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The EU Emission Trading Scheme –
Sectoral allocation patterns and factors determining emission changes

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Abstract

The EU Emission Trading Scheme (EU ETS) that covers emitters from industry and energy supply representing 40% of the EU's greenhouse gas emissions is the biggest implementation of a cap-and-trade scheme worldwide. In this paper, we analyze sectoral allocation caps focusing on three emission intensive sectors ('power and heat', 'cement and lime', 'pulp and paper'), assess the development of emissions and discuss the main drivers for emissions in these sectors since the start of the EU ETS. Our analysis of allocation patterns shows that 'power and heat' is the only sector permanently facing a stringent cap. The disaggregated analysis of the development of CO_2 emissions also reveals pronounced sectoral disparities, which points at differences in the availability of emission abatement options. The data for cement and lime production show changes in CO_2 intensity pointing at an increased import of clinker. For paper and pulp production and for power and heat generation improvements in emission intensities and to a lesser extent energy intensities can be observed, reflecting the role of fuel shifts in short term emission reductions.

Keywords: EU Emission Trading Scheme, allocation caps, decomposition analysis

JEL-Codes: Q58 Q54

Introduction

The EU Emission Trading Scheme (EU ETS) that covers emitters from the energy supply and manufacturing sectors came into effect in 2005. Phase 1, the pilot phase, ran from 2005 to 2007, Phase 2 covers the Kyoto commitment period 2008 to 2012.

The EU ETS is a key instrument in European climate policy. Phase 1 was, however, characterized by a surplus of allowances, mainly due to the generous allocation of allowances by Member States. For Phase 2 the European Commission aimed at improving the environmental effectiveness of the ETS and took a more active role in approving the Member States' National Allocation Plans (NAPs). As a consequence in 2008 verified emissions exceeded allocation for the EU total. Due to the external shock of the global financial crisis and the associated decline in economic activity and emissions the cap was only stringent in 2008 whereas the next years showed again a surplus of allowances.

Differences between allocation patterns, i.e. in the stringency of the cap, have been analyzed on Member State, sector and installation level (e.g. Kettner et al. 2010, Kettner et al. 2008, Ellerman and Buchner 2008). The studies find non-binding caps for most Member States and sectors. This has brought about a lively discussion in economic literature whether or not the EU ETS effectively stimulated abatement or not. Comparing the actual development of emissions with a Business as Usual projection, i.e. estimates regarding the counterfactual no-policy case, several studies conclude that abatement occurred despite over-allocation of allowances (e.g. Ellerman et al. 2010, Egenhofer et al. 2011, Anderson and di Maria 2011, Abrell et al. 2011).

In this article we contribute to this discussion on abatement induced by the EU ETS: We analyze sectoral allocation patterns focusing on three emission intensive sectors ('power and heat', 'cement and lime', 'pulp and paper') and assess the development of emissions since the start of the EU ETS in these sectors based on underlying drivers such as emission or energy intensity.

The structure of the article is as follows: We start with presenting essential design elements of the EU ETS in Phase 1 and Phase 2. We then analyze the empirical evidence on allocation patterns for the period (2005 - 2011) and discuss the development of emissions as well as the underlying drivers in the three emission intensive sectors. The final section concludes.

The design of the EU Emission Trading Scheme in Phase 1 and Phase 2

The EU ETS is the biggest cap-and-trade scheme worldwide and covers 40% of total European greenhouse gas emissions. In Phase 1 (2005 - 2007) and Phase 2 (2008 - 2012) CO_2 emissions from eight activities are covered by the EU ETS[1]. Seven activities that have to be included in the EU ETS by the Member States are explicitly specified: mineral oil refineries, coke ovens, production and processing of ferrous metals, cement and lime production, glass production, ceramics production as well as the production of pulp and paper. The most important category of installations included are combustion installations with a rated thermal input exceeding 20 MW. This category does not only include installations from the energy sector, but also combustion activities in industrial sectors such as the food or chemical industries.

In the first two trading phases the Member States were responsible for allocating emission allowances to sectors and installations via NAPs. Grandfathering was the predominant allocation method: At least 95% of allowances in Phase 1 and 90% in Phase 2 had to be distributed to the installations free of charge in accordance with their historical emissions as defined in the Emissions Trading Directive (2003/87/EC). The remaining share of allowances could be auctioned by the Member States.

The NAPs had to follow certain criteria[2] defined in the emissions trading directive (2003/87/EC) and needed to be approved by the European Commission. Given the experience on over-allocation from Phase 1 the EU Commission took a more active role in evaluating and revising Member States' NAPs for Phase 2. Proposed national allocations on average were cut by 10.4% in the Commission review; only the caps of four EU Member States (Denmark, France, Slovenia and UK) were not revised. Caps proposed by the new Member States were most strongly corrected downward (see Capoor and Ambrosi, 2008).

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[1] For the second trading period some Member States unilaterally included also installations emitting nitrous oxide (Capoor and Ambrosi, 2008). Furthermore aviation is included in the EU ETS from 2012 on (Directive 2009/29/EC). While according to Directive 2009/29/EC the inclusion of EU and international flights was planned, the EU now plans derogation from the EU ETS for international flights until 1 January 2014 (European Commission 2012).

[2] The criteria included consistency with the Member State's emission target and projected progress towards fulfilling the target, considerations regarding the activities' (technical) potential for reducing emissions, consistency with other Community legislation and policy instruments, avoidance of unduly favouring certain undertakings (related to State aid provisions), provisions for new entrants, and early action (see Kettner et al. 2008).

Stringency of the allocation caps

The stringency of the emission cap can be interpreted as indication of the environmental effectiveness of the emissions trading system. Our analysis of allocation discrepancies in the EU ETS addresses this issue in the following section. The analysis is based on data on allocated allowances and verified emissions for the period 2005 to 2010 for 26 Member States[3]; separate analyses are carried out for the two trading periods. As Romania did not join the EU ETS until 2007, for Romania values for 2007 are used for the analysis of the first trading phase instead of average values for the period 2005 to 2007.

Method of data analysis

Verified emissions and allocated allowances on installation level from the Community Independent Transaction Log (CITL)[4] are the basis for the analysis of the impact of the EU ETS. We assign these data to sectors using information from the Member States' NAPs.

The analysis of allocation patterns is based on the indicators developed in Kettner et al. (2008):

- the short position and the long position of an installation as the difference between allocated allowances and verified emissions;
- the gross long (short) position of a sector or a country as the sum of all long (short) positions of the installations of a sector or a country;
- the net long (short) position of a sector or a country as the balance of the gross long and the gross short position if the balance is positive (negative), i.e. if the gross long position exceeds (is below) the gross short position.

With the four indicators – gross long, gross short, net long and net short – the differences between allocated allowances and actual emissions, the allocation discrepancies, can be calculated in tonnes or in percent of allocated allowances. A net short position indicates that the emission cap was binding, while a net long position indicates a non-binding cap.

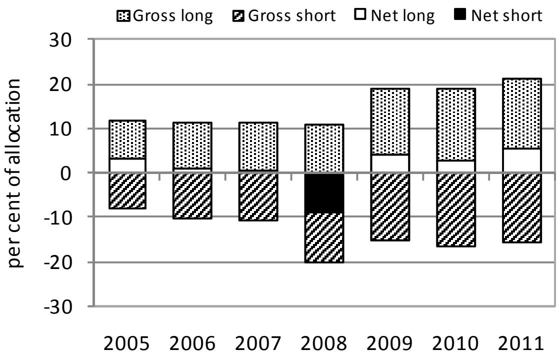
[3] Bulgaria is not included in the analysis as emissions data are not yet available for all years.

[4] Installations covered by the EU ETS need to have an account at the European registry (formerly national registries), in which e.g. the allocation and verified emissions per installation and transactions between installations are recorded. Data collected by the registries are published at the CITL (http://ec.europa.eu/environment/ets/).

EU wide cap

In Phase 1 substantial over-allocation of allowances was observed in most EU Member States and the overall EU emission cap was not stringent for any year. Due to rising ETS emissions and constant allocation over Phase 1 the surplus of allowances declined continuously over the years with rising production growth: While the EU ETS was in a net long position of 3.5% in 2005, for 2006 and 2007 net long positions of 1.2% and 0.7% were observed respectively (Figure 1).

Figure 1. Stringency of the EU-wide cap



Source: CITL; own calculations.

For Phase 2 the European Commission exerted its authority in taking more influence in the NAPs (see above). For 2008, total allocation was reduced by 233 Mt (11%) compared to Phase 1. Emissions, in contrast, only declined by 2% between 2007 and Phase 2 (see Table 1).

Table 1. Development of allocated allowances and emissions in the EU ETS in Mt by sector

	Allocation					Emissions				
	Phase 1	**2008**	**2009**	**2010**	**2011**	**Phase 1**	**2008**	**2009**	**2010**	**2011**
EU	**2,023**	**1,790**	**1,791**	**1,803**	**1,801**	**1,987**	**1,949**	**1,719**	**1,752**	**1,699**
Cement and Lime	186	197	199	202	202	180	179	144	145	144
Ceramics	16	16	17	17	17	13	12	8	8	8
Glass	21	20	20	21	21	19	19	16	17	17
Iron and Steel	189	200	200	200	201	157	157	111	135	131
Power and Heat	1,210	953	945	947	945	1,269	1,218	1,104	1,102	1,068
Pulp and Paper	40	40	41	42	42	32	32	29	31	29
Refineries	148	144	144	148	148	138	141	134	131	129
Other	192	204	208	210	208	162	176	159	169	158
Non-specified	21	17	17	17	17	16	15	14	15	14

Source: CITL; own calculations.

When emission caps were determined average annual GDP growth rates of 2.2% were assumed for the second trading phase. Under these presumptions and the stronger intervention of the EU Commission in National Allocation Plans the cap was set well below the cap of the pilot phase, in a way – it was thought – that would guarantee scarcity of emission certificates in the second trading period. For 2008 the overall EU cap was binding with verified emissions exceeding allocation by 8.9%. If assumed economic growth rates had been realized this would have implied an increased incentive for emission abatement measures resulting from a binding cap and rising allowance prices. For 2009, however, the unexpected exogenous shock of the economic crisis, reflected in a decline of GDP by 4% compared to the previous year, translated into a sharp drop in verified emissions. Allocation again exceeded verified emissions resulting in a total net long position of 4.0%. Although in 2010 the economy started to recover which also resulted in a modest rise in emissions, the EU wide emissions cap was again not binding. For 2011, the surplus of allowances further increased due to the warm winter and still modest economic growth. These results for the second trading period point at the difficulties of ex ante set caps when considerable uncertainty of future economic development prevails.

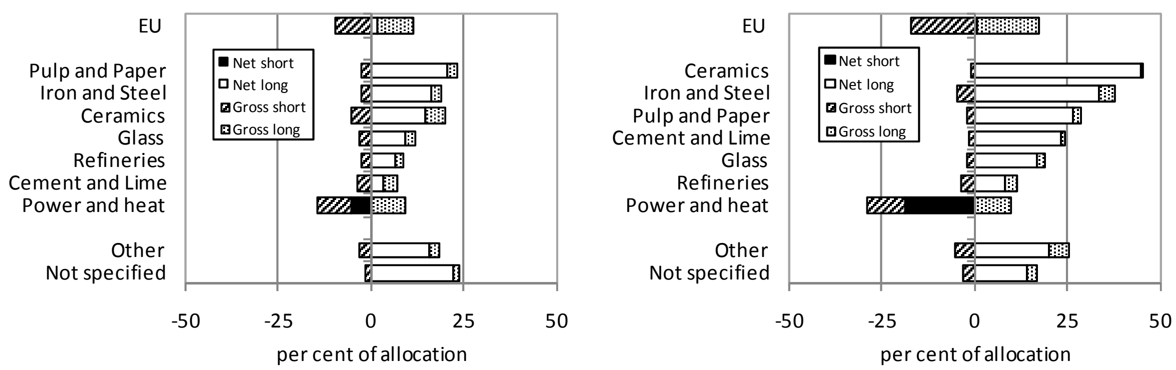
Sectoral caps

In the following, we analyze allocation patterns on sector level. We differentiate between the sectors ‘power and heat’, ‘cement and lime’, ‘iron and steel’, ‘refineries’, ‘pulp and paper’, ‘glass’ ,‘ceramics’ as well as ‘other’ sectors and ‘non-specified’ sectors. The category ‘other’ sectors comprises combustion installations from sectors other than specified, e.g. in the textiles or food industries; the category 'non-specified' includes all installations that we could not assign to a particular sector because of lacking specifications in the NAPs.

With respect to allocated allowances the sector ‘electricity and heat’ dominates the EU ETS in both trading phases (Table 1). In Phase 1 almost 60% of EU allowances accrued to this sector. The sectors ‘iron and steel’ and ‘cement and lime’ each accounted for approximately 9% of the total allowances. In Phase 2 the power and heat sector’s share in EU allocation declined by 6%. The shares of the other sectors in turn slightly increased, especially for the sectors ‘iron and steel’ and ‘cement and lime’[5].

Figure 2 compares the (sectoral) allocation discrepancies in Phase 1 and Phase 2. In Phase 1, the EU ETS on aggregate was in a net long position of 1.8% (37 Mt) resulting from a gross short position of 9.6% and a 11.4% gross long position. In Phase 2, we observe a net long position of 0.9% (65.4 Mt) resulting from a 16.7% gross short position and a 17.7% gross long position. The sector ‘power and heat’ has been the only sector in a net short position in both trading phases. The net short position of the energy sector was even more pronounced in the second trading phase (20% compared to 5% in the EU ETS pilot phase) illustrating also its lower share in allowance allocation as described above. All other sectors in contrast showed (partly pronounced) surpluses of allowances in both trading periods. The highest surplus of certificates is observed for the sectors ‘ceramics’, ‘iron and steel’ and for ‘pulp and paper’.

Figure 2. Long and short positions by sectors in Phase 1 (left) und Phase 2 (right)



Source: CITL; own calculations.

[5] This implicitly shows the EU Commission's considerations of the threat of carbon leakage or a loss in competitiveness.

Differences in allocation patterns, i.e. in the stringency of the cap, have already been anticipated before the start of the EU ETS as Criterion 11 in the design guidelines for the NAPs states that sectoral allocation may be differentiated according to exposure to international competition. Sectoral differences in allocation patterns hence were analyzed in different ex-ante and ex-post studies of the EU ETS. Kolhus and Torvanger (2005) e.g. showed sectoral differences in allocation that were motivated by competitiveness concerns. Ellerman et al. (2007) concluded that most Member States put a tighter cap on the energy sector not only because competitiveness issues are not considered important but also because the sector's emission reduction potential is estimated to be considerable. This discussion is also reflected in the new design elements of the EU ETS for the post-Kyoto period defined by the new ETS directive (2009/29/EC). From 2013 on, preferential allocation rules will apply for sectors potentially affected by carbon leakage; i.e. allowances to these sectors will be distributed for free based on sector-specific benchmarks. For the other sectors allowances will be increasingly auctioned (see Kettner et al. 2010).

Sectoral allocation patterns and emission drivers

The EU ETS was introduced with the objective of achieving emission reductions in the regulated sectors in a cost efficient way. Meanwhile there is a lively discussion in economic literature whether or not it effectively achieved abatement or not. Several studies conclude that abatement occurred despite over-allocation of allowances (see above). The analyses have, however, to be interpreted with caution given the uncertainty related to the fact that actual emissions are only compared to an assumed Business as Usual projection, i.e. estimates regarding the counterfactual no-policy case.

We aim to contribute to this discussion by analyzing the development in three energy intensive EU ETS sectors (electricity and heat, cement and lime, pulp and paper) in more detail regarding their production, energy use and CO_2 emissions. We analyze how the selected sectors were affected by the economic development and whether changes in emissions were mainly related to changes in output or to other factors as well (e.g. fuel shifts). In the analysis, we apply an exact decomposition approach based on a Laspeyres index model as laid out in Sun and Ang (2000). Simplifying, sectoral CO_2 emissions are the result of the output level (p), energy intensity (energy per output, e) and carbon intensity (CO_2 per energy, c):

(1) $$CO_2 = p \cdot e \cdot c$$

Changes in CO_2 emissions compared to 2005 (ΔCO_2) can be interpreted as the result of the combined effects of changes in the three variables:

(2) $$\Delta CO_2 = \varepsilon_p + \varepsilon_e + \varepsilon_c$$

The effects of changes in the different variables on CO_2 emissions can be calculated according to equation (3) in which the production level is used as example and Δ denotes changes in the variables compared to 2005.

(3) $$\varepsilon_P = \Delta p \cdot e_{2005} \cdot c_{2005} + \frac{1}{2}\Delta p \cdot (\Delta e \cdot p_{2005} \cdot c_{2005} + \Delta c \cdot p_{2005} \cdot e_{2005}) + \frac{1}{3}\Delta p \cdot \Delta e \cdot \Delta c$$

For each component the direct effects on CO_2 emissions (first part of the equation) as well as effects from the interaction with the other parameters are considered.

Changes in the fuel mix may account for a large proportion in emission reductions in electricity and heat supply as well as pulp and paper production. In order to analyze the effects of fuel shifts on emissions in more detail we apply an extended decomposition approach developed by Steckel et al. (2011) that differentiates between different energy sources. Equation (4) describes aggregate CO_2 intensity in year t as the result of the aggregate CO_2 intensity (c) in the base year (2005) and energy flows (E; i.e. final energy consumption for pulp and paper production, transformation input for electricity and heat supply) in the base year and in year t as well as of changes in CO_2 intensities and final energy consumption by energy source ($c_{j,t}$ and $E_{j,t}$ respectively).

The aggregate carbon intensity of energy supply or demand (E) of year t can be expressed as the carbon intensity of the base year multiplied with the change in energy flows plus the changes of emission intensities.

(4) $$c_t = c_{2005} \cdot \frac{E_{2005}}{E_t} + \sum_j \frac{c_{j,t} \cdot E_{j,t} - c_{j,2005} \cdot E_{j,2005}}{E_{j,t}}$$

Equation (4) can be reformulated to equation (5) as $E_{2005} = E_t - \sum_j \Delta E_j$.

(5) $$c_t = c_{2005} \frac{E_t - \sum_j \Delta E_j}{E_t} + \sum_j \frac{c_{j,t} \cdot E_{j,t} - c_{j,2005} \cdot E_{j,2005}}{E_{j,t}}$$

The first part of equation (5) denotes changes in the energy sources shares in the fuel mix; the second part of the equation denotes changes in the carbon intensities of the different energy sources. Hence the difference in aggregate carbon intensity between year t and the base year 2005 (Δc) can be expressed in terms of changes in the fuel mix.

(6) $\Delta c = \frac{1}{E_t}\sum_j \left(c_{j,t} \cdot E_{j,t} - c_{j,2005} \cdot E_{j,2005} - \Delta E_j c_{2005}\right)$ [6]

For the analysis of the three ETS sectors various data sources are used: Data on transformation output and input are taken from the IEA Energy Balances. Emission data stem from the UNFCCC National Inventory Reports 2012. Data on lime production as well as on final energy consumption also are taken from the UNFCCC Reports while for pulp and paper production and cement production the FAO database and data from the U.S. Geological Survey are used respectively. Due to limited data availability for the year 2011 the analysis covers the period 2005 to 2010.

Power and heat

The sector 'power and heat' comprises more than 3,000 installations in all Member States. In the first trading phase on average 1,209 million allowances p.a. were allocated to installations in this sector; annual emissions amounted to 1,269 Mt. The sector was hence in a net short position of 5%. Installations from Germany accounted for 31% of the total allocation to this sector, Poland for 20% and 14% of allowances accrued to installations in the UK (see Figure 6 in the Appendix). Differences in the share of allocated allowances do not only reflect differences in the size of countries but also in the structure of the energy sector: As electricity production in France is mainly based on nuclear energy whereas the German power sector relies heavily on coal, Germany's share in allocated allowances is eight times as high as France's.

On average, in Phase 1 the 'power and heat' sector was in a net short position in eleven countries. The highest relative net short position arose in Spain with 52%. The highest net short position in absolute terms showed for the UK with 43 Mt. The energy sector installations of the remaining 15 countries were in a net long position in the first trading phase.

In Phase 2, on average 947 millions of allowances p.a. were allocated to the energy sector and 1,123 Mt of emissions were verified. As indicated in Figure 6 in the Appendix, the sector 'power and heat' was in a net short position in 16 out of the 26 countries. The highest net short position in percent of allocated allowances arose in Sweden with 145% as a strict cap was imposed on installations in the sector 'power and heat'[7]; the highest absolute net short position accrued to Germany with 89 Mt.

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[6] The residuals ($R = p_{2005} \cdot e_{2005} + \frac{1}{2}(\Delta p \cdot e_{2005} + \Delta e \cdot p_{2005}) + \frac{1}{3}(\Delta p \cdot \Delta e)$) have to be subtracted from both sides of the equation.

[7] The reason for the restrictive allocation of allowances were the higher emission reduction potential in electricity and heat generation and that the sector is "not exposed to competition from other countries outside the European trading scheme to any significant extent" (Swedish Ministry of Sustainable Development, 2006, p. 28f)

Compared to the first trading phase a slightly higher spread of allocation discrepancies, i.e. more pronounced gross long and gross short positions, were observed within Member States. The overall spread of long and short positions remained, however, small within the sector. The stringency of the sectoral cap could provide incentives for greenhouse gas emission abatement in the sector. In the following section we therefore aim at providing evidence whether technological change in electricity and heat supply (i.e. increases in energy efficiency or fuel shifts) occurred since the start of the EU ETS.

Changes in emissions from electricity and heat generation are caused by changes in final energy demand as e.g. triggered by the economic crisis, weather conditions or by fuel shifts. Fuel switching to less carbon intensive energy sources or the choice of the dispatch order[8] of power stations is regarded as the most important short-term option for reducing emissions in the power sector (Rickels et al. 2010).

For the analysis of CO_2 emissions we use three indicators: transformation output, energy intensity (transformation input per transformation output), and CO_2 intensity (CO_2 emissions per transformation input).

As illustrated in Figure 3(a), in 2006 and 2007 small increases in emissions are observed: increases in transformation output (ε_p) and carbon intensity were partly offset by an increase in energy efficiency (ε_{EI}). In 2008, in contrast, emissions were 5% below 2005 levels. The main driver for the decline in CO_2 emissions is a reduction in carbon intensity. For 2009, a decline in CO_2 emissions by nearly 10% is found. The emission reduction in this year mainly resulted from declining transformation output and declining carbon intensity. Despite a pronounced increase in transformation output between 2009 and 2010, CO_2 emissions grew only moderately due to higher energy efficiency and a stronger shift towards low carbon energy sources.

Since 2005, the carbon intensity of the sector power and heat has generally been decreasing in the EU, while there have only been minor changes with respect to energy efficiency. As indicated in Figure 3(b) since 2005 the share of coal used in electricity and heat supply decreased while the share of renewables increased, which led to considerably lower CO_2 emissions. A decreasing share of nuclear energy in the fuel mix, however, dampened this effect. To which extent the substitution of coal by

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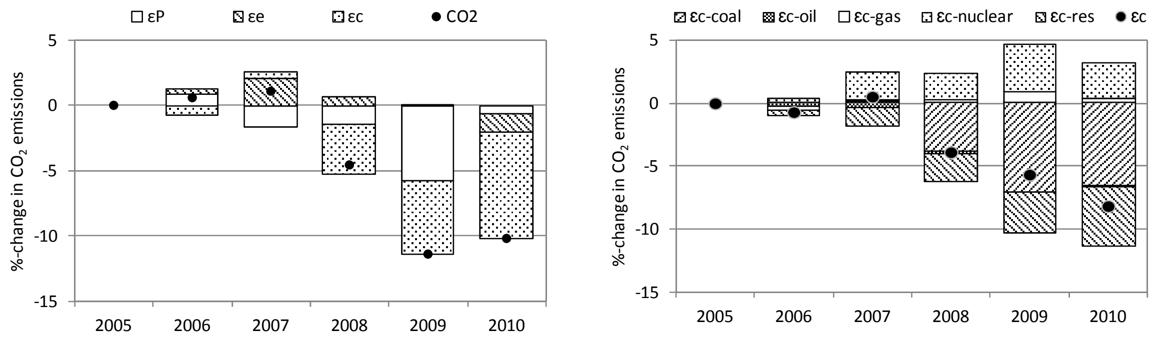
[8] The dispatch order defines the sequence at which different power plants are put in operation which – from the economic perspective – is strongly affected by the respective generation costs. This is especially relevant for the choice between coal and natural gas.

renewables has been induced by the EU ETS or by other policy instruments is beyond the scope of our analysis.

Figure 3. Decomposition analysis of CO_2 emissions from power and heat

(a) Total changes *(b) Changes due to fuel shifts*



Source: UNFCCC (2011), IEA; own calculations.

Cement and lime

The sector ‘cement and lime’ comprises more than 470 installations from 24 Member States. No installations from Latvia and Malta are included in this ETS sector. In Phase 1 on average 186 million allowances p.a. were allocated to installations in this sector; annual verified emissions from cement and lime production on average amounted to 180 Mt indicating the generous allocation for this sector on EU level. Spain, Germany and Italy together accounted for more than 45% of allocated allowances (see Figure 7 in the Appendix). In Phase 1, the sector ‘cement and lime’ was in a net short position in five countries. In the remaining 19 countries the sector was in a net long position; in three countries, allocated allowances exceeded verified emissions for all installations in the sector in the first trading phase. The spread of allocation discrepancies is rather small for most Member States (see Figure 7 in the Appendix).

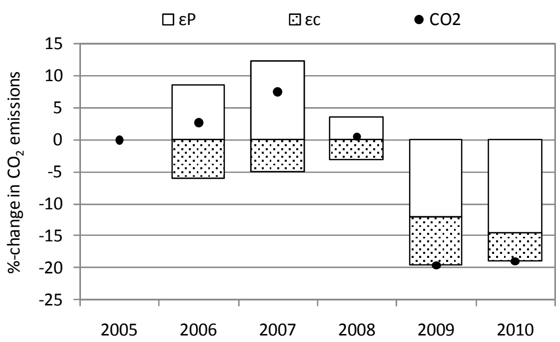
In Phase 2, on average 200 million allowances p.a. were allocated to installations in the sector ‘cement and lime’ and 153 Mt of CO_2 emissions were verified. The sector was thus in a net long position in all countries as illustrated in Figure 7 in the Appendix. The highest relative net long position accrued to Romania with 44%, the highest net long position in absolute terms showed for Spain with a surplus of 11 million allowances. In five countries allocated allowances exceeded verified emissions for all installations. Overall, the spread of allocation discrepancies is negligible for most countries except for

Austria, Slovenia and Estonia. In the third trading phase, allocation for the sector will be based on benchmarks instead of auctioning as the sector has been identified to be at the risk of carbon leakage (see Commission Decision 2010/2/EU). The potential risk of carbon leakage might also have been the reason for ‘generous’ allocation in the first two trading phases. Whether abatement activities were set despite over-allocation is analyzed in the following.

The financial and economic crisis considerably affected the European construction industry with a reduction in economic activity also in the supplying sectors such as cement and lime production: Between 2008 and 2009, gross value added of the construction industry decreased by 9% while cement and lime production fell by 15%. We use two indicators to explain changes in the sector’s CO_2 emissions: output and CO_2 intensity (CO_2 emissions per output).

Figure 4 summarizes the effects of changes in cement and lime production (ε_P) and carbon intensity (ε_c) on CO_2 emissions in the period 2005 to 2010: Until 2007 output continuously increased. This effect could only partly be set off by decreasing carbon intensity due to higher clinker imports[9]. Along with decreasing construction activity in 2008 and the subsequent years also cement and lime production declined. In 2009 and 2010, CO_2 emissions from cement and lime production are almost 20% lower than in 2005. This reflects the drop in output in the course of the economic crisis on the one hand and an improvement of the CO_2 intensity on the other hand, which suggests that the share of imported clinker in European cement production has increased.

Figure 4. Decomposition analysis of CO_2 emissions from cement and lime



Source: UNFCCC (2011), U.S. Geological Survey (2009, 2010); own calculations.

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[9] According to UNFCCC data the CO_2 intensity of clinker production – which is the basis for cement production – has been almost constant since 2005.

Pulp and paper

The sector 'pulp and paper' covers more than 700 installations in 22 EU Member States. For Luxembourg and Malta no installations are included in this sector. In the first trading phase, on average 40 million EUAs p.a. were allocated to the sector, while only 32 Mt CO_2 emissions were verified. As indicated in Figure 8 in the Appendix more than 45% of the sector's allocated allowances accrued to installations in Germany, Spain and Italy. Pulp and paper production was in a net short position only in Italy and Latvia in the first trading period; in the remaining 20 countries the sector was in a net long position (see Figure 8). In four countries, allocated allowances exceeded verified emissions for all installations in the ETS pilot phase. Generally, the spread of allocation discrepancies within Member States is also small for this sector.

In Phase 2, 41 million of allowances p.a. were allocated to installations in the sector 'pulp and paper' and 30 Mt of emissions were verified. For all countries, the sector is in a net long position in the second trading phase as indicated in Figure 8. In two countries, allocated allowances exceeded verified emissions for all installations in the period 2008 to 2011. The spread of allocation discrepancies within Member States further decreased compared to the first trading phase. In the Kyoto commitment period, only for Estonia a considerable spread among installations is observed. Pulp and paper is also a sector considered to be exposed to the risk of carbon leakage (Commission Decision 2010/2/EU); competitiveness concerns might hence also have been a reason for surplus allocation in the first and second trading phase.

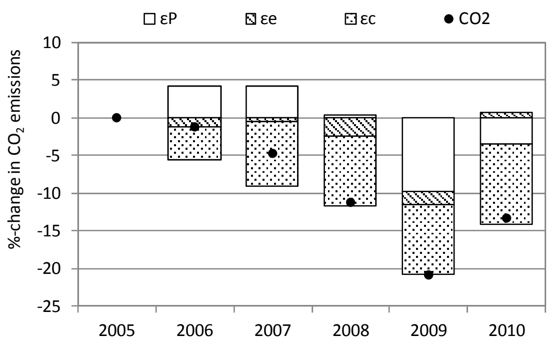
We analyse which factors contribute to changes in CO_2 emissions since the start of the EU ETS. For the decomposition analysis of CO_2 emissions we use three indicators: production, energy intensity (final energy consumption per output) and CO_2 intensity (CO_2 emissions per final energy consumption).

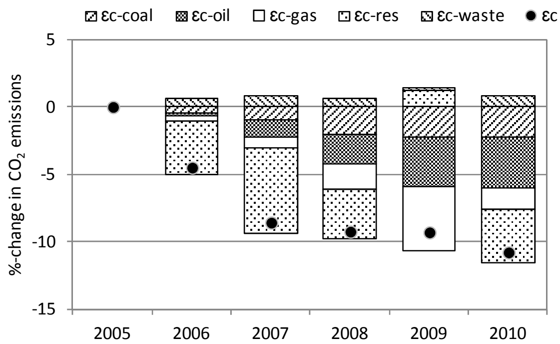
CO_2 emissions from pulp and paper production continuously declined between 2005 and 2009 (Figure 5(a)). A central driver for the decline in emissions has been the decreasing CO_2 intensity (ε_c) whereas the influence of changes in energy intensity (ε_e) have a less clear influence. The additional decline in CO_2 emissions in 2009 compared to 2008 reflects the drop in production (ε_p) in the course of the economic crisis. In 2010 pulp and paper production recovered compared to 2009 but was still lower than 2005, leaving CO_2 emissions at a somewhat lower level than 2008.

Fuel switching is an important strategy for (short-term) emission reductions in pulp and paper production. Figure 5(b) summarizes two effects: A decrease in the share of emission intensive fuels has an emission reducing effect just as an increase in the share of low emission fuels (biomass and gas). Biomass has been increasingly substituting fossil energy sources in the sector except for 2009, where gas substituting emission intensive fuels has been the driving force for declining carbon intensity.

Figure 5. Decomposition analysis of CO_2 emissions from pulp and paper

(a) Total changes *(b) Changes due to fuel shifts*





Source: UNFCCC (2011), FAO; own calculations.

Conclusions

Our analysis discloses marked differences in sectoral allocation patterns in both trading phases: We find that the power and heat sector is the only sector in a net short position while the remaining sectors show rather pronounced net long positions. In the sectors 'cement and lime' and 'pulp and paper' in contrast no national cap was binding in the second trading phase. Generally a stricter cap on the power and heat sector is supported as the threat of carbon leakage is small compared to other industries and thus costs can be passed on to end users and abatement opportunities are considered significant.

The disaggregated analysis of individual ETS sectors since the start of the EU ETS reveals pronounced disparities in their development regarding energy use and emissions, which also points to differences in the respective abatement options. The data for cement and lime production show changes in CO_2 intensity. For paper and pulp production improvements in energy and emission intensities can be observed and to a lesser extent for power and heat generation. However, the significant fall in emissions in 2009 is almost exclusively related to the shrinking output. Our results indicate emission reducing activities in the sectors considered. From our analysis it is however not possible to clearly attribute these activities to the EU ETS, versus the impact of other policies (e.g. promotion of renewables). Furthermore the results point to short term activities like a change in the fuel mix or an increased import of inputs.

Acknowledgements

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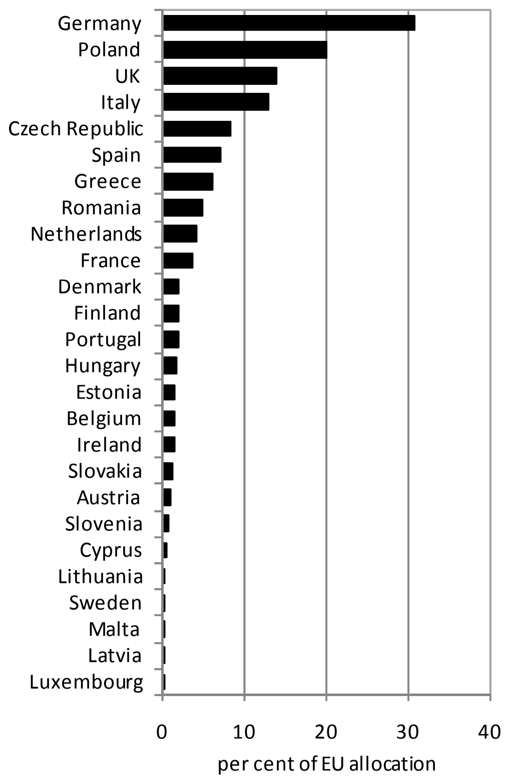
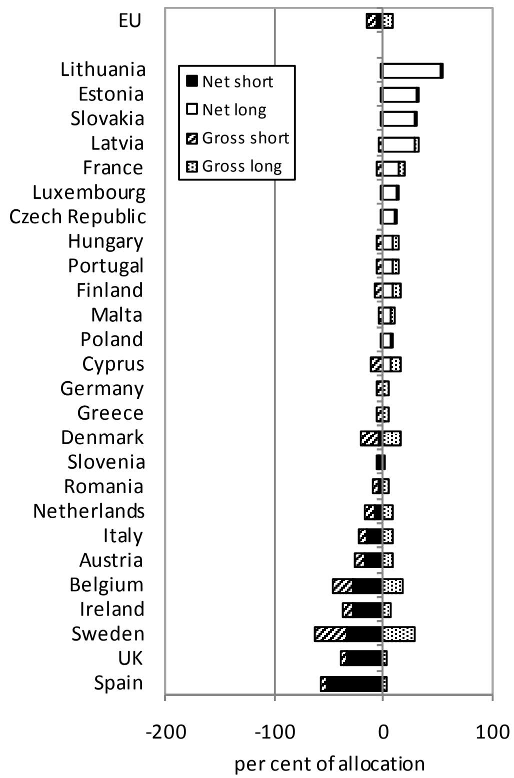
Appendix

Figure 6. Power and heat

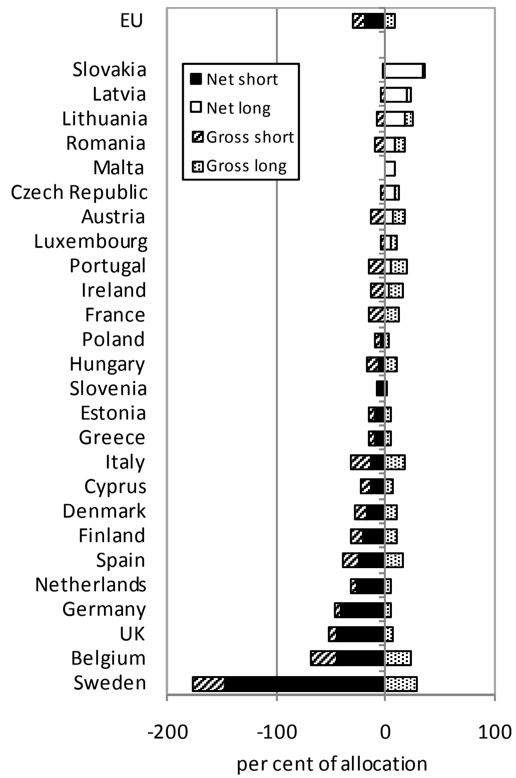
(a) Countries' shares in EU allocation



(b) Long and short positions in Phase 1



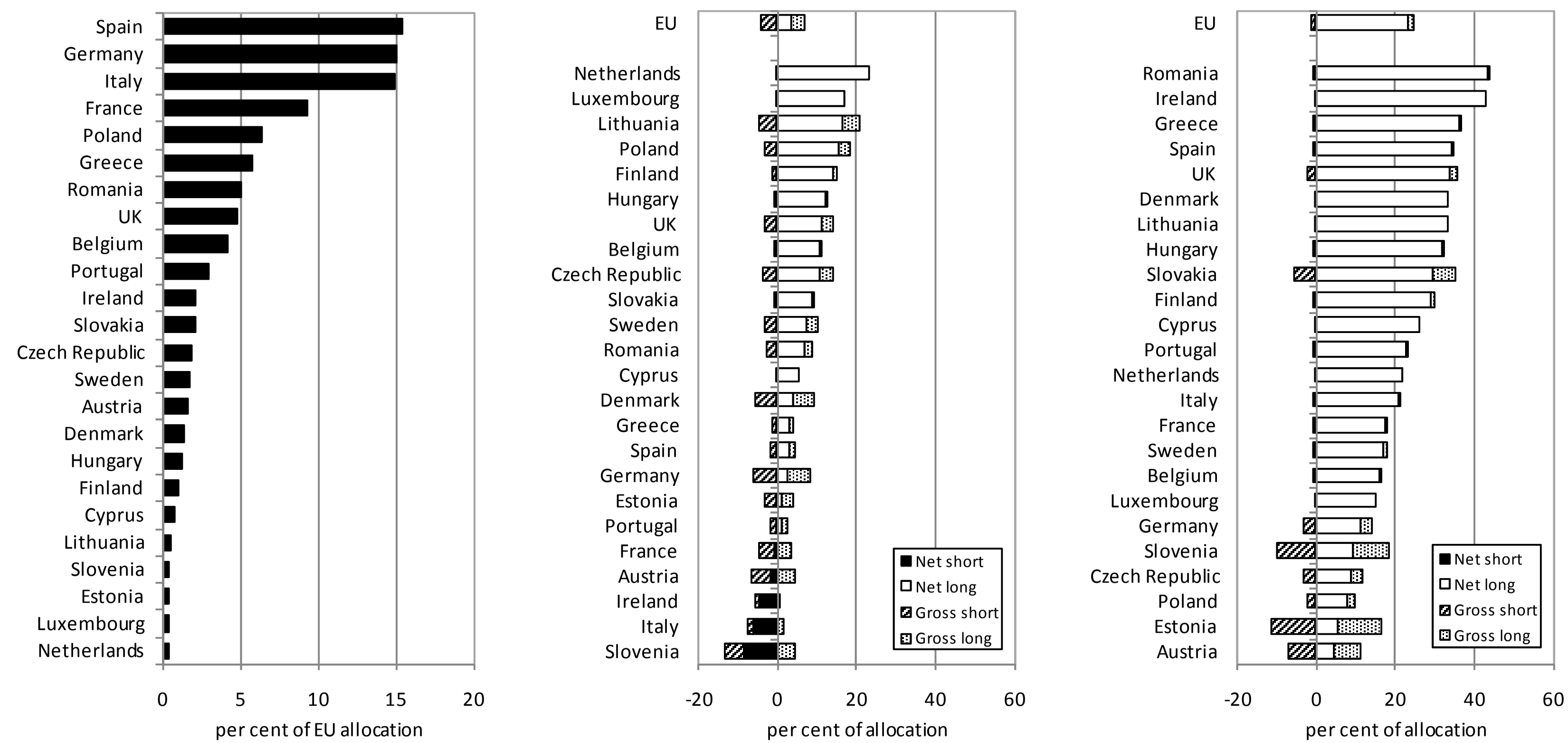
(c) Long and short positions in Phase 2



Source: CITL; own calculations.

Figure 7. Cement and lime

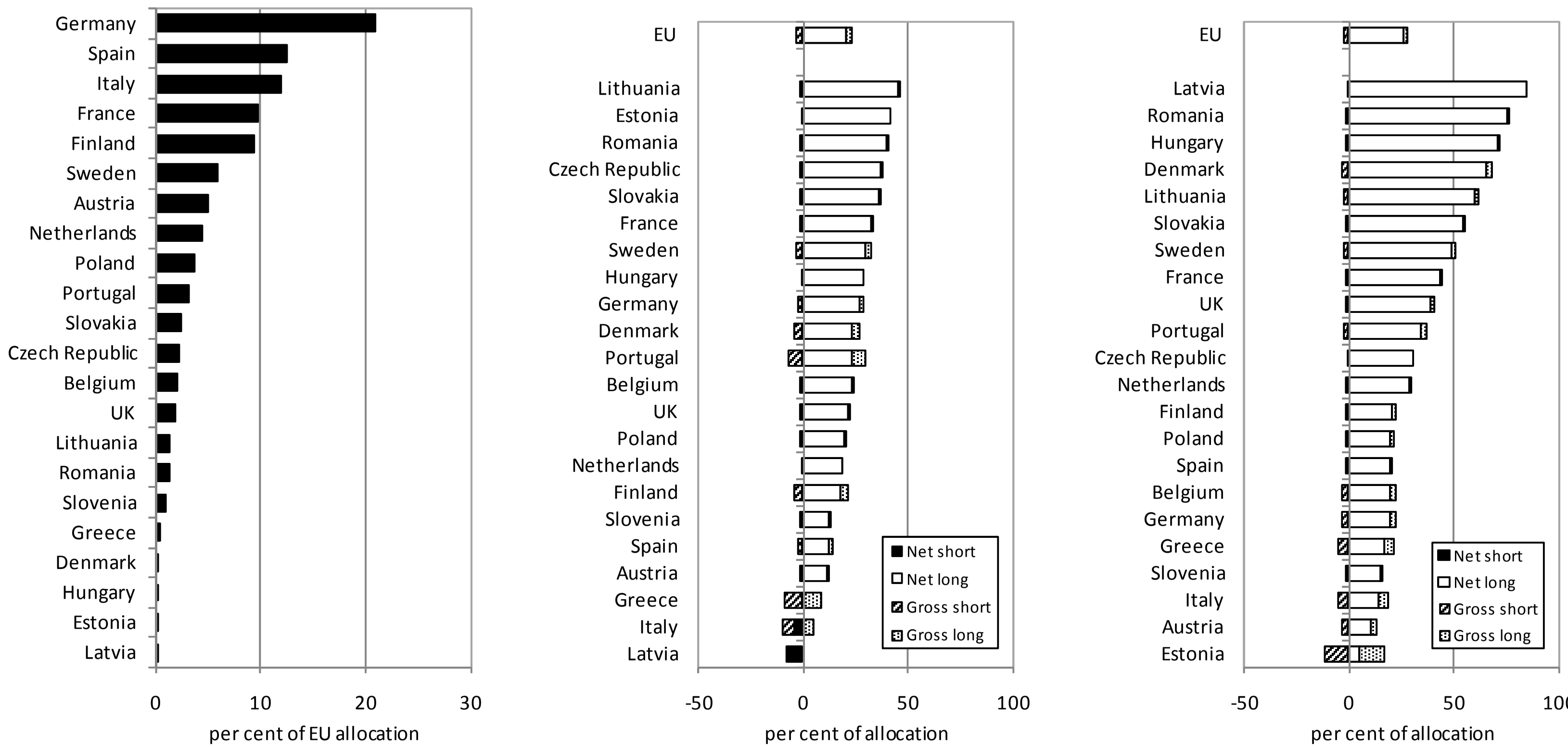
(a) Countries' shares in EU allocation *(b) Long and short positions in Phase 1* *(c) Long and short positions in Phase 2*



Source: CITL; own calculations.

Figure 8. Pulp and paper

(a) Countries' shares in EU allocation *(b) Long and short positions in Phase 1* *(c) Long and short positions in Phase 2*



Source: CITL; own calculations.