Allocation of CO_2 allowances and competitiveness: a case study on the European iron and steel industry

Philippe Quirion
CIRED (CNRS/EHESS)
45 bis avenue de la belle Gabrielle
94736 Nogent sur Marne cedex, France
quirion@centre-cired.fr

Keywords

iron and steel, competitiveness, emission trading, greenhouse gas mitigation, exchange rate pass-through, trade elasticities

Abstract

We quantify the competitiveness impact from a unilateral implementation of the European Commission (COM(2001) 581) allowance trading Directive proposal for the iron and steel industry. This sector is arguably the most sensitive among those covered by the proposal, since it is both highly CO_2-intensive and relatively open to international trade.

Uncertainty on the costs of climate change mitigation is very high and the wide gap among results from applied models is not well understood. Rather than building another complex model, we provide a simple and transparent partial equilibrium model of the steel market and we vary both economic parameters (abatement cost, import, export and demand elasticities) and policy variables (sector coverage, allocation method). We are able to determine what results are robust or sensitive to the different parameters. Although extremely simple, our model provides stimulating results for the ongoing negotiation of the allowance trading Directive proposal.

A first strong result is that competitiveness impacts are minor. This issue is thus not a rationale for blocking or watering down the Directive.

Furthermore, a number of amendments proposed to secure industry competitiveness may in fact harm it. First, output-based allocation, put forward by a number of industrial sectors, performs worse than grandfathering and most often worse than auctioning as regards the impact on profit. Second, the opt-out clause, also endorsed by a number of industry lobbies, could harm production and profit in the iron and steel sector by one percentage point, if applied to sectors in competition with steel.

Introduction

Following recent ratifications by the European Union, most other European states, Japan, New Zealand and Canada, the Kyoto Protocol will now enter into force if these countries are joined by Russia. Compliance with the first commitment period of the Protocol (2008-2012) requires a quick implementation of emission reduction measures, given the inertia of most emission sources: in the European Union, according to the *European Climate Change Programme* (European Commission, 2001b), there is a gap in the range of 6.6% and 8% between emission forecasts including existing policies and measures and the Kyoto target. Given the failure of the European Council to agree on a meaningful European-wide tax scheme so far, the European Commission (2001a) proposal for a Directive establishing a scheme for greenhouse gas emission allowance trading is the most ambitious policy proposal currently on the negotiation table to reach the Kyoto target[1].

However the arbitration of the text inside the Commission has been difficult and so is the current negotiation,

1. Boemare and Quirion (2002) provide an appraisal of the Directive proposal in the light of economic literature and international trading experiences.

which involves both the European Council and Parliament in accordance with the co-decision procedure. After an intense debate, both institutions have voted for the text, although with different amendments. The Directive is expected to be adopted in 2003, after conciliation between the Council and the Parliament.

Opposition to the Directive and attempts to water it down are mainly fuelled by concerns about the competitive disadvantage it would allegedly create for European economies vis-à-vis non carbon-constrained countries like the U.S. and developing countries. Wordings such as "competitive disadvantage", "competitive distortion" and "competitiveness" have different meanings but can basically be reduced to two interpretations: first, a loss in market shares, which in turn may induce industrial relocations, domestic employment losses and carbon leakage; second, a loss in profits, hence in stock value, of domestic firms. Of course, if capital markets are imperfect, a loss in profits will lessen investments in regulated firms, thus reducing their market share. Nevertheless it is essential to disentangle these two effects since, as we shall see, different allocation criteria would impact them in a completely different way.

To prepare the Directive drafting and discussion, the Commission ordered four studies: one is qualitative (Harrison and Radov, 2002), two utilise the partial equilibrium models Poles (IPTS, 2000), and Primes (Capros et al., 2001) and the last is based on the bottom-up database Genesis (de Beer and Phylipsen, 2001; Hendriks et al., 2001). The last three studies provided marginal abatement cost curves for each industrial sector, total cost estimates and an optimal burden sharing among European sectors. More recently, Sijm et al. (2002) used Markal Europe, a partial equilibrium bottom-up model, to assess different grandfathering modalities. Regrettably, they did not intend to provide quantitative estimates on the above issues. Last, Maestad (OECD, 2002) developed a partial equilibrium world model of the steel industry and analysed the impact of various carbon taxes on emissions and production for different OECD zones. Unfortunately, the range of abatement measures included in the latter study is limited to increasing the use of scrap steel and to switching from the traditional basic oxygen furnace process to the more energy-efficient electric arc furnace process; no other abatement possibility is modelled for steel production nor for electricity generation, whose emissions are yet assumed to be taxed[2]. As a consequence costs are likely to be overstated. Furthermore no result on profits is displayed.

We thus provide the first quantitative assessment of competitiveness impacts from a unilateral implementation of the European Commission allowance trading Directive proposal for the iron and steel industry. This sector is arguably the most sensitive among those covered by the proposal, since it is both highly CO_2-intensive[3] and relatively open to international trade.

Uncertainty on the costs of climate change mitigation is known to be very high (Hourcade and Ghersi, 2002). Furthermore the wide gap among results from applied models is far from being well understood. Rather than building another complex model, we provide a simple and transparent partial equilibrium model of the steel market and we vary both economic parameters (abatement cost, import, export and demand elasticities) and policy variables (sector coverage, allocation method). We are thus able to determine what results are robust or sensitive to the different parameters.

We first present our model, which is displayed in more depth in an appendix. We then show the results for a central scenario featuring in particular a constant elasticity of demand and a coverage of most energy intensive sectors, as intended by the Directive proposal. It turns out that even under full auctioning, a unilateral implementation of the European Directive would have, at worst, a trivial effect on profit. Production losses could attain 4%, but would be easily alleviated if, as is expected, allowance allocation was as least partly linked to output. We then drop the constant elasticity of demand assumption by linear demand curves, which are consistent with econometric estimates of the "pass-through" ratio in the iron and steel industry. Firms pass only a fraction of costs on to consumers, which reduces profits but lessens the negative impact on market shares. Next, we present possible consequences of exempting from the Directive some of the sectors which are competing with steel. At last, we sum up the results and stress some potentially useful extensions of the present work.

A partial equilibrium model of the European iron and steel industry

In a very simple and transparent partial equilibrium framework[4], we model the market for iron and steel in Europe, including the NACE sectors presented in Table 1.

We thus deal with a composite of various types of products, not with a well-defined commodity such as a certain quality of steel. In addition, our model implicitly includes all the inputs of this industry, especially electricity generation used in the "electric arc furnace" steel production route.

Most studies of adverse industry impacts of environmental policies feature perfect competition on the product market (Bovenberg and Goulder, 2002; Burtraw et al., 2001;

Table 1. Sector boundary (NACE classification).

27.1	Manufacture of basic iron and steel and of ferro-alloys (ECSC)
27.2 A, 27.2 C	Manufacture of cast iron and steel tubes
27.3	First transformation of steel (drawing, rolling, folding…)
27.5 A, 27.5 C	Casting of iron and steel

2. De Beer et al. (2001: 8-16) present many other options to reduce CO_2 emissions in the iron and steel sector, and numerous studies do so for power generation.
3. According to Ecofys (2000) this industry accounts for about 7% of anthropogenic emissions of CO_2. Energy costs typically account to 15-20% of the costs of steel production (OECD/IEA, 2000).
4. The whole model is presented in an appendix. A Mathematica notebook containing the model and all simulations displayed here is available upon request.

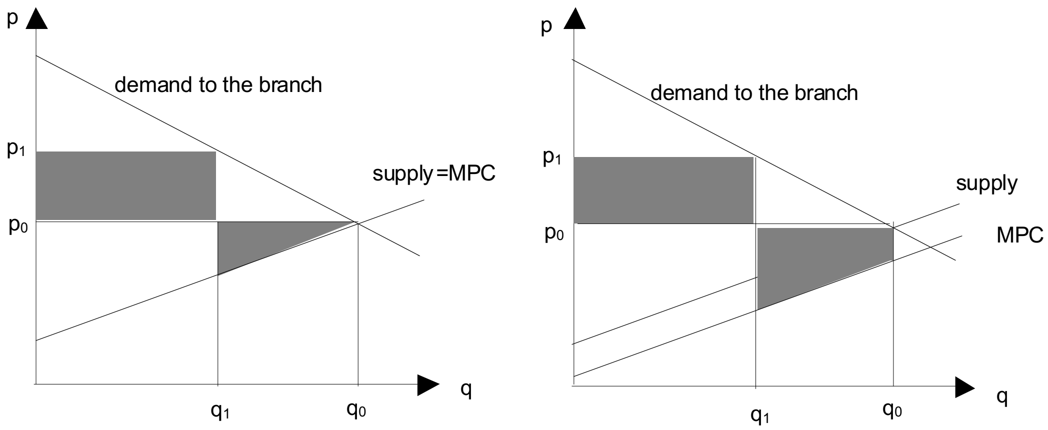

Figure 1. *Neglecting imperfect competition leads to understating profit losses. Left: Perfect competition, right: Imperfect competition.*

OECD, 2002…). However, as shown by the two graphs below, the profit impact of grandfathered permits may be under-estimated by neglecting imperfect competition.

For the sake of simplicity, in both panels (but not in our model) we assume away unitary emission abatement: all the emission reduction comes from a decrease in steel production. A second difference is that in the model, we assume that the marginal production cost is constant, whereas it is increasing in Figure 1. The left panel, reproduced from Bovenberg and Goulder (2002), features perfect competition. After the introduction of freely allocated tradable allowances, production drops from q_0 to q_1 and price increases from p_0 to p_1. The profit loss from the reduced production is indicated by the triangle, the profit gain from the higher price by the rectangle. On the right panel, firms charge a price-cost margin which may originate in product differentiation or in Cournot oligopoly. The same decrease in production entails a much higher profit loss in the right panel case. At the limit, if all regulated firms behave as a perfect collusive oligopoly and maximise their collective profit, any decrease in steel production is profit-reducing, since otherwise the oligopoly would have already reduced its production up to this point.

We take a price-cost margin of 9%, based on Oliveira-Martins and Scarpetta (1999) econometric estimates. In a monopolistic competition framework, this is consistent with a price elasticity of -10 for the demand to the typical firm. We also assume constant returns to scale (whatever the carbon abatement), since there is no empirical evidence in favour of neither increasing nor decreasing returns. The marginal abatement cost curve is approximated from results by two partial equilibrium models of the European economy, Markal (Sijm et al., 2002) and Primes (Blok et al., 2001). Both models simulate emission trading in the whole European industry, not only in the iron and steel sector, which is consistent with the way we utilise their results.

Crucial to the industry impact is the allowance allocation mode. Analytically, three pure methods of allocating allowances have to be distinguished: auctioning, absolute free allocation and output-based allocation:

- when allowances are auctioned, they are allocated to the highest bidders. Various auction methods exist (see Klemperer, 1999, for a general survey or Cramton and Kerr, 2002, for auctioning applied to tradable permits);
- with absolute free allocation, new entrants and expanding firms have to buy their allowances from existing sources. Symmetrically a firm continues to receive allowances forever even if it shuts down its plants. The most common criteria for freely distribution allowances are grandfathering, i.e., a share of historical emissions, and benchmarking, i.e., a proportion of historical production;
- with an “output-based” or “performance standard” allocation, firms receive an amount of allowances proportional to their current production (*x* allowances per ton of steel). Such an allocation method is roughly equivalent to “specific”, “intensity” or “relative” allowances (or credits), i.e., expressed in relative terms (e.g., one ton of CO_2 per ton of steel)[5].

The Directive proposal does not completely specify allocation criteria. It states that in the first period (2005-2007) allowances have to be distributed for free, which excludes auctioning, but the Commission does not completely specify where member states should stand between our last two methods of allowance allocation. Pure grandfathering seems ruled out: if the European Commission (2000) reiterates its judgement on the Danish CO_2 trading scheme, new entrants will be granted allowances for free[6]. Furthermore an extension of an existing plant is likely to be treated like a new entrant (European Commission, 2002). At last, it is very unlikely that a State would continue to distribute allowances to a firm for a plant that has been shut down. However national allocation plans have to specify in advance the quantities allocated, which rules out purely output-based allocation.

5. The vocabulary is not completely stabilised but a distinction made, e.g., by Harrison and Radov (2002) is that with relative targets no absolute overall cap to all participants is set ex-ante, while this is the case with output-based allocation. Both are equivalent in our framework since we do not model all the sectors covered by the Directive.
6. Admittedly, given the existing over-capacity in steel production worldwide, no new integrated steel plant is likely to be built in Europe. However with CO_2 emission control new plants using the electric arc furnace production route may open.

What's more, the allocation method for 2008 onwards is still to be defined. To cope with this uncertainty, we will test various combinations of allocation criteria.

Model structure is as simple as possible. First, the representative firm chooses its price and emission level to maximise the profit function:

$$\pi = p(q)q - TC(q,A) - P_{CO2}\left(E_0 - GF - OBq - A\right) \quad (1)$$

where $p(q)$ is the firm's own inverse demand, decreasing, q the quantity, TC the total cost, increasing in both arguments, A the abatement level for a given level of output, P_{CO2} the exogenous allowance price[7], E_0 the baseline emission level, GF the amount of allowances freely distributed in an absolute way, OB the amount of allowances distributed for each unit of output and q0 the baseline production level. If

$$E_0 > GF + OBq + A \quad (2)$$

then firms have to buy allowances either from other sectors or from the state, if some allowances are auctioned.

Profit maximisation with respect to output and abatement leads to the following first-order conditions:

$$\frac{\partial \pi}{\partial q} = 0 \Leftrightarrow \frac{\partial TC(q,A)}{\partial q} = p(q) + \frac{\partial p}{\partial q}q + P_{CO2}\,OB \quad (3)$$

$$\frac{\partial \pi}{\partial A} = 0 \Leftrightarrow \frac{\partial TC(q,A)}{\partial A} = P_{CO2} \quad (4)$$

Equation (3) states that the firm equalises the production cost to the sum of the marginal receipt of selling steel and the benefit in terms of allowances received per unit of output, and equation (4) that it equalises the marginal abatement cost to the price of CO_2. It is clear from (3) that *GF*, the quantity of allowances freely distributed in an absolute manner, has no influence on productive decisions, but that *OB*, the amount of allowances distributed for each unit of output, increases output, every thing else being equal.

Then, the aggregate quantity produced is determined by the demand to European steel producers which is computed by using econometric estimates of demand, import and export elasticities at the branch level, and market shares taken from Fouquin et al. (2001). This demand to the branch turns out to be less elastic than the demand to the typical firm. Again, this is consistent both with a Cournot oligopoly and with monopolistic competition with differentiated products.

The capital market is assumed to be perfect, which means that a variation in the iron and steel industry profit does not influence investment in this particular sector. In other words shareholders decide in what sector to invest according to future profit expectations, not to lump-sum profits received. This is consistent with Tornell's (1997) conclusions: "During the seventies and eighties the US steel industry received trade protection. However, these rents were not used to improve competitiveness. Instead, they were reflected in higher wages and a greater share of profits invested in sectors not related to steel."

At last, since, first, we model only one sector among those covered by the Directive proposal and, second, the total emission cap is not specified by the proposal[8], we take the European Commission assumption of 20 Euro per ton of CO_2 which, according to the Primes and Poles models, would allow the EU to reach its Kyoto target domestically. Note that opening the EU allowance market to JI or CDM credits or to Russian or Ukrainian allowances would reduce the allowance price dramatically.

A central scenario

In this central scenario, we make two main assumptions. First, we utilise isoelastic demand curves. Second, we assume that the Directive impacts only the repartition of the demand for steel between European and foreign producers, not the total demand for steel. The rationale is that most materials in competition with steel, in particular cement, glass, cardboard and aluminium, will also undergo a cost increase as a consequence of the Directive. Steel is thus likely to gain some market share vis-à-vis concrete in construction and vis-à-vis aluminium in packaging, which may compensate other losses, due for example to a decrease in total material use. Hence we assume in the central scenario that the price increase will not modify total steel consumption – only the part of the market supplied by European, as opposed to foreign, producers.

We display four variants by utilising two marginal abatement cost (hereafter MAC) curves and two values for import and export elasticities. MAC curves are second-degree polynomials fitted to results from Markal Europe (Sijm et al., 2002) and Primes (Blok et al., 2001). However, in all variants, baseline emissions are taken from Markal, since Primes does not seem to take into account process related emissions, that is, CO_2 emissions from fossil fuels used as chemical reducers, which are covered by the Directive proposal.

Two values are taken for import and export elasticities: -1 which is consistent with econometric estimates for the iron and steel sector (Fouquin et al., 2001, Erkel-Rousse and Mirza, 2002, and references therein), and -8 which is utilised by the SIM model (OECD, 2002). Other existing models generally adopt values in between our two variants: -2.8 (elasticity between two foreign producers) and -5.6 (elasticity between a foreign and a domestic producer) for the sector

7. We thus assume away market power on the allowance market which is motivated by the large number of participants forecasted.
8. It will result from the aggregation of "national allocation plans" which will be submitted by member states and reviewed by the European Commission.

Table 2. Auctioning or absolute distribution of allowances.

Import and export elasticities	Low (-1)		High (-8)	
MAC curve	Markal	Primes	Markal	Primes
Emissions in Europe (%)	-18.5	-12.0	-21.1	-15.0
Price (%)	+3.3	+3.5	+3.3	+3.5
Production (%)	-0.5	-0.5	-3.7	-3.9
Total production costs (%)	-0.2	-0.3	-3.5	-3.7
Profit under full auctioning (%)	+2.8	+3.0	-0.5	-0.6
Net purchase of allowances under full auctioning (Mt CO_2)	196	211	189	204
Profit-neutral share of free allocation (% baseline emissions)			1.6	1.7

Table 3. Output-based allocation of allowances (85% of baseline unitary emissions).

Import and export elasticities	Low (-1)		High (-8)	
MAC curve	Markal	Primes	Markal	Primes
Emissions in Europe (%)	-18.1	-11.6	-18.2	-11.8
Price (%)	+0.1	+0.3	+0.1	+0.3
Production (%)	-0.02	-0.05	-0.1	-0.4
Total production costs (%)	+0.2	+0.2	+0.1	-0.2
Profit (%)	-0.2	-0.6	-0.3	-0.9
Net purchase (+) or sale (-) of allowances (Mt CO_2)	-7.5	+8.4	-7.4	+8.4

"ferrous metals" in the GTAP model, for example (GTAP team, 2002). It must be stressed that econometric estimates, even using instrumental variables in order to grasp quality effects, do not exhibit statistically significant estimates much lower than -1 in this particular sector. However a number of industry experts stress the commodity nature of some sorts of steel to claim that the "real" elasticity is in fact higher. Furthermore, there are good reasons to believe than traditional econometric estimates are too conservative (Erkel-Rousse and Mirza, 2002).

At 20 Euro per ton of CO_2, there is more abatement according to Markal Europe than to Primes. Abatement is in a range of 12 to 21% of baseline emissions which is above the gap between the Kyoto target and emission forecasts (c.f. introduction above). This is the only noticeable difference between the two models' results. In other words, competitiveness impacts are quite robust to different estimations of the MAC curve. The explanation is that the large majority of the increase in steel price is caused not by abatement costs, but by the allowance burden which is passed on to consumers. This interesting result invites to devote more attention to other parameters than the MAC curve, which up to now has been the focus of the larger part of applied research.

Production volume is hardly reduced in the low elasticity variant but bears an almost 4% decline in the high elasticity one. This obviously raises concerns on employment. Assessing employment in the whole economy would require a general equilibrium model; however, we display total production costs, which may be a proxy of employment in Europe in the iron and steel sector.

The most surprising result is that even under full auctioning, profit actually increases in the low elasticity variants and only mildly decreases in the high elasticity ones. Hence, in the latter variants, only a tiny fraction of grandfathering (1.6 to 1.7% of baseline emissions[9]) suffices to neutralise the impact on industry profits. The explanation is that firms pass on to consumers not only the financial burden of buying the allowances but also the increase in marginal production cost due to abatement measures. Since the demand elasticity and thus the mark-up rate remains unchanged, total profits increases unless the decrease in production is high enough.

Note that the potential for raising public revenue is important: 189 to 211 million tons of CO_2, amounting to 3.8 to 4.2 billion Euro, under full auctioning. This figure is for the iron and steel sector only; full auctioning to all sectors covered by the Directive proposal may yield as much as 30 to 40 billion Euro a year. When testing auctioning we do not model the recycling of this revenue, which would most likely benefit firms, e.g., through a cut in social security contributions. As a consequence we probably over-estimate competitiveness impacts under these scenarios.

Let us now turn to pure output-based allocation. The rationale for such a solution is straightforward: according to Table 2 results, activity suffers more than profits from auctioning and this risk cannot be alleviated by pure grandfathering since this allocation criterion provides no incentive for maintaining production[10]. Table 3 below displays simulation results with an output-based allocation equal to 85% of baseline unitary emissions, a figure in line with what is expected from an efficient burden sharing among industry sectors.

Variations in price, production level, production costs and profit are all well below 1% in any case. Furthermore, compared to absolute allocation, abatement decreases by at least 2% (Markal MAC curve, low elasticity) and at most 21% (Primes MAC curve, high elasticity). However carbon leakage would be lower and so could be world emissions. The

9. This is even lower than Bovenberg and Goulder (2002) estimates for the U.S. energy sector: 10-15% of potential revenues from auctioned permits.

10. This is because, as in almost all the literature, we assume away revenue effects. If however capital markets were imperfect, the revenue from grandfathered permits would be invested chiefly in firms receiving the permits. The impact of grandfathering would then be closer to that of output-based allocation.

Table 4. Break-even points for output-based allocation.

Import and export elasticities	Low (-1)		High (-8)	
MAC curve	Markal	Primes	Markal	Primes
Share of allocated baseline emissions that turns the sector into a net allowance seller	82	89	82	89
Share that makes production rise	89	94	89	94
Share that makes profit rise	89	94	89	94

Table 5. Mix of output-based and exogenous allocation of allowances.

(40% of baseline emissions + 40% of unitary baseline emissions * actual production)

Import and export elasticities	Low (-1)		High (-8)	
MAC curve	Markal	Primes	Markal	Primes
Emissions in Europe (%)	-18.3	-11.8	-19.8	-13.5
Price (%)	+1.8	+2.0	+1.8	+2.0
Production (%)	-0.3	-0.3	-2.1	-2.3
Total production costs (%)	-0.02	-0.09	-1.8	-2.1
Profit (%)	+12.7	+12.7	+11.1	+10.9
Net purchase of allowances (Mt CO_2)	4.3	20.1	2.5	17.7

iron and steel sector is a net allowance buyer in simulations utilising the Markal abatement cost curves, whereas it is a net seller when utilising Primes abatement cost curves. However in both cases, net allowance transfers are very limited compared to the scenario with full auctioning described above. At last, output-based allocation entails a lower profit not only as compared to grandfathering but also, in most cases, as compared to auctioning. This conclusion is probably unexpected to industry lobbyists since most of them favour output-based allocation, but it is consistent with other simulations (Burtraw *et al.*, 2001).

The economic mechanism behind this result is presented, e.g., by Fullerton and Metcalf (2001): output-based allocation creates no scarcity rent, contrarily to any instrument that allows to reach part of the target by reducing production, such as auctioning, grandfathering or absolute non-tradable emission limits. The drawback, from an efficiency point of view, is that by not raising polluting products price by this scarcity rent, output-based allocation provides few incentive for final or intermediate consumers to switch to less polluting products (Fisher, 2001).

Furthermore, if output-based allocation is generous, production and profit may actually increase and steel price decrease. As displayed in table 4 below, this happens with an allocation of at least 89% (Markal) or 94% (Primes) of baseline emissions. If firms in the iron and steel industry receive, for instance, output-based allowances corresponding to 100% of their baseline unitary emissions, they will still abate in order to sell some allowances to other sectors. Furthermore they will produce more than in the baseline scenario, to receive and sell even more allowances. In other words, with such an allocation plan, firms produce not only to sell steel, but also allowances! Note that this occurs only 5 to 7 percentage points after the steel industry becomes a net allowance seller, as shown in table 4[11].

As discussed above, neither pure grandfathering nor pure output-based allocation seems to be favoured by the European Commission for the first period of the Directive (2005-2007). Thus, Table 5 illustrates the possible consequences of an application of the allowance allocation criteria suggested by the Commission, which could resemble a mix of grandfathering and output-based allocation. In this simulation, firms receive 40% of their baseline emissions on a free absolute basis and some allowances according to their output, more precisely 40% of unitary baseline emissions.

Consistently with our previous results, results on price, production and production costs are in-between that of absolute and output-based allocation. (Tables 2 and 3) and firms are largely over-compensated since profit rises by 11 to 13%.

To sum up the results from this central scenario, the fear of a non trivial profit cut appears unfounded: profit undergoes either an insignificant decrease or a noteworthy growth. Total production costs in the iron and steel industry are roughly constant under the low elasticity assumption but might undergo a 4% cut under the high elasticity one, with absolute allocation. The latter concern may be alleviated by linking, at least partly, the free distribution of allowances to output, which is likely to be the case, as presented above. Another (and almost certainly more efficient) means would be a border adjustment, but we have not tested such a scenario.

Note that two crucial assumptions, unfortunately difficult to check, are the isoelasticity of the demand curves and the assumption of constant returns to production whatever the carbon abatement effort. Next section illustrates the first point by utilising a linear demand curve, and we discuss the second in the conclusion.

11. In Edwards and Hutton (2001) general equilibrium simulations for the U.K., energy-intensive sector output also rises under output-based allocation (labelled by the authors "benchmark and re-allocation"). Although the authors do not provide an explanation, we presume that the underlying mechanism is the one we present here.

Table 6. Absolute distribution of allowances with linear demand curves.

Import and export elasticities	Low (-1)		High (-8)	
MAC curve	Markal	Primes	Markal	Primes
Emissions in Europe (%)	-18.3	-11.7	-19.5	-13.1
Price (%)	+1.5	+1.6	+1.5	+1.6
Production (%)	-0.2	-0.2	-1.7	-1.8
Total production costs (%)	-0.03	-0.03	-1.5	-1.6
Profit under full auctioning (%)	-14.9	-15.8	-16.2	-17.2
Net purchase of allowances under full auctioning (Mt CO_2)	196	228	193	208.5
Profit-neutral share of free allocation (% of baseline)	44.8	47.5	48.6	51.6

Table 7. Output-based allocation of allowances with linear demand curves (85% of baseline unitary emissions).

Import and export elasticities	Low (-1)		High (-8)	
MAC curve	Markal	Primes	Markal	Primes
Emissions in Europe (%)	-18.1	-11.5	-18.2	-11.7
Price (%)	+0.06	+0.1	+0.06	+0.1
Production (%)	-0.01	-0.02	-0.07	-0.2
Total production costs (%)	+0.2	+0.2	+0.2	+0.03
Profit (%)	-0.6	-1.5	-0.6	-1.7
Net purchase (+) or sale (-) of allowances (Mt CO_2)	-7.5	+8.4	-7.5	+8.4

Variable elasticities, partial pass-through and linear demand curves

Most general equilibrium models feature isoelastic import and export functions derived from an Armington (1969) specification which combines domestic and foreign goods through a CES function. However there is no reason, apart from analytical tractability and data availability, to assume that import and export elasticities are constant on all the demand curve. In particular, econometric studies presented by Goldberg and Knetter (1997) show that following a variation in exchange rates, exporters do not pass on to foreign consumers the totality of the price differential. In the iron and steel sector, it seems that about 50% of the change in marginal cost is passed through, which, under monopolistic competition, corresponds to a linear demand curve. In Table 6 we display a simulation featuring linear demand curves, both for the own demand curve of the representative firm and for the demand to the sector. With such a specification, the demand elasticity increases (in absolute value) with the price. The price elasticity of the demand to the representative firm thus decreases from -10 to -12 following the introduction of the emission trading system.

With full auctioning, profits undergo a serious decrease which interestingly is roughly similar under our four variants. Grandfathering about half the baseline emissions is now required to stabilise profits. On the other hand, since European firms are now only able to pass half the marginal cost increase on to consumers, their market share is less impacted, and so are production and total production costs which never decrease by more than 1.8%.

Under output-based allocation, as shown by the comparison of Table 7 with Table 3, the same pattern emerges: the negative impact on profit gets worse than with isoelastic demand curves but remains trivial and the negative impact on production is even smaller.

Opt-out from sectors in competition with steel

Up to now, as explained above, we have assumed a constant total demand for steel on the basis than most substitutes are covered by the Directive proposal: aluminium, cardboard and glass for packaging, aluminium for cars, concrete for building… However the negotiation texts following first votes in the Parliament and Council include an opt-out clause by which a member state could exempt some firms or sector provided that other instruments, such as a voluntary agreement, induce an equivalent abatement effort. The latter criterion is obviously extremely difficult to verify, so the opt-out clause could harm significantly the environmental efficiency of the Directive. Furthermore it could entail competitive distortions between the sectors covered by the Directive and those opting out.

To check the outcome of a sectoral opt-out from sectors competing with steel[12], we assume a price elasticity of -0.3 for the total demand for steel, which is then divided between domestic and foreign competitors. This value is taken from Winters (1995) and utilised by Maestad (OECD, 2002). We turn back to isoelastic demand curves as in the central scenario. Tables 8 and 9 below display the results, respectively with absolute and output-based allowance allocation.

Even under full auctioning, profit impacts remain trivial in any case. However, with absolute allocation, profit, production and production costs decrease by approximately one percentage point compared to the scenario excluding material substitution (compare Tables 2 and 8). Results hardly change under output-based allocation (compare Tables 3 and 9).

12. Apart from such a sectoral opt-out, people discuss the full variety of member state, sector, companies and individual installations opt-outs. Other types of competitive distortions could hence occur.

Table 8. Opt-out of sectors competing with steel, absolute allocation.

Import and export elasticities	Low (-1)		High (-8)	
MAC curve	Markal	Primes	Markal	Primes
Emissions in Europe (%)	-19.3	-12.9	-21.9	-15.9
Price (%)	+3.3	+3.5	+3.3	+3.5
Production (%)	-1.5	-1.6	-4.7	-4.9
Total production costs (%)	-1.2	-1.4	-4.4	-4.8
Profit under full auctioning (%)	+1.8	+1.9	-1.5	-1.6
Net purchase of allowances under full auctioning (Mt CO_2)	194	209	187	202
Profit-neutral share of free allocation (% of baseline)			4.6	4.9

Table 9. Opt-out of sectors competing with steel, output-based allocation (85% of baseline unitary emissions).

Import and export elasticities	Low (-1)		High (-8)	
MAC curve	Markal	Primes	Markal	Primes
Emissions in Europe (%)	-18.2	-11.6	-18.3	-11.9
Price (%)	+0.1	+0.3	+0.1	+0.3
Production (%)	-0.06	-0.2	-0.2	-0.5
Total production costs (%)	+0.01	+0.05	+0.05	-0.3
Profit (%)	-0.3	-0.7	-0.4	-0.9
Net purchase (+) or sale (-) of allowances (Mt CO_2)	-7.5	+8.4	-7.4	+8.4

Emission cuts are higher than in the scenario with opt-out but total European emissions would certainly raise, both because competing sectors would not abate and because they would expand their production to the detriment of steel. All in all, both environmental effectiveness and economic efficiency would be harmed.

Conclusions

Although extremely simple, our model provides quite stimulating results for the ongoing negotiation of the European allowance trading Directive proposal.

A first strong result is that competitiveness impacts are minor: production drops by 0.1 to 4% (5% with the opt-out clause) and profits undergo a significant loss only under auctioning and with the assumption of linear demand curves. Even in this latter case, grandfathering allowances corresponding to 50% of baseline emissions and auctioning the rest suffices to alleviate the profit impact. The competitiveness issue is thus not a rationale for preventing the implementation of the Directive, neither for watering it down by allowing European firms to fulfil their commitments by buying dubious units created by the Kyoto Protocol such as hot air or sinks, bringing back in the opt-out clause or lowering sanctions. Furthermore, since we assume no revenue recycling, competitiveness impacts from auctioning are overestimated.

Furthermore, a number of amendments proposed to secure industry competitiveness may in fact harm it. First, output-based allocation, put forward by a number of industrial sectors, performs worse than grandfathering and most often worse than auctioning as regards the impact on profit. Second, the opt-out clause, also endorsed by a number of industry lobbies, could harm production and profit in the iron and steel sector by one percentage point, if applied to competing sectors.

Uncertainty on marginal abatement cost turns out to be less crucial for competitiveness than import and export elasticities. A research priority is thus to aim at reconciling results from econometric estimations (around -1) and values utilised by applied models (up to -8).

Further research would also be useful on various issues:

- A straightforward means to alleviate competitiveness concerns is a border tax, as shown by Hoel (1996) and Maestad (1998; OECD, 2002). However a world model is required to take into account the disparity in CO_2 intensity of steel production among world regions.
- Very few is known on the shape (beyond the local elasticity) of the demand curve, which is of crucial importance for analysing profit impacts, as we have demonstrated.
- Because of a lack a data, we have assumed constant returns to scale whatever the abatement level. A corollary is that the marginal production cost curve moves up uniformly. But if part of the abatement burden has the character of a fix cost, then marginal cost, thus product price, will increase less than average cost and firms will undergo a higher profit loss. The opposite is also possible: firms often use their more recent and less polluting production installations for baseline production, while switching older ones on for satisfying peak demand. Abatement will then make the marginal production cost more upward-slopping, hence increasing profitability.
- We do not cover all sources of carbon leakage: in most world models, the dominant factor is input price variations. In the OECD (2002) study on CO_2 taxation in steel industry, unilateral CO_2 abatement raises scrap price while reducing coal and iron ore value, both factors boosting emissions in the rest of the world. However note that this kind of effect is cross-sectional by nature: decreasing CO_2 emissions from electricity generation would also lessen coal price although power generation is sheltered from extra-European competition. This kind of effect hardly fits with any definition of competitiveness. Furthermore an "anti-leakage" factor is induced technical change: low-carbon techniques developed in

carbon-abating countries will sooner or later be available in other world regions too.

- Both Markal and Primes assume a long-term equilibrium, neglecting the current overcapacity in iron and steel world production. Admittedly overcapacity would ease plant closing in Europe, but it would also render more unlikely capacity increase in other world regions. However, a political risk for member state governments and European institutions is that some plant closures that would happen anyway risk being presented as a consequence of the allowance trading Directive.

In practice, as exemplified by the recent Nasdaq shrinkage, stock value is not determined only by rational factors influencing future profits but also by imperfect information on capital market. In this respect, industry managers would be wise not to be up in arms against a Directive proposal which objectively does not threaten their competitiveness significantly: financial analysts, banks and shareholders could take such a gesture for justified, leading to a higher risk premium and a lower access to financial capital. After all, as we have seen, this is not the only paradox in the political economy of the Directive proposal!

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Acknowledgements

I thank the Institut Français de l'Energie for financial support as well as participants at the 3rd CATEP workshop and CORE environmental seminar.

Appendix. Model description

DEFINITION OF OUTPUT

The model actually represents an aggregate of the various products presented in table 1 above. We assume away any change in average steel quality or in the relative market share of these products. For convenience we use the ton of crude steel as the quantity unit but since we grasp other, more expensive products, the price of our aggregate is thus well above the actual crude steel price. The quantity produced in baseline scenario is Primes reference scenario for 2010: q_0=160 million tons (Capros et al., 2001). This is similar to Hidalgo et al. (2003): 158 million tons. The baseline price, in 1999 Euros, is computed by dividing the turnover of the iron and steel sector, taken from the OECD STAN database, by crude steel production in the E.U. in 1999. We get p_0=900 Euro per ton of crude steel (recall that this does not refer to the price of crude steel but of a composite good).

DEMAND TO THE BRANCH

Assuming an equal price elasticity of imports and exports, , and the same relative variations in European steel price *p* in Europe and on export markets, we can write:

$$\varepsilon = \frac{\partial Qx}{Qx} \Big/ \frac{\partial p}{p}$$

where Qx is the exportation by European producers (excluding intra-EU trade).

$$\Leftrightarrow \frac{\partial Qx}{Qd} \Big/ \frac{\partial p}{p} = \varepsilon \frac{Qx}{Qd}$$

$$\varepsilon = -\frac{\partial Qm}{Qm} \Big/ \frac{\partial p}{p}$$

where Qm is the importation in Europe (again excluding intra-EU trade)

$$\Leftrightarrow -\frac{\partial Qm}{Qd} \Big/ \frac{\partial p}{p} = \varepsilon \frac{Qm}{Qd}$$

In addition we define ϕ, the price-elasticity of total steel demand in Europe Qt, satisfied by foreign and European producers:

$$\phi = \frac{\partial Qt}{Qt} \Big/ \frac{\partial p}{p} \Leftrightarrow \frac{\partial Qt}{Qd} \Big/ \frac{\partial p}{p} = \phi \frac{Qt}{Qd}$$

The price elasticity of the demand Qd addressed to domestic (European) firms is then:

$$\mu \equiv \frac{\partial Qd}{Qd} \Big/ \frac{\partial p}{p} = \frac{\partial (Qx + Qt - Qm)}{Qd} \Big/ \frac{\partial p}{p} = \frac{\partial Qx}{Qd} \Big/ \frac{\partial p}{p} + \frac{\partial Qt}{Qd} \Big/ \frac{\partial p}{p} - \frac{\partial Qm}{Qd} \Big/ \frac{\partial p}{p}$$

Thus, inserting (1), (2) and (3):

Table 10. Parameters for MAC curves.

	α	β
Markal	0.181	0.051
Primes	1.377	0.035

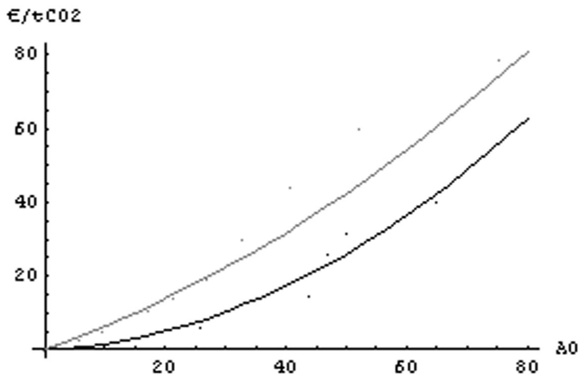

Figure 2. *Approximation of MAC curves for Primes (in Black) and Markal Europe (in Grey). A0 is the abatement in million ton of CO_2 for a given production level q0.*

$$\mu = \varepsilon \frac{Qm + Qx}{Qd} + \phi \frac{Qt}{Qd} = \varepsilon \frac{Qm + Qx}{Qd} + \phi \left(1 + \frac{Qm}{Qd} \right)$$

From Fouquin et al. (2001, p. 43), we have Qm/Qd=1.3+3.5=4.8%. This study does not provide directly Qx/Qd for E.U. 15 but only for each member state: the average figure for E.U. includes exports towards other member states. We thus compute Qx/Qd using Qm/Qd, exports (p. 108) and imports (p. 110): (Qx/Qd)=(14.1/6.9)*(Qm/Qd)=9.8%. We thus get:

$$\mu = 0.146\varepsilon + 1.048\phi$$

ε equals -1 or -8 throughout the paper and ϕ is equal to -3 in the section on opt-out and to zero elsewhere. The collective demand curve is then:

$$DemColl = \left(\frac{p}{p_0} \right)^{-\mu} q_0$$

in the isoelastic case, and:

$$DemColl = \left(1 + (1 - \frac{p}{p_0})\mu \right) q_0$$

in the linear case.

DEMAND TO EACH FIRM (DEMIND)

Without loss of generality the number of firms is normalised to 1. In the baseline scenario we take a price-cost margin of 9%, consistent with Oliveira-Martins and Scarpetta (1999) econometric estimates for the iron and steel sector. Under a monopolistic competition or a Cournot oligopoly framework, this figure corresponds to an own-demand price elasticity ϕ of -10, since a profit-maximising firm in such a context charges a price-cost margin:

$$\frac{\theta}{\theta - 1}$$

The demand to each firm is thus:

$$DemInd = \left(\frac{p}{p_0}\right)^{-\theta} q_0$$

in the isoelastic case, and

$$DemInd = \left(1 + (1 - \frac{p}{p_0})\theta\right) q_0$$

in the linear case.

PRODUCTION AND ABATEMENT COST

Total production cost of the representative firm depends on quantity produced and on abatement: . We assume constant returns to scale, whatever the emission level. Total production cost in the reference scenario is deduced from the price and price-cost margin:

$$TC_0 = \frac{\theta - 1}{\theta} p_0 \, q_0$$

Equilibrium total cost stems from baseline total cost TC_0, actual production q and marginal abatement cost curve:

$$TC = \frac{q}{q_0} \int_0^{A_0} MAC \, dA_0 + \frac{q}{q_0} TC_0$$

where A_0 is abatement in million tons of CO_2 for a given production level q_0[13]. *MAC is the marginal abatement cost function, in million Euros, fitted by ordinary least square from model results (Table 10 and Figure 2 below):*

$$MAC = \alpha A_0 + \beta A_0^{\ 2}$$

Baseline emissions for 2010 amount to 240 million tons of CO_2, as in Markal Europe (Sijm et al., 2002). This figure is consistent with the 228 million tons for the E.U. (excluding Sweden and Finland) used in Maestad's steel industry model (OECD, 2002), but significantly higher than Hidalgo et al. (2003) estimates: around 180 million tons.

13. In other words we have $A=(q/q_0)A_0$.