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The UK Climate Change Levy Agreements:

Combining negotiated agreements with tax and emission trading

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Abstract

The paper describes the recent implementation of the UK Climate Change Levy Agreements and discusses their environmental effectiveness and cost efficiency. They are negotiated agreements covering the energy-intensive sectors, which are combined with a tax and an emission trading programme. We show how the combination with the tax leads to a better environmental effectiveness and how the combination with emission trading improves the cost efficiency. Nevertheless we conclude that the performances of the policy mix would not be affected by the absence of NAs.

Keywords: negotiated agreements, climate change, energy tax, emission trading.

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1. Introduction

This chapter deals with the negotiated agreements (NAs) recently launched in the UK to reduce greenhouse gas emissions in the energy-intensive sectors. These agreements are part of a comprehensive policy, the UK Climate Change Programme, which was presented in 2000. The overall programme plans to reduce greenhouse gas emissions by 23% beyond 1990 levels, to 2010. This is more ambitious than the UK target under the EU burden sharing agreement related to the Kyoto Protocol, which requires a reduction of 12,5%. Even if all sectors (business, domestic, transport, agriculture and public sector) are affected, the measures aiming at reducing industrial emissions are in the heart of the overall programme. The industry should contribute to no less than 50% of the total expected reductions whereas in 2000 it contributes to 20% of the total emissions. A peculiarity of the UK programme is the use of a broad range of policy instruments: market-based instruments (energy tax, emission trading, auctions), command and control regulations (minimum renewable energy use requirement, energy efficiency objectives) and negotiated agreements.

In this chapter, we consider one part of the overall UK programme. We focus on energy-intensive industrial sectors that are covered by a policy mix consisting of NAs with tax rebate and emission trading. Our aim is to make a preliminary assessment of the cost efficiency and the environmental effectiveness of this part of the programme, which is centred, on NAs. It should be underlined that the evaluation is purely ex ante since it is essentially based on theoretical arguments. The reason is basically that CCLAs have just been signed. We show how the combination of NAs with a tax rebate secures the environmental strictness of the negotiated targets and how it provides an incentive to comply. The combination with emission trading ensures the cost efficiency of the instrument. This leads us to a positive judgement on the expected performance of the policy mix. However, we raise a critical question: what is the contribution of NAs to this positive outcome? Or put differently, what would have been the performances of the policy mix in the absence of NAs, that is a policy mix limited to a tax combined with emission trading? More or less, the same, since the environmental strictness is basically secured by the tax and cost efficiency is achieved through emission trading.

Section 1 is devoted to the characterisation of the NAs and their articulation with the other instruments. Section 2 analyses the environmental effectiveness of these NAs, using economic arguments to demonstrate how the combination with the energy tax could improve it. Section 3 explains how the coupling with emission trading increases the economic efficiency of NAs even if efficiency concerns arise from the connection of different markets. Lastly, we analyse the contribution of the NAs in a concluding section.

1.1. Description of the agreements

Agreements essentially consist in quantitative objectives of energy use reduction to be met by 2010. Until now, 43 trade associations have signed a Climate Change Levy Agreement (CCLA) covering the emissions of more than 7000 firms or industrial sites. Their contribution to the overall British Climate Change policy is quite significant. They are expected to represent more than 25% of the reductions in industry. It corresponds to a reduction of 9 Mt CO_2 below Business-as-usual by 2010.[1] As the CCLAs are estimated to cover a total of 75Mt CO_2 (nearly 44% of total UK industry emissions), this will result in an average 12% reduction below 2000 levels.

As their name suggests, these agreements are intimately linked with an energy tax launched in April 2001: the Climate Change Levy, The tax targets downstream energy consumption by industry and covers all types of energy sources (electricity, gas, coal and LPG) but fuel oil, which is targeted by another tax[2]. The key point is that signing a CCLA offers to the participating firms a 80% tax rebate.

The combination of the CCLAs with the tax is the result of the willingness of the British government to reduce the tax burden for energy-intensive firms. Ten industrial sectors were initially identified by the UK government to be eligible for the scheme: aluminium, cement, ceramics, chemicals, Food and drink, foundries, glass, non-ferrous metals, paper and steel. This choice was based on IPPC[3] criteria to select energy-intensive industries. However criteria have been relaxed to include similar installations not covered by the IPPC regulation. The list of the sectors covered (which can be found in Table 1) by a CCLA is in the end much larger: indeed, the agribusiness and the motor industry are included even if these sectors are not particularly energy-intensive. While the participation to CCLAs was voluntary, all eligible sectors have opted for a CCLA.

1.2. The nature of the commitments

Agreements share a common design across sectors even though they have been modified where necessary to reflect particular circumstances. They are two-tiered agreements[4] comprising an umbrella agreement negotiated between the former Department of the Environment, Transport and the Regions (DETR)[5] and the sector association and sub-agreements ("underlying agreements") between the DETR and individual companies. The umbrella agreement includes sector wide targets while underlying agreements specify individual objectives consistent with the sector wide targets.

The quantitative targets of the CCLAs could be expressed in four ways: energy per unit of output, absolute energy consumption, carbon emission per unit of output, absolute carbon emission. In practice, almost all sectors have opted for primary energy use targets for

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[1] According to energy consultants ETSU, mandated by the government to conduct the negotiation with sector associations.

[2] The CCL rates are: 0.43p/kWh for electricity, 0.15 p/kWh for gas, 1.17p/kg for coal and 0.96p/kg for LPG. This tax indirectly awards a price to the emission of a ton of CO_2, from 3.04 to 9.77 £ per ton of CO_2. The focus of the paper is not the evaluation of this tax. However, it is worth mentioning that different tax rates prevent equalising marginal abatement costs. This has been pointed out by the Royal Society (2002).

[3] Integrated Pollution and Prevention Control. See the chapter by Albrecht for a description of the IPPC directive.

[4] In fact, another type of agreements was offered to the choice of industry but was hardly adopted. It consisted in an agreement limited to the collective commitment by the sector association to meet a sector specific target without burden sharing between individual companies. One possible explanation for this design being rejected by industry is the fact that the option was based on a mechanism of collective compliance: a firm could lose the exemption, even if it has complied with the target in the case the whole sector fails to comply.

[5] Now overseen by the Department for the Environment, Food and Rural Affairs (DEFRA).

practical reasons: energy consumption is already monitored. Only two sectors agreed on targets expressed in specific carbon emissions: aluminium and metal packaging.[6] And all but two sectors have opted for relative targets, i.e., a percentage of energy efficiency improvement per unit of output. The two exceptions are the aerospace and steel industry, which have committed for absolute targets, irrespective of their production level. In fact relative targets act as an insurance mechanism against the fluctuations of the future production level. In case of an increase of production, a firm subject to a relative target will have to make less effort to comply than a firm subject to an absolute target. In compensation, a firm subjected to a relative target will not benefit from a decrease of its production level whereas a firm subject to an absolute target will do less effort to comply. Relative targets prevent fluctuations of the future production levels to affect compliance efforts. Given this, a possible explanation of the choice of the steel and aerospace industry might be that they expect their production to decrease in the coming decade.

Of course, relative targets are specific to each sector depending on many criteria: growth rate, hypothesis on technological evolution, market structure, negotiating skills of the sector association… The baseline year, the targets refer to is also sector specific because of differences across sectors in terms of energy data availability or early actions of energy efficiency. As a result, the sector targets are very heterogeneous as shown in Table 1.

The agreements include the possibility for renegotiating the targets in 2004 or in 2008. However, the precise renegotiation procedure has not yet been defined. Even if renegotiation could add flexibility, it could also lead to a higher uncertainty on the environmental impact of the scheme.

1.3. Monitoring and enforcement aspects

In comparison with Negotiated agreements observed in France, or Germany for instance (see OECD, 1999), the British CCLAs include a complete monitoring and enforcement apparatus. In addition to the final 2010 target, agreements set interim targets for each of the two-yearly milestones (2002, 2004, 2006 and 2008). Renegotiations of the targets are allowed at the second and fourth checkpoints (2004 and 2008). For each milestone, individual firms or sites have to report energy and production data to their sector association. Independent crosschecks will be undertaken by the DEFRA. As far as enforcement is concerned, the key feature of CCLAs is that they are both based on a collective liability principle through the umbrella agreement and an individual liability principle through the agreements signed with individual companies. More specifically, if the sector target is met, there is no further action. Otherwise the non-compliant members are identified and have to make a case to DEFRA for a retention of discount[7].

[6] The aluminium sector has chosen to refer to carbon because carbon savings not only come from improvements in energy efficiency but also from reductions in process related carbon and other greenhouse gases

[7] If a firm fails to comply, it loses the tax exemption for the next two years but it does not have to pay back the rebate corresponding to the period of non-compliance. At the end of the next period, it could again enjoy the discount if it succeeds to comply with the next interim target. In 2010, if a firm fails to comply with its target, it will have to pay back the whole exemptions it has enjoyed.

1.4. The emission trading programme

Firms, which have signed a CCLA, can voluntarily participate in an emission trading scheme. The programme gives the opportunity to be rewarded with emission credits if they over-comply with their CCLA targets or to buy credits to comply. Put differently, it is a Baseline & Credit scheme of which the CCLA targets constitute the initial permit allocation.

This Baseline & Credit scheme for CCLAs participants is one piece of a broader emission trading programme. The other components apply to other sectors:

- A Cap & Trade scheme with voluntary participation through the auctioning of an incentive to take absolute targets of abatement. The scheme is open to every CO_2 emitters except those covered by a CCLA. The auction took place in March 2002. 34 firms qualified for the incentive and shared among themselves 215 M£ for accepting a total abatement of 4.7 Mt CO_2 to 2006. The incentive rewards each ton of CO_2 with almost 54 £[8].

- A Renewable targets trading scheme which rewards over-compliance with Renewable Obligation Certificates that are convertible into tradable emission permits. This scheme increases the flexibility of the Renewable Obligation Scheme, which imposes to all electricity producers a minimum share of renewable energy use.

- An energy efficiency trading scheme which rewards over-compliance with Energy Efficiency Certificates that are convertible into tradable emission permits. This scheme increases the flexibility of the Energy Efficiency Commitments, which imposes to all electricity and gas suppliers a target of energy efficiency improvements in the domestic sector.

[8] One can possibly infer from the observed clearing price of the auction (54 £/tCO_2) that the energy tax rate (max. 9.77 £ / tCO_2) is too low to have an incentive effect on CO_2 emitters. However, some elements suggest that the auction price is much higher than the marginal abatement cost. In particular, the observed price in the CO_2 market during its first year of operation lies in between 3 and 7£ per ton. This suggests that the auction failed to reveal the competitive price.

Figure 1 summarizes the connections between the different markets. Note that the scheme is expected to be connected to the EU market in 2005.

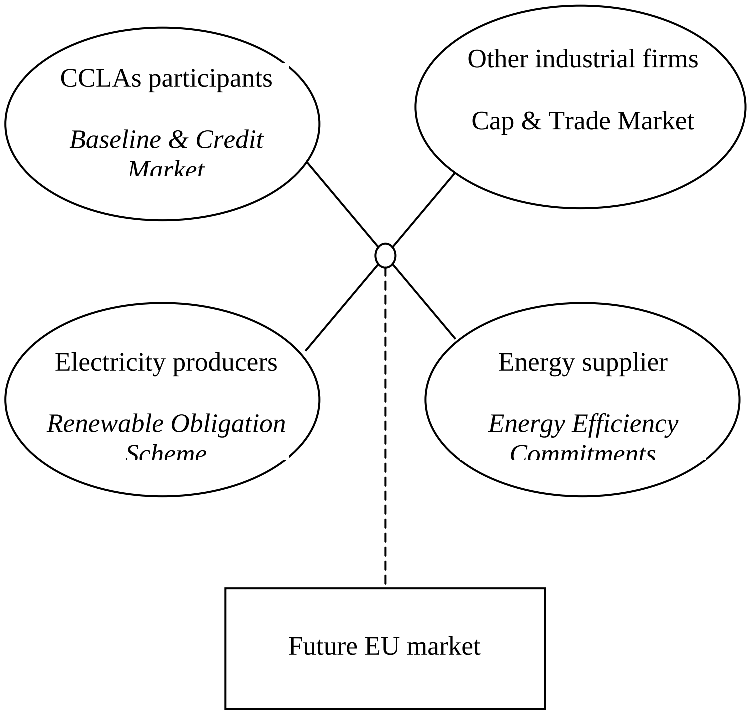

Figure 1. UK emission trading scheme

If CCLA participants over-comply with their targets, they receive emission credits which can be sold to other CCLA participants or converted into tradable emission permits which can be sold to the non-CCLA participants of the emission trading programme. Conversely, they can buy emission credits or permits to comply with their CCLA target.

We have seen that nearly all CCLA participants use relative targets whereas the participants of the Cap & Trade scheme own absolute emission permits. One consequence is that, under particular conditions, it can lead to reduce the environmental outcome of the Cap & Trade market. To preserve the environmental integrity of the Cap & Trade market, a Gateway mechanism has been designed: any transfer of allowances between a relative sector and an absolute sector is subjected to the approval by the public authority. It is allowed if and only if the net total flow towards the relative sector is positive. Given the risk of erosion of the environmental impact through the transfer of permits to the Cap & Trade market, one could wonder why a simple prohibition of any permit transfers between the two markets could not have done the job in a simpler way. The Gateway is seen as a better mechanism, however, since it increases the "thickness" of the market as the number of trade participants is increased by the connection of the two groups. We will analyse further the efficiency of the mechanism in section 4.2.

2. Environmental effectiveness

Environmental effectiveness refers to the ability to achieve an ambitious environmental target. This requires stringent abatement targets and sufficient mechanisms to ensure compliance.

2.1. The controversy on the expected environmental impacts of the CCLAs

CCLAs targets are expected to lead to a reduction of around 12% in the period 2000 - 2010. Is it ambitious? Energy consultants of ETSU, a subsidiary of the company AEA Technology plc were mandated by DEFRA to give assistance during the negotiation process. They have provided some elements to answer the question.

The evaluation of the expected environmental impact of any policy option requires establishing at first a baseline scenario describing what would have occurred without policy. As it is a hypothetical scenario, it is necessary to make many assumptions on parameters like the sector growth rate, the likely technological trajectory etc. In fact, ETSU has compared the CCLAs targets with two reference scenarios:

- A baseline Business-as-usual scenario (BAU) which describes what would have occurred if firms did not change their behaviour. This scenario is basically an extrapolation of the recent trend.
- An All-Cost-Effective scenario (ACE) in which all cost effective measures of energy efficiency are implemented by the companies. In comparison with the BAU scenario, ACE measures include major plant replacement, retrofit of particular components and better energy management. The forecasting of the investments is based on standard assumption of plant replacement schedules on the investment criteria that are believed representative in the particular sector. It also assumes neither restriction on capital availability or on managerial time.

ETSU (2001) has estimated that if all cost-effective measures were implemented in the sectors covered by the CCLAs, it would lead to an annual reduction of 1.1 Mt CO_2. In comparison, the completion of CCLAs targets result in a yearly reduction of 0.7 Mt CO_2 beyond the Business-as-usual scenario. Thus the Agreements will lead to bridge about 60% of the gap between BAU and ACE. Do these figures correspond to strict targets? Basically, the answer depends on the judgement about the strictness of the ACE scenario. On the one hand, it can be viewed as a particular "Business-as-usual" scenario if we assume that companies spontaneously implement cost saving options. On the other hand, the assumptions of unlimited management time and capital availability are very optimistic. To give a reference point, ETSU has estimated that the price effect of the full-rate levy with no agreements would give rise to a saving of 0.07 Mt CO_2 (0.77 Mt CO_2 beyond the Business-as-usual scenario instead of 0.7 MtCO_2). Say differently, the CCLAs is 10% less environmentally effective than the full tax. Based on this evidence, ETSU drew up a very positive assessment of the negotiation outcomes and estimated that the CCLAs targets would lead to real improvements below the Business-as-usual scenario and result in a very modest lowering of the environmental impact in comparison with the full-rate levy.

The Association for the Conservation of Energy[9] disagree with ETSU conclusions. Their view is that CCLAs targets are very close to the BAU (ACE, 2000). They quote two different studies, one made by the European Commission, the other by the Department of Industry and Trade which respectively estimate that the BAU scenario will result in a 9% and 13% reduction of CO_2 emissions by 2010. Comparing those figures with the CCLAs targets (an average 12% reduction in the period 2000 – 2010), their conclusions are far less optimistic.

2.2. Tax rebate: a strong incentive to accept ambitious targets and to comply

Who is right between ETSU and the Association for the Conservation of Energy? It is not possible to conclude without detailed information on the methodology used in the different studies to elaborate the baseline scenarios. To push further the evaluation of the genuine environmental impacts of the CCLAs, we can rely on theoretical arguments. One possible way to proceed is to consider the incentives for the firms to accept strict targets. If these incentives are high, one can assume that targets are strict. In this regard, it is quite clear that the energy tax rebate provides CCLA participants with high incentives to accept ambitious objectives.

The tax also provides incentives to comply since, when found non-compliant, a firm looses its tax exemption for at least two years. As CCLAs are offered to energy-intensive sectors, the financial impact of tax exemption is huge and creates a powerful incentive to comply. Note also that each individual firm has to demonstrate progress on meeting targets in the CCLA every two years with an independent verification check by DEFRA. The probability of being detected in case of non-compliance is thus very high. Hence, simple theoretical arguments suggest that the CCLA design is favourable to environmental effectiveness.

3. Cost efficiency

Cost efficiency is the ability of the CCLAs to meet CO_2 reduction at least cost. This requires the equalisation of marginal cost of abatement among the participants.

3.1. The advantage of a combination with emission trading

In fact, CCLAs targets simply provide the initial allocation of pollution credits between the companies participating in the baseline & credit market. Thus, assuming that the emission credit market is competitive and does not entail significant transaction costs, one can expect an efficient market outcome. We can add that theory suggests that the CCLAs do not contribute to this positive result. More precisely, the Coase theorem establishes that, in the absence of transaction costs, the initial allocation rule has no impact on the market outcome

[9] The Association for Energy Conservation was formed in 1981 by a number of major companies active within the energy conservation industry. It aims to encourage a positive national awareness of the need for and benefits of energy conservation. www.ukace.org

and its efficiency. The initial allocation is just a distributive issue - how the costs are allocated within industry - not an efficiency issue.

These results crucially depend on two assumptions: the fact that the market is competitive and the absence of transaction costs. In the British case, we can expect the market to be competitive, as the number of participants is high. More than 7,000 firms or industrial sites are covered by CCLAs corresponding to a quantity of credits of 75MtCO_2 in the Baseline & Credit market. 34 firms take part in the Cap & Trade market for which 40MtCO_2 of permits have been distributed). The zero transaction cost assumption may be less realistic at least in the short term. At the beginning, participants need time and experience to learn the use of the market mechanism, as this is quite a new instrument for them in the field of pollution. This may prevent some efficient transactions to occur and decrease the efficiency of the instrument. Transaction costs are however expected to decrease, as participants become more familiar with the instrument.

3.2. The Gateway mechanism prevents the contamination of the absolute sector by the relative sector

The market associated with CCLAs is a Baseline & Credit market because CCLAs participants have mostly opted for relative targets. This type of market poses efficiency problems. In fact, relative targets induce inefficiency on the market of goods as they act as an output subsidy. The underlying intuition is quite simple: producing more output is rewarded with extra emission credits. This adds to the marginal benefit of increasing its output a shadow price, which is proportional to the price of the emission credit on the market as shown in the simple model developed in the Appendix.

Furthermore, the Baseline & Credit market is connected with the Cap & Trade market in which participants face absolute targets. On the one hand, this connection improves the cost efficiency in that the market achieves the equalisation of private marginal abatement costs across a higher number of participants. On the other hand, the "output subsidy" effect of the Baseline & and Credit market can contaminate the absolute market. The model presented in the Appendix establishes the particular conditions under which inefficiency rises. This will ultimately depend on the strictness of the targets in the Baseline & Credit market relative to the Cap & Trade market:

- **Case 1**: if relative targets are stricter, the permit price on the connected markets will be lower than the credit price on the relative market. In this case, the connection will reduce the distortion associated with relative targets: connection induces the selling of relative permits on the absolute market thereby increasing the number of absolute permits.

- **Case 2**: if the absolute targets are stricter, the permit price on the connected markets will be higher than the credit price on the relative market and the distortion of relative targets will be higher. Hence the number of relative permits rises along with the output subsidy effect.

In practice, the connection is constrained by a regulatory mechanism: the Gateway. Any transfer of allowances from a relative sector to an absolute sector is subjected to the approval by the public authority. We have seen that is allowed if and only if the net total flow towards the relative sector is positive. It is easy to demonstrate that this constraint on market transactions mitigates the efficiency concerns attached to the connection of both markets. As shown in the Appendix, depending on the relative strictness of the targets in the two markets, the Gateway mechanism has different effects:

- **Case 1**: the Gateway does not allow a net transfer to the absolute sector. A single price on the market can not emerge and the equilibrium is the same before and after the connection. The only effect of the Gateway is that it can increase the fluidity of the markets.

- **Case 2**: the Gateway acts as if the connection was free between the relative and the absolute sectors.

Thus, the mechanism prevents the absolute sector to be contaminated by the inefficiency of the relative targets (case 1) but allows the scheme to benefit from the connection in the absence of contamination (case 2). If markets were efficient, a prohibition on transfers from the relative sector to the absolute sector would simply lead to the same effect: indeed the Gateway mechanism does not allow a net transfer to the absolute sector. It can allow a transfer to the absolute sector if and only if a similar transfers to the relative transfer has already been made. In the case of efficient markets, this sequential transaction (from absolute sector to relative sector, then back to absolute sector) would be equivalent to a transaction within the relative sector and within the relative sector. But in practice, some liquidity problems and sequential transactions may prevent some cost-effective transactions from occurring (Sorrell, 2001). The greater number of participants adds flexibility and the Gateway mechanism, even if a little more complex, could be more advantageous than a simple one-way trading.

In conclusion, our argument is the following. The combination of CCLAs with emission trading improves the cost efficiency of the policy mix in one way: as the negotiated CCLA targets have no reason to minimise the aggregate abatement cost, the market allows for a efficient reallocation of the efforts among CCLAs participants. In another way, the scheme is inefficient in that the market is a relative Baseline & Credit scheme. This type of market de facto generates an inefficient implicit output subsidy. This disadvantage is partly mitigated by the existence of the Gateway mechanism. This mechanism constrains the transactions between the two markets and prevents the inefficiency of the relative market to contaminate the other market.

4. Conclusions

Our analysis leads us to a positive overall assessment of the policy-mix centred on NAs to deal with energy-intensive industrial sectors. We have pointed out how the combination of CCLAs with the energy tax is crucial to secure the environmental effectiveness while the combination with a tradable permits market allows for cost efficient outcomes.

However, this conclusion applies to the whole combination. If the contribution of the tax and of the emission trading scheme to this result is quite clear, the same is not true for the CCLAs. What is their contribution to the overall performance of the policy mix? Or put differently, what would have been the performances of the policy-mix in the absence of NAs?

This calls for a cautious examination of the role of the CCLAs in the policy mix. They are basically the initial allocation mechanism of the Baseline & Credit market. In this regard, they perform two functions. First, they determine the quantity of permits, i.e., the environmental strictness of the scheme. Second, they determine how the permits are distributed among the participants. We have argued that there exists a strong theoretical argument – the Coase theorem – claiming that the second function does not have any efficiency impact and is only a distributive matter. What about the former? In fact, it leads to a new question: what would have been the strictness of the policy mix if NAs had not been used? Of course, the answer ultimately depends on the policy that would have been implemented instead.

A first possible scenario is to consider that the policy would have been restricted to the full-rate energy tax. According to ETSU results that we have commented in the chapter, the global environmental target would have been 10% higher. This is a very modest difference. Moreover, implementing the tax would have raised a strong political opposition by the energy-intensive sectors. Indeed paying the full tax is very costly for them. The measure would have been challenged by industry through an intense lobbying lowering its probability of adoption or diminishing the environmental strictness of the tax. In the end, the environmental impact of the tax could have been lower than that of the CCLAs due to the political constraints.

However given the existence of assumedly tight political constraints, more plausible is a second scenario in which energy-intensive sectors would have relied only on emission trading with a grand-fathering allocation rule. This policy would have been much simpler to implement than the policy mix. It would have reduced the political opposition while being cost efficient. In comparison with this benchmark scenario, the use of NAs seems to complicate the scheme with no obvious efficiency advantages. If the two challenges are to design a climate change policy in energy intensive sectors which is both efficient and acceptable by industry, emission trading would have done the job in a simpler way. In the end, the contribution of NAs to the performance of the British programme is disputable.

Appendix: Relative targets are implicit output subsidies

CCLAs targets and subsequent emission credits are expressed in relative terms – emission reduction per unit of output. It may impede the cost efficiency of the CCLAs policy mix in that this provides an implicit subsidy to output. Gielen, Koutstaal and Vollebergh (2002) have made this point, for instance. A convenient way to introduce it is to use basic microeconomics.

Consider a small and open economy with *n* identical firms. Each firm produces a quantity x of a good and emits a quantity q_0 of CO_2 in the absence of environmental policy. Each firm's production cost is $\Gamma(x)$, with $\Gamma_x(x) = d\Gamma(x)/dx > 0$ and $\Gamma_{xx}(x) > 0$ and the cost to abate a quantity q is $C(q)$ with $C_q > 0$ and $C_{qq} > 0$. For sake of simplicity, we assume that pollution and production are fully separable activities. Hence there is no relationship between x and q.

The firms sell the good at a competitive price p. They participate to an emission trading programme where the price of a unit of emission is p^e.

The reference case: absolute targets

Each firm maximises its profit:

$$\max_{x,q} \left\{ px - \Gamma(x) - C(q) + \left(\frac{Q}{n} - (q_0 - q) \right) p^e \right\} \quad (1)$$

The two first order conditions follow:

$$p = \Gamma_x(x) \quad (2)$$

$$p^e = C_q(q) \quad (3)$$

We observe that, unsurprisingly, the permit price p^e equals marginal abatement cost. The overall cost of abatement is thus minimised. The second condition states that output price p equals marginal production cost. The level of output is thus optimal. These two conditions establish the first best outcome. Is a Baseline and Credit market able to reach this first best outcome? We will see that the answer is negative.

Relative targets

Consider now that the targets are relative. More specifically, assume that each firm has a relative target of r tCO_2 per unit of output.

Its profit maximisation programme is now:

$$\max_{x,q}\left\{px-\Gamma(x)-C(q)+\left(rx-\left(q_0-q\right)\right)p^e\right\} \tag{4}$$

which leads to:

$$p=\Gamma_x(x)-rp^e \tag{5}$$

$$p^e=C_q(q) \tag{6}$$

If we compare these two conditions with Eq. (2) and Eq.(3), which defines the social optimum, we observe that the permit price still equals marginal abatement costs. Hence aggregate abatement cost minimisation holds. However, Eq. (5) differs from Eq. (2) as a new term appears: rp^e. This is the marginal revenue generated by a marginal increase of the level of output due to the extra permits it grants. A permit market with relative targets performs as a subsidy on output, by modifying the price-signal perceived by the firms. The output subsidy effect of the relative targets introduces a distortion on the market of the products.

Trading between relative and absolute sectors

We now assume that we have two disconnected tradable permits markets, one with relative targets, the other with absolute targets. The markets equilibrium is:

- On the market 1 (with absolute targets):

$$\begin{cases} p=\Gamma_x(x_1) \\ p_1^e=C_q(q_1) \\ \dfrac{Q}{n}=q_0-q_1 \end{cases}$$

- On the market 2 (with relative targets):

$$\begin{cases} p=\Gamma_x(x_2)-rp_2^e \\ p_2^e=C_q(q_2) \\ rx_2=q_0-q_2 \end{cases}$$

Connecting these two markets leads to a unique price of the permit:

$$\begin{cases} p = \Gamma_x(\tilde{x}_1) \\ \tilde{p}^e = C_q(\tilde{q}_1) \\ \\ p = \Gamma_x(\tilde{x}_2) - r\tilde{p}^e \\ \tilde{p}^e = C_q(\tilde{q}_2) \\ \\ \frac{Q}{n} + r\tilde{x}_2 = 2q_0 - \tilde{q}_1 - \tilde{q}_2 \end{cases}$$

We distinguish three cases, depending upon the difference between the price of the permit on the relative sector market and on the connected markets:

- **Case 1**: if $p_1^e > p_2^e$, the connection of the two markets has increased the subsidy effect, leading to a greater gap with the optimal level of output and a higher volume of emissions. The relative sector has been encouraged to raise its level of output in order to sell permits to the absolute sector.
- **Case 2**: if $p_1^e < p_2^e$ Connecting the two markets leads to a decrease of the subsidy effect, a smaller gap with the optimal level of output and less emissions.
- **Case 3:** if $p_1^e = p_2^e$, The only effect of the connection is to increase the fluidity of the market as the number of participants increases.

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Sectors	Target by 2010	Base year
Aerospace	-8.5 %	2001
Agricultural Supply	-7.1 %	1999
Aluminium	-32.2 %	1990
Brewing Industry	-11.6%	1999
Cathode Ray Tubes	-21 %	2000
Cement	-25.6 %	1990
Cementitous	-10 %	1999
Ceramics:		
- potteries	-12.4 %	2000
- heavy clay	-10.22 %	2000
- fletton bricks	-8.1 %	2000
- refractories	-10.33 %	2000
- ceramic materials	-10.1 %	2000
Chemicals Industries	-18.3 %	1998
Craft Bakeries:		
- bakery	-9 %	1999
- shop	-4.5 %	1999
Dairy	-9.2 %	1999
Egg Producers	-11.5 %	1995-2000
Egg Products	-9.3 %	1999
Environmental Services	-10.1 %	1999
Food and drink	-8.1 %	1999
Foundries	-11 %	2000
Glass	-9.2 %	1999
Gypsum Products	-7.2 %	2000
Leather	-9.8 %	1999
Lime	-7.9 %	1998
Malting	-7.8 %	1999
Metal Packaging	-9 %	1999
Metal Forming	-7 %	2000
Mineral Wool	-14.9 %	1999
Motor Manufacturers and Traders	-15.3 %	1995
Non Ferrous	-14.7 %	1998
Paper	-24 %	1997
Pig Rearing	-16 %	1995-2000
Poultry Meat Processing	-12.5 %	1999
Poultry Rearing	-13.7 %	1999
Printing	-12 %	2000
Red Meat	-10.8 %	1999
Renderers	-9 %	1999
Rubber Manufactures	-10.3 %	1999
Semiconductors	-59 %	2000
Spirits	-4.5 %	1999
Steel	-11.5 %	1997
Supermarkets	-4.5 %	1999
Surface Engineering	-10.3 %	1999
Textiles	-9 %	1999
Vehicle Builders and Repairers	-10 %	2000
Wallcoverings	-9 %	1999
Wood Panel	-7.3 %	1999

Table 1: Summary of sector targets – source: ETSU (2001)