further work with more complete data on ETS installations will be required to further our understanding of impacts of the benchmarking rules at installation level. Nevertheless, the preliminary evidence provided here is consistent with the EU-policy makers stated aims in designing phase 3 allocation rules.

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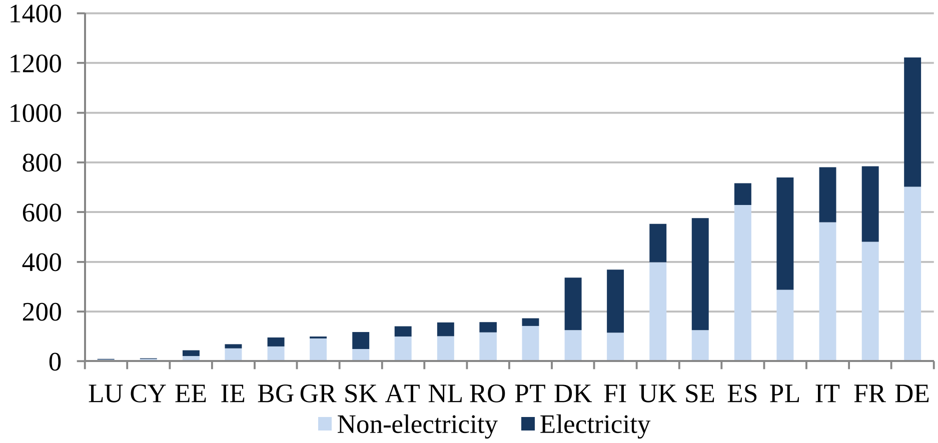
7 Annexes

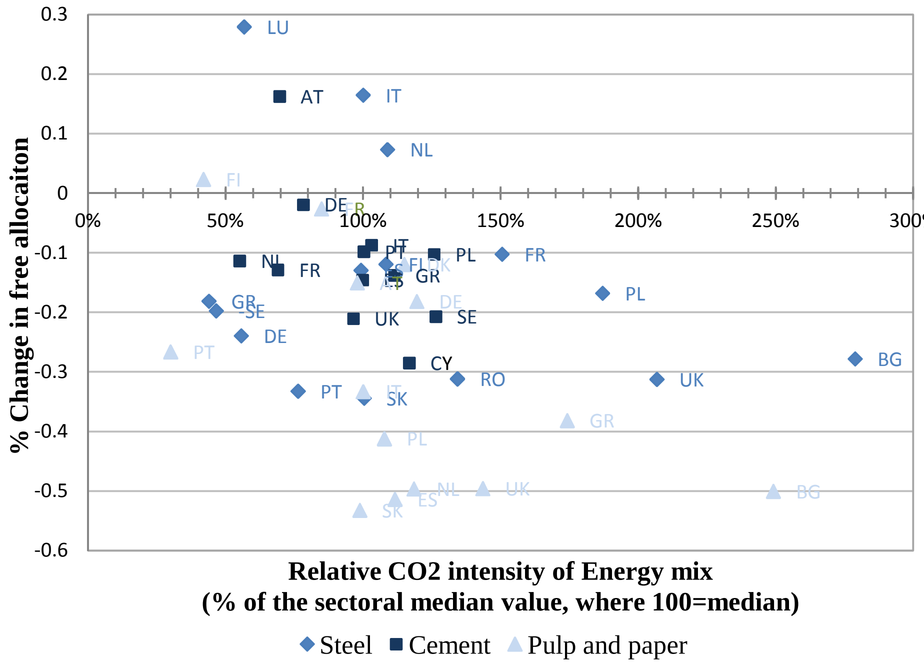
7.1 Count of installations from each Member State included in the final database



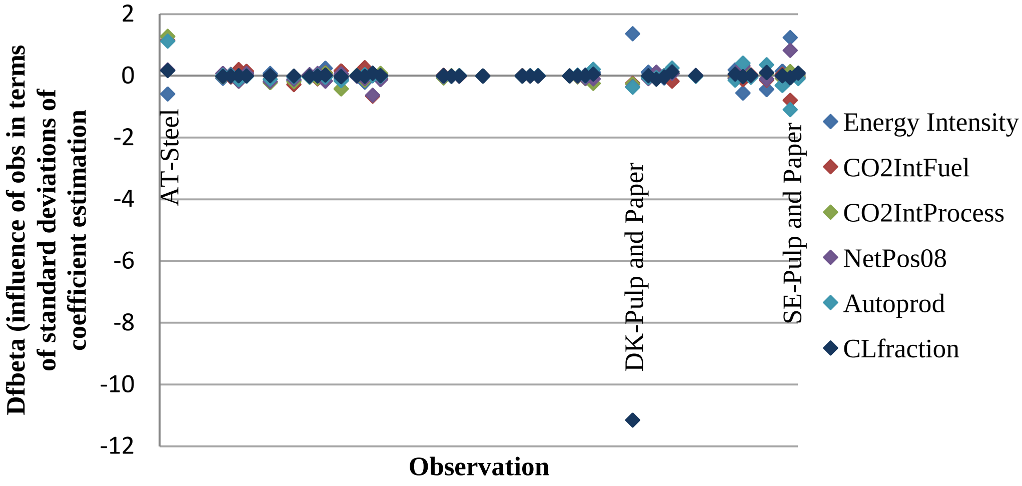
Note: Electricity installations were defined as those having a 3-digit NACE code 40.1

7.2 Data and results of econometric tests

<u>Changes in Phase 3 free allocation vs. relative CO_2-intensity of fuel mix by sector</u>



Dfbeta Test Results for determining Influential Outliers of the dependent variable:



Breusch-Pagan Test for presence of random effects

Null Hypothesis, H_0: Var(u) = 0, Test:

$X^2(1)$	5.03
Prob> $X^2(1)$	0.0249

Conclusion: Strong evidence that sectors have different intercepts

Hausman test for the consistency of random effects with fixed effects

H_0 = difference in coefficients is not systematic

$X^2(4)$	65.10
Prob> $X^2(4)$	0.0000

Conclusion: Strong evidence of systematic differences in coefficients between the two models. Hence, random effects cannot be safely used.

Shapiro-Wilk Test for normally-distributed residuals:

H_0: Residuals of specification 4. in Table 4 are normally distributed. Test:

Variable	Observations	w	v	z	Prob>z
Residuals	41	0.97053	1.187	0.362	0.35875

Conclusion: Insufficient evidence to reject H_0

Modified Wald test for groupwise heteroskedasticity in the fixed effects regression model

H_0: $\sigma(i)^2 = \sigma^2$ for all i (i.e. there is no groupwise heteroskedasticity in errors of specification 4 in Table 4 . Test:

$X^2(3)$	5.14
Prob> $X^2(3)$	0.1617

Conclusion: Insufficient evidence to reject H_0

7.3 Sectoral distribution of installations' expected net positions for low (left) and high (right) emission scenarios (allocation change expressed as a fraction on y axis)