Oxera

CO_2 emissions trading: How will it affect UK industry?

Report prepared for: The Carbon Trust

July 2004

About Oxera

Oxera is an independent economic consultancy—one of the longest established in Europe—with an international reputation for integrity, intellectual rigour and work of the highest quality. Since its inception in 1982, the Company has been offering economic advice using a combination of extensive industry knowledge and unsurpassed expertise in industrial and quantitative economics and corporate finance, placing it at the forefront of developments for company strategy, government policy, competition policy, and regulation.

For more information on Oxera, visit www.oxera.com

Contact

Robin Smale
Managing Consultant
Oxera
Tel: +44 (0) 1865 253 031
Fax: +44 (0) 1865 251 172
robin_smale@ oxera.co.uk

Karen Lewis
Head of Business Development
Oxera
Tel: +44 (0) 1865 253 010
Fax: +44 (0) 1865 251 172
karen_lewis@ oxera.co.uk

Executive summary

Oxera was commissioned by The Carbon Trust to study the impact of the EU Emissions Trading Scheme (EU ETS) on the competitiveness of a sample of UK industry sectors, with particular focus on the profitability of the firms within those sectors. The objective of the study, which began in January 2004 and was completed in May 2004, is to inform The Carbon Trust's work with industry, with the aim of increasing understanding of climate change and helping industry to respond to it.

The impact of the EU ETS is simulated in this study using an economic model of oligopoly behaviour, suitable for markets with a small number of firms and high capital intensity. The model predicts the impact on EBITDA (earnings before interest, taxes, depreciation, and amortisation), volume of sales, number of firms, and investment in energy efficiency and emissions abatement. Notably, it also predicts the degree of cost pass-through that may be expected in a particular market, based on the fundamental characteristics of that market. Scenarios are used to reflect the EU ETS trading periods: 2005–07, 2008–12, and beyond 2012.

The model is applied to five markets in the electricity, cement, newsprint, steel and aluminium sectors. Each market has different characteristics in terms of level of penetration of imports, geographical scope and CO_2 intensity. In the case of the aluminium smelting market, the participants are, at present, outside the EU ETS. However, as the EU ETS is likely to result in higher electricity prices, participants in this market will also be affected. Data on each market is sourced from company accounts and discussions with individual companies, economic literature, national statistics, and government research reports.

The results of the modelling challenge the widely accepted belief that the EU ETS will have a major negative impact on the profits of UK firms. In four of the five markets examined in this study, UK participants are not predicted to suffer a reduction in profits, indeed making gains in some cases. The fifth sector studied here faces a loss of market share to competitors operating outside the EU and a reduction in profits, and similar results might be expected in other sectors with similar characteristics.

The headline figures are shown in Tables 1 to 5. The assumptions underpinning the three trading periods are set out in section 5 of the report. The 'value at stake' figure refers to the extent to which EBITDA would be altered by the EU ETS if firms did not respond in any way to its introduction (ie, by changing prices or investing in abatement technology), expressed as a percentage of original EBITDA.

Table 1 Electricity headline results (%)

Trading period	Increase in marginal cost (%)	Increase in price (%)	% of marginal cost increase passed on to customers	Change in quantity demanded (%)	Change in EBITDA (%)	Value at stake (%)	Change in number of firms
2005–07	12	8	90	–3	47	0.7	no change
2008–12	23	15	90	–6	63	33	no change
2012–	49	31	90	–12	162	88	no change

Table 2 Cement headline results (%)

Trading period	Increase in marginal cost (%)	Increase in price (%)	% of marginal cost increase passed on to customers	Change in quantity demanded (%)	Change in EBITDA (%)	Value at stake (%)	Change in number of firms
2005–07	27	7	83	–2	12	1.0	no change
2008–12	55	14	83	–4	25	1.9	no change
2012–	136	35	83	–10	35	33	no change

Table 3 Newsprint headline results (%)

Trading period	Increase in marginal cost (%)	Increase in price (%)	% of marginal cost increase passed on to customers	Change in quantity demanded (%)	Change in EBITDA (%)	Value at stake (%)	Change in number of firms
2005–07	1	0	83	0	3	0	no change
2008–12	1	1	83	–1	6	0	no change
2012–	3	2	83	–2	9	5.7	no change

Table 4 Cold-rolled steel headline results (%)

Trading period	Increase in marginal cost (%)	Increase in price (%)	% of marginal cost increase passed on to customers	Change in quantity demanded (%)	Change in EBITDA (%)	Value at stake (%)	Change in number of firms
2005–07	3	2	67	–3	8	2	no change
2008–12	7	3	67	–5	17	4	no change
2012–	17	8	67	–13	4	55	no change

Table 5 Aluminium smelting headline results (%)

Trading period	Increase in marginal cost (%)	Increase in price (%)	% of marginal cost increase passed on to customers	Change in quantity demanded (%)	Change in EBITDA (%)	Value at stake (%)	Change in number of firms
2005–07	3	1	66	–3	–16	25	no change
2008–12	5	3	66	–6	–31	51	no change
2012–	13	10	102	–24	–20	127	–1

The primary use of the results should be to identify the factors that are of greatest importance in determining the financial impact of the EU ETS. While the estimates generated by this simple model can be used to challenge the widely accepted understanding of the impact of emissions trading, *they are not sufficiently robust to be used in financial analysis*.

Given this, the model indicates that the market features that are most important in determining the financial impact of the EU ETS are as follows.

– *The degree of non-EU competition faced by participants in the particular market*—the greater the degree of such competition, the more likely it is that firms will suffer as a result of the EU ETS being implemented. This is because firms outside the EU will not face the marginal cost increase associated with the scheme and hence will gain a competitive advantage that results in a relative increase in their market shares, at the expense of those companies that are within the EU. The non-EU competitors will also place a limit on the extent that the cost increases of the EU firms can be passed on to customers in higher prices.

– *The degree of concentration of firms in the market*—the greater the concentration, the more likely it is that each of these firms will suffer as a result of the scheme being implemented. This result, while perhaps counterintuitive, is caused by the fact that the more competitive the market is, the more firms behave like price-takers and thus prices become more cost-reflective.

– *The own-price elasticity of demand for the product in question*—the more elastic the product, the greater the likelihood that firms will suffer. This is because, for any given increase in prices, the greater the own-price elasticity of demand (in absolute terms), the greater the demand response will be.

Of these three features, the modelling suggests that the first will be most critical in determining the financial impact of the scheme.

The results in Tables 1 to 5 make no allowance for strategic behaviour among firms—in particular, the use of increased profits to pursue aggressive price competition, which could lead to the predicted increases in profits and prices not materialising. This only arises when there are increased profits: where profits are reduced by the EU ETS, firms will not have the same freedom to behave strategically to counter the effects of the scheme.

The model also demonstrates some important dynamics. When CO_2 prices rise, the marginal cost of production also rises, but so does the value of grandfathered allowances. As a result, the allocation decision becomes potentially even more important. However, although the allowance allocation is a powerful tool, at relatively high CO_2 prices, the extent of competition from outside the EU ETS is a more important determinant of financial impact, and allocation becomes a decreasingly effective means of compensating those participants facing extensive non-EU international competition.

Contents

Contents

List of tables

Contents

List of figures

1 Introduction

1.1 The objective of this study

Oxera was commissioned by The Carbon Trust to study the impact of the EU Emissions Trading Scheme (EU ETS) on the competitiveness of a sample of UK industry sectors, with particular focus on the profitability of the firms in those sectors. This report explains how we carried out the brief and presents the results.

The objective of the study, which began in January 2004 and was completed in May 2004, is to inform The Carbon Trust's work with industry, with the aim of increasing understanding of climate change and helping industry to respond to it.

The report will be of general interest among policy-makers and within industry for two reasons:

– it presents one approach to modelling impacts on competitiveness within industry at a sectoral/market level—an issue of interest to policy and financial analysts; and
– it presents estimates of the impact of the EU ETS on the volume of sales and profits of a typical firm, which may be pertinent for industry and market observers.

1.2 The structure of this report

This report is structured as follows:

– the recent debate on competitiveness and climate change policies is reviewed in section 2;
– sections 3 and 4 describe Oxera's approach to modelling the impact of the EU ETS on individual UK industrial sectors, and the choice of those sectors;
– the assumptions made in the modelling are outlined in section 5;
– sections 6 to 10 present the results, one section for each industry sector;
– section 11 concludes;
– the appendix outlines the mathematical basis to the model.

2 Background

2.1 What has been said about competitiveness and the EU ETS?

The EU ETS has been hotly debated since the publication of the European Commission's Green Paper in 2000.[1] At the forefront of the debate are competitiveness concerns surrounding two issues:

– by acting unilaterally, the EU's economy might be damaged and its firms might lose out to non-EU firms;
– by allowing Member States to determine allocations of allowances for their industrial sectors, with only broad guidance to harmonise approaches across the EU, some Member States might use the allocation as a means of state aid, providing their firms with a reserve of cash with which to compete against firms in other EU Member States.

According to Margot Wallström, European Commissioner, the Emissions Trading Directive 'has enabled the EU to act swiftly in following up on our commitments under the Kyoto Protocol, and to do so at least cost to industry'.[2] Moreover, she has declared that 'companies across 25 countries must now start incorporating climate change into day to day commercial decisions, and begin assessing what innovative steps they can take to reduce emissions.'[3]

UK government ministers have claimed that the UK's draft National Allocation Plan 'recognises the need to preserve the competitive position of UK industry';[4] whereas the CBI has been vocal on the issue, but less supportive of the UK government's approach, arguing that it is 'risking the sacrifice of UK jobs on the altar of green credentials',[5] and that 'if we go too far and other countries don't make similar commitments, we are going to put our hard-pressed manufacturers in an extremely difficult position in global markets.'[6]

It is Oxera's understanding that this is the first study of its kind in the UK that attempts to prove or refute the claims made about the impacts of the EU scheme on competitiveness across a range of different markets.

2.2 What does competitiveness mean?

The OECD defines competitiveness as:

> The degree to which a nation can, under free trade and market conditions, produce goods and service that meet the test of international markets, while simultaneously maintaining and expanding the real incomes of its people over the longer term.

For UK industry to be competitive, the production costs and costs of delivery to consumers must be comparable to the costs of rival producers overseas. Being competitive also means having access to finance for investment at a cost that is comparable or lower than its rivals.

[1] Commission of the European Communities (2000), 'Green Paper on Greenhouse Gas Emissions Trading within the European Union', March.

[2] Commission of the European Communities (2003), 'Commissioner Welcomes Final Adoption by Council of EU Emissions Trading Directive', IP/03/1073, July 22nd.

[3] Commission of the European Communities (2003), 'Greenhouse Gas Emissions Trading: Commissioner Wallström Hails Final Agreement on Climate Change Breakthrough', IP/03/93, July 2nd.

[4] Defra (2004), 'UK Announces Consultation on Draft National Allocation Plan for the EU Emissions Trading Scheme', January 19th.

[5] CBI (2004), 'Carbon Emissions Targets: CBI Chief Calls for Government Guarantees on Competitiveness', January 19th.

[6] CBI (2004), 'Carbon Emissions Targets: UK Must Not Go It Alone', March 11th.

2 Background

However, UK consumers want choice, quality and low prices; as such, what they are most likely to want is a high degree of competition in the market, wherever their suppliers are located.

For these reasons, this assessment of the impact of the EU ETS on UK competitiveness addresses the potential changes in the prices, volume of sales and profits of UK firms and in those of their rivals, as a result of the trading scheme.

3 Overall approach

3.1 Choice of sectors

Although it is estimated that the installations within the EU ETS are responsible for causing 46% of all CO_2 emissions from the UK,[7] the number of sectors involved, as classified by Defra, is relatively low. In the UK, 12 sectors together represent 98.8% of all the emissions covered by the trading regime, but only approximately 11.1% of UK value-added in 2001.[8]

Furthermore, these sectors tend to have several characteristics in common: they are all energy- and capital-intensive relative to the UK average, and hence not labour-intensive. Energy is an important input into production and the production plant tend to be large because of the associated economies of scale, which lower the average production costs. Moreover, these firms are often vertically integrated into companies that produce the raw materials for their production process, or consume or retail their product. In combination, these factors tend to lead to sectors where there are relatively few firms, and entry by new firms into the sector is relatively expensive.

The sectors chosen for examination were cement, aluminium, paper, iron and steel, and electricity. These are highlighted in Table 3.1 below, which illustrates the number of firms and energy intensity of all the sectors covered by the EU ETS. (Aluminium is not separately identified, as much of the sector is not within the EU ETS—it will, however, be affected by the increase in electricity prices that is likely to be induced by the scheme.)

[7] Defra (2004), 'UK Draft National Allocation Plan for 2005–07', January.

[8] National Statistics (2002), 'United Kingdom National Accounts Blue Book', and further information provided by National Statistics.

3 Overall approach

Table 3.1 UK participants in the EU ETS

Sector	Proportion of EU ETS emissions[1] (%)	Estimated number of firms	Energy intensity (expenditure on energy as % of gross value added)
Electricity	**59.8**	**38**	**not available**
Refineries	18.1	12	8.2
Iron and steel	**9.6**	**8**	**46.9 basic iron and steel and ferro alloys**
			14.6 casting of iron
			8.0 casting of steel
Offshore	6.0	25	not available
Cement	**4.1**	**5**	**24.7 cement, lime and plaster**
Chemical	3.3	58	40.4 inorganic
			45.2 organic
Pulp and paper	**2.0**	**58**	**22.9**
Food and drink	1.6	65	24.9 starch products
			20.5 malt
Bricks and ceramics	1.3	54	18.1 bricks
			8.6 ceramic tiles and flags
Non-ferrous	1.2	4	29.2 aluminium
			31.6 lead, zinc and tin production
Lime	1.2	7	24.7 cement, lime and plaster
Glass	0.9	18	11.3

Note: [1] As measured by the allowances allocated to each sector under the draft National Allocation Plan.
Sources: Defra (2004), 'UK Announces Consultation on Draft National Allocation Plan for the EU Emissions Trading Scheme', January 19th; and DTI (undated), 'Competitiveness, Trade and Regional Implications of EU Emissions Trading Scheme', available at http://www.dti.gov.uk/energy/sepn/euetsimplications.pdf.

The impact of the EU ETS is likely to differ significantly across sectors. The sectors were selected to show this variation between those:

– in which exposure to international competition is a particular concern and those that are more insulated from overseas rivals;
– for which energy expenditure constitutes a high proportion of their production costs and those for which it constitutes a low proportion of production costs;
– that have access to low-cost CO_2-abatement options and those that do not;
– covered by the EU ETS, which will therefore pay for their CO_2 emissions, but will also receive grandfathered allowances, and those outside the scheme, for which the effect will only be the projected increase in electricity prices.

In selecting sectors, the practicalities of data availability and the suitability for representation by a simple model were also important.

3.2 Sectors and markets

Although the choice of sectors was an important first step, at least some of these sectors involve the production of a wide range of products, each of which may have different demand and supply characteristics. This would mean that the financial and competitiveness impacts of the EU ETS could vary between products. For example, within the same sector, some products may be offered by many competing suppliers worldwide, while others may be offered by a few local suppliers only.

The appropriate level of aggregation for analysis is the 'relevant market'. Economists have devoted considerable attention to defining the relevant market, particularly in competition law investigations. Essentially, a market can be defined along two dimensions: the product market and the geographical market. For both dimensions, the issue is whether other products/regions provide an effective competitive constraint on the production of the particular product or on the region of production under examination.

For example, if there were just one (hypothetical) supplier of cola drinks, and this supplier attempted to increase prices, cola drinks would not represent the relevant product market if lemonade provided a sufficiently competitive constraint that enough consumers switched to lemonade so as to make the price rise unprofitable. Similarly, if a cola manufacturer that was a monopolist in region X attempted to raise its prices and, as a result, a sufficient number of consumers switched to the cola produced in region Y, such that the price rise was unprofitable, the relevant geographical market would include both region X and region Y. Using these examples, it can be seen why a market is frequently defined as 'something worth monopolising'.

A number of tools have been developed to test the scope of the relevant market. However, it was not necessary to use these tools in undertaking this study, since, in all cases, an appropriate market had already been defined in competition law investigations at both the UK and the EU level. The products chosen within these sectors, and associated geographical markets as established in competition cases, are set out in Table 3.2. As all these decisions were arrived at recently, there is little reason to believe that the nature of the markets will have changed substantially since then.

Table 3.2 Market definitions

Sector	Product market	Geographical market	Selection of European Commission cases
Electricity	Electricity generation	Has always been left open, although it has been suggested to be England and Wales, but possibly also including Scotland and France	EDF/Seeboard (Comp/M.2890, 25.07.2002) EDF/London Electricity (Comp/M.1346, 27.01.1999) EDF/TXU Europe/West Burton Power Station (Comp/M.2675, date 20.12.2001)
Cement	Grey cement	'a set of markets, centred around the various factories, overlapping one another and covering the whole of Europe'	Lafarge/Blue Circle (Comp/M.1874, 07.04.2000)
Paper	Newsprint	The two earlier cases determined it to be 'at least EEA wide'; the later two to be 'no wider than the EEA'	Repola/Kymmene (IV/M. 646, 31.10.1995) UPM-Kymmene/Finnpap (IV/M.871, 21.02.1997) UPM-Kymmene/Haindl (Comp/M. 2498, 21.11.2001) Norske Skog/Parenco/Walsum (Comp/M. 2499, 21.11.2001)
Iron and steel	Cold-rolled carbon steel flat products	Either 'at least' Western Europe or 'not wider' than Western Europe	Usinor/Arbed/Aceralia (Comp/ECSC.1351 21.11.2001)
Aluminium	Aluminium smelting	Worldwide	Alcan/Alusuisse (Comp/M.1663, 14.03.2000) Norsk Hydro/VAW (Comp/M. 2702, 04.03.2002) Elkem/Sapa (Comp/M.2404, 26.06.2001)

In all five sectors, it was necessary to distinguish a particular product market. In two sectors, electricity and cement, this was a straightforward choice. The choice of a particular product was driven in part by the same considerations that drove the choice of sectors, and by the importance of the product to the UK economy. Newsprint was chosen as the paper product to be examined, cold-rolled carbon steel flat products as the product in the iron and steel sector, and smelting as the aluminium sector activity.

3.3 Choice of model

As mentioned earlier, many of the sectors in the EU ETS contain a relatively small number of large firms. When these sectors are narrowed to particular markets, the number is even smaller. This suggests that it is appropriate to consider the markets as oligopolistic rather than perfectly competitive. There are important differences between oligopolistic and perfectly competitive markets in the way prices are determined: in a perfectly competitive market, prices are set by the marginal cost of production (the cost of producing an extra unit of output),[9] and firms make profits equal to their cost of capital. In an oligopolistic market, the process is more complicated: marginal cost still plays an important role, but the presence of fixed costs often means that prices are above marginal costs,[10] allowing for the recovery of these costs, and, potentially, if there are barriers to entry, significant profits to be made.

[9] Provided that this exceeds the average variable cost of production—ie, the sum of the variable costs at that level of production, divided by the number of units.
[10] Depending on the precise behaviour within the markets.

3 Overall approach

A number of theoretical models seek to explain the behaviour of firms in oligopolistic markets.[11] Since an important element of this study is to compare the impact of the EU ETS across a range of sectors, a framework was chosen that would be reasonable for all of the sectors; namely, a Cournot oligopoly model. It could be argued that this is the standard oligopoly model,[12] and it is often used in competition policy as a first approximation of how competition works.[13] The key assumptions of the Cournot model, as it is applied in this study, are as follows:

- firms are profit-maximising;
- firms compete on quantity rather than price;
- the output that firms produce is homogeneous;
- the cost structure consists of a fixed cost and a constant marginal cost, although the levels of these costs within this structure may, and in this model do, differ across companies;[14]
- the relationship between consumer demand and price is constant for all price/quantity combinations (ie, there is a linear demand curve).

Using these assumptions, a model can be constructed to predict market price, total sales, individual firm output, and individual firm profits. The model's mathematical basis is explained in the appendix. At first glance, the assumption about which there may be greatest concern is

[11] Depending on whether firms compete on price or quantity, act simultaneously or 'follow a leader', and (tacitly) collude or otherwise.

[12] The Cournot model is described in a leading industrial economics handbook as the 'industrial economics' workhorse model of oligopoly'. Martin, S. (1993), *Advanced Industrial Economics*, Blackwell Publishers.

[13] See, for instance, the frequent use of Herfindahl indices, which are directly linked to the Cournot model, in particular in US merger control, and to some extent in EC competition law.

[14] In theory, it is possible to assume that firms have different cost structures and/or that the marginal cost function is not linear.

that firms compete on quantity. Experience suggests that, in many markets, firms compete on price. However, economic literature has shown that the outcome predicted by the Cournot model may also be realised when firms first choose their capacity levels and then later compete on price.[15] The Cournot model was tested in each market and the results are reported in sections 6 to 10.

[15] Kreps, D. and Scheinkman, J. (1983), 'Quantity Precommitment and Bertrand Competition Yield Cournot Outcomes', *Bell Journal of Economics*, **14**, 326–37.

4 Using the model to illustrate the impact of the EU ETS

Section 3 discussed the choice of sectors, markets and model. This section explains how the Cournot model is applied to the EU ETS.

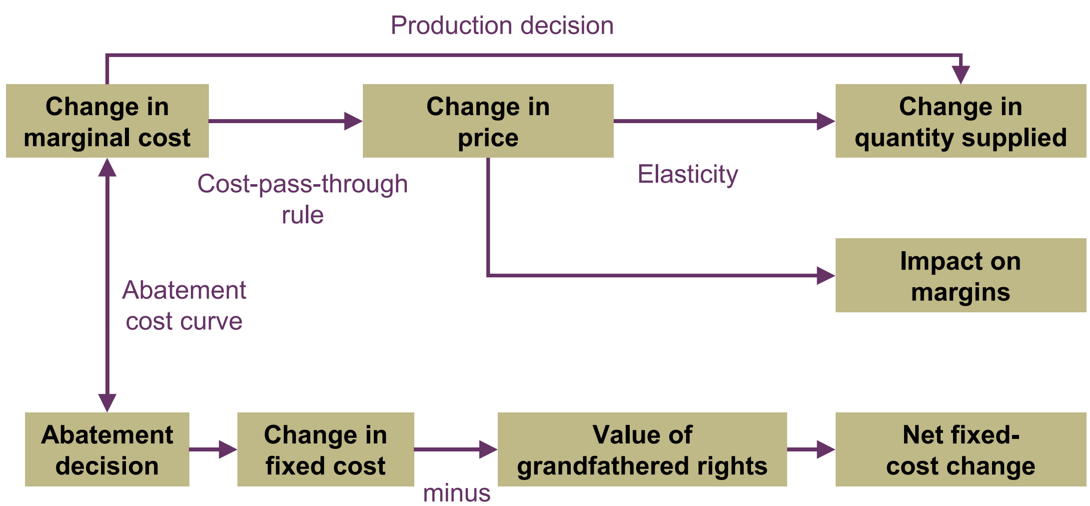
4.1 Basic operation of the model

In the model, prior to the impact of the EU ETS, the market is assumed to be supplied by a number of identical, 'typical', firms.[16] All of the firms choose the same volume of output to maximise their individual profits.[17] If, at this optimal level of output, the firms cannot pay their fixed and variable operating costs, including providing a 'reasonable' return to providers of finance,[18] at least one firm would close. As a consequence of the closure (exit) of a firm, the individual outputs of the remaining firms would increase and their profitability would improve. The model automatically reduces the number of firms in the industry until the remaining firms cover their costs, including a reasonable profit.

4.2 Modelling the short-run financial impact of the EU ETS

The EU ETS affects costs (both fixed and variable), prices, and quantities in the market. It is helpful to divide these impacts into marginal and fixed effects: marginal effects determine the impact on the price or quantity sold; fixed effects do not alter these 'allocative' decisions, but have a direct impact on the profit made and hence on the number of surviving firms. Figure 4.1 illustrates how the model treats the relationship between these effects, which are described in turn below.

Figure 4.1 Modelling the short-run financial impact of the EU ETS



[16] The percentage of the market that is supplied by companies outside the EU ETS is noted.

[17] Had the firms produced more than this optimal amount, the marginal increase in their revenue (taking into account that increasing output will reduce prices) would not have been as great as the marginal cost of producing this extra output, and hence profits could be increased by reducing production. If the firms produced less than this optimal amount, the marginal revenue from a further unit of output would be greater than the marginal cost, and profits could be increased by further production.

[18] A reasonable profit or return to providers of finance is given by the weighted average cost of capital (WACC) for a firm in the sector, estimated using the capital asset pricing model (CAPM) to assess the cost of equity. London Business School estimates of the beta coefficient are used in this study in calculating the cost of equity.

4.3 Change in marginal cost

Under the EU ETS, CO_2 emissions become a factor of production that has to be paid for, in the same way as labour or raw materials. It is assumed in the modelling that marginal costs are constant across the range of output considered—ie, that each additional unit of output has the same marginal impact on costs.

The introduction of the EU ETS leads to two potential changes to the marginal cost of production:

– the direct CO_2 cost—CO_2 emissions from producing an additional unit of output * the market price of allowances. This affects EU ETS participants only;

– an increase in the price of electricity—electricity consumed in producing an additional unit of output * the change in wholesale market price of electricity caused by the EU ETS. This will affect all companies within the EU.

4.4 Transmission of marginal cost increase

An increase in marginal cost has an impact on a firm's profits in three ways:

– *the level of production is reduced*—as the costs of production increase, quantity supplied is reduced, regardless of whether prices are changed;

– *some costs are absorbed by the firm*—this does not lead to an increase in price, but the margin achieved on each unit is eroded;

– *some costs are passed on to customers*—this does not erode margins, but the increase in price leads to a decrease in volumes and hence revenues.

The first of these impacts, which always takes place, reflects the fact that, as each unit of production is now more costly, the level of output at which marginal cost equals marginal revenue will also necessarily be lower. The extent to which this factor results in lower output depends critically on the number of other firms in the market that also face the marginal cost increase.

The second and third impacts depend on the extent to which the marginal cost increase is passed on to customers, and occur in inverse proportions. In the Cournot model, the extent of this pass-through is determined by each firm pursing a profit-maximising strategy. A paper by Ten Kate and Niels summarises the effect.[19] The authors show that, under certain assumptions,[20] the extent to which a change in cost leads to an increase in price is given by the formula $x/(n + 1)$, where x is the number of companies affected by the cost change, and n is the total number of companies operating in the market.[21]

[19] Ten Kate, A. and Niels, G. (2004), 'How Sensitive are Equilibrium Prices to Cost Changes in Oligopoly Models?', mimeo. See also Bulow, J. I. and Pfleiderer, P. (1983), 'A Note on the Effect of Cost Changes on Prices', *Journal of Political Economy*, **91**, 182–5.

[20] Most notably, a linear demand curve.

[21] Strictly speaking, it is the number of firms within the industry that remain profitable, in the long run, after the cost increase. In this short-run analysis, this will be assumed to equal the initial number of firms in the industry. Longer-run dynamics are discussed in section 4.

The implications of this rule are somewhat counterintuitive: monopoly industries (ie, where $n = 1$, and therefore x also = 1), pass through half of any increase in costs. However, as the sector becomes more competitive, and the number of firms increases, the amount of cost pass-through to customers rises until it is close to 100%. In other words, the more competitive the industry, the greater the cost pass-through. This is explained by the fact that, as an industry becomes more competitive, prices become more aligned with costs.

This rule also shows that the smaller the proportion of firms in the market that are affected by the marginal cost increase, the lower the level of cost pass-through. Thus, a lower proportion of costs will be passed through if a larger proportion of demand is satisfied by small or overseas firms not affected by the EU ETS.

4.5 Impact on demand

Once the proportion of cost increase that is passed on to customers is known, the impact on profits from a decrease in margins can be established relatively easily. The magnitude of this effect is given by the sensitivity of demand to price, the 'own-price elasticity of demand'. Estimates of this elasticity are available in the economic literature.

4.6 Fixed-cost effects

The final impact is on the fixed costs of firms. A firm's fixed costs may rise as a result of abatement investment undertaken to reduce exposure to the marginal cost impact of the EU ETS. Knowing the cost of CO_2 emissions, a company can decide whether to invest in abatement technology to reduce emissions. Using published abatement cost curves, the model estimates the level of abatement investment for both CO_2 emissions and electricity consumption. For simplicity's sake, it is assumed that the cost associated with the introduction of new technology is entirely a capital cost, and that the new technology does not change the fixed or variable operating costs of production, except to the extent that marginal costs are reduced due to the lower intensity of electricity or CO_2 consumption.

More important than abatement investment (in financial terms) is the free allocation of allowances to firms. This is equivalent to a fixed, lump-sum revenue transfer to the firm, because the revenue that the company could generate from selling these allowances is independent of its own production volumes.

4.7 Long-run financial impact

While, in the short run, the number of companies in the sector is fixed, in the long run firms can enter or exit. The model shows the financial impact of the EU ETS as though it were distributed equally across all the firms in the market. If the reduction (increase) in profitability is sufficiently great, it is expected to cause firms to exit (enter) the market. This alters the degree of cost pass-through (through the $x/(n + 1)$ rule), and requires further iterations of the model, giving a new financial impact estimate. The iterations continue until a long-run equilibrium number of firms in the industry is established.

A further long-run issue arises from the economic literature on the degree to which firms can mitigate the financial (and competitiveness) impact of environmental regulation by undertaking 'innovation offsets'[22]—for example, through unanticipated changes to production costs from developing innovative production techniques, or by establishing a niche market by producing a 'greener' product. This area does not lend itself to quantitative, *ex ante* analysis, and has therefore not been considered in this study.

[22] See, for instance, Jaffe, A., Peterson, S., Portney, P. and Stavins, R. (1995), 'Environmental Regulation and the Competitiveness of US Manufacturing: What Does the Evidence Tell Us', *Journal of Economic Literature*, **XXXIII**, March, 132–63.

5 Assumptions

The data input to the model is of three types: market data, production cost, and trading scenarios. These are each examined in turn below.

5.1 Market data and production cost scenarios

The market data concerns the relationship between demand for the product and its price (the measure for this is the own-price elasticity of demand); the total volume of product consumed; the number of firms manufacturing the product; and the proportion of total consumption supplied by imports. The market data is sourced from sector market reports; while the elasticity estimates are taken from economic literature, although, in the case of aluminium smelting, no elasticity could be found.

The production cost data concerns the marginal cost of production (although the average variable cost of production is often used as a proxy); the fixed cost of production (including fixed operating costs, depreciation of capital assets and financing costs); and an abatement curve of the unit cost and potential for reducing electricity use and abating CO_2 emissions. The production cost data is taken from published sector studies and was corroborated with company accounts from a sample of firms. Abatement cost data is taken from a database developed for Defra,[23] supplemented with industry discussions and previous Oxera work Table 5.1 details the various market and production cost assumptions.

Table 5.1 Market and production cost assumptions

	Electricity	Cement	Newsprint	Cold-rolled carbon steel flat products	Aluminium smelting
Price elasticity of demand	–0.25	–0.27	–0.5	–0.62	–0.8
Marginal/average variable cost of production	£16.5/MWh	£14/t	£275/t	£190/t	£786/t
Tonnes CO_2 emitted/ marginal unit output	0.6/MWh	1.09/t	0.63/t	1.75/t	4/t
Electricity consumed/ marginal unit output (kWh/t)	n/a	136	834	330	15,351
Market share of non-EU suppliers (%)	0	5[1]	15	20	35

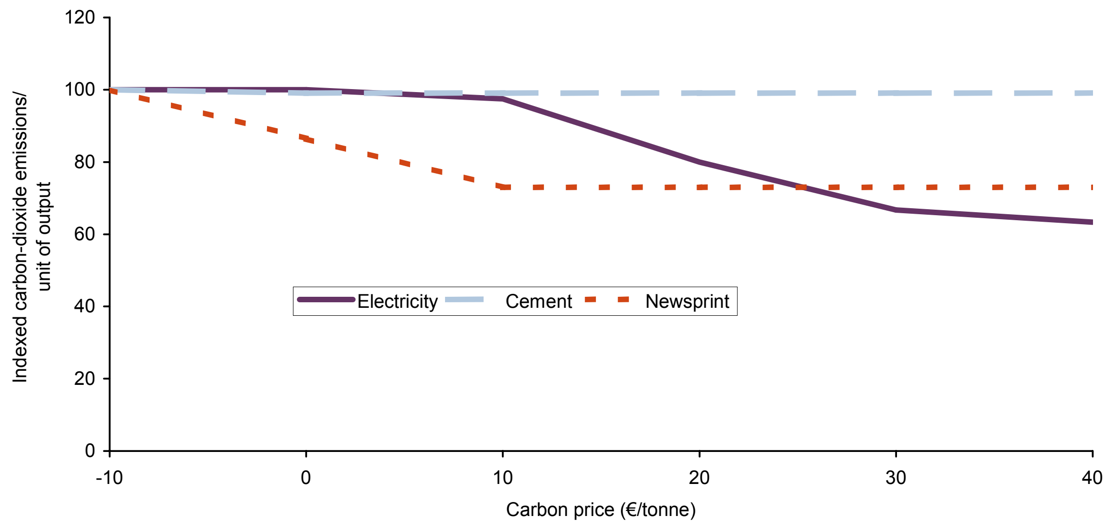
Note: [1] A sensitivity analysis on this assumption is provided—see section 6.
Sources: The sources for these assumptions are detailed in the results section for each of these markets—see sections 6 to 10.

Abatement curves for the electricity, cement and newsprint markets, showing how the intensity of CO_2 changes according to the CO_2 price, are presented in Figure 5.1. No results are provided for the steel market as the data collected suggested that no carbon-saving abatement options were available. In addition, no abatement curve is given for the aluminium smelting market as its participants will not operate within the EU ETS.

[23] Entec UK and Cambridge Econometrics (2003), 'Impact of the Climate Change Programme on Industrial Carbon Dioxide Emissions', August.

5 Assumptions

Figure 5.1 CO_2 abatement cost curves

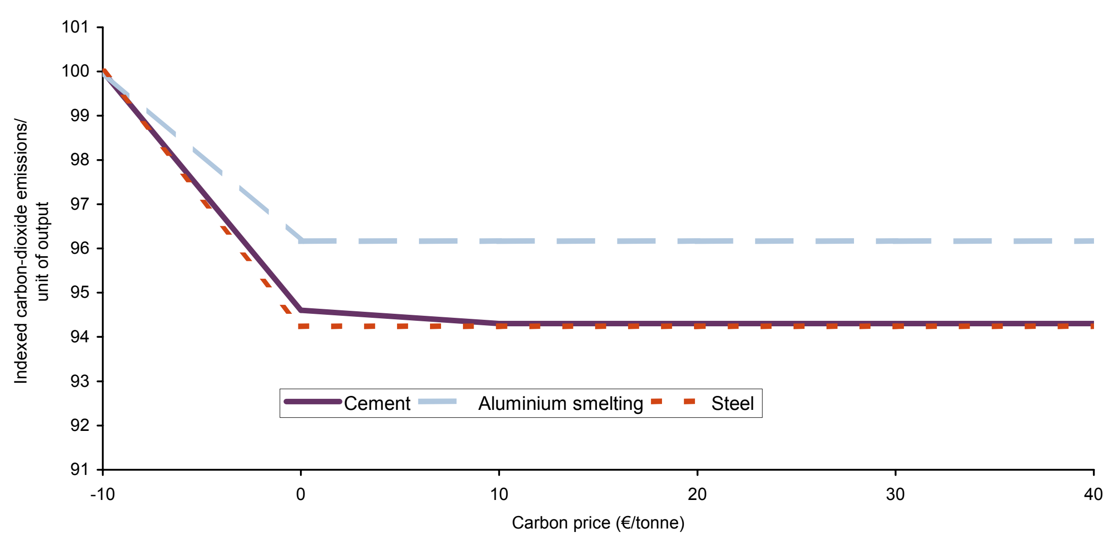


Sources: Entec UK and Cambridge Econometrics (2003), op. cit., industry discussions, and Oxera calculations.

According to this data, at low carbon prices the abatement opportunities are greatest in the newsprint sector, while abatement in the electricity generation is potentially substantial, but only at sufficiently high CO_2 prices. There are few abatement opportunities available in the cement sector.

In addition to companies undertaking abatement activity to insulate themselves from the cost of emitting CO_2, there is likely to be activity to reduce exposure to electricity price increases. As explained below, it is assumed that this activity will only be carried out by participants in the cement, steel and aluminium smelting markets. The assumptions in the modelling relating to this abatement are given below.

Figure 5.2 Electricity consumption abatement in cement, steel and aluminium smelting



Sources: Entec UK and Cambridge Econometrics (2003), op. cit., industry discussions, and Oxera calculations.

In all three cases, the profitable abatement opportunities occur at relatively low CO_2 prices.

5.2 Trading scenarios

The price of allowances will be determined by the generosity of Member State allowance allocations and the terms of the Linking Directive. This Directive will determine the eligibility of credits from Kyoto flexible mechanisms.

Since allowances in the EU ETS can be traded across Europe, it is the *aggregate* allocations that determine prices. The UK accounts for about 15% of total emissions from the EU (including the accession countries), thus, as a first approximation, the price will be independent of the UK allocation decision. For the first trading period (2005–07), there are no directly agreed constraints, although allocations are supposed to be consistent with trajectories towards Kyoto targets for each Member State; whereas, for the second trading period (2008–12), allocations will be constrained by the targets agreed under the Kyoto Protocol. It is widely assumed that allocations will be more lenient (and hence prices lower) in the first trading period.

The upper end of possible prices will tend to be constrained by the ability to switch from coal to gas in the power sector, which is expected to occur at prices in the region of €15–€20/tCO_2. Externally, they will be constrained by the price of the Joint Implementation and Clean Development Mechanism credits, which are currently trading well below this level. Table 5.2 shows price assumptions taken from two recent consultant reports. Table 5.3 shows the combinations of periods and assumptions given to Oxera by The Carbon Trust.

Table 5.2 Price assumptions (€/tonne) of CO_2 in two recent studies

Study	2005–07	2008–12
ICF		
Low	2	4
Central	5	10
High	10	20
ILEX Energy Consulting		
Low	5–7	5–7
High	15–18	19–25

Sources: ICF Consulting (2003), 'EU Power Markets and CO_2 Emissions Trading—A Detailed Analysis of the Competitive Implications of the Proposed EU Emissions Trading Scheme and Allowance Allocation on EU Power Markets (2003 to 2020)', March; and ILEX Energy Consulting (2003), 'A Review of Cost Effectiveness and Carbon Savings Data for the UK Climate Change Programme', December.

Table 5.3 Policy considerations that drive carbon price assumptions

Scenarios		Policy considerations
Low	2005–07: €5, 2008–12: €5	Allocation generous, uncertainty about Kyoto future, loose rules on external credits
Mid	2005–07: €10, 2008–12: €10	Allocation to ensure compliance with Kyoto Protocol, Commission acts against allocations that are inconsistent with Kyoto targets, Linking Directive offers limited supply of credits
High	2005–07: €15, 2008–12: €25	Kyoto enters into force, trading sector provides headroom for greater CO_2 emissions from non-EU ETS sectors (such as transport), Linking Directive tight

Source: The Carbon Trust.

The UK's draft National Allocation Plan proposes that all the non-electricity sectors will receive allocations equal to their targets under the revised Climate Change Agreements (for those participating in the CCAs), or their emissions as estimated in the DTI's Updated Energy Projections (UEP+). In this study, it is assumed that this is equivalent to companies receiving sufficient allowances to cover their CO_2 emissions at existing output levels. The electricity sector would receive allowances equal to its UEP+ projections, less an amount that would rise linearly to 5.5MtCO_2/yr below projections in 2010, which also equates to the electricity sector receiving 5.5MtCO_2 less in total over the period 2005–07 than its projected emissions.

The assumptions used in this study are based on the UK draft National Allocation Plan. In the first trading period, allocation follows the principles set out in the plan and a price of €5/tCO_2 is assumed. For the second period, a price of €10/tCO_2 is assumed, with allocations that would achieve a national 20% CO_2 reduction, again following the principles of the National Allocation Plan, which mean that all the reduction in allocation is borne by the electricity sector. (This equates to electricity receiving 28.3% below its UEP+ projection/current emission level.) Finally, a third, longer-term, trading period is modelled—a stronger case in which prices rise to €25/tCO_2, with free allocations 30% lower across the board than projected emissions. The three scenarios are summarised in Table 5.4.

Table 5.4 Allowance prices and allocations

Trading period	Allowance price (€/tCO_2)	Allowance allocation as a proportion of UEP+ CO_2 emissions/as a proportion of current CO_2 emissions at existing output levels (%)
2005–07	5	100 (98.8 electricity)
2008–12	10	100 (71.7 electricity)
2012–	25	70

Source: The Carbon Trust.

6 Electricity generation results

6.1 Approach

The geographical scope of the market for electricity generation has been discussed in a number of European Commission competition cases, some of which suggest that this may be as narrow as England and Wales, while others raise the possibility that it might include Scotland, Northern Ireland and even France. The case for including Scotland is very strong. For the purposes of this study, the market is defined as Great Britain, reflecting the fact that there will be a single set of electricity trading arrangements across Great Britain from 2005.

Intuitively, the demand for electricity would be expected to be inelastic—ie, it would not respond to changes in price. This is confirmed by academic and government studies. For example, in 'Energy Projections for the UK', an elasticity of –0.29 for domestic consumption is given,[24] while the Treasury uses a figure of –0.187.[25] Other studies suggest a range between –0.25 and –0.37 for the Australian market,[26] –0.3 for the Swiss residential market,[27] and –0.37 for the US residential market.[28] An elasticity of –0.25 is used in this study.

Since the modelling approach, in the first instance, assumes that all firms in the market are identical, parameter estimates are used that are close to the industry average,[29] with these calculations based on the Oxera wholesale electricity market model, discussed below. As such, the marginal cost is assumed to be £16.5/MWh, and the estimate of carbon intensity is taken as 0.6tCO_2/MWh. Fixed-cost estimates were derived from company accounts and the Oxera electricity wholesale market model.[30] Similarly, abatement figures were taken through running the Oxera electricity wholesale market model at the different carbon prices and observing the difference in generating capacity and its carbon intensity under these different assumptions.

A Cournot framework is not typically used to model price determination in electricity generation markets. As mentioned above, Oxera already possesses a wholesale electricity market model of the UK generation sector. Therefore, the Cournot results were compared with the results of the despatch model for all of the scenarios. The despatch model has the added advantage that it shows the winners and losers within the sector, as it does not assume that all firms are typical.

In terms of corroboration with the real world, the Cournot model predicted a wholesale price of £23.1/MWh prior to the implementation of the EU ETS, compared with a figure of £21.5/MWh for 2005 predicted by the Oxera electricity wholesale market model with a zero CO_2 price. The Cournot model also predicted that nine companies would generate an output of 251 TWh per annum, while in reality the UK generation is currently dominated by ten companies, each of which owns capacity in excess of 2,500 MW, and which collectively are responsible for approximately 261 TWh of generation per annum. As the purpose of this

[24] See http://www.parliament.the-stationery-office.co.uk/pa/cm199900/cmhansrd/vo000515/text/00515w08.htm

[25] See http://www.parliament.the-stationery-office.co.uk/pa/cm199798/cmhansrd/vo980210/text/80210w09.htm

[26] http://www.nemmco.com.au/publications/soo/410-0023.pdf

[27] Filippini, M. (1999), 'Swiss Residential Demand for Electricity', *Applied Economic Letters*, **6**:8, 533.

[28] Miller, J. I. (2001), 'Modeling Residential Demand for Electricity in the U.S.: A Semiparametric Panel Data Approach', Department of Economics, Rice University, Preliminary Draft, November.

[29] Averages were calculated over the entire non-nuclear portfolio of GB plant that run at some point over the 'average' year.

[30] In reality, a number of electricity generators appear to be making losses at present. However, as the model does not allow for loss-making firms to continue to operate, a low fixed-cost estimate was used in order to attain a reasonable estimate of the number of firms in the market. This was considered reasonable as the cost-pass-through rule is determined by the number of companies in the market. It was therefore deemed important that the model reflected this.

analysis was primarily cross-sectoral, and given the difficulties associated with modelling radically different sized companies, focusing on these largest generators was considered reasonable. As such, the results from the Cournot model below can be considered as indicative of those that would pertain if the industry structure did not include the fringe players. The additional small players are not expected to have a significant effect on the results.[31]

6.2 Results

A standard set of results is displayed in this and subsequent sections. In all cases, the results refer to the estimated effect of the EU ETS on the particular parameter with everything else held constant—ie, they are not predictions of what that parameter will actually be in a particular period, which is likely to be affected by other factors, such as economic growth. Table 6.1 shows the change in EBITDA under each trading period. In this sector, the percentage changes refer to the effect both on the typical generator and on the UK generation sector as a whole. (This is because there is no change in the number of participants in the market.)

Table 6.1 Headline changes in EBITDA in the electricity generation market (%)

Trading period	Change in EBITDA
2005–07	+47
2008–12	+63
2012–	+162

Source: Unless otherwise stated, all sources in sections 6 to 10 are Oxera.

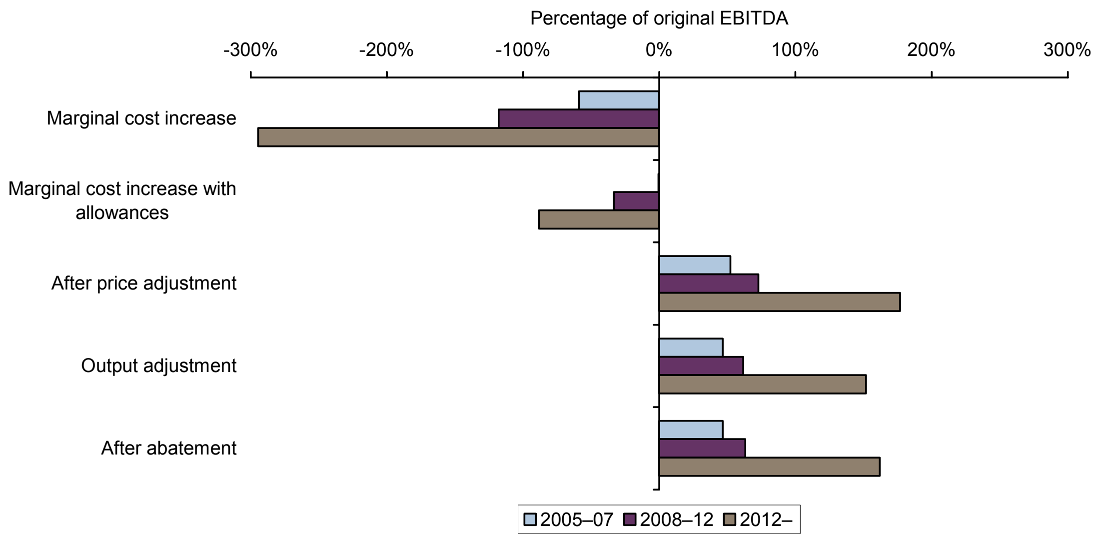
The change in EBITDA is broken down into a number of components, as shown in Figure 6.1 below. These components are explained below:

- when the EU ETS is introduced, the immediate impact will be on the firm's marginal cost of production and this will reduce its profits, as shown in the first row in Figure 6.1;
- however, this financial impact is netted off against the (lump-sum) value of the allowances allocated to the firm. The net position is shown in the bars labelled 'marginal cost increase with allowances'. The difference between the first and second row reflects the value of the allowance allocation;
- firms pass on to customers a proportion of the marginal cost increase. The net impact on profits after this effect is shown in the third row;
- the price rise comes at the expense of lower sales,[32] giving the profits in the fourth row;
- finally, firms may abate emissions, reducing the intensity of CO_2 and electricity use, and boosting profits, giving an overall net position, as shown in the last row.[33]

[31] Indeed, if anything, the results presented are likely to provide a conservative estimate of the financial impact. This is because including the fringe players within the analysis would increase the degree of cost pass-through and would provide more companies among which to share the price-induced reduction in demand.
[32] Lower sales also result directly from the fact that marginal costs have increased. This effect is also captured in this part of the chart.
[33] This can be considered as a second cost 'shock', although on this occasion it is a cost saving, which will have its own impact on prices and quantities and hence EBITDA. However, as abatement tends to be a second-order effect, and, in the interests of simplicity, these effects are aggregated together in this final row.

6 Electricity generation results

Figure 6.1 Decomposition of EBITDA impact in the electricity generation market



A range of other outputs from the model is provided in the two tables below. The first table presents market outcome/financial parameters. 'Value at stake' shows by how much EBITDA would fall if firms did not respond at all to the introduction of the scheme—ie, it corresponds to the second row 'marginal cost increase with allowances' in the above figure. The second table presents outputs related to how the EU ETS operates, and its environmental implications, as predicted by the model. In this table, the abatement investment figure applies to the sector as a whole.

Table 6.2 Market/financial results in the electricity generation market (%)

Trading period	Increase in marginal cost (%)	Increase in price (%)	% of marginal cost increase passed on to customers	Change in quantity demanded (%)	Change in EBITDA (%)	Value at stake (%)	Change in number of firms
2005–07	12	8	90	–3	47	0.7	No change
2008–12	23	15	90	–6	63	33	No change
2012–	49	31	90	–12	162	88	No change

Table 6.3 Further electricity generation market results

Trading period	Value of allowances as % of total operating costs (post-implementation)	Abatement investment undertaken (cumulative, £ billion)	Reduction in UK firm's CO_2 emissions (%)
2005–07	9.3	0	3.0
2008–12	12.9	1.1	12.0
2012–	28.4	4.0	29.7

Note: The reduction is CO_2 emissions in this table, and the equivalent tables in sections 7–10 is due to both abatement activity and the reduction in output caused by the cost impact of the EU ETS.

6.3 Discussion

The results suggest that the typical firm in the electricity generation sector, and the sector as a whole, are likely to benefit from the introduction of the EU ETS. The firms can recover costs under the scheme from two sources:

– first, they pass on 90% of the marginal cost increase to customers, and, because demand is inelastic, the volume of sales is only affected slightly. Consequently, revenues increase almost enough to compensate for the rise in marginal costs;

– second, at the same time, the firms receive grandfathered allowances, the value of which is added to the firm's bottom line.

This positive financial result is consistent with a published study for the DTI by ILEX Energy Consulting, which examined the impact of the EU ETS on the electricity generation market.[34] Hence, the simple 'value at stake' measurement included in Table 6.2 is of limited value in assessing the financial impact of the EU ETS.

The positive impact on EBITDA is greater in the second trading period than in the first, and greater again in the third trading period, even though the number of allowances allocated falls. This is because the value of each allowance rises proportionately more than the allocation is reduced in size.

Although firms' profits increase and CO_2 emissions fall, it is the case that consumers pay. The model predicts electricity price increases, with the new wholesale prices being £25/MWh (a 8% increase), £27/MWh (15%) and £30/MWh (31%) in each trading period. These trigger a reduction in electricity demand of up to 12%.

6.4 Variation across firms

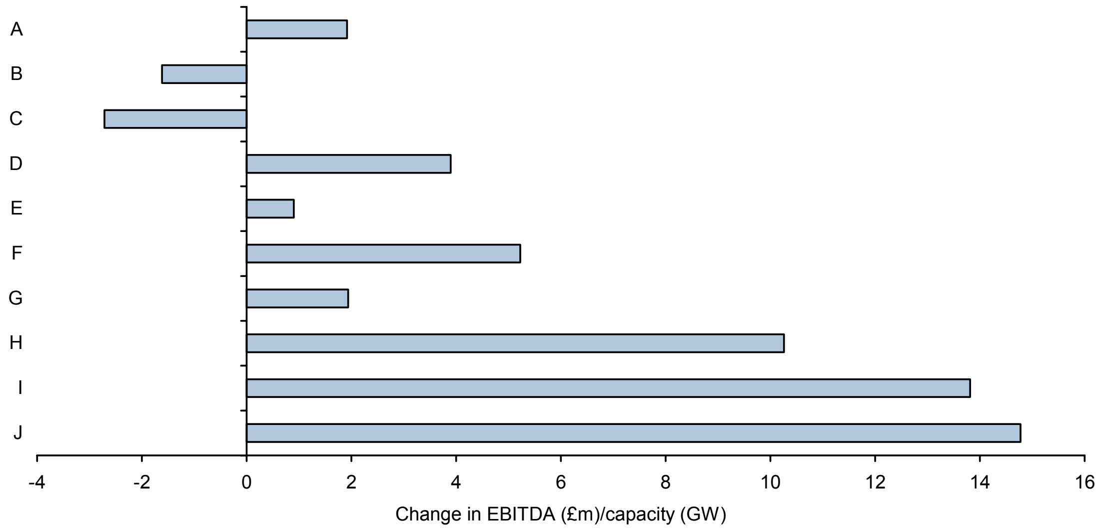
In the generation sector, firms have portfolios of plant (coal, gas, nuclear, renewables) and each of these plant types has a different cost structure and CO_2 intensity. Furthermore, a feature of the UK electricity market is that demand varies considerably, particularly by time of day and season; as such, the assumption that marginal costs are constant across all levels of output may not fully capture important market dynamics.

Therefore, although the results already presented are valid for a typical firm, there are significant differences across the sector. To explore these differences, and their financial implications, the scenarios were run using the Oxera electricity wholesale market model. This model predicts a magnitude of wholesale price increases similar to those given above: 6%, 14% and 43% in each of the trading periods respectively. It also indicates that the sector as a whole will benefit from the scheme. The change in EBITDA at a firm level, given the firms' current portfolios of plant, is shown in Figure 6.2 for the second trading period.

[34] ILEX Energy Consulting (2003), 'Implications of the EU ETS for the Power Sector', September.

6 Electricity generation results

Figure 6.2 Winners and losers in the electricity generation market



The figure shows that although it appears that participants in the market as a whole will gain, there is a considerable discrepancy in the impact across the market participants. These results are driven by the extent to which the merit order of plant within the generation sector will be altered as a result of the EU ETS. Generators with a relatively high CO_2 intensity will become less competitive following the scheme's introduction, triggering a fall down the merit order, leading to output reductions and a fall in EBITDA. As a corollary, those that are relatively less CO_2-intensive are likely to benefit from the scheme.

7 Cement results

7.1 Approach

The definition of the geographical scope of the market in the cement industry is complicated. In a recent European Commission inquiry, the relevant geographical market was defined as:

> A set of markets, centred around the various factories, overlapping one another and covering the whole of Europe. The size of each market and the extent of overlap are determined by the distance from the factory at which the cement may be sold. While transport by road is expensive, rail transport is less so and cement can be transported considerable distances by sea at reasonable cost.[35]

This definition means that the scope of a geographical market for cement is variable, and may not correspond to an administrative area for which data may be readily available. As a reasonable approximation, it is assumed that the market for cement is national. For many sites in the UK, this implies a wider market definition than that given above. Indeed, in the merger case quoted above, the parties argued that markets were national because it was in their interest to use as wide a market definition as possible.

However, to reflect a possibility that, for some sites in the UK, the relevant geographical market may include supply from outside the EU ETS, a downside case has been modelled, in which the extent of non-EU imports is 30%. This broadly reflects the current market conditions in Spain. The outcomes from this downside case should be treated with caution, however, as other assumptions in the model use national rather than international data. The other assumptions used in the model are:

- an own-price elasticity of –0.27, as estimated by a recent academic paper considering the cement industry in a Western European country;[36]
- a marginal cost estimate of £14/tonne cement based on discussions between The Carbon Trust and industry representatives, and a British Cement Association memorandum to a select committee hearing in which cost structures were discussed;[37]
- a CO_2 intensity of 1.1 tCO_2/tonne cement, based on discussions with industry representatives;
- an electricity consumption figure of 136 kWh/tonne cement, taken from discussions with industry representatives;
- abatement curve data based on discussions between The Carbon Trust and industry representatives.

These assumptions provide a baseline consistent with observed market conditions. The model predicts a price of £45/tonne cement and UK consumption of 11 million tonnes per annum (mtpa). The actual market price varies between £40 and £50, and an estimate of UK consumption in 2002, based on National Statistics data, was 12 mtpa.[38] The model predicts the existence of five firms, while there are actually four firms plus 5–10% of imports.

[35] Lafarge/Blue Circle, Case Comp/M.1874, 07.04.2000.

[36] Funding La Cour, L. and Mollgaard, H.P. (2002), 'Market Domination: Tests Applied to the Danish Cement Industry', *European Journal of Law and Economics*, **14**, 99–127.

[37] The British Cement Association memorandum is available at http://www.parliament.the-stationery-office.co.uk/pa/cm199899/cmselect/cmtrdind/678/9070627.htm

[38] Calculated as production minus exports plus imports minus stocks.

7 Cement results

7.2 Base-case results

The results presented below follow the same format as those for the electricity generation sector in section 6.

Table 7.1 Headline changes in EBITDA in cement market (base case) (%)

Trading period	Change in EBITDA
2005–07	12
2008–12	25
2012–	35

Figure 7.1 Decomposition of EBITDA impact in the cement market (base case)

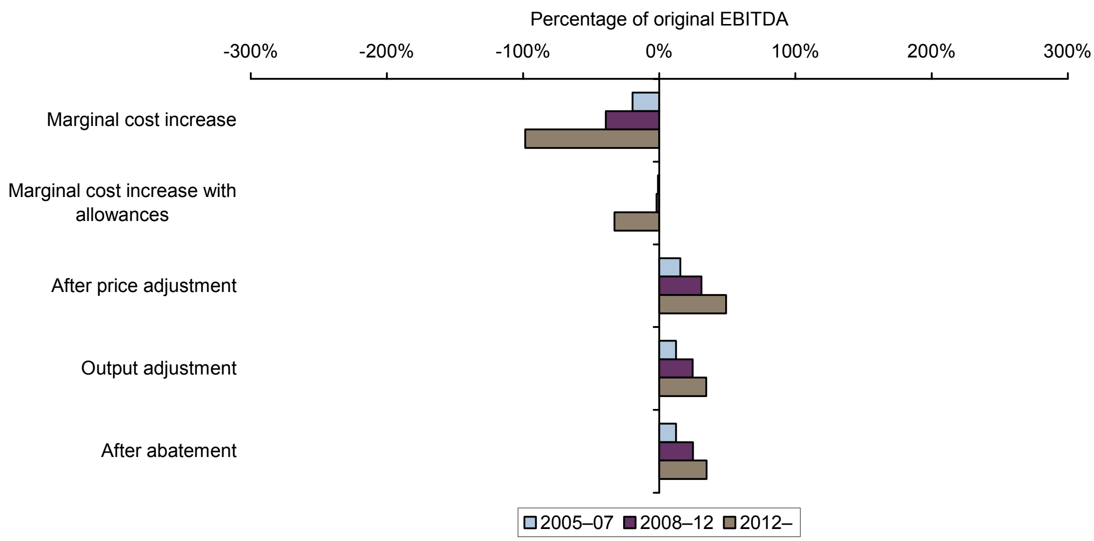


Table 7.2 Market/financial results in the cement market (base case)

Trading period	Increase in marginal cost (%)	Increase in price (%)	% of marginal cost increase passed on to customers	Change in quantity demanded (%)	Change in EBITDA (%)	Value at stake (%)	Change in number of firms
2005–07	27	7	83	–2	12	1.0	no change
2008–12	55	14	83	–4	25	1.9	no change
2012–	136	35	83	–10	35	33	no change

7 Cement results

Table 7.3 Further cement market (base case) results

Trading period	Value of allowances as % of total operating costs (post-implementation)	Abatement investment undertaken (cumulative, £m)	Reduction in UK firm's CO_2 emissions (%)
2005–07	12.8	2.6	3.0
2008–12	23.1	2.9	5.1
2012–	31.9	2.9	11.1

7.3 Downside case results

Table 7.4 Headline changes in EBITDA in cement market (downside case) (%)

Trading period	Change in EBITDA
2005–07	6.0
2008–12	13
2012–	7

Figure 7.2 Decomposition of EBITDA impact in the cement market (downside case)

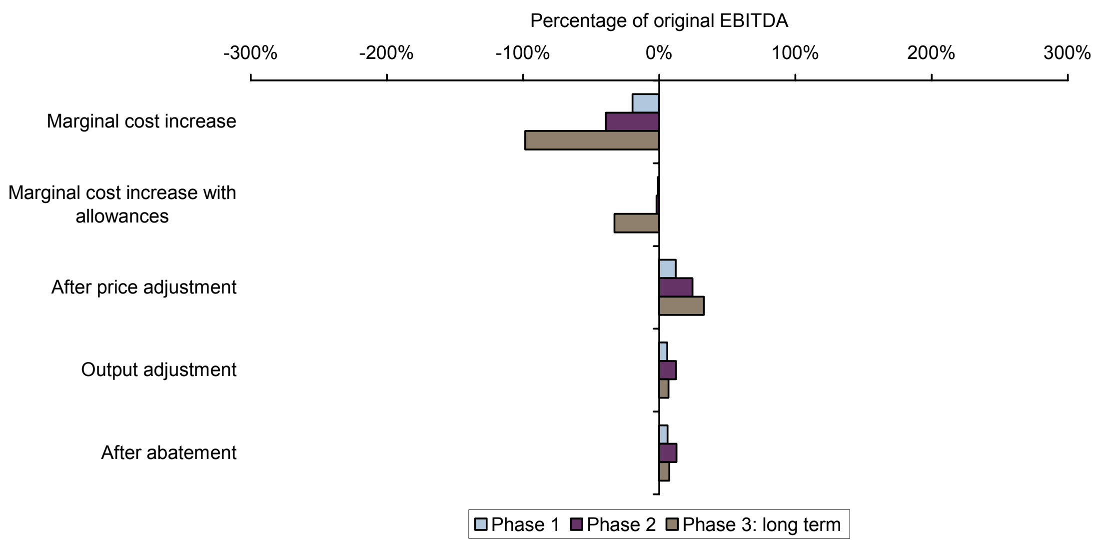


Table 7.5 Financial/market results in the cement market (downside case) (%)

Trading period	Increase in marginal cost (%)	Increase in price (%)	% of marginal cost increase passed on to customers	Change in quantity demanded (%)	Change in EBITDA (%)	Value at stake (%)	Change in number of firms
2005–07	27	6	66	–4	6	1.0	no change
2008–12	55	11	66	–8	13	1.9	no change
2012–	136	28	66	–21	7	33	no change

Table 7.6 Further cement market results (downside case)

Trading period	Value of allowances as % of total operating costs (post-implementation)	Abatement investment undertaken (cumulative, £m)	Reduction in UK firm's CO_2 emissions (%)
2005–07	13.0	2.6	5.0
2008–12	23.8	2.9	9.1
2012–	34.7	2.9	21.3

7.4 Discussion

The base-case results show the UK cement industry benefiting from the EU ETS, although to a lesser extent than electricity generators. The reasons are the same as for the electricity sector: firms are able to recover the marginal cost increases through higher prices and at the same time are allocated grandfathered permits. The rate of cost pass-through is lower than in electricity, and the sensitivity of consumer demand to price rises is slightly higher, with the result that, although the sector receives a relatively higher allocation of allowances, the overall impact is slightly less positive.

Again, the profit impact is higher in each of the successive trading periods because the value of the allowances increases through the trading periods.

The downside scenario assumes a significant market share from non-EU importers. The effect of the EU ETS is still positive, but much less so: for the same increase in costs, the price increase is lower (only 66% cost pass-through); moreover, despite this lower price increase, output falls by almost twice as much as it did in the base-case results. The result is that, in the first and second trading periods, the EBITDA impact is approximately half that in the base-case results. Nonetheless, the impact is still positive. However, this situation reverses if it is assumed that cement manufacturers are unable to pass through any of the marginal cost rise, as has been suggested in some reports[39] and by the manufacturers themselves. In this situation, the EBITDA impact is –1% in the first trading period, –3% in the second and –34% in the third.

The downside results show that, if a sector is exposed to significant non-EU competition, the allocation of allowances becomes increasingly ineffective at maintaining profitability as the CO_2 price rises. This can be seen in Figure 7.2, where the output adjustment in the third trading period (the fourth row down in the diagram) has a much more significant effect on profit than that between the first and second trading period. Consequently, in the third trading

[39] Dresdner Kleinwort Wasserstein (2004), 'Emission Trading Carbon Derby: Cement Falls at the First Hurdle', February 3rd.

period of the downside case, even though the high price of CO_2 makes the allowances allocated to the cement industry very valuable, this is more than offset by the marginal cost rise resulting from the high CO_2 price, meaning that the sector is worse off in the third trading period than in the second. The opposite occurs in the base case, where international competition is less of a threat.

8 Newsprint results

8.1 Approach

In the most recent European Commission competition law cases concerning the newsprint industry,[40] it was declared that the relevant market for newsprint was 'not wider than the EEA'. This conclusion was reached on the basis that imports from outside the EEA (primarily from Canada) accounted for approximately 9% of total EEA consumption, and as a result of the observation by the Commission that this level did not appear to have changed in recent years, despite reduced tariffs, exchange-rate fluctuations and business cycles. Earlier cases had suggested that the relevant geographical market was 'at least EEA wide' and that, although the EEA as a whole may have a relatively low level of import penetration, the figure for the UK is above the average for the market as a whole.

Given this, the newsprint market is taken to be EU-wide, but with a relatively high level of import penetration, namely 15%.

The other assumptions are:

– an elasticity estimate of –0.50 based on a pan-European study;[41]
– a marginal cost of £275/tonne based on company accounts data and estimates of the industry supply curve;
– an intensity of 0.63tCO_2e/tonne of newsprint produced based on data contained in companies' environmental reports;
– that firms do not face an electricity price uplift as a result of the EU ETS, reflecting the fact that all of the UK newsprint producers have combined heat and power (CHP) plant; and
– that abatement curve data for the paper and board sub-sector can be applied on a pro-rata basis to the newsprint sector.

As before, it is useful to check the predictions of the model prior to implementation of the EU ETS with those observed in the real world. The price predicted by the model is £341/tonne of newsprint, which compares with a forecast 2003 price of €530/tonne,[42] which is £353/tonne at an average exchange rate of €0.66/£1. The EU consumption at this price is 9.9 mtpa, compared with data which states that deliveries to Western Europe by Western European suppliers were forecast to be 8.4 mtpa,[43] to which must be added the 9% from overseas suppliers, which results in a broadly comparable figure. The model predicts that this output is shared equally between 11 companies, of which it is assumed that ten are based within the EU and one is outside.

[40] UPM-Kymmene/Haindl, Comp/M. 2498, 21.11.2001, and Norske Skog/Parenco/Walsum, Comp/M. 2499, 21.11.2001.

[41] Chas-Amil, M. L. and Buongiorno, J. (2000), 'The Demand for Paper and Paperboard: Econometric Models for the European Union', *Applied Economics*, **32**, 987–99.

[42] Presentation by Aylesford Newsprint on June 19th 2003. Available at http://www.angloamerican.co.uk/investor /downloads/Aylesford.pdf

[43] CEPIPRINT (2003), 'Demand and Supply Report'.

8 Newsprint results

8.2 Results

Table 8.1 Headline changes in EBITDA in newsprint market (%)

Trading period	Change in EBITDA
2005–07	2.9
2008–12	5.7
2012–	8.7

Figure 8.1 Decomposition of EBITDA impact in the newsprint market

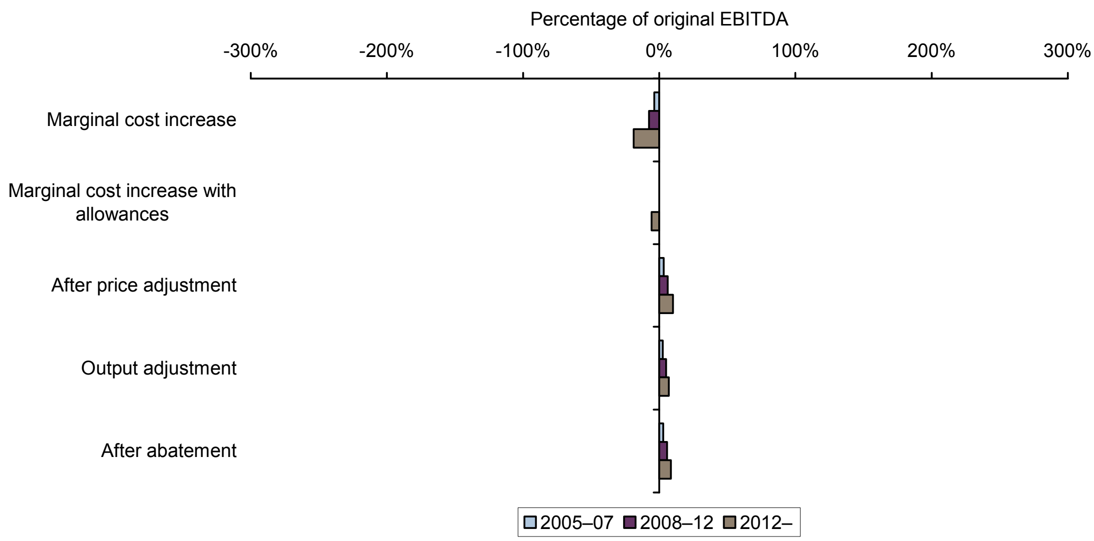


Table 8.2 Financial/market results in the newsprint market (%)

Trading period	Increase in marginal cost (%)	Increase in price (%)	% of marginal cost increase passed on to customers	Change in quantity demanded (%)	Change in EBITDA (%)	Value at stake (%)	Change in number of firms
2005–07	1	0	83	0	3	0	no change
2008–12	1	1	83	–1	6	0	no change
2012–	3	2	83	–2	9	5.6	no change

Table 8.3 Further newsprint market results

Trading period	Value of allowances as % of total operating costs (post-implementation)	Abatement investment undertaken (cumulative, £m)	Reduction in typical EU firm's CO_2 emissions (%)
2005–07	0.8	2.5	27.3
2008–12	1.5	2.5	27.6
2012–	2.6	2.5	28.4

In this case, although the market is EU-wide, the abatement figures refer to the abatement undertaken by newsprint mills in the UK.

8.3 Discussion

These figures and tables indicate that the model suggests a much more marginal effect of the EU ETS on the European newsprint sector compared with the two previous sectors analysed. In all three trading periods, it is estimated that the effect of the EU ETS is a net improvement in the financial health of the sector, with the impact increasing through the three trading periods.

Despite the marginal cost increase being much smaller, and the value-at-stake figure being much lower than in the other sectors, participants in the newsprint market come much closer to being detrimentally affected by the EU ETS than some other sectors. This is driven by the non-EU competition within the market. Although the overall market elasticity is –0.5, it can be seen that price rises of 1% and 2% lead to a –1% and –2% decrease in the sales volume of EU firms.

Despite the threat from non-EU competition, the model predicts that the combination of the grandfathered allowances and marginal cost recovery through increased prices—albeit at the expense of some loss in sales volume—is sufficient to make the impact of the EU ETS on the industry slightly positive. It is noteworthy that abatement has a slightly more significant impact on EBITDA than in the other sectors.

9 Cold-rolled flat steel results

9.1 Approach

Many aspects of the steel industry are discussed in the Usinor/Arbed/Aceralia merger case (Comp/ESCC.1351), the findings of which were published in November 2001. According to this case, although the geographic extent of the market for cold-rolled flat steel products is probably not wider than Western Europe (consisting of the EU15 plus other countries in Western Europe), it is a market that has both the highest degree of import penetration (17.9%) and the fastest rate of growth of such penetration, of all the markets considered by the authority.[44] The case also notes that the imports from outside Western Europe do not suffer any severe quality disadvantages, as the vast majority of cold-rolled flat steel is commodity-grade steel. For modelling purposes, an import share of 20% from outside of the EU was used.

In terms of the production process for cold-rolled flat steel products, they are manufactured through further processing of the hot-rolled product, reducing the thickness, and providing greater dimensional accuracy, a smoother surface and potentially greater strength than the initial hot-rolled product. The modelling approach assumes that all of the hot-rolled steel that is then further processed to create cold-rolled flat steel has been produced through the 'integrated' route rather than through electric arc furnaces (the EAF route). The essential difference between these two processes is that the latter uses scrap material and therefore tends to be less $C0_2$-intensive than the integrated route. Although some have argued that increasing amounts of cold-rolled steel may be processed from steel produced through the EAF route over the next century, discussions with industry representatives suggest that this modelling assumption was reasonable. As such, the marginal/average variable cost of producing one tonne of cold-rolled steel was assumed to be £190/tonne, and it was assumed that, for every tonne of cold-rolled steel produced, 330 KWh of electricity was consumed and 1.75 tonnes of $C0_2$ emitted. These assumptions were based on discussions with industry representatives, analysis of company financial statements and market research reports.[45]

An own-price demand elasticity of –0.62 was used, based on academic research.[46]

Testing the modelling outputs prior to the introduction of the EU ETS, the model predicted a price of £274/tonne, a market supply figure of 12.8m tonnes, with this output being spread across five firms. The price figure compares with an average price for 2003 of €393–€411 (equivalent to £260–£274 at an exchange rate of £1:€1:50) reported by *Steel Business Briefing*.[47] The quantity figure compares with a figure of 13.1m tonnes for Western Europe, reported in the Usinor/Arbed/Aceralia case for 2001. Moreover, although it was not possible to find further information on market supply figures for the period since 2000, the Iron and Steel Statistics Bureau reports a generally stable market supply for flat products as a whole in the EU (broadly equivalent to Western Europe) in the period up to 2002.[48] Finally, the HSBC report, referred to in footnote 46, notes that flat steel production (both cold- and hot-rolled) is dominated by four companies with an 80% market share.

[44] The markets consisted of hot- and cold-rolled flat carbon steel products, quarto plates, non-grain-oriented electrical steel sheets, galvanised steel, organic coated carbon steel, steel for packaging, hot- and cold-rolled stainless steel flat products.

[45] HSBC (2003), *Global Steel Book*, July.

[46] Lord, R. and Ken Farr, W. (2003), 'Collusion and Financial Leverage: An Analysis of the Integrated Mill Steel Industry' *Financial Management*, Spring, 127–48.

[47] *Steel Business Briefing* (2004), 'SBB Steel Prices'.

[48] http://www.issb.co.uk/?p=keystatistics

9 Cold-rolled flat steel results

9.2 Results

Table 9.1 Headline changes in EBITDA in cold-rolled flat steel market (%)

Trading period	Change in EBITDA
2005–07	8.4
2008–12	17.5
2012–	4.2

Figure 9.1 Decomposition of EBITDA impact in the cold-rolled flat steel market

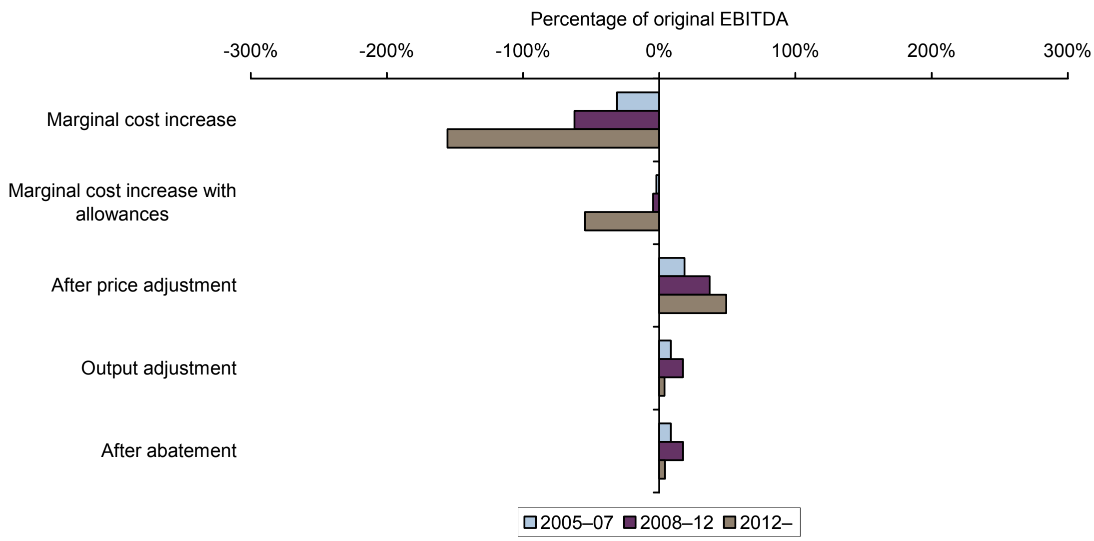


Table 9.2 Financial/market results in the cold-rolled flat steel market (%)

Trading period	Increase in marginal cost (%)	Increase in price (%)	% of marginal cost increase passed on to customers	Change in quantity demanded (%)	Change in EBITDA (%)	Value at stake (%)	Change in number of firms
2005–07	3	2	67	–3	8	2	No change
2008–12	7	3	67	–5	17	4	No change
2012–	4	8	67	–13	4	55	No change

Table 9.3 Further cold-rolled flat steel market results

Trading period	Value of allowances as % of total operating costs (post-implementation)	Abatement investment undertaken (cumulative, £m)	Reduction in UK firm's CO_2 emissions (%)
2005–07	2.3	2.5	2.5
2008–12	4.6	2.5	5.0
2012–	8.1	2.5	12.5

The abatement investment figures refer to the estimated abatement costs for UK participants in the market.

9.3 Discussion

To a large extent, these results are similar to those found in the other markets analysed. Through the combination of the grandfathered allowances and the passing of higher costs on to customers (because the market is predominately supplied by companies affected by the EU ETS), the model predicts that the impact of the scheme will be net-positive for the market participants.

These results rely on the 'rationality' of all participants in the market seeking to maximise profits and this contributing to the 67% pass-through rate. By contrast, observers of the market have suggested that at least some companies are more interested in market share and other strategic considerations than pure profit maximisation.[49] Although the effects of this 'irrationality' are inherently difficult to model, if such strategies were pursued, they could well lead to a lower degree of cost pass-through and potentially a negative shock to EBITDA as a result of the EU ETS.

A further interesting observation from this set of results is that the market participants in the third trading period do less well than in the first and second trading periods. This is the same pattern as found in the cement downside results, but differs from the pattern in the electricity generation, cement base case and newsprint markets. These different patterns are driven by the degree of international exposure assumed in each case, and illustrate that, in markets with a moderately high degree of non-EU competition, the threat from the EU ETS as it matures, and so CO_2 prices rise, will also increase.

[49] HSBC (2003), *Global Steel Book*, July.

10 Aluminium smelting results

10.1 Approach

Modelling the aluminium smelting market was complicated by the fact that firms own plant both within and outside the EU, and that some sites are jointly owned by several companies. Noting these complications, the initial modelling approach was as follows:

– data was taken from accounts in those circumstances where individual plant are registered as limited companies, and from economic literature.[50] This gives an estimate of marginal costs of £786/tonne (US$1,180/tonne), and provides an estimate of fixed costs;
– it was assumed that a 'typical' company would be likely to own three plants;
– the market was assumed to be worldwide in scope, with firms being designated as either EU producers or non-EU producers, to give a proportion of EU production consistent with this real-world value:
– as the only reference that could be found to elasticities in the aluminium smelting market stated that: 'While short run demand for ingot was inelastic, long-run demand was relatively elastic'[51] and it is the long-run impact that is of interest in this study, an elasticity of –0.8 was used.

These modelling assumptions provided a reasonably accurate reflection of the pre-EU ETS market conditions with a total output level of 26.3 mtpa (compared with actual output of around 26.1 mtpa in 2002) and a simulated price of £895/tonne (US$1,343), as against an average long-run price of around $1,400/tonne.[52] It was assumed that there were 11 companies that provided this output, of which two were based entirely within the EU.

Using this set of assumptions, the model predicted in all three scenarios that the two EU companies would exit the market. It was considered that this was an extreme result, and reflected the fact that the cross-sectoral model could not easily capture the effects that are likely to result when companies own plant both within and outside the EU.

To overcome this problem, and present results on a comparable basis to the other markets examined, it was decided to simulate the aluminium smelting market as European but with a high degree of import penetration. This may underestimate (overestimate) the financial cost (benefit) of the EU ETS, since it ignores the loss of exports that may arise from the introduction of the scheme and results in more firms within the market facing equivalent operating conditions.

Under this revised approach, the model predicts five companies, of which four operate entirely within the EU and one operates outside the EU. Total EU consumption was 5.9 mtpa (compared with estimates of actual consumption of 6.3 ktpa[53]). The simulated price was £1,000/tonne (US$1,500/tonne), compared with an actual market price of around US$1,400/tonne.

[50] Rosenbaum, D. (1989), 'An Empirical Test of the Effect of Excess Capacity in Price Setting, Capacity Constrained Supergames', *International Journal of Industrial Organisation*, **7**, 231–41; and Gagne, R. and Nappi, C. (2000), 'The Cost and Technological Structure of Aluminium Smelters Worldwide', *Journal of Applied Econometrics*, **14**, 417–32.
[51] Ibid.
[52] Brook Hunt (2003), 'Aluminium Metal Service'.
[53] Ibid.

10 Aluminium smelting results

Aluminium smelters currently operate outside of the EU ETS, and this assumption was followed in the modelling. They are affected only via electricity prices, assuming that smelters do not generate their own electricity. In practice, around 20% of smelters in the EU generate their own power.[54]

10.2 Results

Table 10.1 Headline changes in EBITDA in the aluminium smelting sector (%)

Trading period	Change in EBITDA
2005–07	–16
2008–12	–31
2012–	–20

Figure 10.1 Decomposition of EBITDA impact in the aluminium smelting market

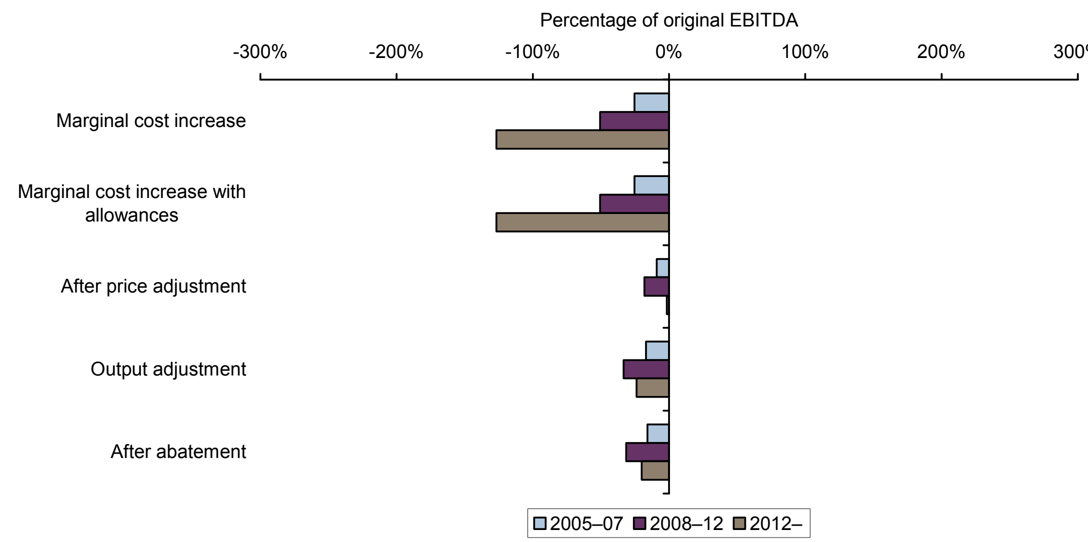


Table 10.2 Market/financial results in the aluminium smelting market

Trading period	Increase in marginal cost (%)	Increase in price (%)	% of marginal cost increase passed on to customers	Change in quantity demanded (%)	Change in EBITDA (%)	Value at stake (%)	Change in number of firms
2005–07	3	1	66	–3	–16	25	No change
2008–12	5	3	66	–6	–31	51	No change
2012–	13	10	102	–24	–20	127	–1

[54] Information provided to Oxera by the European Aluminium Association.

Table 10.3 Further aluminium market results

Trading period	Value of allowances as % of total operating costs (post-implementation)	Abatement investment undertaken (cumulative, £m)	Reduction in typical EU firm's CO_2 emissions (%)
2005–07	0	48	3.1
2008–12	0	48	6.3
2012–	0	48	24.1

The investment figures refer to the estimated cost to the UK participants in the market.

10.3 Discussion

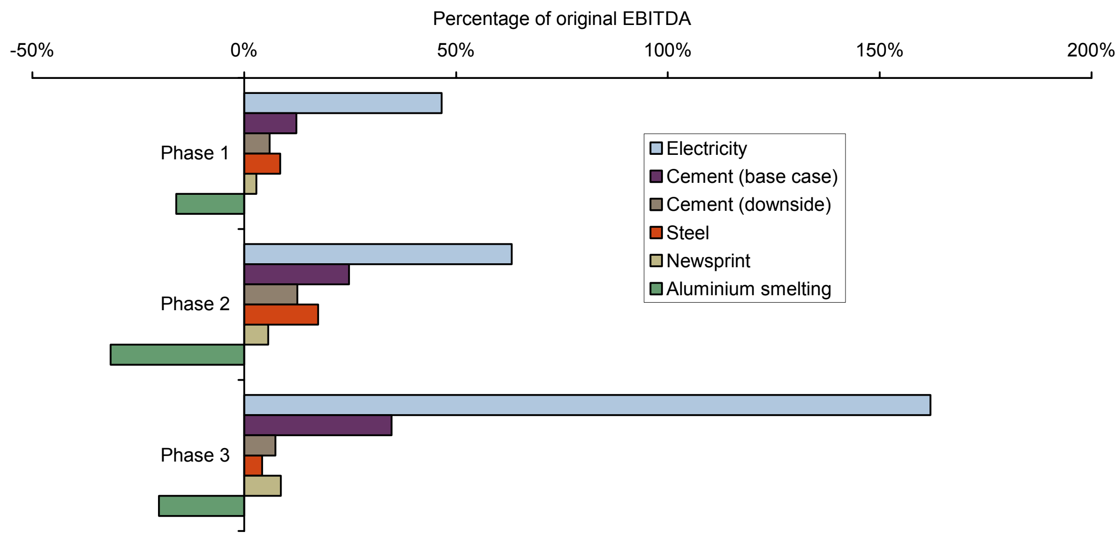
The model predicts a negative impact on profits from the EU ETS. The sector is exposed to electricity price increases and European plant operators have a limited ability to pass on costs to customers. However, if the EU ETS causes one or more firms to exit the market, the overall effect could be beneficial for the remaining firms; the question is then whether those plant closures would take place within or outside the UK. The demand previously satisfied by the closed firm will be absorbed by the remaining firms and the increased concentration allows for a greater mark-up of prices above marginal costs. This can be seen in Table 10.2, with the EBITDA impact in the third trading period (with one firm closing) being lower than in the second (with none closing).

11 Conclusions

The use of a generic economic model to simulate the impact of emissions trading on a sample of UK industrial sectors has been shown to be feasible: it offers detailed insights into the effects of the scheme that have not hitherto been seen. The exercise demonstrates the power of economic analysis in delivering quantitative results, and the ease with which it could be applied to assessments of new or existing regulations in the future.

The results from the modelling are presented in Figure 11.1.

Figure 11.1 Comparison of changes in EBITDA across sectors



The primary use of the results should be to identify the factors that are of greatest importance in determining the competitiveness impact, as this allows more general lessons to be drawn from the modelling. The actual estimates of impact generated by this simple model can be used to challenge the generally accepted understanding of the impact of emissions trading; however, they are not sufficiently robust to be used in financial analysis. The results show that exposure to non-EU competition is by far the most important consideration in determining the profit impact of the scheme. Sectors that do not face this threat are quite likely to benefit from the scheme. Other factors that are of importance include the price elasticity of demand for the product and the degree of supplier concentration in the market.

The results reveal interesting dynamics as the CO_2 price rises. Marginal cost increases as the price rises, but so does the value of grandfathered allowances. As CO_2 prices rise, allocation decisions become even more important. However, although allowance allocation is a powerful tool, international exposure is a more important determinant of financial impact, and allocation becomes a decreasingly effective means of compensating sectors that do face international competition as the CO_2 price rises.

The results make no allowance for strategic behaviour among firms, in particular the use of increased profits to pursue aggressive price competition, which could result in increased profits being competed away. This only arises with windfall profits: where profits are reduced by the EU ETS, firms will not have the same freedom to behave strategically to counter the effects.

12 Mathematical appendix

In this section, the solution to the non-identical, n-player, Cournot model is presented.

Let the market consist of N firms that produce a homogeneous product. Let q_i be the output produced by firm i, and let:

$$Q = \sum_{i=1}^{N} q_i$$

be the total output of the market.

Let:

$$P(Q) = a - bQ$$

be the inverse demand function with a>0 and b>0. Each firm i (I = 1…N) has a cost function of the form:

$$C_i = c_i q_i + F_i$$

where c_i is the constant marginal cost of production and F_i the fixed costs of production.

Firms choose quantities so as to maximise profits. This occurs at the point where:

$$P(Q) - c_i - bq_i = 0 \qquad \text{(Equation 1)}$$

As all firms have the same profit-maximising condition, it is also the case that:

$$NP(Q) - bQ = \sum_{i=1}^{N} c_i$$

Dividing by N yields $P(Q) - bQ/N = \bar{c}$, where $\bar{c} = (\sum_{i=1}^{N} c_i)/N$—ie, the unweighted average of marginal costs.

Substituting P(Q) = a – bQ into the above expression and simplifying gives the total output in the market as:

$$Q = \frac{\frac{N}{N+1}(a - \bar{c})}{b}$$

This expression for Q can then be substituted into the inverse demand function to give the following expression for price in the market:

$$P = \frac{1}{N+1}a + \frac{N}{N+1}\bar{c}$$

With the price established, it is simply necessary to substitute this expression into Equation 1 to give:

$$q_i = \left(\frac{a + \sum_{i=1}^{N} c_i}{n+1} - c_i \right) \Big/ b$$

With price and individual quantities calculated, it is straightforward to establish profits, taking into account the fixed costs, Fi.

Oxera

Blue Boar Court
Alfred Street
Oxford OX1 4EH
United Kingdom

Tel: +44 (0) 1865 253 000
Fax: +44 (0) 1865 251 172

www.oxera.co.uk