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CLIMATE STRATEGIES REPORT

DIFFERENTIATION AND DYNAMICS OF EU ETS INDUSTRIAL COMPETITIVENESS IMPACTS

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Executive summary

Concerns about the loss of industrial competitiveness and leakage of CO_2 emissions remain one of the major barriers to placing more robust CO_2 mitigation obligations on industrial sectors in the EU. Existing literature has defined concepts, established the analytics, and offered some quantitative insights on the impacts of profitability, production and market-share.

There is consensus in the literature that most sectors have the theoretical potential to make short-term profits from the existing structure of the EU ETS, if they receive CO_2 allowances for free, and pass opportunity costs of CO_2 through to product prices. However, for manufacturing sectors of internationally mobile products, their ability to pass through CO_2 costs it is constrained by:

- the potential loss of exports, and displacement of domestic production by imports from existing facilities in response to the resulting price differentials;
- the extent to which sectors do face cost increases that are not matched by allowances (principally through electricity price effects);
- possible impacts of CO_2 price differentials on location decisions for new production facilities.

This study aims to take the analysis of competitiveness issues further by (a) more robust and comprehensive analysis of data, also with brief international comparisons, (b) a more systematic analytic framework, and (c) modelling and more extensive discussion on the two sectors of potentially greatest concern. We aim to shed some light on the determinants of the balance between short-run profit potential versus leakage over time, by examining in particular the relative magnitude of carbon-related costs for different sectors at the 4-digit SIC level, and discussing issues, evidence, and impacts on (and for two sectors, modelling) trade effects.

Our focus is on the long-term effects of unilateral or asymmetric CO_2 prices in industrial sectors. Firstly, we quantify CO_2 cost impact for a wide range of manufacturing sectors and use a screen to identify specific economic activities that face relatively high CO_2 costs. We then use simulation models and qualitative analysis to assess the risk of leakage and competitiveness distortions in these potentially exposed sectors. Finally we discuss to what extent free allowance allocation can address these concerns.

I. Screening to find industry activities that face high CO_2 costs.

We assess which sectors of the economy face high CO_2 cost impacts due to direct CO_2 emissions (combustion and process) and indirect emissions from electricity. Impacts are quantified for manufacturing sectors defined using the Standard Industry Classifications at 4 digit level. A CO_2 price is €20/t CO_2 and induced electricity price increase of €10/MWh are assumed. Findings from the CO_2 cost screen are summarised in Figure 1. The results have been discussed in industry consultations and incorporated various feedbacks and updates of official government data available at the time of publication to the authors' knowledge. To improve the robustness of results, this data has been compared with results from other studies where possible.

The height of the lower part of the bars depicts the *indirect* cost increase from anticipated electricity price increase with the ETS, relative to gross value added (GVA) of the sector. The upper part of the bars reflects the *direct* cost increases relative to GVA, due to CO_2 emissions in combustion and process.

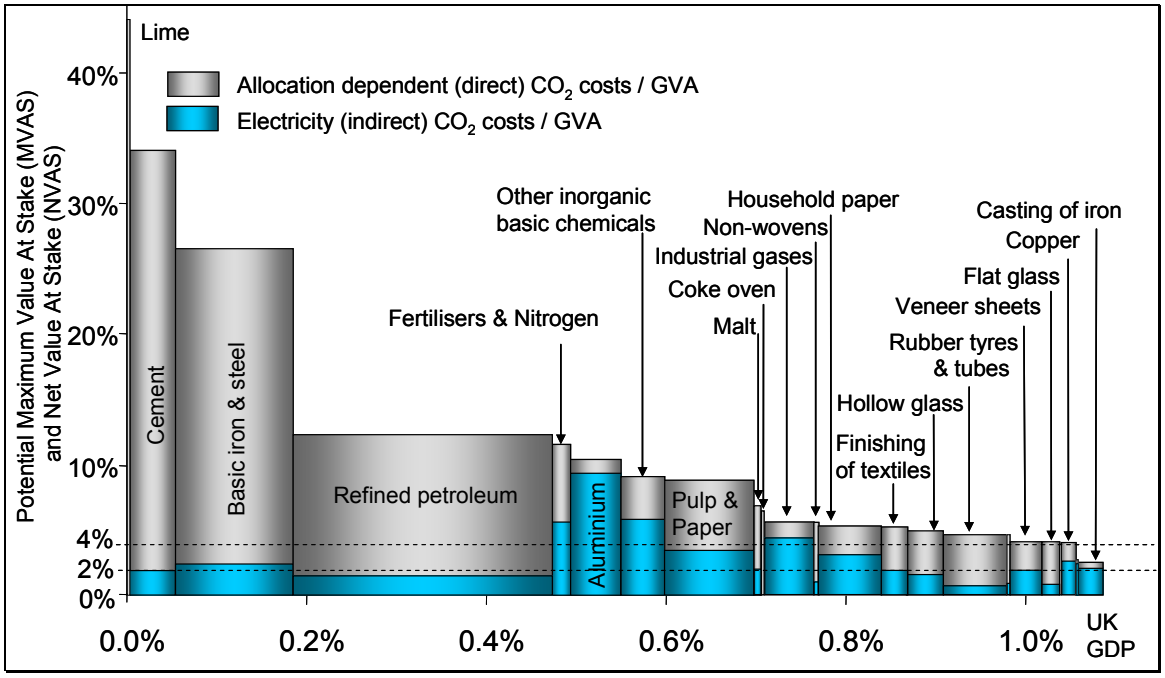


Figure 1 CO_2 cost screen: Subsectors potentially exposed under unilateral CO_2 pricing

Threshold levels of 2% *indirect* cost increases relative to GVA and 4% cumulative impact are applied. Low threshold levels are selected so as to enable sector specific discussions for a broad set of potentially exposed sectors. Cost increases at and below these levels are likely to be dwarfed by volatility and variability of factors like exchange rates, taxation, labour costs or infrastructure provision. Of the 159 sectors in the manufacturing section examined:

- Two sectors stand out in terms of maximum impact on costs relative to value added: Cement and Basic Iron and Steel.
- In 4 sectors (Aluminium, Other Inorganic Basic Chemicals, Fertilisers and Nitrogen, and Industrial Gasses) the *indirect* impact from electricity price increase alone results in cost increases relative to value added in excess of 4%.
- In 20 sectors, cumulative cost increase exceeds 4% of GVA.
- All together, 23 sectors exceed either 2% indirect or 4% cumulative impact. Direct emissions from the 23 potentially exposed sectors collectively contribute 11% of total UK GHG emissions. Their indirect emissions from electricity contribute 3%.
- Their share of UK GDP and employment are 1.1% and 0.5% respectively.

The small relative share does not mean that the leakage issue can be ignored. To the contrary, the focus on specific subsectors allow for tailored and technical solutions where leakage is a valid concern, thus improving robust economic performance and the credibility of EU ETS as an instrument for delivering emission reductions.

For sectors where the distinctions between processes may be more important than the final product, analysis focusing on the production process chain is necessary to compliment understanding gained from this analysis. As such, the cement and steel industries were chosen for the case studies for this report.

II. Impact of unilateral CO_2 prices – how they impact exposed sectors

For the sectors that emerged from the screening process applied to UK data, we test various metrics in order to understand more fully the potential impact of persistent CO_2 price differentials.

First, we look at the share of the market that is traded with other EU countries and with the rest of the world. As expected due to the geographical position of various countries, the intensity of trade with other EU countries is larger for Germany, while trade with non-EU countries is larger in the UK. Trade intensity is low for three reasons. Firstly, if transport costs are high relative to value added, for example in lime, cement and complex refined products, there is less incentive to trade. The second reason is that safety procedures increase transport costs, as in the case of industrial gases. Lastly, trade intensity is reduced when local resources are used as inputs, for example, in the recycled paper and pulp sector.

Second, we assess whether changes in technology and industry structure can increase trade intensity. In a case-study for cement we observe a steady, but moderate, increase of clinker and cement imports. Current imports are, however, focused on EU countries where unexpected demand growth cannot be satisfied domestically and additional materials are provided by countries with spare production capacity. Increasing globalisation of companies facilitates imports from foreign production sites. However, our cement and steel case-studies did not yet provide quantitative evidence for such a transition. One concern raised is that imports might accelerate once global demand growth declines, and large excess supplies are available at low prices.

Third, we discuss whether CO_2 prices may change these trade patterns. In principle there are multiple effects. CO_2 prices can increase transport costs, and asymmetric CO_2 policy can also trigger national and international regulatory responses and thus act as a disincentive for internationalisation of production. However, where CO_2 costs contribute a large share of overall costs and transport barriers are relatively low (e.g. for intermediate products like clinker and coke), some response in trade flows from cost differences is expected.

Fourth, we simulate the mid-term equilibrium trade flows resulting from asymmetric CO_2 prices, using economic estimates of trade elasticities and ranges of CO_2 price pass through. We assume full auctioning of allowances as a reference case. If producers pass CO_2 costs through to product prices, then profitability is unaffected. Yet at the same time market share losses can be significant, particularly in the cement sector and to a smaller extent in the steel sector if we assume trade elasticities at the upper end of values reported in the literature. If producers do not or cannot pass through CO_2 prices to product prices, then market share losses are low, but profitability is significantly reduced and could limit the ability of the sector to pursue future investments. Results of the simulations are sensitive to the assumed rate of opportunity cost pass-through and trade elasticities.

Fifth, we discuss how investment and closure decisions (which are likely to be a main determinant for future trade flows) might respond to CO_2 price signals. Namely, we examine potential leakage and re-location of semi-finished products of cement and blast furnace steel. The cost impact of CO_2 is high, while the commodity nature and internationalisation of producers increases the profitability of relocation. The political economy of national, and more importantly international, climate policy implies significant uncertainties about the future stringency of carbon prices. This creates an option of waiting until more clarity has evolved, which delays investment and closure decisions. In contrast, our preliminary analysis for the refining sector suggests that despite moderate cost increases relative to value added, re-location of existing production is improbable. New refining capacity or capacity expansion is not expected irrespective of EU ETS.

III. Impact of unilateral CO_2 prices – does free allowance allocation address leakage?

Continued free allocation of allowances in the period 2013-2020 is frequently discussed as a means to address leakage concerns raised for some sectors, whilst the system as a whole moves towards a base case scenario in which all allowances would be auctioned.

- **Impact of free allocation on profitability and its trade-offs**

Our simulation results suggest that free allowance allocation may lead to significant profit for cement and steel sectors, due to the pass-through of opportunity costs of allowances to product prices. Transmitting the CO_2 price signal throughout the economy is an important and desired effect, necessary to shift demand away from carbon intensive products.

The political debate discusses whether opportunity costs of using freely allocated certificates are treated differently from incurred costs. However, there has been little convincing evidence that firms behave against the fundamental principles of economics and pass opportunity costs of CO_2 to product prices.

It is difficult to anticipate what fraction of costs firms in the cement and steel industry will be able to pass through, most likely more than 0% and at least in the island situation of the UK also less than 100%. If we assume for example that 50% of the costs of CO_2 allowances are passed through, then free allocation covering about half the emissions retains current profit levels. This result is sensitive to assumptions on international trade elasticities.

The Phase 1 experience has shown that free allocation can not only create pure rent, but it also creates perverse incentives. For example, it gives additional compensation to producers of CO_2 intensive goods for losses induced by demand side response – a shift in demand from high to lower carbon products. This not only increases the overall costs of emissions reductions in the economy but also sends mixed signals that may affect long-term investment decisions.

- **Impact of free allocation on leakage and its trade-offs**

This analysis has identified that leakage concern focuses on very specific CO_2 intensive intermediary products used in production. For example in the cement industry, leakage concerns are focused on the production of clinker (the most carbon intensive process in cement-production where significant process emissions are released from heating limestone)

which could be relocated while companies retain the free allowances for the duration of allocation period (e.g. 2013-2020). In the production of steel using a blast furnace (BOF steel production), some of the emissions are due to burning coal in a low oxygen environment to produce coke. While process gases are currently used in integrated steel works, the existing transport chain for coal could easily be used for imports of coke.

These examples suggest that free allocation would have to be conditional on continued production. In sectors like cement, with low annual fixed costs relative to the value of potentially freely allocated CO_2 certificates, firms might retain installation operational at minimum production volume. In these cases, addressing leakage requires an allocation proportional to current or recent production volumes.

- **Impact on free-allocation on inter-EU competition**

In many sectors, trade volumes between EU countries are higher than those towards third countries. At the same time, transport and non-transport related trade barriers tend to be lower internally compared with trade with Non-EU countries. Hence the impact of distortions between Member States is likely to be bigger, suggesting that any free allowance allocation should be harmonised across Member States, for example with a minimum auction level for different sectors.

IV. Tipping points

This study examined possibilities of identifying tipping points of CO_2 prices above which trade patterns would suddenly change. We argue that tipping points can be identified only by making simplifying assumptions about various factors which are intrinsically uncertain and may evolve over time. These parameters include the future evolution of transport costs, product and service differentiation, stringency of different climate and other policy frameworks, potential trade restrictions, and the demand-supply balance in different countries.

V. Data

The analysis and discussions showed that particular attention to data quality is required for at least three reasons. First, classification of industrial activities and attribution of energy use is not trivial and there were some significant classification errors in earlier data. Also, data based upon energy expenditure surveys is subject to price uncertainties and does not capture process emissions. Second, projected emissions data and industry data on emissions, except for a few sectors had a systematic tendency to over-estimate emissions compared to 2005 verified emissions data, to varied but sometimes remarkable degrees. Third, literature estimates for trade elasticities, demand responsiveness and potential of efficiency improvements vary significantly. Where these values had significant impact on the results, we have pursued sensitivity analysis.

We believe we have obtained a reasonably consistent and accurate representation of emissions for the sectors studied, from a range of estimates available (BERR 2007, DEFRA 2007, UNFCCC 2006, European Commission, 2006).

Our analysis is based on a moderate price for CO_2, in the range of €20 to perhaps €50 /t CO_2 and a time frame to 2020. Leadership and a successful example will contribute towards a

more harmonised international solution that can support higher CO_2 prices where they are required to deliver the necessary decarbonisation.

VI. Key Conclusions

- The CO_2 cost screening process has assessed manufacturing subsectors for potential leakage. In only a few subsectors, CO_2 costs are significant relative to GVA and could therefore influence trade and locational decisions.
- Non-price aspects restrict the propensity for trade and thus reduce leakage concerns in some sectors. In particular, local resource base, constraints on transport of hazardous substances, high transport costs relative to CO_2 costs, integrated production processes, customer specific product and service specification and more broadly customer relationship are relevant.
- Several approaches can address leakage concern and need to be assessed on a sector by sector basis. They include government lead sectoral agreements, border adjustments pursued in an appropriate international framework, and continued free allocation.
- Whilst continued free allowance allocation is politically convenient, it also creates perverse incentives that reduce the economic efficiency of the scheme.
- Implementing targeted policies for the few identified subsectors can allow unilateral pursuit of stringent emission reductions by a region without risking economic performance or inducing significant leakage.
- Closer trade relationships among European countries indicate the priority for harmonisation of allocation methodologies and volumes, for example by sector specific minimum auction requirements.

Introduction

The EU Emissions Trading Scheme (EU ETS) covers 45% of European CO_2 emissions and is the backbone of European climate policy. The scheme covers over 11,500 installations and has successfully established a CO_2 price signal across Europe. Moreover, the EU ETS has provided valuable experience and learning in emissions trading enriching the global debate on climate policy and energising international negotiations.

One of the most heated debates surrounding the EU ETS is the impact on industrial competitiveness and leakage. A body of literature has examined competitiveness impacts from different perspectives using a variety of approaches including empirical and analytical models as well as sector model simulations. They have concluded that in general and in line with economic theory, sectors in aggregate have the ability to profit from the scheme in the short-term. This results because sectors receive allowances for free and have the ability to pass through the CO_2 costs to product prices as well as adjust supply.

Transmitting the CO_2 price signal throughout the economy is an important and desired effect, necessary to shift demand away from carbon intensive products. In particular, studies of the power sector using empirical approaches give strong evidence on CO_2 cost pass through in the power sector. However, less certain are A) the varying degrees of ability to cost pass-through between and within sectors (particularly traded sectors that trade with regions without CO_2 pricing) and B) the longer-term impacts on leakage from the international price differentials that result if firms pass-through CO_2 cost.

This report makes contribution to the competitiveness debate by conducting vigorous and evidence-based examination of two key questions:

1) For which specific sectors is leakage a concern?
2) Does free allocation address competitiveness and leakage concerns?

The organisation of the report is as follows. The first chapter sets the scene by summarising where we stand today in the competitiveness debate and understanding. It focuses upon the "real-world" features that differentiate impact of EU ETS within and across sectors including heterogeneity between countries, firms, production processes, and scope for abatement technologies. The first chapter presents some "competitiveness impact indicators" to help judge the nature of potential impacts on price, profitability, market share and leakage. These indicators are illustrated with reference to UK data. The quantitative insights highlight that the current structure of the EU ETS affects competitiveness of different sectors in very different ways.

The second chapter takes a closer look at the sectors to identify the specific industrial activities that might be exposed to leakage. It applies the competitiveness impact indicator to sectors defined using Standard Industrial Classification at higher resolution (4 digit). This screening process suggests the anticipated competitiveness impacts of emission trading concentrated on a far smaller fraction of industrial activities than suggested by analysis using broad definition of sectors.

The two sectors that stand out in the screening process as the focus of potential leakage concerns in the case of unilaterally high CO_2 prices – cement and steel – are then examined in more depth in Chapter 3. This chapter offers further insights not only on short-term

profitability dimensions of competitiveness, but also into the market share dimension. It identifies and discusses non-tariff trade barriers (e.g. transportation costs, product differentiation, import restriction) which soften the international pressure they are subjected to. A short analysis on the refining industry is added in Annex 2.

Throughout this report, "short-run" refers to timescales up to five years, and "long-run" indicates a post-2012 timescale over which strategic decisions on allocation of new investment start to bear fruit.

Chapter 1. Differentiation of competitiveness impacts from the EU ETS an overview

1.1 INTRODUCTION

This chapter sets the scene by summarising where we stand today in the competitiveness debate. First, section 1.2 briefly reviews three groups of relevant literature: A) the wider literature on competitiveness and leakage issues in climate policy, B) literature evaluating the competitiveness impacts of the EU ETS C) literature exploring approaches to address competitiveness and leakage. Section 1.3, provides a summary of the key factors that differentiate impacts of the EU ETS on potential exposure to leakage, drawing upon the basic insights derived from the literature. We then translate qualitative insights into quantitative estimates of impacts by developing and applying a metric to measure the impact of CO_2 costs. We distinguish between *direct* impacts (contingent on CO_2 intensity of production and allocation) and *indirect* impacts resulting from increased electricity prices. Section 1.4 focuses upon the "real-world" features that differentiate impact of EU ETS within and across sectors, including heterogeneity between countries, firms, production processes, and scope for abatement technologies. The final section offers conclusions.

1.2 LITERATURE REVIEW

1.2.1 Competitiveness in the context of spillover effects from climate policy

The debate about EU ETS industrial competitiveness impacts forms an important part of wider discussions on the spill-over effects of climate policy; that is, the effects of abatement measures taken in one country or a group of countries on sectors in other countries. In theory, the first order impacts on prices (change in profits) drives secondary industrial competitiveness impacts such as re-location in the longer term. Spillover effects add an environmental dimension to this relocation in the form of carbon leakage, measured by the increase in CO_2 emissions in outside countries where abatement actions are being undertaken (Kuik and Gerlagh 2003). Spillover effects explored in the literature also include the impact on energy prices (Barnett, Dessai et al. 2004; Pershing and Tudela 2004), and positive spillovers such as impacts on sustainable development (Kemfert 2002; Gundimeda 2004) and technology spillovers (Rosendahl 2004; Sijm, Kuik et al. 2004).

The implication of international trade theory is that the imposition of a CO_2 constraint in one country increases costs, and hence reduces the competitiveness of the CO_2 intensive sectors exposed to international trade. At the country level, competitiveness is maintained in the long-run, as exchange rates adjust to compensate for the loss of competitiveness. However, it is misleading to discuss competitiveness on a country level because a household or transportation in one country does not compete with their counterpart in another country, hence the concept of nationwide economic competitiveness is ill-defined (Krugman 1994; Babiker, Criqui et al. 2003). Rather, competitiveness is a concept relevant at a firm or sector level. Implementation of a uniform CO_2 price impacts on sectoral competition, by reducing the competitive advantage of CO_2 intensive sectors, and shifting the advantage to less CO_2

intensive sectors. Within a CO_2 intensive sector, the international competitive position may be disadvantaged under certain conditions (e.g. if CO_2 price is sufficiently high and trade barriers are sufficiently low), where for example, EU companies are subject to a CO_2 price and compete with companies in a region without CO_2 pricing.

In general, little evidence to support the hypothesis that climate policy has yet had large adverse effects on competitiveness is observed in the empirical literature (IPCC 2001; Zhang and Baranzini 2004). In their survey of spillover effects and competitiveness, Sijm et al (2004) compare results of empirical studies on the issue of relocation of energy-industries and find no satisfactory explanation for the different outcomes between empirical studies. They conclude that if a relation between climate policy and relocation could exist, then it is statistically weak and insufficient for policy making. A statistical analysis carried out on four energy-intensive sectors in nine OECD countries by Baron and ECOEnergy (1997) estimate an average 3% increase in production costs from a CO_2 tax of ~$US30/t$C0_2$ supporting these conclusions. An evidence-based statistical study examining the role of eco-tax reform in seven European countries on unit production costs in eight manufacturing sectors conclude there is no consistent pattern to suggest that eco-taxes reform was a significant contributing factor for changes in trade flows (Gerald and Scott, 2007).

Conclusions derived from modelling analysis are more diverse. The IPCC Third Assessment Report (IPCC 2001) reviews studies that use CGE models with exogenous technological change to estimate spillover effects (measured in the form of leakage rates) resulting from implementation of the first-period Kyoto commitments through uniform carbon taxes. It reports estimated leakage rates range of 5 to 20% (increase in CO_2 emissions outside of Annex I divided by reductions in Annex I). Grubb et al (2002) argue that such models overstate the net-leakage, because they do not account for global diffusion of induced technological change, which has been demonstrated to have central importance in relation to climate change by Grubler et al. (1999), Gritsevskyi and Nakicenovic (2000) and others. On the other extreme, much higher leakage rates were reported by Babiker (2005), using a global CGE model for 7 regions, 7 goods and 3 industries with increasing returns to scale and strategic behaviour in energy-intensive industries. The model's estimates range from 25% (with increasing returns) to over 100% leakage rates, dependent on the assumptions made.

1.2.2 Industrial competitiveness impacts of the EU ETS

In recent years, a growing body of literature on the evaluation of the EU ETS has examined competitiveness impacts in this context. Principles of how in the short-run, sectors within the EU ETS are likely to adjust price and output, have been set out, for example, by the work of The Carbon Trust (2004 and 2005), Reinaud (2005a), Smale et al. (2006) and McKinsey and Ecofys (2006). They have presented numerical results for the current design of the scheme with high proportion of allocation granted for free. Most sectors are likely to profit by passing through the opportunity costs of the allowances to their product prices.

These conclusions have been supported by studies of the power sector using both empirical and model simulation approaches. For example, the empirics relating to cost pass-through and wind-fall profits in the Dutch and German power sectors estimate pass-through rates range from 60-100%[1] (Sijm, Bakker et al. 2005; Sijm, Chen et al. 2006; Sijm, Neuhoff et al. 2006).

1 In theory, a profit maximising firm adds the costs of CO2 emission allowances to its other marginal (variable) costs when making (short-term) production or trading decisions, hence pass on the cost of CO2 allowances onto product prices, even if allowances are allocated to them for fee (Burtraw et al. 2002 and 2005; Reinaud 2005). This is because as long as allowances can be sold on the market for a positive price, using allowances to cover its emissions carries an opportunity cost. Transmitting the CO2 price signal throughout the economy is an important and desired effect, necessary to achieve emissions reductions via the demand side substitution effect. The CO2 pass through has been empirically established in the electricity sector, where

There is less empirical evidence on cost pass-through abilities of sectors other than power such as cement, steel and chemicals, though some evidence is emerging on cement (Walker et al 2006). Hence studies using detailed global sectoral models (e.g. Quirion 2003, Demailly and Quirion 2006a, Hidalgo, Szabo et al. 2005, Palmer et al. 2006) have assumed a range of cost-pass through rates as well as other parameters such as trade elasticity. They provided estimates of the impact of a CO_2 price on both profits, output and market share. In addition, they examine the role of allocation methodology in determining competitiveness impacts (Quirion 2003; Demailly and Quirion 2006a) . A literature review and discussions of EU ETS competitiveness in a wider context (macroeconomic impacts such as in employment) is provided Oberndofer et al (2006). In addition, Johnston (2006) considers the legal implications of free-allocation and profit-making.

1.2.3 Approaches to address industrial competitiveness beyond Kyoto

Several approaches can address leakage concern and need to be assessed on a sector by sector basis. They are explored in the literature and in general policy discussions.

Firstly, output-based allocation (whereby firms are allocated allowances according to proportion of production) in theory reduces product prices and increases production relative to the grandfathering approach. This approach is frequently advocated by producers of CO_2 intensive products because it would reduce the cost increase of CO_2 intensive products and delays substitution effects towards less CO_2 intensive alternatives (Eurofer 2005; Cembureau 2006). Indeed, studies using sector models to quantify impacts (Burtraw, Palmer et al. 2001; Quirion 2003; Demailly and Quirion 2006b) estimate that compared with allocation by grandfathering or auctioning, the impact on leakage of production (fall in domestic production and rise in imports) to non-EU regions is less under output based allocation, and profits are also less.[2] However, CO_2 abatement is also less under this approach because prices do not reflect the CO_2 externality and therefore substitution effects towards less CO_2 intensive (intermediary) products is reduced.

Secondly, both government-lead and voluntary global sectoral agreements covering sectors with high international exposure, is discussed widely in the literature (Groenenberg, Phylipsen et al. 2001; Thomas, Cameron et al. 2004; Bosi and Ellis 2005; Watson, Newman et al. 2005; Schmidt, Helm et al. 2006; Baron and Ellis, 2006; Bodansky 2007). They are advocated by sector associations – for example, International Iron and Steel Institute (IISI), International Aluminium Institute (IAI), Cement Sustainability Initiative (WBCSD). Also the International Petroleum Industry have put forward proposals as means to support technological improvements and raise energy efficiency sector-wide. However, their role in providing sufficient CO_2 price signals necessary for investment decisions is uncertain. Sectoral crediting mechanisms are also explored in the literature e.g. OECD/IEA (Baron and Ellis 2006; Bosi and Ellis 2005) and CCAP (Schmidt and Helme 2005). Here, baseline levels/rates and certified emissions are defined as a sector and emissions reductions are linked to the ETS. Main issues include baseline data and data collection and governance issues (Baron and Ellis 2006).

high carbon impact, hourly pricing decisions and wholesale markets with public information on spot and forward prices allowed for robust assessments despite the short time frame of less than two years of high carbon prices (Sijm, Neuhoff et al 2006). Other sectors might have more difficulty to pass through opportunity costs where exposed to international competition. However, even where such cost pass through occurs, it is more difficult to analyse where (i) the carbon component of prices is smaller (ii) pricing decisions are confidential and perhaps only on annual basis.

2 Quirion (2003) also finds that total production costs (the proxy for employment in European iron and steel sector) rises slightly as reductions in production level is more than offset by increased abatement measures.

Thirdly, the use of border adjustments is explored in the literature as an instrument to address leakage for specific CO_2 intensive products traded widely (Biermann and Brohm 2003; Hoerner 1998; Ismer and Neuhoff 2004; Saddler and Muller et al. 2006; Demailly and Quirion 2006b). It has the advantage that there is no trade-off between addressing the leakage problem and maintaining functioning of efficient CO_2 price signals domestically. While economically desirable and from a WTO most likely viable, the challenge for the implementation are political sensitivities associated with trade related measures. A joint international approach is therefore desirable to ensure alignment with the wider efforts of cooperation on climate policy. Discussions are emerging in Europe, US and Australia (Sadler et al, 2006; CEC, 2007; Peterson, and Schleich, 2007).

In the short-run, the free allocation approach will continue for the Phase 2 of the ETS, and is also considered as the fall-back option for Phase 3. Whilst continued free allowance allocation is politically convenient, it also creates perverse incentives that reduce the economic efficiency of the scheme (Neuhoff, Keats et al. 2006). Hepburn et al (2006) argue that greater use of auctioning can facilitate investment decisions by removing uncertainty about the level of free allocation. In addition, an announced reservation price in auctions translates into a price floor and can offer protection against the risk of extremely low carbon prices that can be an obstacle for financing of low carbon projects. Auction and revenue recycling can allow compensation at minimum costs whilst raising revenues that can also be used to compensate domestic consumers for CO_2 related price increases.

1.3 SUMMARY OF SECTORAL ECONOMIC IMPACTS FROM EU ETS

1.3.1 Key determinants of competitiveness exposure

The three main factors that influence a sector's potential exposure level to the EU ETS are: i) CO_2 intensity of production; ii) ability to pass cost increases through to prices; and iii) opportunity to abate carbon.

If sectors have the ability to pass through the CO_2 costs they incur to product prices, then their profitability is unaffected by the ETS. There is consensus in the literature that most sectors have the theoretical potential to make short-term profits from the existing structure of the EU ETS, if they receive CO_2 allowances for free, and can pass through opportunity costs to product prices. However, for manufacturing sectors of internationally mobile products, the ability to pass through CO_2 costs is constrained by:

- the potential loss of exports, and displacement of domestic production by imports from existing facilities that penetrate domestic markets in response to the resulting price differentials;
- the extent to which sectors do face cost increases that are not matched by allowances (principally through electricity price effects);
- possible impacts of CO_2 price differentials on location decisions for new production facilities.

1.3.2 Maximum and Net cost impacts relative to value added

To translate these general principles into quantitative insights, we develop and apply indices to quantify impacts for a wide range of sectors. We illustrate this with reference to 2004 UK data.[3] Results are plotted in Figure 2 and Figure 3.

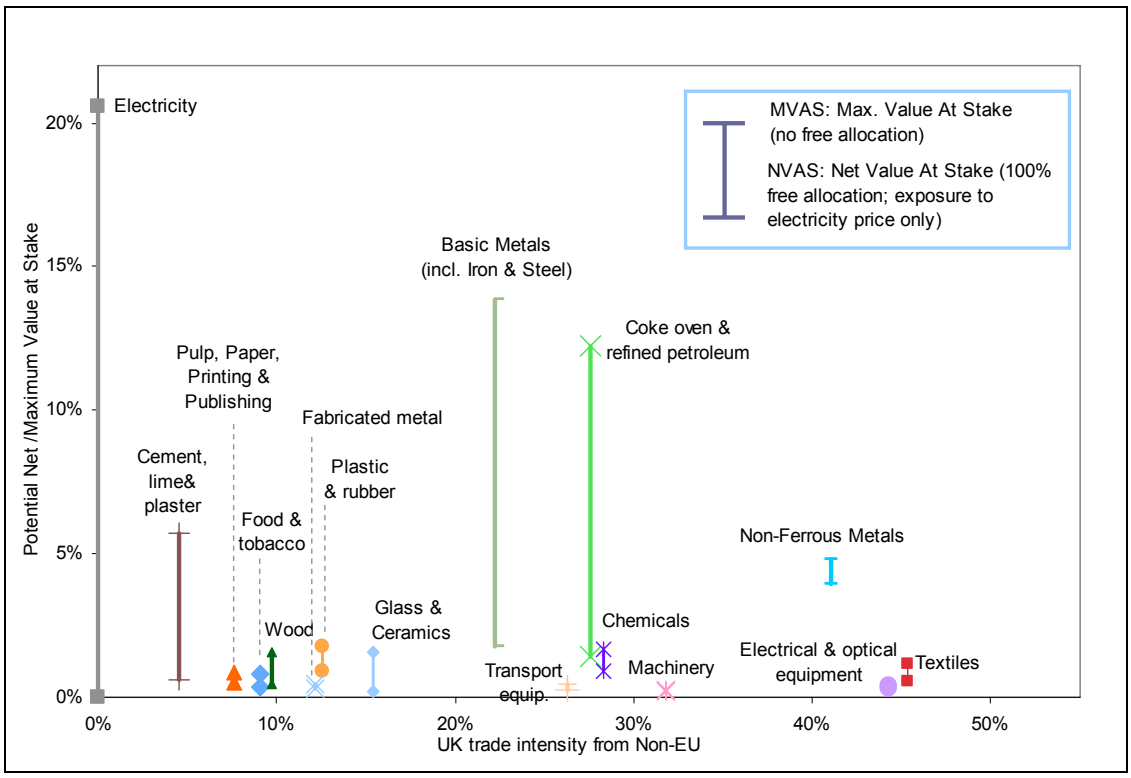


Figure 2 -Value at Stake for main industrial activities, relative to UK trade intensity from outside the EU, for €20/t CO_2.

Notes: Upper end of range indicates zero free allocation, and lower end of range indicates 100% free allowances (effect of €10/MWh electricity price increase to sectors). CO_2 related cost increases of non energy inputs to a sector (e.g. higher cement costs for construction in chemical industry) are not considered. Trade intensity here is defined as:

$$\text{Non-EU trade intensity} = \frac{\text{Value of exports to non-EU} + \text{Value of imports from non-EU}}{\text{Annual turnover} + \text{Value of imports from EU} + \text{Value of imports from non-EU}}$$

The biggest single constraint on ability to pass CO_2-related costs on to customers is foreign competition from regions outside the EU ETS region, and the simplest measure of this is the existing degree of trade intensity. This forms the x-axis in Figure 2 (see figure notes for definition). Obviously this is an imperfect indicator, and in response to large price differentials could change substantially over time; but it remains by far the most plausible aggregate indicator of the barriers to large scale imports and exports.

The vertical axis combines the full range of potential indices of *value added at stake* which we define as the impact of CO_2 pricing on sector costs relative to sector GVA[4]. The lower end shows the *indirect*, "Net" or "minimum" exposure level of sectors, irrespective of participation or allocation. This estimates the indirect impact from electricity price increase as a consequence of CO_2 price pass through in the electricity sector. We term this Net Value At

3 See Chapter 2 Section 2.2 for detail and discussion on methodology, source data and assumptions.

4 See Section 2.4.4 examining the robustness of this indicator.

Stake (NVAS). All sectors are affected except *Electricity* itself, for which NVAS is zero. For sectors participating in the EU ETS, the lower end shows the impact if a sector receives free allocations equal to its Business as Usual emissions and if there was no abatement action.

The upper end shows the impact if there were no free allocations – equivalent to 100% purchase on markets or auctioning at the market price. The chart shows results for a carbon price of €20/tCO_2 and an electricity pass-through resulting in wholesale electricity cost increase of €10/MWh. This assumes marginal electricity generation costs are set by gas. In countries where the marginal price is set by coal, the electricity price increase would be between €15/MWh and €20/MWh. Scaling the electricity price would move the lower point of the bars in direct proportion, whilst scaling the CO_2 price would scale the height of each bar.

The significance of the upper level (no free allocation) is that *it also gives an indication of the impact of the Carbon price on marginal cost,* irrespective of any (fixed) free allocation. We term this level the Maximum Value At Stake (MVAS). As long as production of more or less output is not accompanied by any change in free allowances, it faces the full cost of extra allowances, or the opportunity cost of not selling allowances. In addition, if firms price at or close to the marginal cost of last unit produced, the upper level gives a rough indication of the corresponding potential impact on output prices (relative to value-added).

Marginal cost pricing (i.e. taking account of the opportunity cost of free allowances in pricing decisions) is an important and desired effect and necessary to achieve demand-side responses to CO_2 mitigation policies. Most sectors are expected to have some degree of cost pass-through ability. As emphasised in previous modelling studies, high levels of free allocation lead to large profit gains from the EU ETS for most sectors. However, this may be at the expense of a cost differential that could increasingly lead to loss of market share to foreign imports in the longer term.

Sectors outside of the EU ETS face the cost impact at the bottom of each bar (electricity price exposure) and an equivalent incentive to change the price of their products. There would be no divergence between average and marginal costs, and no resulting scope for profiting from such divergence. [5]

The first striking feature of the graph is that three sectors stand out: *Electricity*, *Basic metals* (including iron& steel), and *Coke oven and refined petroleum.* This is also true to a lesser extent for the *Cement, lime and concrete products* sector. The wide vertical ranges for these three sectors reflect their high intensity of direct carbon emissions relative to electricity; the narrow bar for others like *Non-ferrous metals* reflects its dependence on electrical processes.[6] If sectors receive 100% free allocation, only *Non-ferrous metals* (including Aluminium) face NVAS exceeding 4%. For all other sectors, NVAS is 2%, or below, assuming carbon price of €20/tCO_2.

Zero free allocation – or pricing at the marginal (opportunity) cost – gives a very different picture. *Basic metals* (including iron and steel) and *Refined petroleum* with a NVAS of 14%

5 Note that this is a complementary treatment to that presented in The Carbon Trust analysis (Carbon Trust, 2004) which focused on the variation in value at stake for a range of electricity price pass through and a modest range of allocation cutbacks (0-10%). The intent in Figs 3 and 4 here is to give an insight also into the marginal cost impacts that can drive imports under profit-maximising behaviour. Also the chart in The Carbon Trust (2004) was indexed on total sector turnover, rather than value-added.

6 Hence Aluminium sometimes being termed "solid electricity". Electricity costs for aluminium production average a quarter of operating costs, with 95% of electricity used for smelting stage (equivalent to 80% of emissions of all primary production of aluminium).

and 12% of its total value-added then stand out. The equivalent NVAS of *Cement, lime and concrete products* is about 6%. For the UK, no other EU ETS sector in aggregate has NVAS above 2% even for zero free allocation.

Figure 3 shows the same value at stake range for UK industrial sectors, but this is set against the import intensity *from other EU* countries. High intensity of trade *within* Europe is a potential reason for concern about differential allocations methods and volumes between countries. Closer trade relationships among European countries indicate the priority for harmonisation of allocation methodologies and volumes, for example by sector specific minimum auction requirements. Sensitivity to inter-EU competitiveness for sectors, however, are likely to be as much on electricity differences (for participating installations) as on allocation differentials.

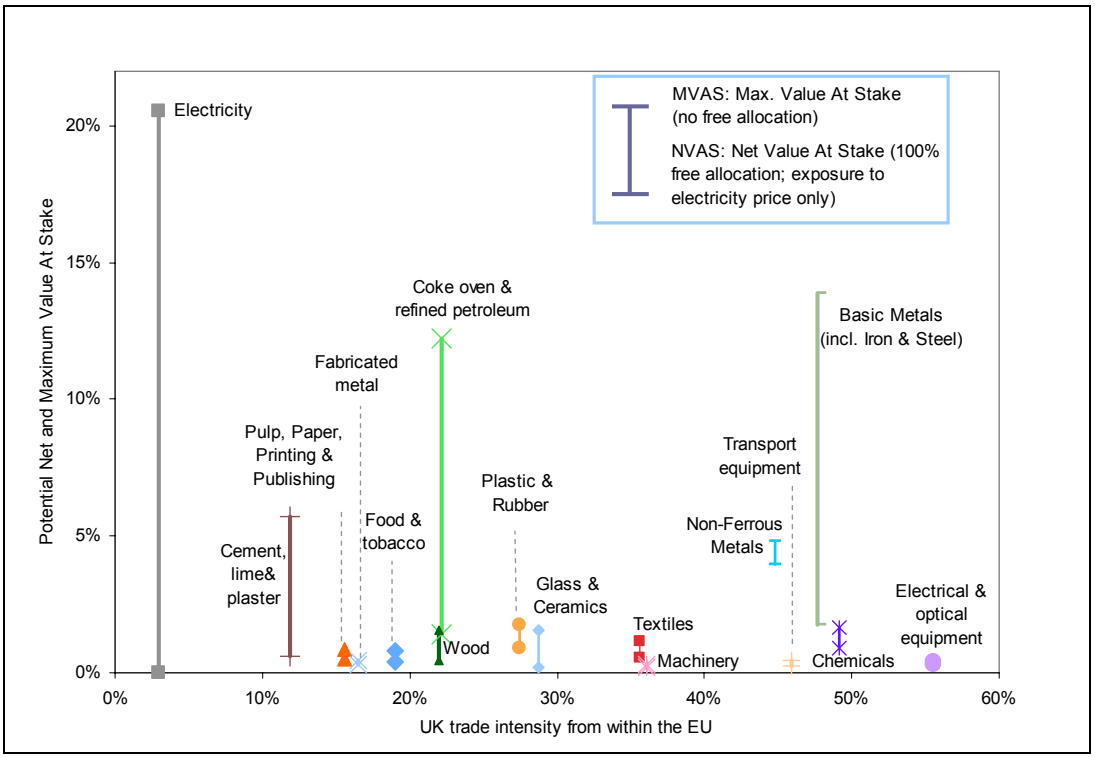


Figure 3 – Value at Stake for main industrial activities, relative to UK trade intensity from within the EU, for €20/t CO_2

Notes: See Figure 2 notes for assumptions and data sources. Trade intensity here is defined as:
EU trade intensity= Value of exports to EU + Value of imports from EU
Annual turnover + Value of imports from EU + Value of imports from non-EU

Figure 2 and Figure 3 illuminate the need to account for cross-sectoral difference in analysing competitiveness and leakage issues. We now turn to examine more closely the potential factors that differentiate impacts *within* sectors e.g. differentiation by processes or country. Here we focus upon those EU ETS sectors - *Electricity, Cement, Basic metals,* and *Pulp and paper*.

1.4. DIFFERENTIATION WITHIN SECTORS

1.4.1 Electricity generation sector

The ability of the power generation sector to pass through the opportunity cost of carbon is mainly attributed to the low trade intensity and in the shorter-term supported by price inelastic demand. In Phase I of the EU ETS, large volumes of free allocation allowed power generators to profit substantially. Empirical studies on cost pass-through such as that by Sijm et al. (2006) on the German and Dutch electricity sectors observe high pass through rates, ranging between 60 and 100% of CO_2 costs as mentioned above.

However, as partly captured by this range, the ability to pass through opportunity costs varies across electricity generators. There are major differences at the individual firm level due to the differences in technology portfolios (and corresponding CO_2 intensity of generation), market size and structure, institutional structures, regulatory regimes and demand patterns, all of which potentially affect pricing strategies, generator's windfall profit levels, and also the *indirect* impact of the EU ETS experienced by electricity consumers.

- **Process/technology differentiation**

The mix of power generation technologies varies across firms and countries with different shares of coal, gas, nuclear, hydro and renewables. The fuel costs, other variable costs and investment costs for the generation technologies differ, and so does carbon intensity. In competitive markets, the wholesale price increase is determined by the carbon intensity of the marginal technology. Companies are therefore affected differently due to the changes in merit order induced by the EU ETS and a plant's carbon intensity relative to that of the marginal technology's carbon also matters.

The intent of carbon pricing is to make generators with less low CO_2 intensity more competitive, hence provide incentives to for low-carbon investments. For example, combined cycle gas turbines (CCGT) are more than twice as CO_2 efficient than coal/lignite fired power plants (down to 350 kg CO_2/MWh compared to 850-1,100 kg CO_2/MWh).

In the short-term, generators face a range of mitigation options depending on existing technology profiles. For example, replacing a coal-fired steam turbine with pulverised-coal technology can achieve 27% emissions reductions, and replacing a single cycle gas turbine with CCGT reduces emissions by 36%.

- **Geographic differentiation**

With the different generation mix also carbon intensities of electricity generation vary across Europe (Figure 4).

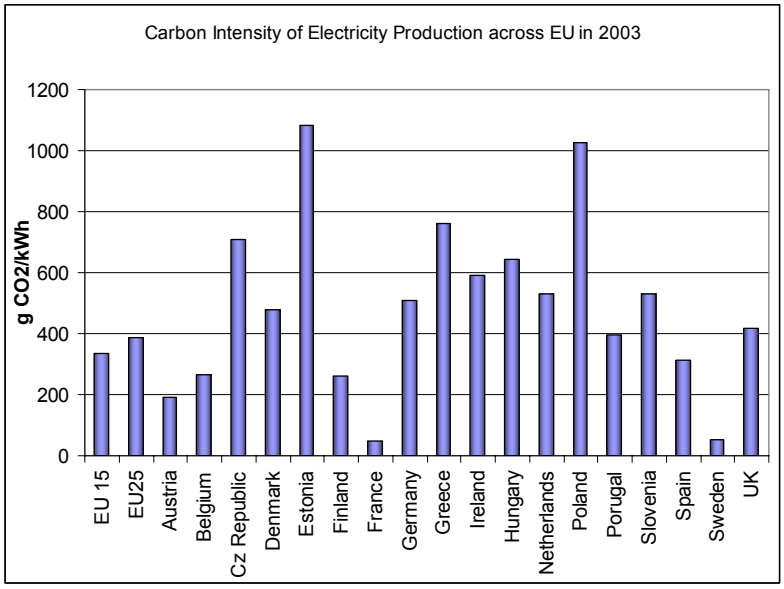


Figure 4 - Carbon intensity of electricity production in EU countries (total: fossil and non-fossil), EU 25 average is close to 390 g CO_2/kWh, Source: World Resource Institute (2007).

However, as stated above, it is not the average Carbon intensity that determines the wholesale price increase in competitive markets, but the Carbon intensity of the marginal technology. Thus while average carbon intensities are similar in Germany and the UK, coal power stations are more frequently at the margin in Germany. Table 1 illustrates that as a result, models (and empirical evidence) show a larger price increase in Germany than in the UK.

	Belgium	France	Germany	Netherlands	United Kingdom
COMPETES	2–14	1–5	13–19	9–11	
IPM			17	15	13–14

Table 1 Model estimates of electricity price increases (in Euro/MWh) due to CO_2 costs at €20/t CO_2, (Sijm et. al 2006).

Such effects will be moderated by regional differences in ownership structures, level of concentration in the market and regulatory regime. For example, fixed retail prices as in France and contractual arrangements limit firms' ability to reflect CO_2 costs in electricity price. Theses differences may explain why pass-through rates differ considerably between power companies in different countries.

Additionally, whilst resource and technical potentials for mitigation in the power sector are large in most Member States, economic potentials vary across power generators according to technology portfolios and policy environments (e.g. level of R&D support and deployment policies).

- **Allocation differentiation**

The differing levels of free allocation across Member States have been highlighted by Neuhoff et al (2006) and Betz et al 2006. Such variations will affect levels of windfall profits in Phase 2 – they will reduce in Member States such as the UK that have cut free-allocation levels for the power sector. As repeated or new entrant free-allocation in the power sector creates perverse incentives (Neuhoff et al. 2006) allocation differentials may also impact cost

pass-through abilities. However, again, such effects will be moderated by regional differences in ownership structures, level of concentration in the market and regulatory regime.

1.4.2 Cement

Competitiveness impacts of this sector are examined in depth in Chapter 3 of this report. In general, protected by high transport costs, cement producers are expected to have high ability to pass through the opportunity cost of carbon to their consumers. There are three main channels open to cement producers to reduce their exposure to CO_2 pricing: A) replacing clinker production with clinker imports; B) reducing clinker content of cement and C) energy efficiency improvements. Here we summarise factors that may differentiate EU cement producers' ability to take advantage of these channels.

- **Process/technology differentiation**

Cement is a relatively homogeneous product. By far the largest proportion of CO_2 released in the cement manufacturing is attributed to the combustion and process emissions from the cement kiln stage producing the intermediate product, clinker. Clinker is the solid input material which is then milled and blended with other materials to make cement. Vertical kilns produce low quality cement and have been replaced by rotary kilns in most of the developed world (Szabo et al 2003). Rotary kiln technology is further divided into four types – wet, semi-wet, semi-dry and dry – the latter being the most modern and least energy-intensive process. 60% of kilns in Europe are dry. Compared with plants using a long kiln, dry kilns with pre-heater and pre-calciner require 45% less energy input.

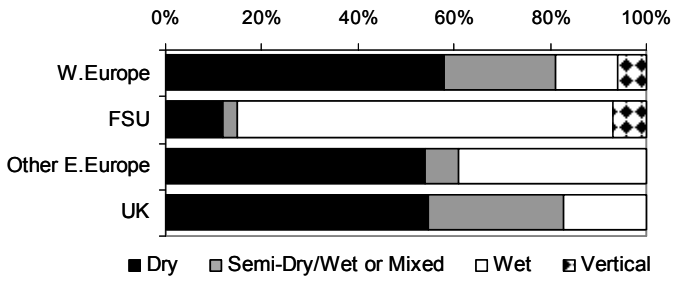
Currently, clinker and cement are often produced in the same location yet clinker imports into the EU have also been rising (see Chapter 3). Because cement mills tend to be located close to the demand, leakage in cement is likely to focus on clinker production.

For existing facilities, the technical potential of mitigation options vary across production processes and can be pursued via three channels: improving the energy efficiency of the process; switching from high to low carbon fuels and using blended cement with reduced clinker content. The degree of uptake is likely to be influenced by A) allocation volume and methodology used for CO_2 allowance and B) other existing 'clean air' policies in each Member State.

- ***Geographic differentiation***

As argued in Chapter 3, cement import is likely to be a localised issue and largely demand-driven. The extent to which this similarly applies to clinker imports is less well understood.

Figure 5 shows kiln technology and carbon intensity by region in the mid 1990s, production volume and varying CO_2 intensities across the EU. It suggests varying levels of mitigation opportunities via reducing clinker content and making energy efficiency improvements.



	Emission factor ($t CO_2/t$)	Total Production (Mt)
Spain	0.76	26.7
Italy	0.75	33.2
Germany	0.68	36.1
France	0.62	21.2
W. Europe	0.71	181.9
Japan	0.62	91.6
China	0.88	423
US	0.89	77.9
FSU/E. Europe	0.79	100.7

Figure 5 Kiln Type (%) and production for cement, by region

Source: Adapted from Worrell, Price et al. (2001), Humphreys, M..et al. (2002), and CEMBUREAU (2000)

- ***Allocation differentiation***

Whilst inter-EU levels are low relative to other sectors, leakage (particularly via clinker) can concern producers in all Member States, and approaches to address leakage are likely to require EU-wide solutions. An important consideration for such approaches is to reduce the risks in avoiding the full carbon price incentives. For example, *ex-post* allocations based on output per tonne of cement would in practice have to be indexed on the production of clinker, to prevent companies from simply importing this most emission-intensive part of the production process (Demailly and Quirion, 2006a). Alternatively, some industry groups have argued for the complete exclusion of process emissions from the ETS as a 'stop-gap' measure. Because there are major uncertainties about production and the extent to which emissions cannot be avoided, it is argued that eliminating process emissions may make the cap more effective. However, there are difficulties in defining the line between process and non-process emissions. Differences in definitions would exacerbate internal market distortion and pose difficulties for emissions monitoring and reporting.[7] In addition, such a system – or indeed, *ex-post* output based allocation –removes incentives either for substitution of products (e.g. wood for cement in construction), or for truly radical production technology changes.[8]

1.4.3 Iron and Steel

Iron and steel is one of the most energy intensive manufacturing sectors and accounts for an estimated 5.2% of total global GHG emissions (Watson, Newman et al. 2005). Earlier studies quantifying competitiveness impacts on the iron and steel sector (Carbon Trust, 2004; Carbon Trust, 2005; Smale et al., 2006; Demailly and Quirion, 2006b; and McKinsey and Ecofys, 2006) estimate limited short-run impact. However, the sector is characterised by multiple interactions across production processes. These imply that the competitiveness impacts and leakage concern may be focused in specific production activities within a sector. Here we summarise the key differentiating factors. This sector is examined in depth in Chapter 3 of this report.

- **Process differentiation**

Two process routes are used for iron and steel production. In the primary or blast oxygen furnace (BOF) route, CO_2 is emitted through a series of processes to produce hot metal (during the conversion of coal to coke or in blast furnaces). Similar to process emissions in

7 It is for this reason that, in the case of expansion in the UK National Allocation Plan for Phase II expansion activities (e.g. gypsum), once an installation is in, all its CO2 emissions are in.

8 In the cement sector, a possible example might be the 'carbon safe' proposals for producing cement through catalytic processes, with the carbon for the cement absorbed from the atmosphere rather than through crushing of rocks. If feasible, this would ultimately turn cement production from being one of the biggest sources of CO2 emissions into being one of the biggest 'sinks' (New Scientist, 2002). Allocation approaches that protect the cement sector from the carbon intensity of clinker production and the associated process emissions, however, would largely remove the incentive for the industry to explore or invest in such processes.

cement production, CO_2 is also a by-product of chemical reactions throughout the iron making process, including the production of coke inputs, reduction of iron ore to iron, reduction of materials from coke input, and limestone reduction for sulphur removal in the molten iron[9].

Similar to the role of clinker in cement production, the production of coke from coal constitutes a CO_2 intensive intermediate product in BOF steel making. Again, currently EU manufacturers use integrated processes for the production of coke and steel, however, the risk of carbon leakage via coke imports or relocation of coke production remains.[10]

The secondary route of producing steel involves melting scrap metal using electrodes in an Electric Arc Furnace (EAF). The EAF route uses only 30-40% of energy required in the primary route but almost all energy input is sourced from electricity, hence CO_2 emissions is a function of source of electricity.[11]

Mitigation potentials in both BOF and EAF processes have been estimated by several authors. In an examination of 47 energy efficiency improvements in the US iron and steel sector, Worrell et al (2001) found a technical potential of 24% efficiency improvements out to 2010, and a economic potential of 18% using a 30% discount rate. De Beer et al (2001), using a discount rate of 4% estimate the cost-effective potential in EU-15 out to 2010 to be 10.2% (18 Mt CO_2/yr) compared with baseline emissions. In addition, technical potentials of around 15 Mt CO_2/yr for eight energy saving technologies in 2030 in Western Europe are estimated by Tanaka et al (2006) using a Monte Carlo approach. Adopting such technologies offers steel makers the opportunity to reduce exposure to EU ETS competitiveness impacts. However, the economic potential for energy efficiency improvements varies widely across individual plants, depending on plant configurations and on local markets for fuels, heat and electricity (Watson, Newman et al. 2005).

- **Product differentiation**

Unlike cement, steel is not a homogeneous product. Steel grades and quality vary to satisfy a wide range of applications including construction, automotive, packaging, appliances, and manufacturing industries. To a large extent, the process determines the final product e.g. stainless steel is produced using EAF. These various intermediate and finished products and grades are manufactured using different steelmaking pathways. Degrees of trade and hence the ability to pass through opportunity costs of carbon is likely to differ across products. In general, EU producers with high technological specialisation (combining product differentiation and advanced production methods) in combination with trust in customer relationships (service differentiation) are expected to have some degree of cost pass-through ability (See Chapter 3 for more detailed discussion).

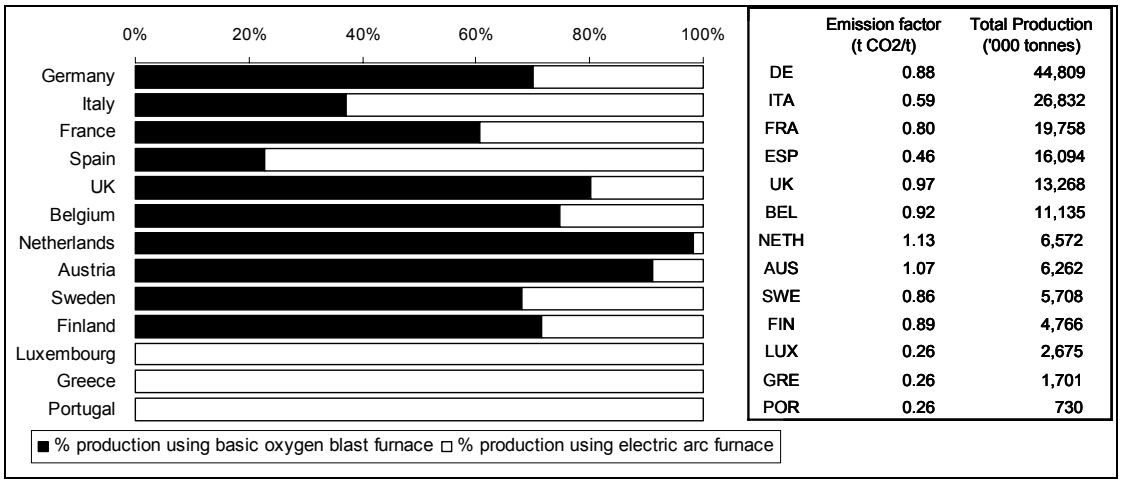
9 On average, a tonne of steel produced using BF consumes around 400kg of coke and around 300kWh electricity.

10 Coke ovens, often an integral part of blast furnace steel works, is a major source of fugitive air emissions including particulate matter, SOx, Nox, methane, volatile organic compounds as well as waste water. The EU is said to normally source one-third of their coke needs from China (US Trade Representative, 2004). In the 1990s, tightening of environmental regulation of the EU lead to a decline in coke oven production capacities (UK Steel, 2004) and increased dependency on imports from under 8 million tonnes of coke in 1995 to around 15 million tonnes in 2003, mainly from China, Poland and Australia, (Eurostat, 2006). This suggests that pollution leakage occurred via coke imports. Yet this trend experienced a black-slash in 2004. Chinese authorities escalated the cost of export licensing on coke exporters and Chinese export prices (indicator for world markets) peaked in April 2004 at around $410-420/t foundry coke,half of which was the cost of export licence. These were argued on grounds of environmental and natural resources protection (People's daily Online, 2005) and to secure coke supply for domestic steel production. In May 2004, European Commission negotiated with the Chinese government to secure 4.5 million tonnes of coke exports for EU steel producers in 2004(FT, 2004).

11 On average, a tonne of steel produced using the integrated route in the OECD has an emission factor of 2.2 t CO2/t, of which fossil fuels accounts for 2.1 t CO2/t and electricity accounts for only 0.1 t CO22/t. In contrast, the emission factor for steel produced using the EAF process is 0.5 t CO2/t, of which electricity accounts for 0.3 t CO2/t (Watson et al, 2005).

- **Geographic differentiation**

The product mix and hence production routes are largely driven by the economics of input materials for production.[12] This explains to a large extent, the international variation in the ratio between the primary and secondary production routes, and the corresponding rate of CO_2 tonnage emitted per unit of steel output as shown in Figure 6.



	Emission factor (t CO2/t)	Total Production ('000 tonnes)
DE	0.88	44,809
ITA	0.59	26,832
FRA	0.80	19,758
ESP	0.46	16,094
UK	0.97	13,268
BEL	0.92	11,135
NETH	1.13	6,572
AUS	1.07	6,262
SWE	0.86	5,708
FIN	0.89	4,766
LUX	0.26	2,675
GRE	0.26	1,701
POR	0.26	730

Figure 6 - Comparison of Carbon Dioxide Generation and Method of Steel Production in 2003 Source: ***Data from The Carbon Trust based on IISI, OECD.***

- **Allocation differentiation**

In general, national allocation plans of all European countries use Business as Usual projections to determine the volume of allowance allocation to the steel sector. There are some differences in new entrant and closure rules. The impact of EU ETS can also vary across countries due to different levels CO_2 cost pass through in electricity price.

Due to high levels of inter-EU trade in the steel industry, harmonisation of allocation has been raised as key priority in future trading periods. Moving allocation away from free-allocation and towards a more harmonised approach to addressing leakage, as has happened in the cement sector, has caused discussions about whether CO_2 allowances should be allocated proportional to current or very recent production volumes. This, as simulated by studies quantifying impacts on the steel sector (Burtraw, Palmer et al. 2001; Quirion 2003) provides incentives for firms to maintain production levels and avoids leakage. However, it also reduces the substitution effect towards less CO_2 intensive products.

1.4.4 Pulp and paper

Although analysis on the UK newsprint production in Smale et al (2006) estimates that the EU ETS has a very small impact, this result may not be generalised to the entire sector and EU for the following reasons: newsprint represents only a small proportion of production in the sector, its raw material basis and production technologies are not representative of the whole EU, and the P&P industry in the UK is extremely small relative to Scandinavian or central European countries. One cross-cutting feature of P&P is reflected in the results. With high levels of use of on-site Combined Heat and Power (CHP) generation based on waste as

12 Integrated steelmaking pathways are dependent on availability of coal and iron ore, while the secondary route relies heavily on scrap steel availability. High sunk costs and the volatility of world scrap supply and prices also constrain the substitutability of the two production processes.

fuel, production costs are relatively less exposed to the indirect effects of increased electricity prices if the CHP plant receives free allowance allocations or is not covered by ETS.

- **Process and product differentiation**

Comparing the energy efficiency and CO_2 factors of pulp and paper plants internationally is difficult as product mixes and energy supplies differ dramatically between plants and countries (Siitonen and Ahtila 2002). The sector is characterised by: multiple production technologies (mechanical and chemical pulping); different product types (pulp, newsprint, fine papers, packaging, and sanitary and household); multiple raw materials (wood and recycled fibre); and energy as a side product in some of the production technologies (chemical pulping produce waste liquor, and heat recovery with mechanical pulping) (Phylipsen, Blok et al. 1998).

Whereas some production processes are self-sufficient with respect to energy supply (chemical pulping) and might even produce a surplus, others (mechanical pulping and fine paper - when not integrated with chemical pulping) require a significant external supply of energy, especially electricity. Recycled fibre based paper production is much less energy intensive process than wood based paper production (Siitonen and Ahtila 2002). Table 2 summarises the differences in carbon intensity between pulp and paper production technologies.

Industry	**Indirect CO_2 emissions**	**Direct CO_2 emissions**	**Total CO_2 emissions**
Chemical pulp	0.07	0.04	0.12
Chemical P&P	0.62	0.00	0.62
Mechanical P&P	1.03	0.00	1.03
Thermo-mech.P&P	0.12	0.02	0.14
Recovered fibre P&P	0.27	0.34	0.61

Table 2 - Carbon intensity in pulp and paper production, tons of CO_2 per ton of pulp/paper produced. ***Source: McKinsey and Ecofys (2006), p.32.***

- **Geographic differentiation**

It is possible to divide Europe into countries where wood material is available, allowing for large scale production (Scandinavia), and countries where most paper is produced by recycled fibre or imported pulp (rest of Europe). As shown in Figure 7, Scandinavian countries produce large volumes of high quality products for export (using highly energy efficient processes) while Central Europe has smaller and less efficient facilities for local consumption. In addition to Scandinavia, Germany is a significant paper producer (European Commission 2001).

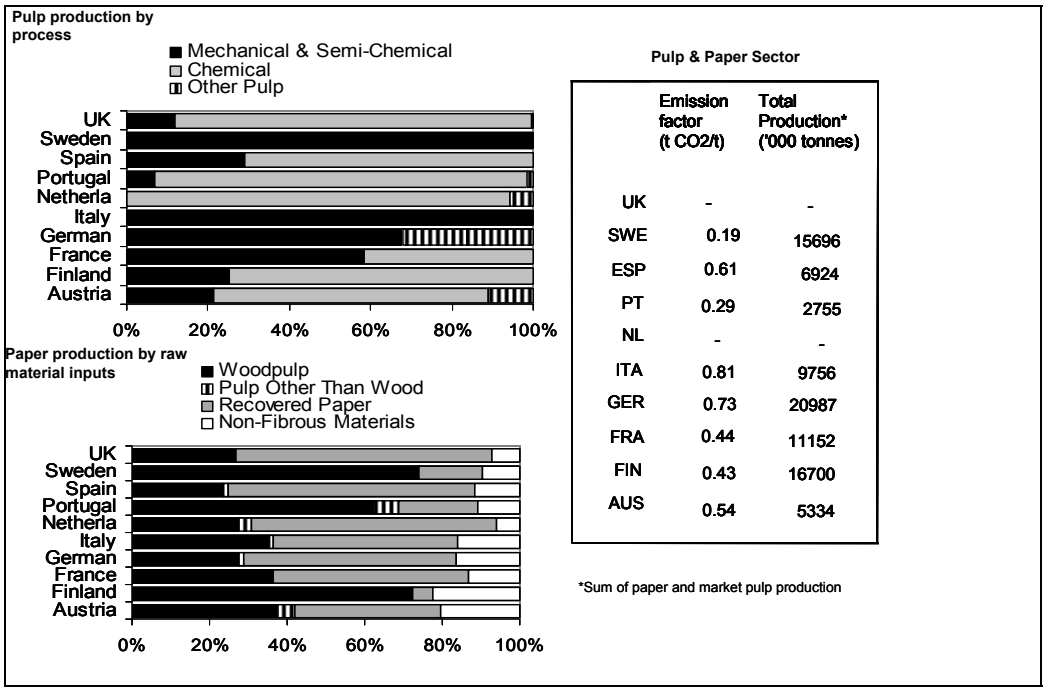


Figure 7 - Pulp and Paper production of selected EU countries in 2002 ***Source: adapted from CEPI Annual Statistics 2002 & Finnish Forestries Industries federation.***

Exposure to imports is unevenly divided between plants and EU countries as some products are produced for domestic or local markets while others are mainly exported. The largest producers, namely Finland and Sweden, export a significant share, almost 1/3 of total production outside the EU, while the EU remains the most important market (Swedish Forest Industries Federation 2005). Competitiveness impacts from EU ETS concerns in the pulp and paper sector therefore affect Scandinavia more than rest of Europe, as the sectoral share of GDP is high (Kemppi, Honkatukia et al. 2002).

Mitigation potentials differ considerably by region. There are three main avenues for reducing CO_2 emissions in the sector:

1) Saving energy by new modes of operation: improvements of skills and motivation of personnel; energy audits; process integration; monitoring and control.
2) Introduction of more energy efficient technologies; and electrical devices with low energy consumption (Siitonen and Ahtila 2002). Also gasification of fuels, especially bio fuels, provides emission reductions.
3) Fuel switching can be an importance source of emission reductions. Practical examples include further introduction of CHP and increasing energy sourced from renewable energy sources.

Many of these grouped potentials, particularly those involving fuel switching and increasing CHP capacity, have already been used in Scandinavia, but large potentials remain in Central Europe. The fact that own CHP capacity reduces the exposure to electricity price rises (The Carbon Trust 2004) has also been largely recognised. In Scandinavia, CHP is already common amongst pulp producers as a result of the supply of waste liquor that can be used as a fuel.

Most of the pulp and paper firms in Finland own significant shares of electricity producing companies which mitigates the impact of electricity price increases at the group level (Siitonen and Ahtila 2002; Korppoo unpublished).

One additional concern is the influence of carbon pricing and renewable energy/bio-fuel support programs to the availability of wood raw material for pulp production as carbon costs may encourage using the carbon neutral wood as a fuel rather than as raw material of paper (McKinsey and Ecofys, 2006; CEPI 2003).

- **Allocation differentiation**

The pulp and paper market is global (Kemppi, Honkatukia et al. 2002; CEPI 2003) and pricing is competitive due to fairly low concentration of the sector (McKinsey and Ecofys 2006) which increases the sensitivity of the sector to competition from outside the EU where carbon is not priced. Consequently, European pulp and paper producers have limited ability to pass through CO_2 prices to product prices, however, this varies between products. According to the same study, 50% of the expected increased costs of chemical pulp production can be passed on to the customer while the respective figure for paper is 0-20%, and 0-0.7% for recovered pulp.

The EU ETS is expected to influence the division of markets between pulp and paper producers inside and outside the EU as the carbon cost, especially those linked to increasing electricity prices, is not added to prices outside the EU (McKinsey and Ecofys 2006, p.33; CEPI 2003).

McKinsey and Ecofys (2006) estimated that the short and mid-term effect of the EU ETS on competitiveness (assuming 95% free allocation of allowances) is reflected as the following net cost increases: 0% for chemical market pulp, 1.2-1.9% for recovered fibre, 0.6-1.1% for paper produced of chemical pulp, 3.1-4.2% for paper produced of mechanical pulp and 4.7-6.2% for paper produced of thermo-mechanical pulp. These figures illustrate the large differences of the influence of the EU ETS on different pulp and paper production technologies.

The complexity of the sector makes the competitiveness issues and incentive issues difficult to conceptualise. For instance, the UK newsprint producers argue that integrated producers of pulp and paper (mainly in Scandinavia) have a competitive advantage as they are able to use the waste stream of their pulp production as a carbon neutral source of energy (The Carbon Trust 2004). It is true that for instance Finnish pulp and paper industry is self-sufficient of heat, and produces some 40% of its electricity demand (Siitonen and Ahtila 2002). This advantage might be balanced, because producers in the rest of Europe benefit if they use processes involving recycled fibre, as the required processes are more energy efficient and thus less exposed to CO_2 costs.

Business actors around Europe have argued that early action, which refers to investments in advanced low carbon technologies such as efficient production processes, CHP and bio fuels, has not been recognised in the national allocation plans for of CO_2 allowances (Kylä-Harakka-Ruonala 2004; The Carbon Trust 2004). One Finnish pulp and paper producer even suggested plans to delay the improvement of technology in order to increase the EU ETS allocation.

1.5. Summary

A common theme across allocation plans in Phase I and II of the EU ETS was their limited differentiation across sectors. Many allocation plans treated virtually all sectors in the same way, by allocating according to their expected Business as Usual needs, with the result that most sectors are over-compensated.

This chapter identified the main factors that differentiate impacts of the EU ETS on the competitiveness and leakage across sectors. To translate qualitative into quantitative insights, it developed "competitiveness impact indicators" that help to estimate potential impacts faced by sectors. Illustrated with reference to 2004 data for the UK, the quantitative insights gained from this exercise highlighted that the current structure of the EU ETS affects competitiveness of different sectors in very different ways. It then presented a summary of "real-world" features that differentiate impact of EU ETS within and across sectors – e.g. heterogeneity between countries, production processes and scope for abatement technologies.

Chapter 2: Industrial competitiveness impacts: A sectoral and sub- sectoral analysis

2.1. INTRODUCTION AND OBJECTIVES

This chapter focuses on differentiation between products *within* a sector. To do so, we move to higher resolution of sectoral definitions. Using the Net and Maximum Value At Stake (NVAS and MVAS) indicators introduced in Chapter 1, we now quantify competitiveness impacts for industrial sectors defined using Standard Industrial Classification (92) at 4 digit resolution. Of the 239 manufacturing, 159 sectors are examined. Again, impacts are estimated for a carbon price of €20/t CO_2 and assume they results in wholesale electricity cost increase of €10/MWh.

Acting as a first screening process, the MVAS and NVAS analysis allows us to identify potentially exposed sectors. This analysis highlights: 1) the extent to which results, from aggregate sector level analysis of competitiveness impacts from the EU ETS and CO_2 pricing in general, mask differences in the impacts experienced at subsector or firm level; 2) that the impact of emission trading on competitiveness is restricted to a far smaller fraction of the overall industrial sectors than previously assumed; 3) the extent to which the continuation of free-allowance allocation raises allocation harmonisation issues across Member States.

While we depict the level of international trade on the x-axis for all sectors, we do not use this criterion in the screening process. This is because international trade patterns might change in response to fluctuations to prices, costs and regulations. In the discussion, we point out where subsectors that exhibit significant cost increase relative to GVA face significant barriers to trade, either due to transport cost or local access to input factors (processing of agricultural input factors).

2.2. METHODOLOGY, ASSUMPTIONS AND DATA

2.2.1 Sectoral coverage and mapping

The Standard Industrial Classification(92) divides manufacturing as follows:

Resolution	Number of manufacturing classes	e.g.
2 digit	23	- Manufacture of pulp, paper and paper products (SIC 21)
3 digit	101	- Man. of pulp, paper and paper board (SIC 21.1) - Man. of articles of paper and paper board (SIC 21.2)
4 digit	239	- Man. of pulp (SIC 21.11) - Man. of paper and paper board (SIC 21.22)

Analysis in this chapter covers manufacturing sectors grouped as follows.

SIC	Included in this analysis	Excluded
15, 16	Food, Drink and Tobacco	
17, 18, 19	Textiles and Leather	
20, 21, 22	Wood , Paper, Printing and Publishing	
23	Refining & fuels	
24	Chemicals	
25	Plastic and Rubber	

26.1-26.4	Glass and Ceramics	
26.5-26.8	Cement, Lime and Plaster	
27 excluding 27.4, 27.53, 27.54	Basic Metals (incl.) Iron & Steel	
27.4, 27.53, 27.54	Non-Ferrous Metals	
28		Fabricated metal products
29		Machinery and Equipment
30 - 33		Electrical and Optical Equipment
34, 35		Transport Equipment
36		Manufacture not elsewhere classified

Sector coverage was based on the analysis in Chapter 1 and further stakeholder consultation. The excluded sectors in general are characterised by low CO_2 emissions (see Figure 8) and production of high value-added goods. For example, MVAS was below 1% for all subsectors in Transport Equipment. Sectoral coverage of this report is therefore not restricted to EU ETS sectors, as post-2012 the coverage might change or other additional policy instruments might be implemented to deliver a carbon price for sectors not covered by EU ETS.

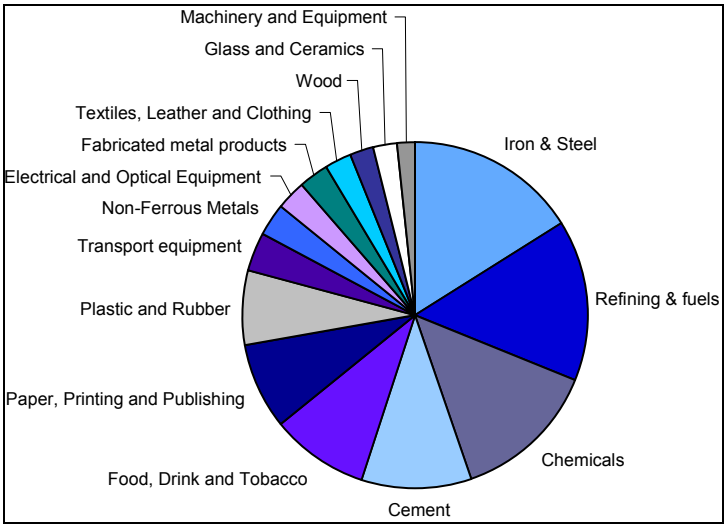


Figure 8 UK Manufacturing CO_2 Emissions Shares by Sector. Sources: See Section 2.2.

Standard Industrial Classification is the standard reporting format for industry data. Data is readily available at high resolution disaggregation and can thus enable detailed evidence-based cross-sectoral analysis. SIC definitions are end-product driven, however, and often do not capture distinctions between manufacturing processes and carbon intensities, for example that between BOF and EAF processes in steel. For sectors where differentiation between processes is key to competitiveness and leakage impacts (see Chapter 1), explicitly looking at examination of the production or value chain is required. In addition, some sectors are covered under different Classification (SIC) codes (e.g. Mineral Wool is defined under 26.14 for Glass Wool and 26.82 for Rock Wool).

2.2.2 Exposure indicators

- ***Y-axis: Maximum and Net Value At Stake (MVAS and NVAS)***

Here we use the same indicators as explained in Section 1.3.2. of this report. NVAS is defined as the net impact of a CO_2 price on sector costs relative to sector gross value-added (GVA).[13] If sectors are covered under the EU ETS and receive free allowances to cover BAU emissions levels, then the impact from the EU ETS on value-added is limited to the indirect cost increase through higher electricity prices. This is indicated by the lower end of the bar on the charts. The upper end of the bar represents the impact if there were no free allocations, which is equivalent to 100% purchase on markets or auctioning at the market price i.e. maximum value at stake (MVAS).

- ***X-axis: Trade Intensity***

As an indicator of the various barriers to a sectors' ability to pass through costs, we quantify the EU and Non-EU trade intensities expressed in percentage terms i.e. the share of the market that is traded with other EU countries and the rest of the world. For example, EU trade intensity is defined as:

$$= \frac{\textit{Value of exports to EU + Value of imports from EU}}{\textit{Annual turn over + Value of imports from EU + Value of imports from non-EU}}$$

This indicator aggregates the multiple trade barriers and trade intensity can change substantially over time in response to large price differentials. However, it offers a first indication of current trade volumes and allows comparison across sectors and countries. The various barriers to trade are further examined in Chapter 3.

2.2.3 Data

- ***Direct and indirect CO_2 emission levels***

Data on the energy and electricity inputs to production at the 4-digit level is obtained from BERR Energy Statistics Publication (2007) "Table 4.6: Detailed industrial energy consumption, by fuel, 2004" (updated in summer 2007).[14] The data gives a representation of energy consumption by fuel for industrial sectors defined using SIC at 4 digit resolution[15] Consumption of coal, manufactured fuel, LPG, gas oil, fuel oil, natural gas and electricity are reported separately. Consumption of fuel for non energy purposes, e.g. for the reduction of iron ore in steel production, is not reported and has been identified separately. To convert energy inputs into CO_2 emissions, we use emission factors from USA EPA (2004).

The estimated CO_2 emissions for each 4 digit sector using this approach were compared with several other sources for sectoral emissions including DEFRA (2007); European Commission (2006) CITL verified emissions; and UNFCC (2006). These results were also discussed in industry consultations, conducted throughout the project period in Paris, London and Berlin. Section 2.3 details data sources used for subsectors where we deviate from the default BERR Energy Statistics Publication data.

- ***Gross Value Added data and Annual Turnover Data***

Approximate GVA at basic prices (£million, 2004) are obtained from UK Office of National Statistics Annual Business Inquiry (ONS ABI) reports (2006).[16] For subsectors where GVA

13 GVA was selected as the basis for our calculation for reasons detained in Section 2.4.4.

14 This data was updated in July 2007 to take account of newly obtained information. This analysis has taken account of these updates.

15 This is estimated by BERR based on annual company reports of fuel consumption to the Annual Business Inquiry collected by the Office for National Statistics, using average price data and then scaled to the aggregate volumes reported for12-sector figures published in Detailed UK Energy Statistics(DUKES) by BERR (2006).

16 The UK ONS states that "Gross value added (GVA) represents the amount that individual businesses, industries or sectors contribute to the economy. Broadly, this is measured by the income generated by the business, industry or sector less their intermediate consumption of goods and services used up in order to produce their output. GVA consists of labour costs (e.g. wages and salaries) and an operating surplus (or loss). The latter is a good approximation to profits, and out of which the cost of capital investment, financial charges and dividends to shareholders are met." (http://www.statistics.gov.uk/abi/variable_info.asp)

data is not available for the year 2004, data for the latest available year (or an average of several years), is obtained from the same source. In a few cases, they are obtained from other data sources - Section 2.3 details where we deviated from the default data source. Annual turnover is also obtained from ONS ABI. Again, Section 2.3 details our deviations from the default data source.

- ***Trade Data***

Trade Data are obtained from the "Trade in Goods Industry BOP MQ10" published by UK ONS (2004). There is uncertainty over the reliability of this data as: A) it relies on trade data collected using a self-reporting approach; B) for most subsectors, there are no alternative sources to verify this data[17]; and c) if emission trading induces large price differentials, the trade flows could change. The interpretation of our results therefore relies more heavily on the y-axis dimension of exposure.

- ***Summary of Data sources and issues***

	Data	Source	Sector definition	Issues	Extent addressed
Energy	Industrial energy and electricity consumption	BERR Energy Statistics Publication	4 digit SIC (92)	Does not account for all fuel sources, own fuel sources and process emissions.	Yes, by comparing and complementing with other CO_2 emissions data.
		Industry and Industry Associations	4 digit SIC (92)	Tendency to over-estimate emissions compared with BERR data	Used for comparison/ verification purpose
	CO_2 emission	DEFRA[18]	2 digit SIC	Separation between direct and indirect emissions for Climate Change Agreement installations	Estimated by applying the direct: indirect ratio from above BERR statistics.
		EU Commission CITL	various	Broad sector classification	Used for comparison/ verification purpose
		UNFCCC	CRF sector	Broad sector classification	Used for comparison/ verification purpose
	CO_2 emission factors	US EPA			
Sector Accounts	Gross Value Added/ Turnover	ONS Annual Business Inquiry	4 digit SIC (92)	Focus principle	No
				No 2004 data	Using latest available year/ average of available years/ other sources
		ONS Input-Output Tales	2/3-digit	Broad sector classification	Used for comparison/ verification purpose
Trade	Imports/Exports (Inter and Non-EU)	ONS, Trade in Goods Industry BOP MQ10 (EU2004)	4 digit SIC (92)	Self-reporting, non-verifiable, snap-shot picture	Discussed

Table 3 Summary of data sources and issues

17 For some subsectors, trade data was verified during the industry consultation period.

18 http://www.defra.gov.uk/environment/climatechange/trading/eu/results/

2.3. RESULTS

2.3.1 Food, Drink and Tobacco

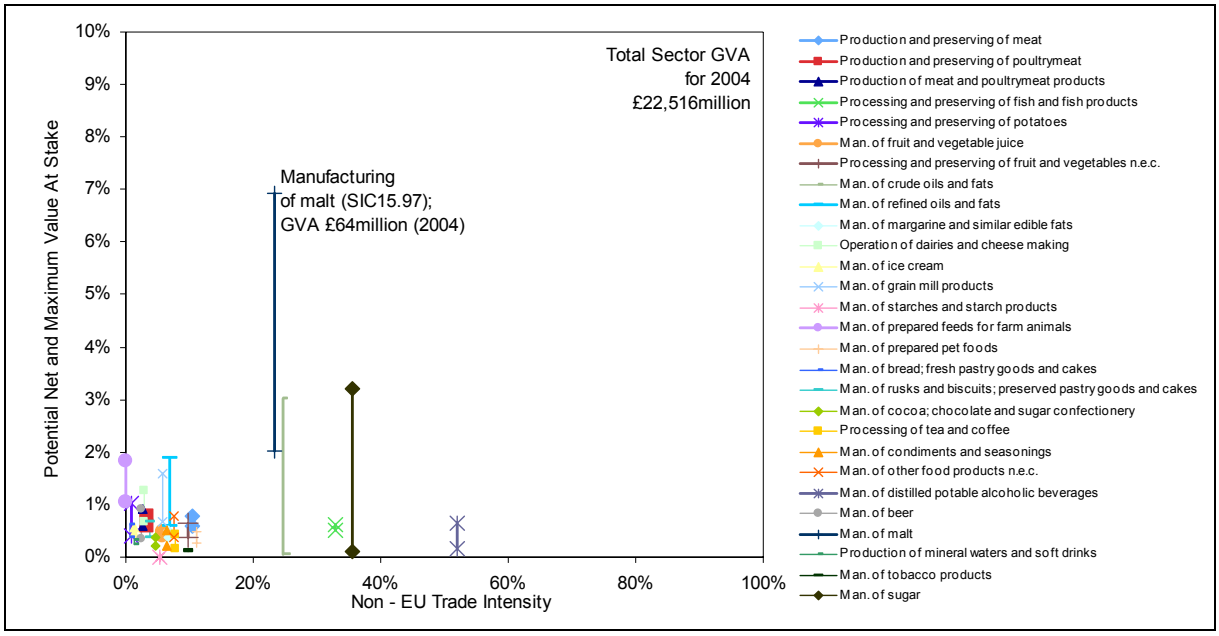


Figure 9 Value at stake for the Food, Drinks and Tobacco sector relative to UK trade intensity from outside the EU

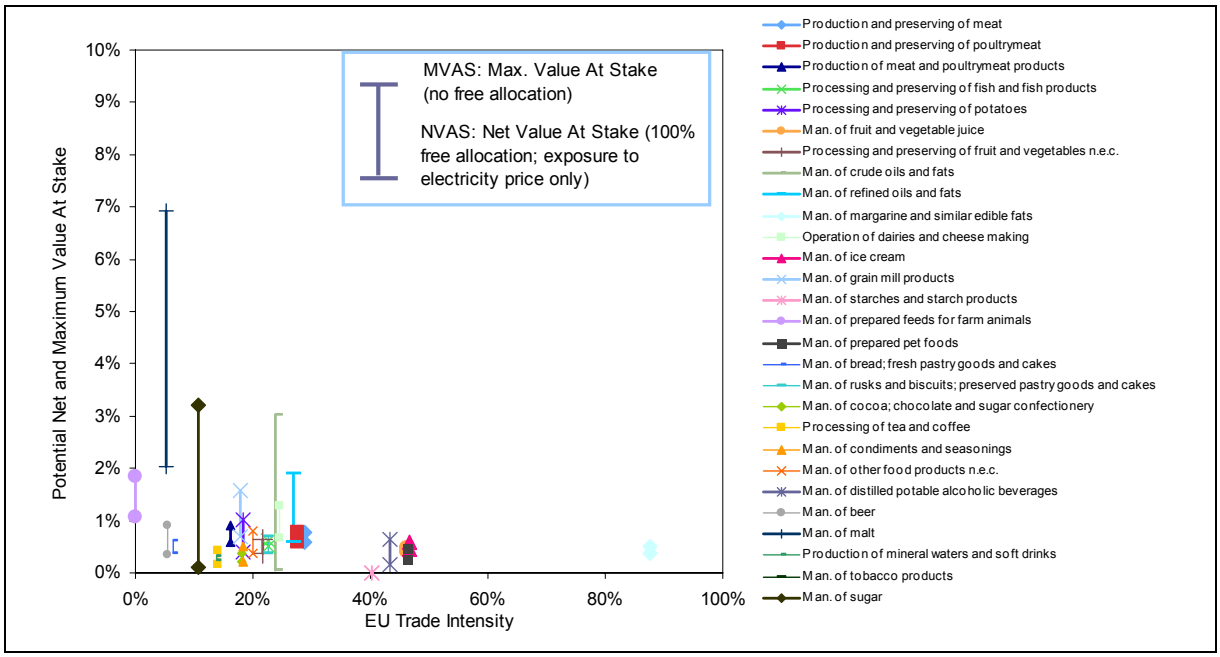


Figure 10 Value at stake for the Food, Drinks and Tobacco sector relative to UK trade intensity from within EU

- ***Key observations***

Food, Drinks and Tobacco is the largest manufacturing sector in the UK in terms of GVA and consists of 34 subsectors. Only one of these - *Manufacturing of malt* (SIC 15.97) – has high carbon intensity relative to value-added 7%. The current trade intensity within and beyond the EU is moderate, however, it is necessary to understand origins of inputs (local or imported

barley) and transport costs of both raw material and final product in order to understand potential leakage impacts from carbon pricing. The low share of GVA as a proportion of turnover (below 20%) suggests that relocation of processing is unlikely to be economically viable for this sector.

- ***Data Issues***

GVA and turnover data is not available in the ONS ABI for some subsectors. Of these, *Manufacture of sugar* (SIC 15.83) has high natural gas consumption in production. To estimate potential exposure for this subsector, we obtained GVA data for *Sugar* from UK ONS (2005) Input-output tables. This database uses a more aggregate grouping of sectors hence the indicator may underestimate impact. However, given equivalent specification of product, this risk is likely to be small.

2.3.2 Textiles and Leather

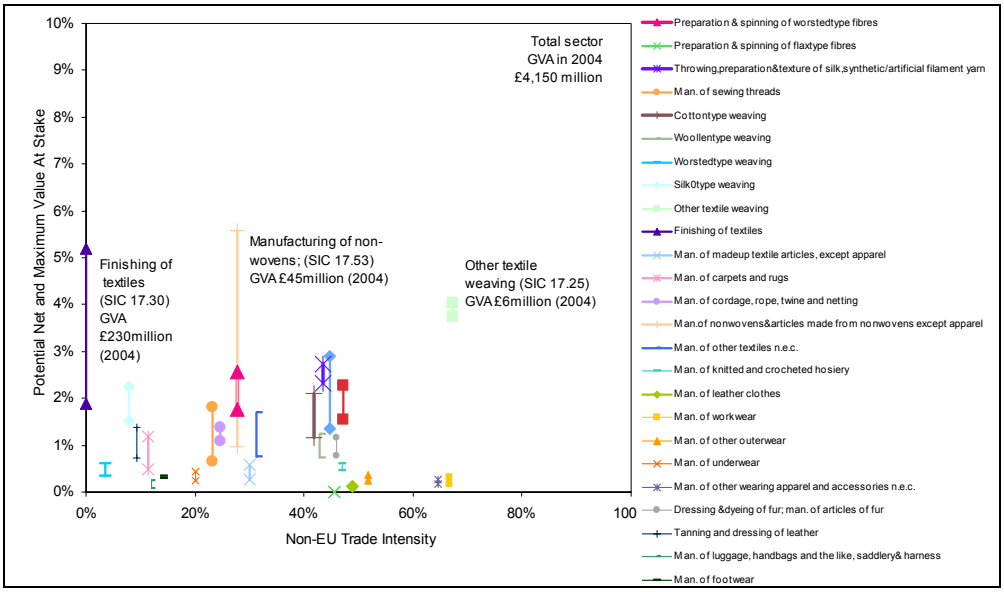


Figure 11 Value at stake for the Textiles and leather sector relative to UK trade intensity from outside the-EU

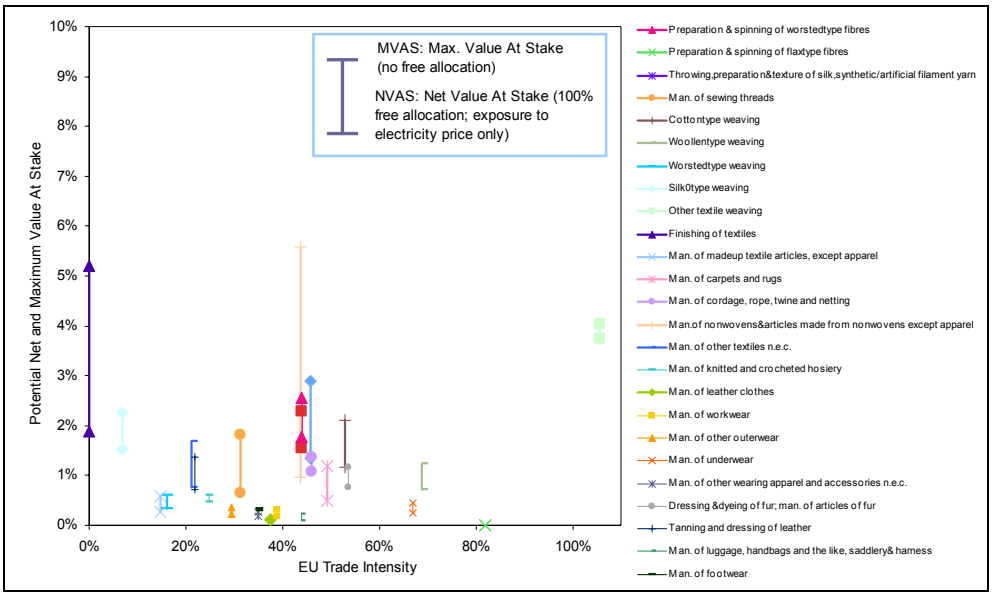


Figure 12 Value at stake for the Textiles and Leather sector relative to UK trade intensity from EU

- ***Key observations***

The textiles sector overall comprises of a complex subsector structure, but no major activities appear subject to significant EU ETS impacts. *Manufacturing of non-wovens and articles made from non-wovens except apparel* (SIC 17.53) has MVAS exceeding 5% and is extensively traded, but accounts for just £45m of GVA. This GVA also forms a small share of turnover (around 20%). The two activities indicated as most exposed to indirect electricity impacts are the relatively small subsectors and data may be correspondingly suspect due to focus principle. By the far most economically significant, *Finishing of textiles* (SIC 17.30) at £230m GVA), according to our source data, trades only domestically.

- ***Data Issues***

Data for this sector may contain distortions induced by the focus principle. All company activities are attributed to the subsector where the major activities of the company occur. Company activities active in several subsectors can thus distort the reported relative size of subsectors.

No comments from industry participants where received on this section.

2.3.3 Wood, Pulp, Paper, Paper Products and Printing

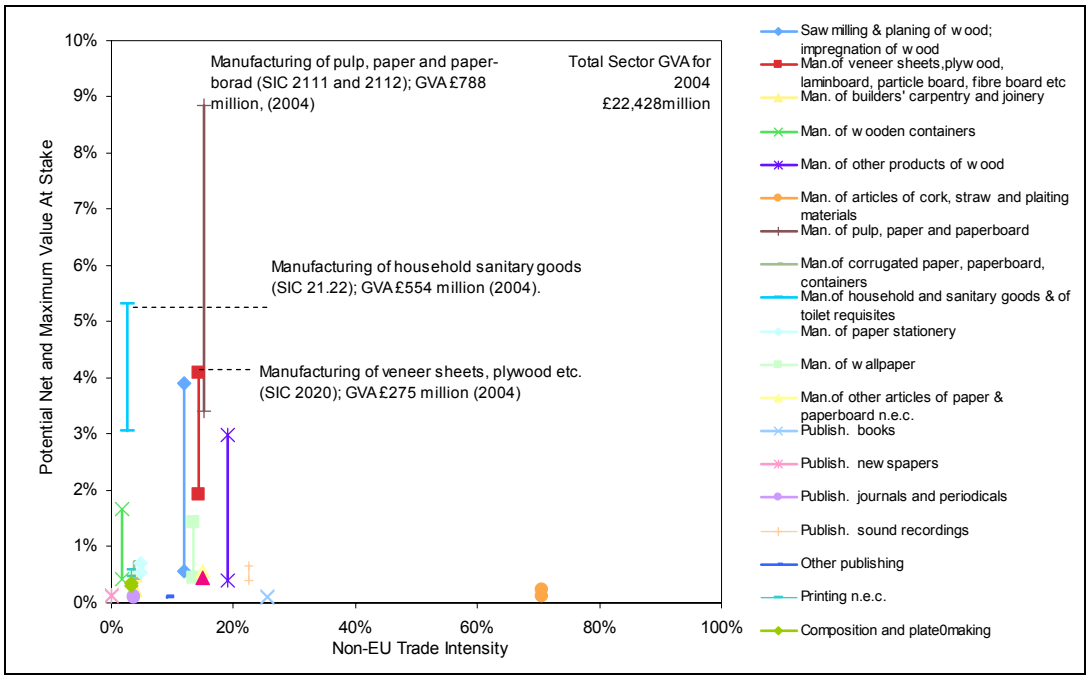


Figure 13 Value at stake for the Wood, Paper and Printing sector relative to UK trade intensity from outside the EU

Notes: The brown bar aggregates two 4 digit sectors -Manufacturing of pulp (SIC 21.11) and Manufacturing of paper and paperboard (21.12), hence it represents sector 21.1. The split into two subsectors at 4 digit level is not available for energy inputs, GVA and turnover data. In terms of production volume in 2006, 21.12 accounts for over 95% of 21.1. As such trade data for subsector 21.12 is used to estimate trade-intensity for this sector.

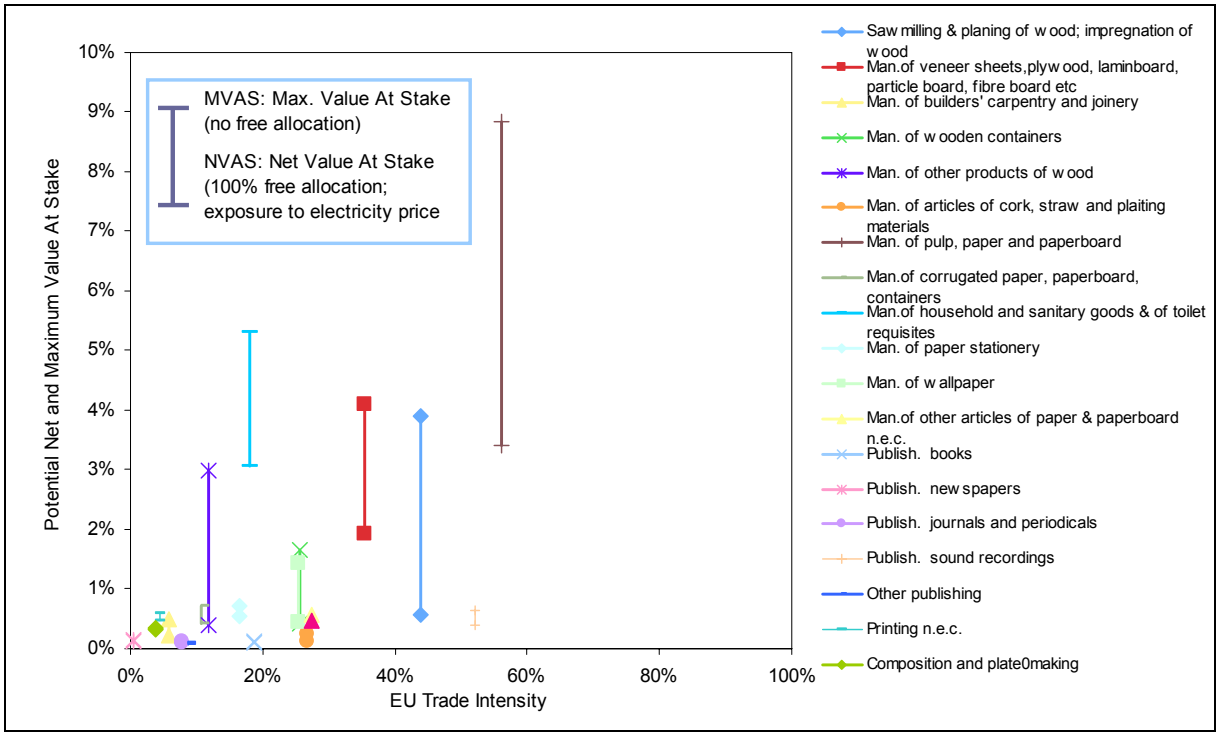


Figure 14 Value at stake for the Wood, Paper and Printing sector relative to UK trade intensity from EU

- ***Key observations***

In this sector, two subsectors stand out. These are *Manufacturing of pulp, paper and paperboard* (this is a 3-digit representation combining SIC 21.11 and 21.12 due to lack of disaggregated data) and *Manufacturing of household and sanitary goods and of toilet requisites* (SIC 21.22). is a large industrial consumer of both direct energy and electricity. Most of the other subsectors here represent secondary production, which requires low energy inputs, and hence limited impact from carbon pricing.

- ***Data issues***

For *Manufacturing of pulp, paper and paperboard* (SIC 21.1), whilst retaining electricity inputs data from BERR Energy Statistics Publication, the direct combustion emissions have been adjusted upwards to match the sector emissions reported to DEFRA (2007).

- ***Open questions***

From published or industry data, it was not possible to differentiate between the basic pulp production and the manufacturing of paper and paperboard in terms of energy input and GVA. The close integration of the production process frequently cited as an explanation. The published trade data, however, separates between the two. In the UK, the production volume of *paper and paperboard* (21.12) is a multiple of the *pulp production* (SIC 21.11). The trade both with non-EU countries is focused on pulp. In 2004 non-EU trade intensity of pulp was 66% compared to 15% for paper and paperboard. The paper production is in general more energy and electricity intensive per unit of output than the pulp production (see Chapter 1). A closer analysis was beyond the scope of this study but might be of interest.

In addition, compared to other Member States, the UK Pulp & paper industry is small. Pulp production in the UK is dominated by the chemical process, whereas other countries use Mechanical pulping, which is more electricity intensive. Given the high intra-EU trade intensity of both pulp (36%) and paper & paperboard (56%), a closer coordination of analysis and policy responses with other countries, particularly in Scandinavia, might be beneficial.

2.3.4 Manufacture of Coke and Refined Petroleum Products

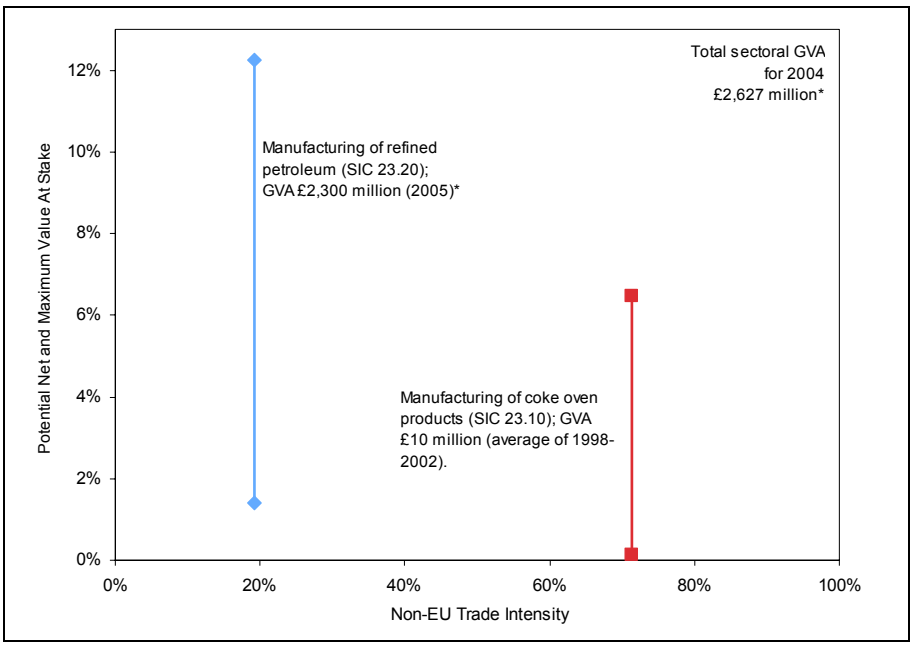


Figure 15 Value at stake for the Refining sector relative to UK trade intensity from outside the EU

*Note: Total sector GVA includes *Manufacturing of refined petroleum* (SIC 23.20). This sector is not represented in the graph as no energy data is available.

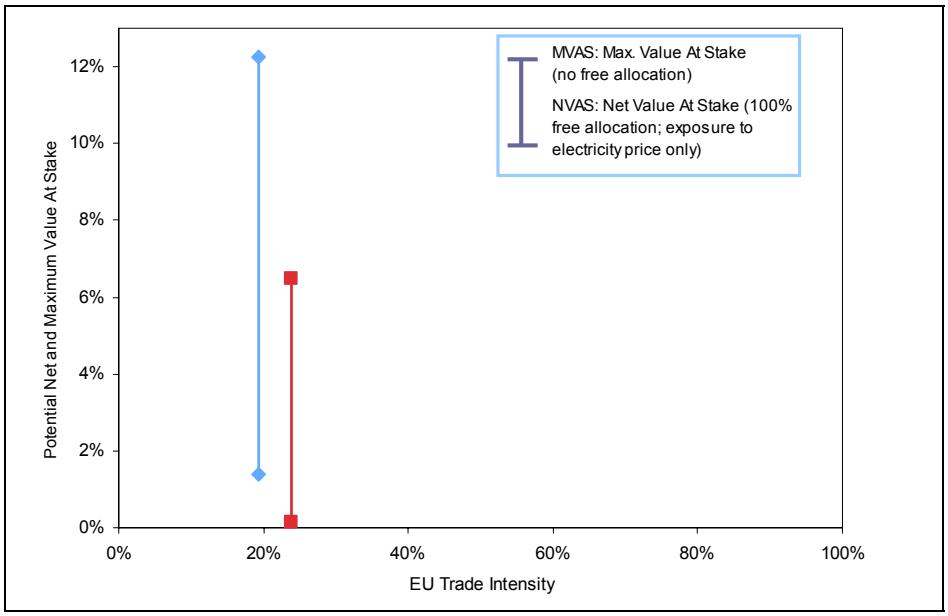


Figure 16 Value at stake for the Refining sector relative to UK trade intensity from EU

- ***Key observations***

Manufacturing of refined petroleum (SIC 23.20) emits over 20Mt CO_2 annually (direct and indirect). According to DEFRA (2007), CO_2 emissions from refineries have stayed roughly constant, despite fluctuations in throughput and output volumes. The refinery sector exhibits high sunk costs for initial construction of facilities and barriers for new location through by planning and permitting. Also, international transport of refined products is largely limited to a swap between gasoline and diesel between Europe (larger diesel consumption) and the US

(larger gasoline consumption). This suggests limited concern that carbon pricing will influence locational decisions of the sector. See Annex 2 for a case-study on the refining.

Manufacture of coke oven (SIC 23.10) is extremely CO_2 intensive and is a relatively low value-added product hence the MVAS is high. In coke production, emissions are associated with burning coal in a low oxygen environment - i.e. manufacturing of coke oven. Mainly used as fuel inputs for Blast Oxygen Furnace (BOF) steel manufacturing, coke production is often vertically integrated with steel production. The resulting gases can be used in integrated steel works, and are accounted for under *Manufacturing of basic iron and steel* (SIC 27.10). The majority of coke production in the UK is attributed to steel and Figure 15 shows only the residual (one out of three plants is independent).

- ***Data Issues***

According to ONS ABI, GVA for the refining sector as a whole in 2004 was £ 2.627 billion. This includes three subsectors: *Manufacturing of refined petroleum* (SIC 23.20); *Manufacture of coke oven* (SIC 23.10) and *Processing of nuclear fuel* (SIC 23.30). However, the breakdown of GVA is not available. Based on the report to the UK BERR (Wood Mackenzie, 2007), we attribute £2.3bn of the sector GVA to *Manufacturing of refined petroleum* (SIC 23.20). For *Manufacture of coke oven* (SIC 23.10), we take an average of published figures for 1998- 2002, at £10 million.

Fuel consumption for *Manufacture of coke oven* (SIC 23.10) reported in the BERR Energy Statistics Publication (2007) aggregates that of three coke oven production plants, two of which are owned by steel manufacturers. To avoid double counting with steel, we distinguish between coke oven emissions that are from coke ovens integrated with steel production and those which are emitted from other sources. To do this, we obtain emissions data for the independent plant from 2005 verified emissions data reported to CITL (CEC 2005). GVA, Turnover and trade data reported for this subsector are assumed to be attributable to the independent plant. The very small scale (value-added) of the residual coke activity in here may make it prone to data errors.

Therefore whilst the *Manufacture of coke oven* (SIC 23.10) represented here is small, we highlight the potential leakage of coke in the steel sector (analogous to importing clinker for cement production), as the existing facilities and transport chain for coal could easily be used for imports of coke. No energy input data is available for *Processing of nuclear fuel* (SIC 23.30) hence it is not represented in the graph.

2.3.5 Chemicals

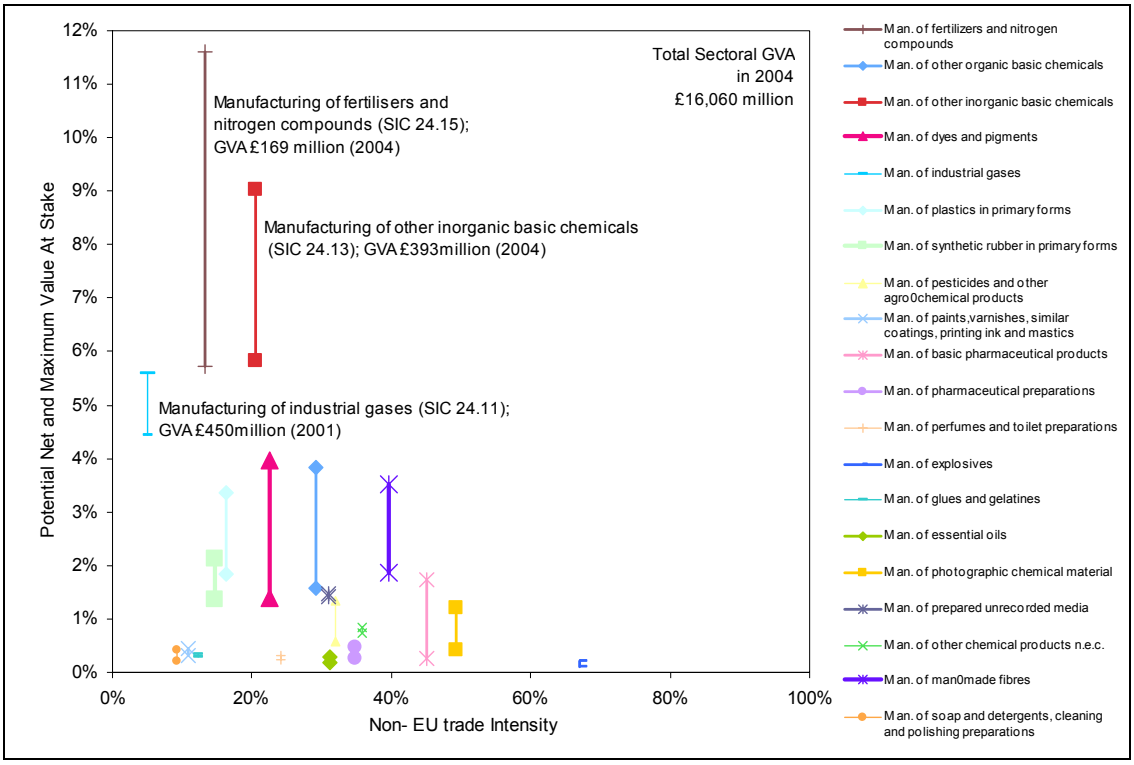


Figure 17 Value at stake for the Chemicals sector relative to UK trade intensity from outside the EU

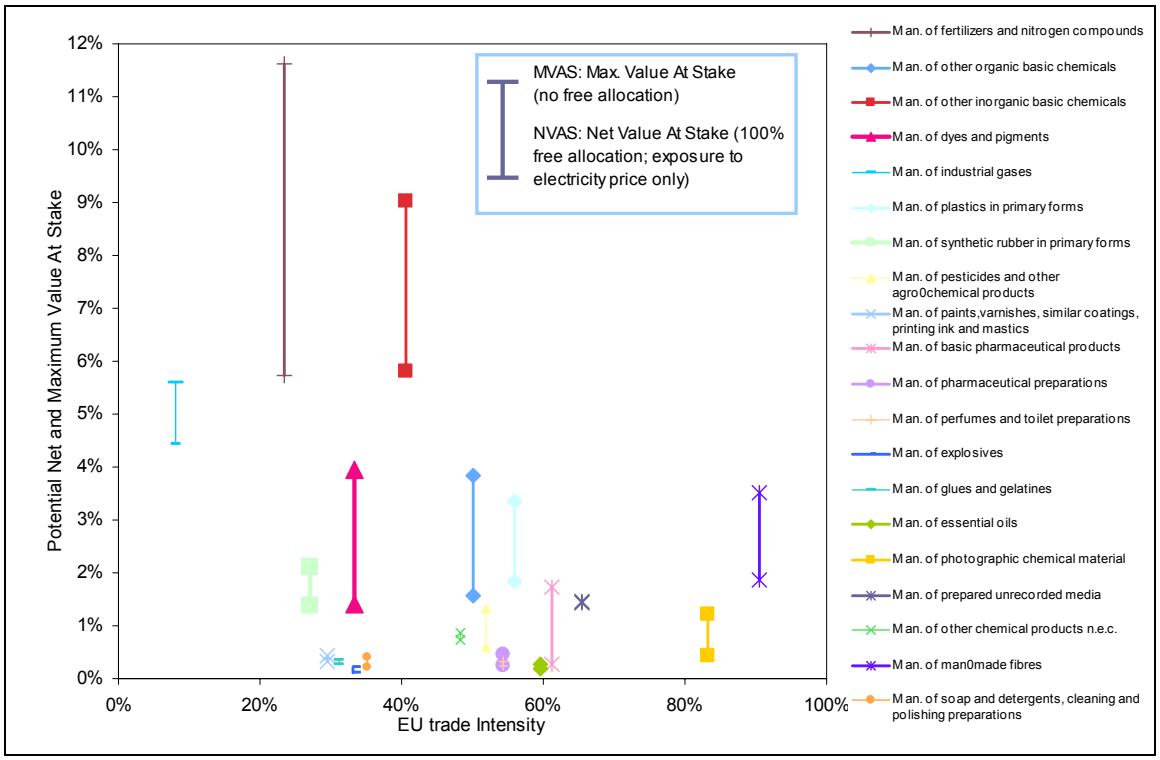


Figure 18 Value at stake for the Chemicals sector relative to UK trade intensity from EU

- ***Key observations***

Chemicals is a complex sector comprising of 20 subsectors. Impacts vary widely and two stand out: *Manufacturing of fertilisers and nitrogen compounds* (SIC 24.15) including the

production of ammonia and *Manufacturing of inorganic basic chemicals* (SIC 24.13). Their MVAS are over 11% and 9% respectively. The latter is likely to be attributed to the high electricity intensive production of chlorine. The non-EU trade intensities for these sectors are low, reflecting high risks associated with transports of chemicals like chlorine. In addition, whilst they are non-trivial in terms of GVA (comparable to cement), the GVA share of turnover is low for both sectors at 17% for *Manufacturing of fertilisers and nitrogen compounds* and 26% for *Manufacturing of inorganic basic chemicals*. These factors suggest there are barriers for relocation of individual substances. These complexities warrant further analysis on the interactions between chemical products to understand potential leakage concerns. In addition, indirect impact through higher electricity prices leads to a cost increase of 6% relative to GVA for *Manufacturing of industrial gases* (SIC 24.11).

- ***Data issues***

Our estimation on CO_2 emissions of the sector in aggregate is 17.8 Mt CO_2 including both direct and indirect emissions. This estimate is derived from BERR Energy Statistics Publication (Table 4.6). This number is aligned with BERR (2006)'s DUKES Table 1.8 (17.7Mt CO_2) and close to the mean of the broader range of estimates – lower bound set by DEFRA (2007) (including New Entrant Reserve and plants covered under Climate Change Agreements) at 15Mt CO_2 and higher bound given by industry data.

For *Manufacturing of industrial gases* (SIC 24.11) and *Manufacturing of dyes and pigments* (SIC 24.12), GVA data from 2001 is used, as no later data is available. Industrial energy consumption time-series data (Energy Statistics Publication 4.6) suggests that production has increased marginally for the *Manufacturing of industrial gases*, whereas the latter has contracted. Hence NVAS and MVAS plotted here for *Manufacturing of dyes and pigments* (SIC 24.12) may be downward biased.

- ***Open questions***

As SIC does not accurately represent the different processes of the chemicals sector including heat exchange and opportunities for CHP, the impacts of carbon pricing on competitiveness and leakage is difficult to assess. A more comprehensive sector study is therefore worthwhile. In addition, this report does not take account of other gases such as nitrous oxide which are most likely to be included under Phase 3 of the EU ETS at the latest, and as such may not reflect the full impact on some subsectors.

2.3.6 Plastic and Rubber

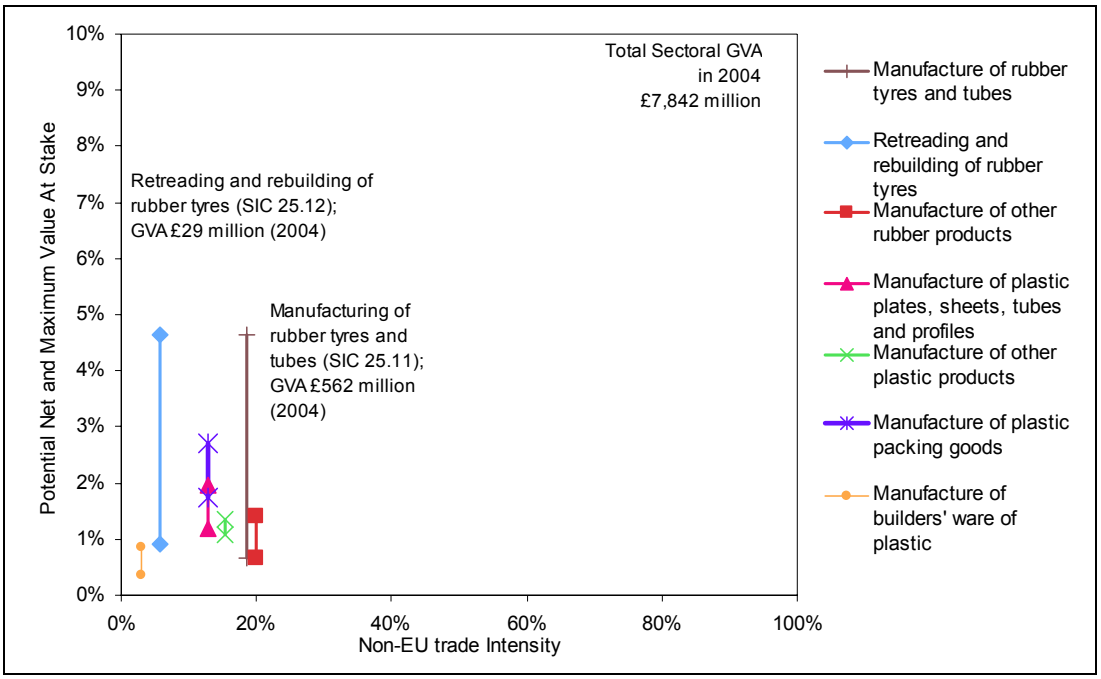


Figure 19 Value at stake for the Plastic&Rubber sectors relative to UK trade intensity from outside the EU

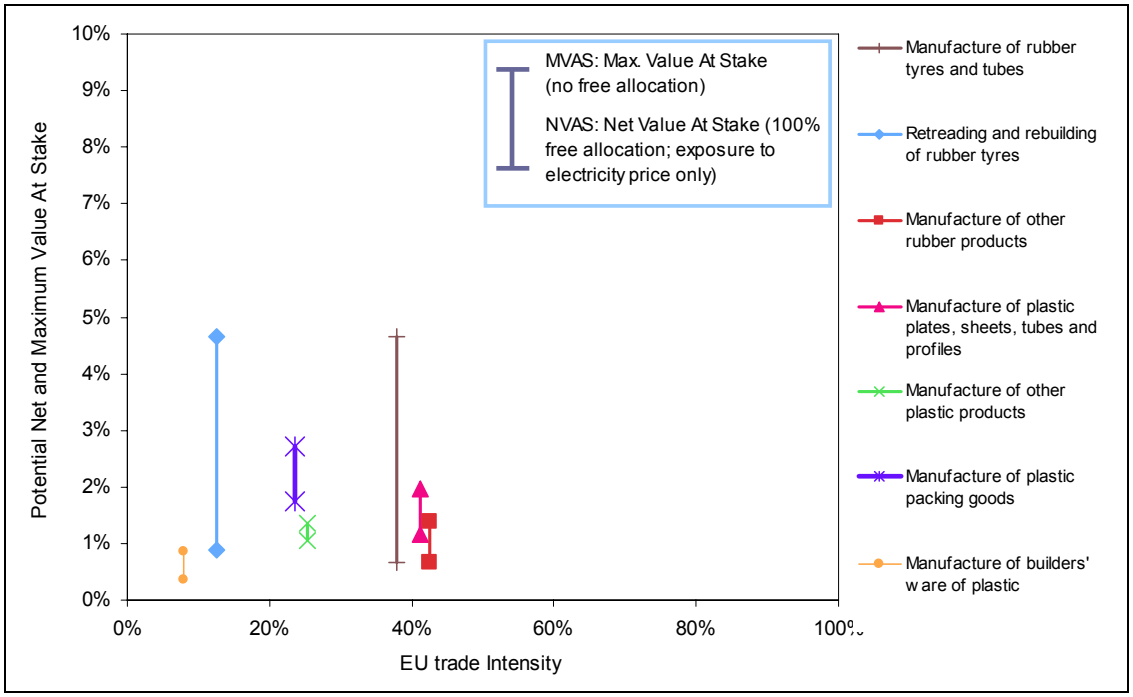


Figure 20 Value at stake for the Plastic and Rubber sector relative to UK trade intensity from EU

- ***Key observations***

The plastic and rubber sector is economically sizable in GVA terms. Impacts of carbon pricing are expected to be small for all activities. *Manufacturing of rubber tyres and tubes* (SIC 25.11) accounts for a large share of the sector GVA, and MVAS is relatively high for the sector at 4.6% followed by *Retreading and rebuilding of rubber tyres* (SIC 25.12). There are no obvious constraints for the trade of such products. The trade intensities suggest that trade barriers are lower for the former subsector. For both sectors, GVA is around 30% of turnover.

2.3.7 Glass and ceramics

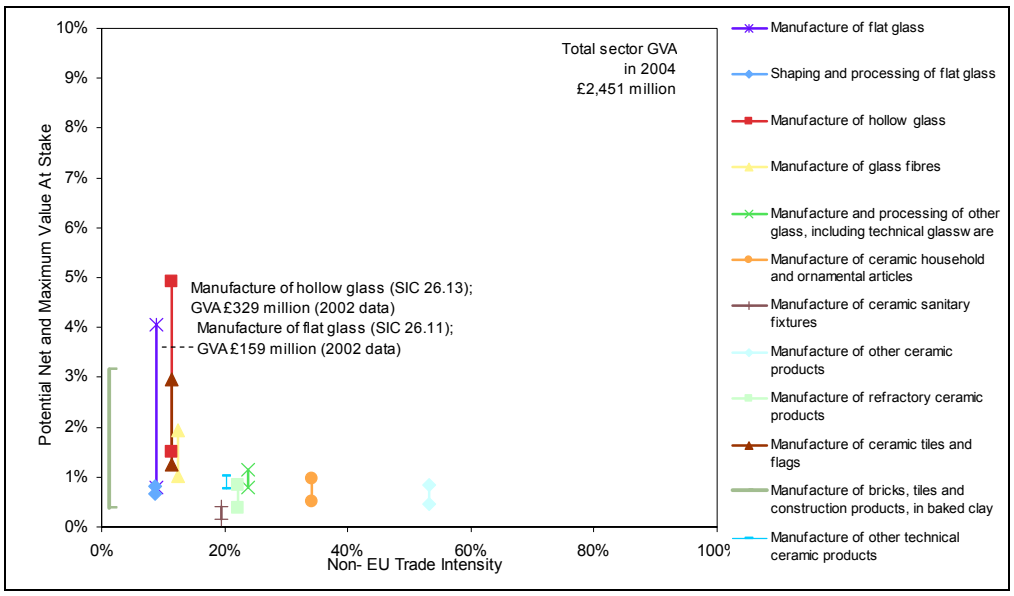


Figure 21 Value at stake for the Glass and ceramics sector relative to UK trade intensity from non-EU

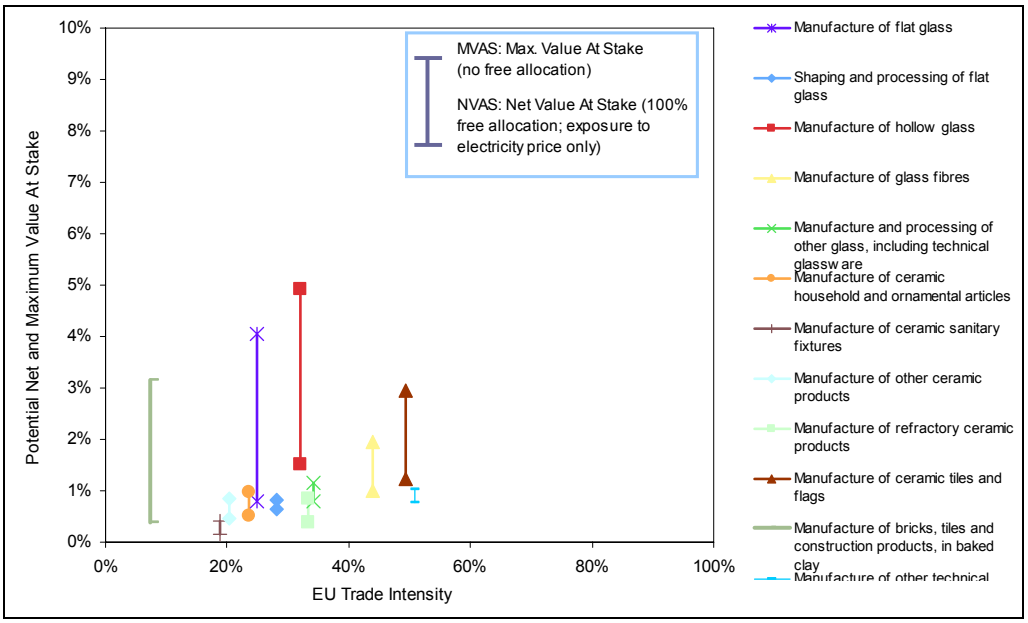


Figure 22 Value at stake for the Glass and ceramics sector relative to UK trade intensity from EU

- ***Key observations***

Impacts of carbon pricing are expected to be small for activities in this sector. *Manufacture of flat glass* (SIC 26.11) and *Manufacture of hollow glass* (SIC 26.13), both representing the basic products in this sector, have MVAS exceeding 4%. They collectively account for around £500m GVA or a fifth of total sector GVA, and have relatively similar carbon and trade characteristics. The relatively low external trade intensity suggests significant transport costs, as might be expected given the relatively fragile nature of the product.

- ***Data issues***

2004 GVA data is not available for four subsectors. Reported GVA from the latest available year (2002) is used for *Manufacture of flat glass* (SIC 26.11) and *Shaping and processing of flat glass* (SIC 26.12).

For *Manufacturing of other technical ceramic products*[19] (SIC 26.24), only 1998 and 1999 data is available (£51million and £17million respectively). BERR Energy Statistics Publication reports marked increase in the electricity consumption of this sector in 2004 compared to previous years. To align with the available GVA data, we use the average of 1998 and 1999 for energy consumption data.

To account for process emissions, the BERR Energy Statistics Publication industrial energy consumption data is complimented with other sources. For process emissions from *Manufacture of flat glass* (SIC 26.11) and *Manufacture of hollow glass* (SIC 26.13), we take the values of 180kt and 247kt CO_2 respectively, were reported by British Glass.[20] This data was verified using the combination of combustion emission and electricity consumption data from BERR Energy Statistics Publication and the sector's verified emissions reported in DEFRA (2007). For process emissions from *Manufacture of bricks, and construction products in baled clay* (SIC 26.40), we take the value 273kt reported by British Ceramic Confederation[21] and verified using the same approach.

- ***Open Questions***

At first glance, it does not appear viable to transport flat and hollow glass products globally, given their relatively low Non-EU trade intensity. These somewhat cement-like characteristics imply potential for the main glass manufacturing activities to make profits from free allocation, but also with potential for leakage at higher carbon prices and pass-through rates. Further analysis is required to understand the potential for leakage.

19 This class includes: manufacture of ceramic laboratory, chemical and industrial products.

20 Submitted via the UK Emissions Trading Group consultation.

21 Submitted via the UK Emissions Trading Group consultation.

2.3.8 Cement, Lime and Plaster

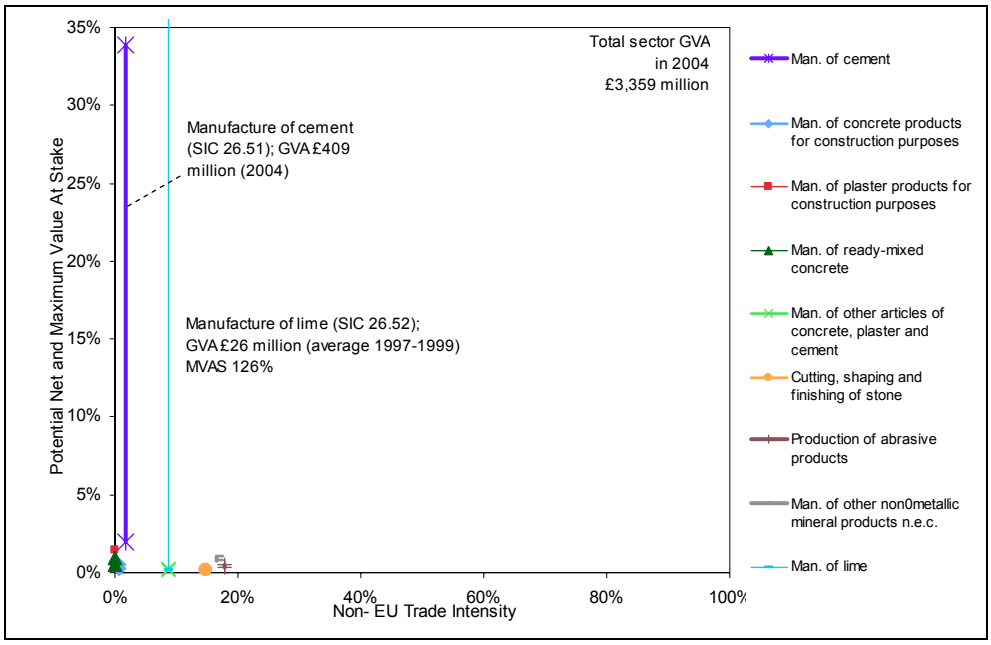


Figure 23 Value at stake for the Cement sector relative to UK trade intensity from non-EU

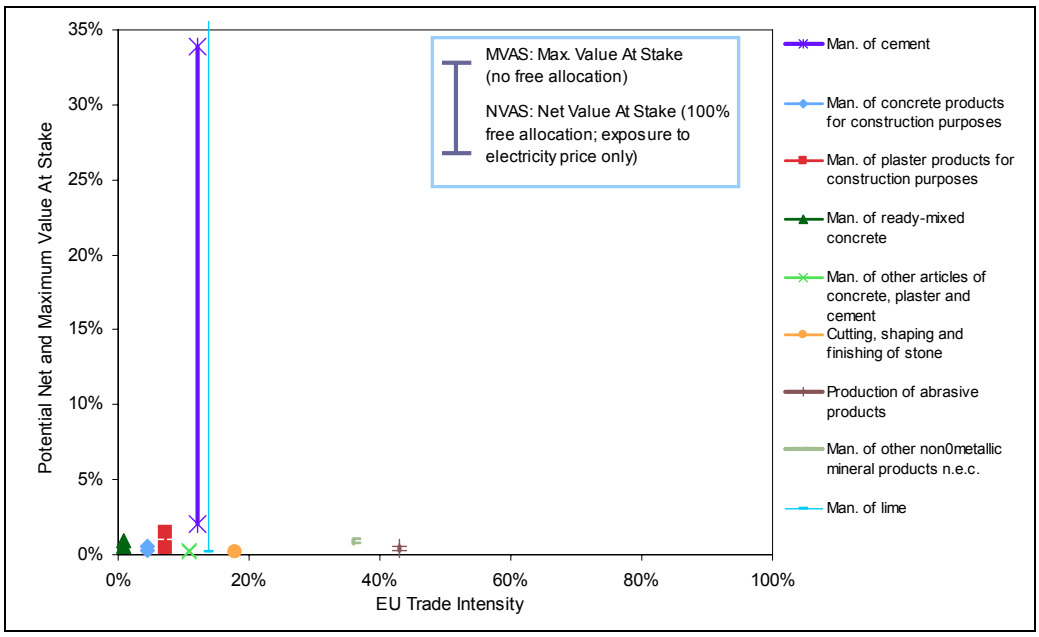


Figure 24 Value at stake for the Cement sector relative to UK trade intensity from EU

- ***Key observations***

The *Manufacturing of Cement* (SIC 26.51) and *Manufacturing of Lime* (SIC 26.52) dominate this sector's potential competitiveness exposure. High value added secondary products such as *Manufacture of concrete products for construction purposes* (SIC 26.61) and *Manufacturing of concrete products for construction purposes* and *ready-mixed concrete* (SIC 26.63) have little exposure.

The high exposure of *cement* and *lime* reflects the high intensity of direct carbon emissions relative to electricity. The potential cost increase of a carbon cost of €20/t CO_2 relative to GVA is 34% and 126% respectively. This sector is examined in further depth in Chapter 3.

- ***Data issues***

For both *Manufacturing of Cement* (SIC 26.51) and *Manufacturing of Lime* (SIC 26.52), direct CO_2 emissions (product of fuel inputs to production and process emissions, but excluding indirect emissions from electricity inputs to production) are obtained from DEFRA (2007). Indirect emissions from electricity are calculated from BERR Energy Statistics Publication data.

For Lime GVA, only data for 1997-1999 is available from the ONS ABI (£47M, £15M and £16 million respectively). We take an average of the three years of published data (£26 million) given that the above DEFRA (2007) indicates A) that production volume has stayed roughly constant over the period 2000-2005 and B) total emissions have stayed roughly the same over 1998 -2005.

- ***Open Questions***

As stated above, carbon emissions from cement manufacturing are concentrated in the production of the input factor, clinker. Trade barriers for clinker are likely to be lower than cement itself, therefore separate data on the economic (eg. value-added) significance of clinker for cement production is necessary to understand the potential leakage in this sector.

In addition, while it is sometimes argued that the ability of the cement sector to pass through costs may also be limited by competition from other building materials, we would not interpret this impact as a competitiveness effect. If reflecting the CO_2 price in the product price results in a substitution of less carbon intensive materials, or more labour intensive production methods, then the climate policy has had its intended effect.

2.3.9 Iron & steel (SIC 27 excluding 27.4, 27.53, 27.54)

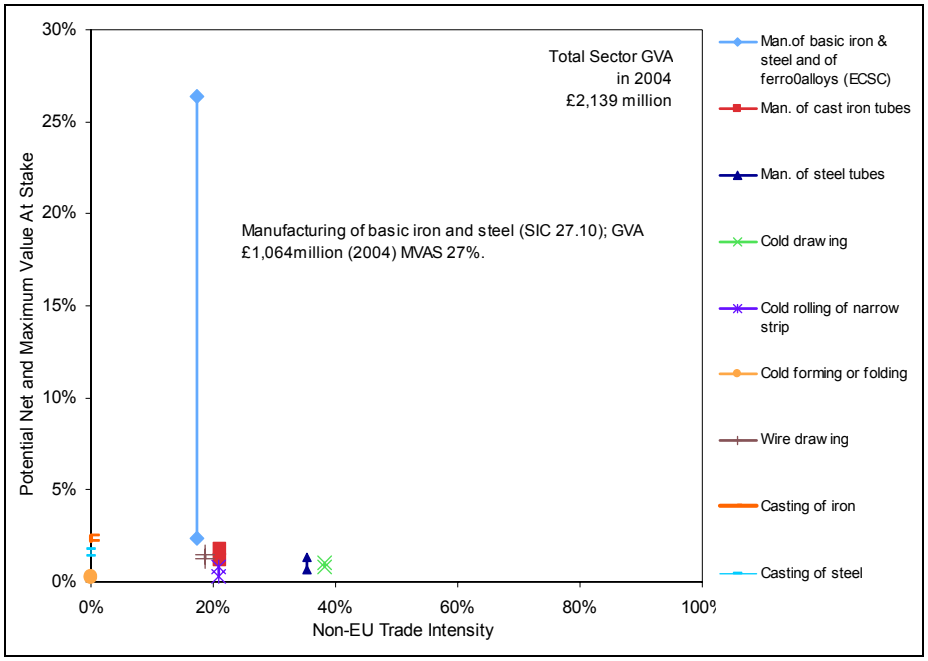


Figure 25 Value at stake for the Iron and Steel sector relative to UK trade intensity from non-EU

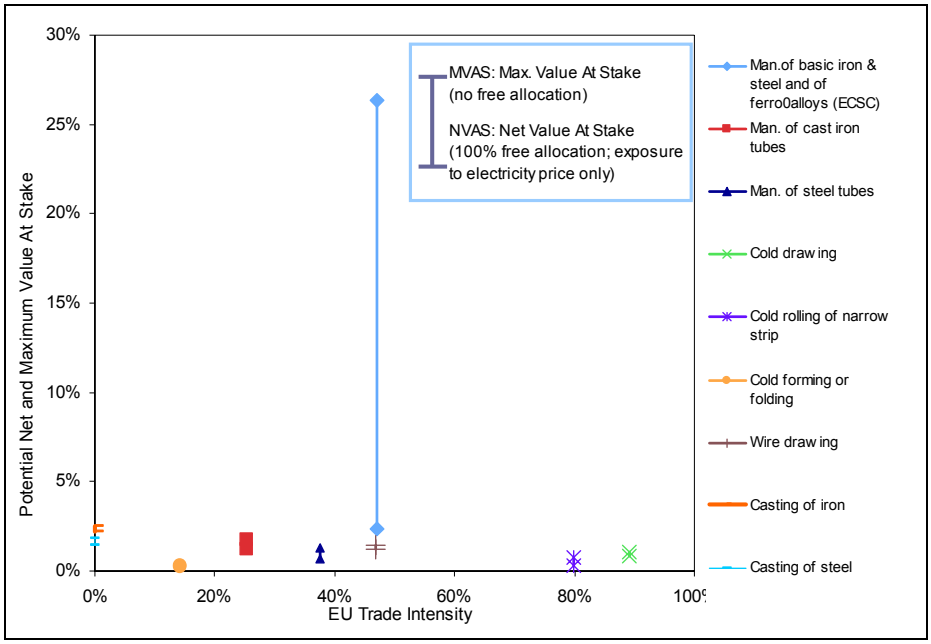


Figure 26 Value at stake for the Iron and Steel sector relative to UK trade intensity from EU

- ***Key observations***

Carbon emissions in steel are concentrated at the upstream BOF processes producing basic commodities with low costs per tonne, whilst the secondary process of EAF or more downstream activities are characterised by much less energy intensive production methods. *Manufacturing of basic iron, steel and ferrous-alloys* (SIC 27.10) thus bears most of the cost increase from carbon pricing. Emissions from this subsector represent 95% of emissions for the UK iron & steel sector as a whole, and are produced by three BOF plants owned by one firm. This subsector accounts for around half of total sector GVA.

As shown in Chapter 1, around 80% of steel is produced from the BOF process, and the remaining by the secondary EAF route. The raised lower end of the bar for *Manufacturing of basic iron, steel and ferrous-alloys* (SIC 27.10) is therefore largely attributed to the electricity consumed in the EAF process.

Non-EU and EU trade intensities for *Manufacturing of basic iron, steel and ferro-alloys* are 17% and 47% respectively. The high EU trade intensity gives a strong indication of fierce competition between European producers. This suggests that a harmonised approach to allocation is important to avoid distortions that might result if EU countries start to favour plants located in their own country.

The low international trade exposure of only 17% reflects two aspects. First, European demand and supply are currently in a balanced state; otherwise we would observe large net export or net import volumes. Second, in the case of basic commodities, transport costs relative to value are high enough to prevent significant simultaneous shipments in opposite directions, which would result in higher trade volume. Chapter 3 offers further analysis on trade barriers in this sector.

- ***Data issues***

Process emissions are estimated at around 15.1Mt CO_2. This is the difference between 2005 verified sectoral emissions of 18.8 Mt CO_2 (DEFRA 2007 and European Commission 2006), and CO_2 emissions from the sector attributed to direct energy use of 3.7 Mt CO_2 in 2004 (BERR 2007). Since the total volume of UK crude steel production decreased by only 0.7% between 2004 and 2005 according to IISI (2007), we assume that emissions have stayed constant during the two time periods. We have assumed all process emissions for the aggregate steel sector are attributed to the 4-digit SIC subsector *Manufacturing of basic iron, steel and ferrous alloys* (27.10). This sector includes the basic oxygen furnace (BOF).

- ***Open Questions***

SIC industrial classification at 4 digit level does not offer the key separation of the two main basic iron and steel production processes: BOF and EAF. As stated in Chapter 1, two distinct sets of drivers for the economics and investment decisions that lie behind the industry dynamics are separated to a large extent by these processes.

2.3.10 Non-ferrous Metals

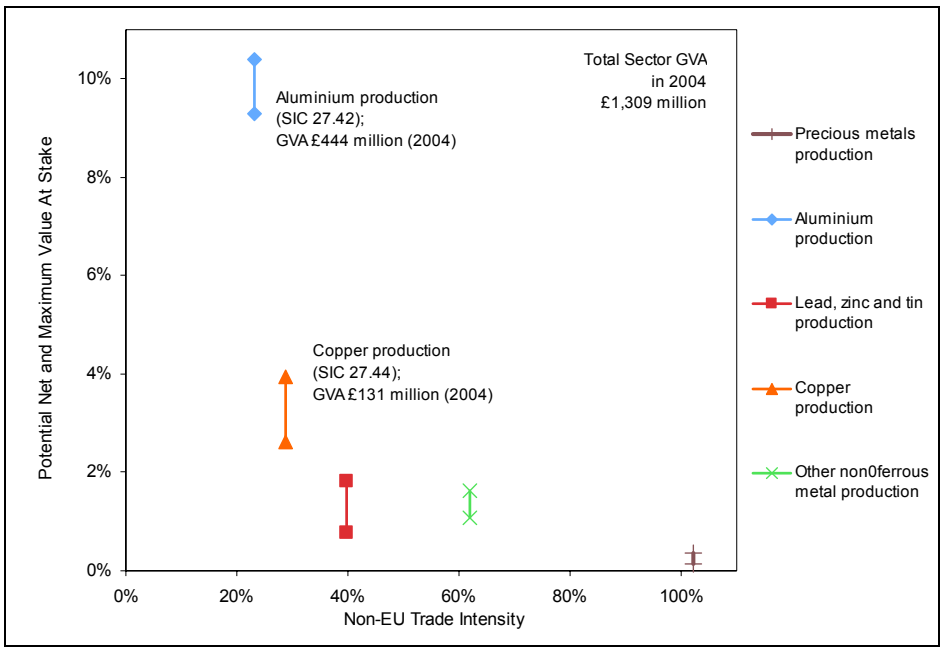


Figure 27 Value at Stake for the Non-ferrous metals sector relative to UK trade intensity from non-EU

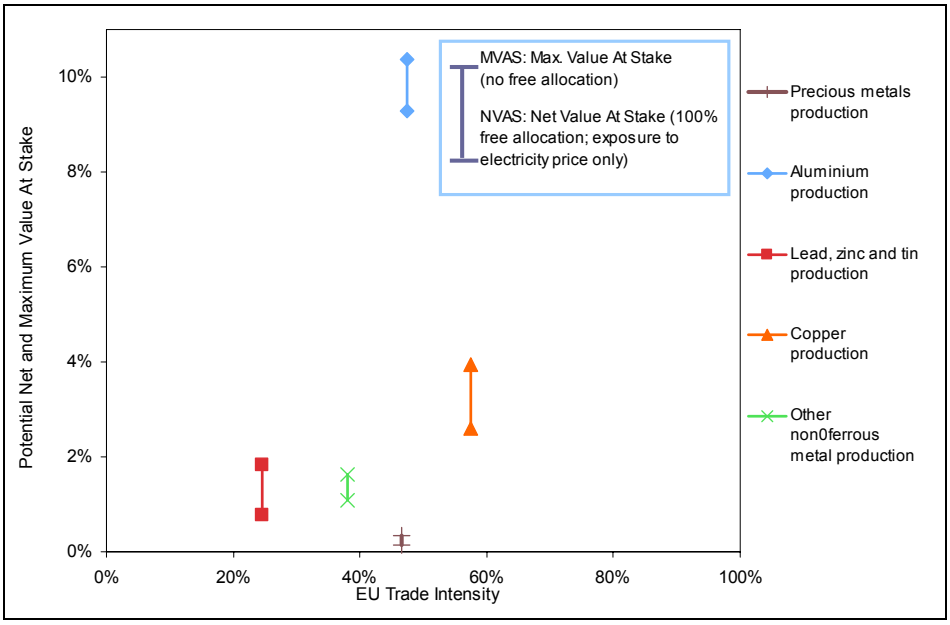


Figure 28 Value at Stake for the Non-ferrous metals sector relative to UK trade intensity from EU

- ***Key observations***

Consistent with earlier studies that pointed out the potentially exposed position of non-ferrous metals from electricity impact (Smale et al 2006), NVAS for *Aluminium production* (SIC 27.42) in the UK is, according to our data, in excess of 9%. There are currently three Aluminium plants in the UK, which in general are powered by dedicated on-site power facilities. The data also includes production steps beyond the initial smelter and recycling of aluminium, which uses significantly less electricity and is therefore less energy intensive than primary aluminium production. This suggests large differences in cost impacts from carbon

pricing across the three plants, and the need to consider leakage issues at the level of individual smelters. *Copper production* (SIC 27.44) also faces MVAS exceeding 4%. The special characteristics of aluminium and potentially copper might warrant a more detailed investigation which was beyond the scope of this study.

- ***Data issues***

After consultation with industry and government, and availability of revised Energy Statistics Publication, the initially different numbers have now been aligned.

2. 3.11 Summary of Results

Of the 159 4-digit SIC sectors examined in this section, 20 sectors have MVAS exceeding 4% (cumulative impact) and further three sectors have NVAS exceeding 2%.

The histogram representation in Figure 29 plots the "top 20+3" sectors with share of UK GDP[22] on the x-axis. All together, they account for just above 1% of UK GDP. The areas of the bars are proportional to size of CO_2 emissions. Direct emissions from these 23 subsectors collectively contribute 11% to total UK CO_2 emissions in 2004. Indirect emissions, from electricity, contribute 2.5%.. These "top 20+3" potentially exposed sectors represent about 1% of UK GDP and 0.5% of UK employment. The small share of these sectors to GDP and employment does not mean that they can be ignored. On the contrary, the fact that the impact and potential leakage is focused on few specific subsectors allows for tailored and technical solutions to address leakage concerns.

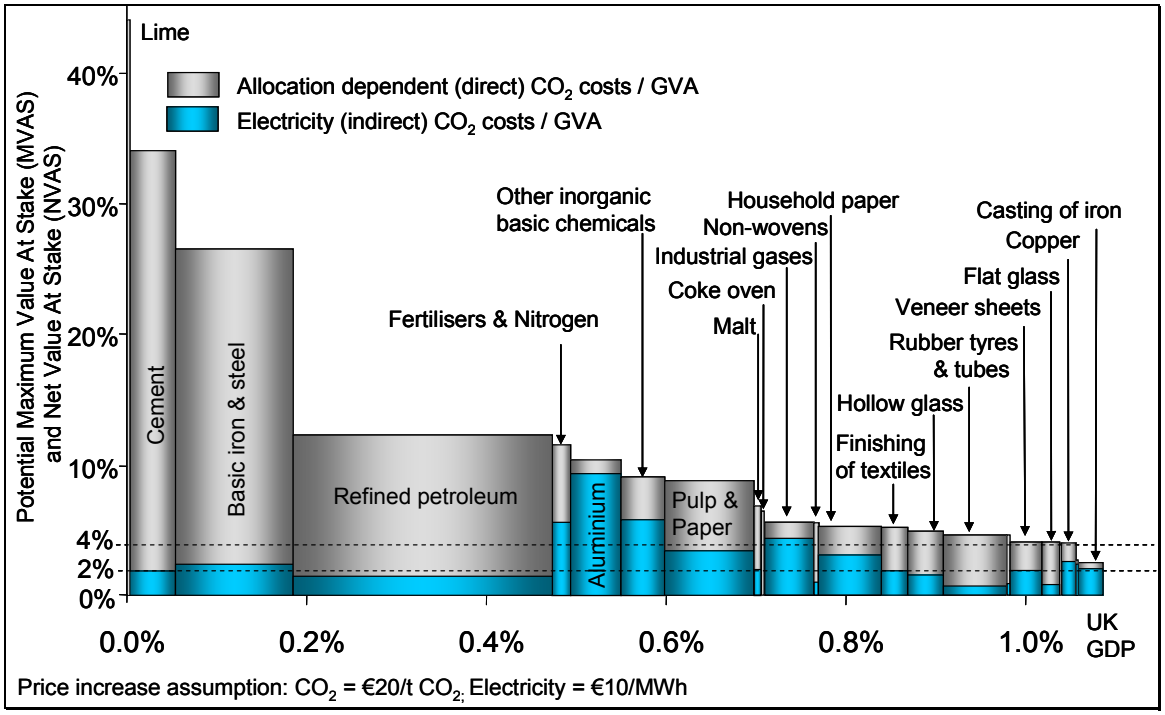


Figure 29 CO_2 cost screen: sectors potentially exposed under unilateral CO2 pricing, based on 2004 data.

Source: UK total GVA in 2004 is 800,000 computed from Annual Business Inquiry and Total UK employment for 2004 = 28410(000) from Office of National Statistics.

22 Here, GVA and GDP are used interchangeably. According to UK Office of National Statistics, "GVA is used in the estimation of Gross Domestic Product (GDP). GDP is a key indicator of the state of the whole economy. In the UK, three theoretical approaches are used to estimate GDP: 'production', 'income' and 'expenditure'. When using the production or income approaches, the contribution to the economy of each industry or sector is measured using GVA.

2.4. INTERNATIONAL COMPARISON and ROBUSTNESS TEST

To what extent are the results in Section 2.3 representative internationally and over time? To test robustness of our approach, we first conduct a cross-country comparison. UK manufacturing sectors' relative contribution to national GVA is compared with counterparts in other EU Member States. Then the NVAS/MVAS and trade intensity values are compared for the "top 20+3" manufacturing subsectors identified fin the UK analysis, with equivalent subsectors in Germany. We then assess to what extent results derived for an individual year are robust over time using time series data for Germany. Finally we examine the robustness of GVA as a denominator relative to other metrics.

2.4.1 The role of Carbon intensive sectors in EU economies

In an attempt to understand how the role of manufacturing in the economy compares across EU Member States, we first conduct a cross-sectional comparison. Grouping sectors broadly, (2digit level SIC), Figure 30 plots the manufacturing sectors' relative contribution to national GVA in each Member State, and also the average. The closeness of the UK bar to the EU average suggests UK's economy is a microcosm of the region.

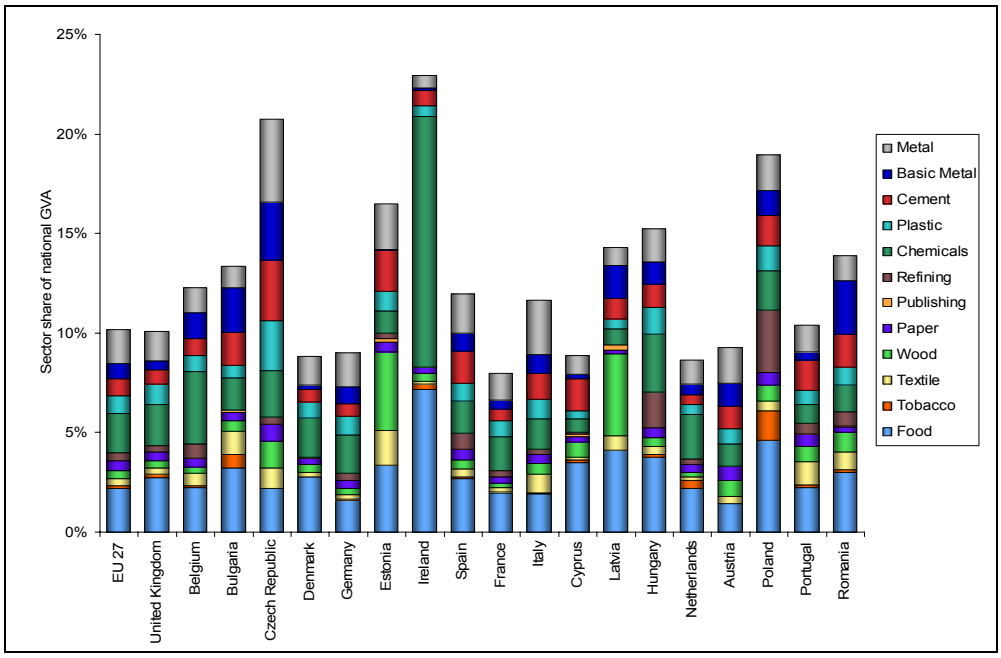


Figure 30 Manufacturing sectors' relative share of national GVA across EU (2004) Source: Eurostat (2007a).

2.4.2 Comparing the two dimensions of competitiveness indicator

Figure 31 compares the EU and Non-EU trade intensities of the UK's "top 20+3" subsectors, with their German counterparts.

This comparison illustrates that for most sectors, the overall trade intensity is comparable in Germany and the UK. In all sectors for which we had data, other than copper and lime, the overall trade intensity is bigger in Germany. As one would expect from the geographical location and Commonwealth affiliation of the UK, in all sectors but the Malt sector, the UK exhibits higher trade intensity with non-EU countries while share of intra-EU trade intensity is far higher for Germany.

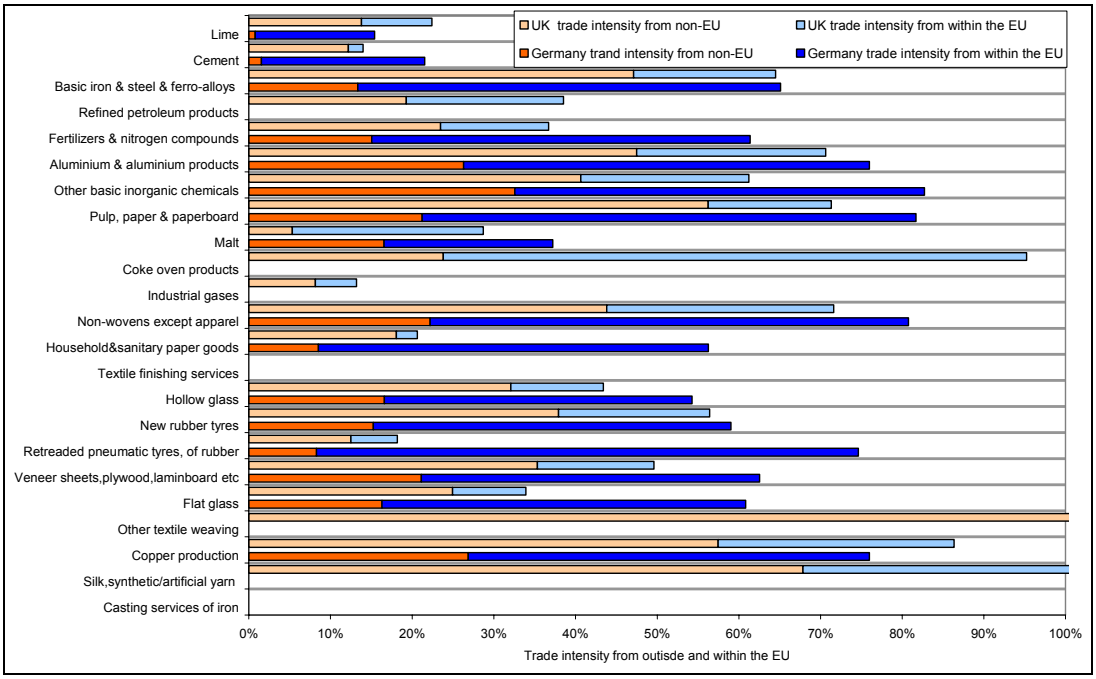


Figure 31 Trade intensity of top 23 sectors with Non-EU and EU countries in UK and Germany, 2004 data. Source: Statistisches Bundesamt (2004) for Statistics on Germany

Moving onto cost impacts from carbon pricing, the first difficulty in this exercise arises because in Germany, industry energy consumption by fuel (like the UK BERR Energy Statistics Publication) is not publicly available at the 4-digit SIC level. Thus is not possible to directly calculate CO_2 emissions for the detailed sectors in Germany as was possible for the UK. However, it is possible to compare sectors' energy expenditures relative to value added if we assume that industry fuel mix and fuel prices are similar in both countries. The share of energy expenditure relative to GVA gives indication of cost impacts from carbon pricing.

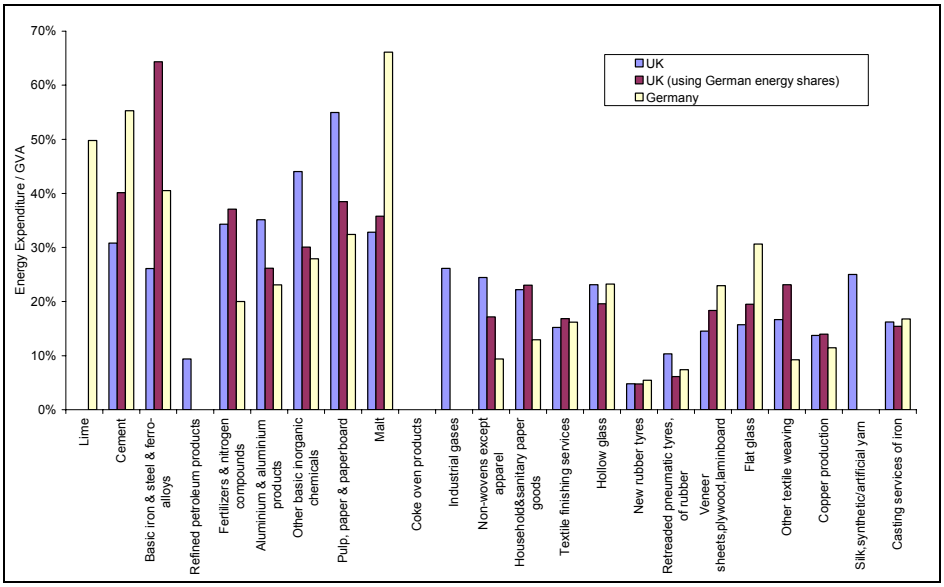


Figure 32 Ratio of energy expenditure relative to value added in Germany and UK, 2004 data.

Figure 32 depicts the results. Differences can result either because the sector in one country spends a larger share of the turnover on energy compared with the other or, because in one

country a smaller share of the turnover is retained as value added in the sector compared with another. The middle bar in Figure 32 accounts for this – it applies share of energy expenditure relative to turnover in Germany, to the UK sectors.

The comparison shows some non-trivial differences between the countries. As the differences are not consistent in magnitude or sign, they are likely to reflect national sectoral characteristics more than generic differences between the countries. The following factors may offer plausible explanations.

Lower energy to GVA ratios might be explained by sectors producing less energy intensive products (e.g. recycled Steel, Aluminium, Paper), or by the production of higher value products involving more machinery or labour input and thus higher value added, or by lower product price levels (e.g. cement in Germany after the cartel was dissolved).

To offer some intuition as to how sensitive the value at stake screen is to these assumptions, we compare the UK value at stake estimates with that Germany. To conduct this comparison, for each sector, we assume consistent energy expenditure to CO_2 emissions ratio, in Germany and the UK.

Figure 33 show the results. Again, overall the NVAS and MVAS are comparable. The main differences are: A) higher value at stake in Germany for Malt, Flat glass, Cement and Basic iron and steel, and B) significantly lower value at stake for Non-wovens, Fertilisers & nitrogen compounds, Aluminium, Other basic inorganic chemicals and Pulp, paper and paperboard.

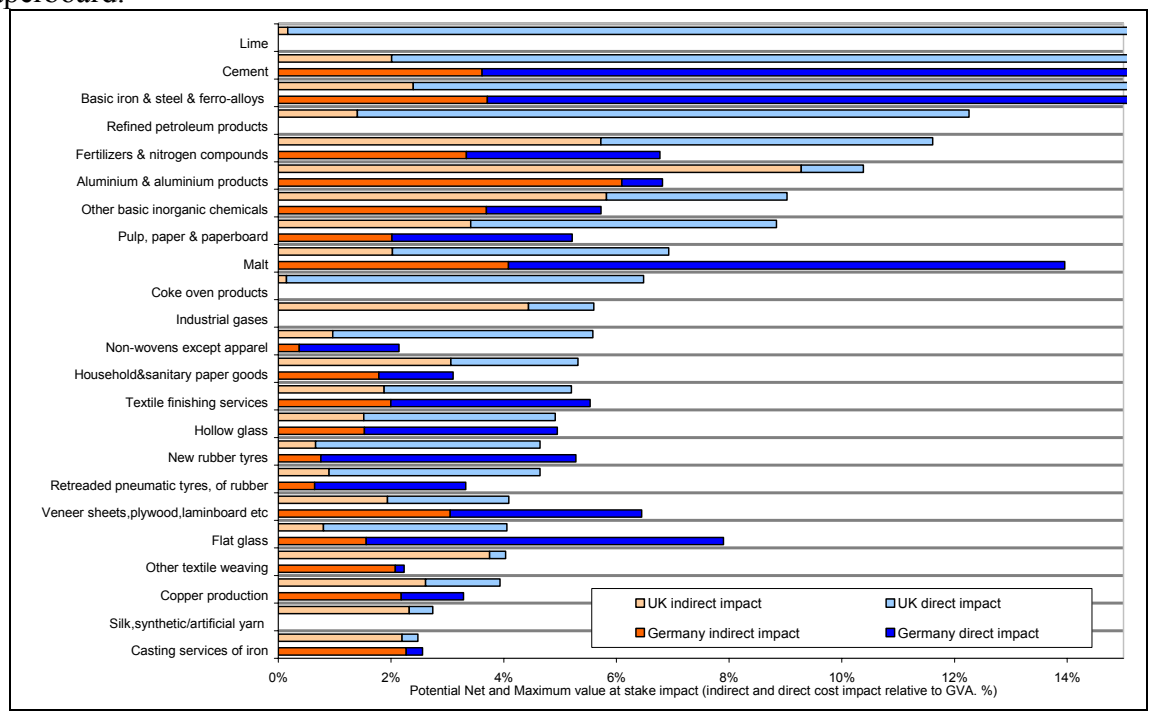


Figure 33 Value at stake for Germany and UK, 2004 data.

2.4.3 Robustness of indicators over time

The main variation expected on a short time scale relates to price changes with increasing scarcity prices, and changing national or international competitive landscape. Higher price mark-ups translate into higher profit margins, and these feed through to higher shares of GVA in the turnover.

Figure 34 and Figure 35 depict variations of this share in the "top 20+3" sectors in the period 1995-2005 in Germany. In general the level of variation is limited, creating reassurance that the most volatile component of our screen is still reasonably stable. An exemption with rather big volatility of GVA is the cement sector – where cartel profits suddenly vanished.

The time series is too short to identify robust time trends in most commodities. The first observation with EU ETS in 2005 is likely to be not too informative, because of delays in price formation.

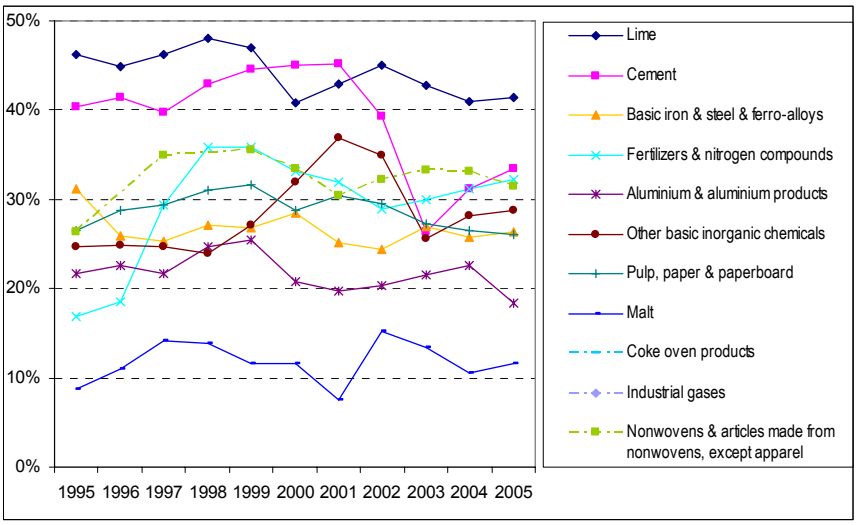


Figure 34 Share of gross value added in the turnover for German sectors (1)

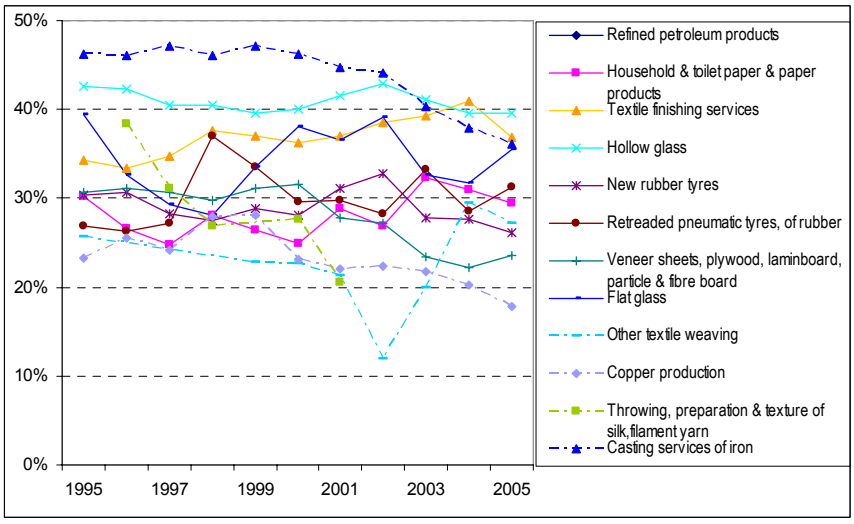


Figure 35 Share of gross value added in the turnover for German sectors (2)

Finally, we explore lead indicators of changes in industry activities. To do this we returned to the standard indicator that reflects industry expectation about future market evolution – capital investment. Only where there is some confidence in future market demand will industries pursue investment projects. Figure 36 and Figure 37 depict the investment volume of the top 23 sectors relative to their turnover in the period 1995-2005 for Germany. Three main trends are observed: long-term decrease (Cement, Basic iron and steel); strong variability (Non-wovens, Flat glass, Pulp & paper); more of less flat and low trends

(Aluminium, Copper). The low investments rates have existed from the mid 1990s and are therefore unrelated.

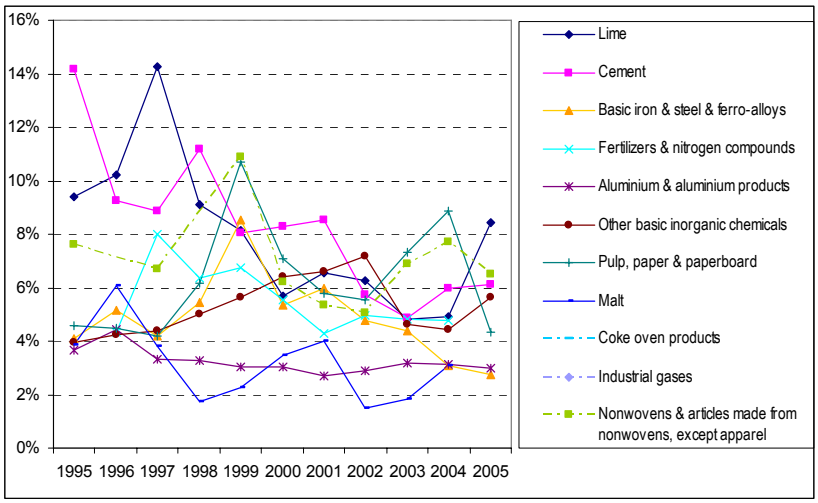


Figure 36 Share of investments in the turnover for German sectors (1)

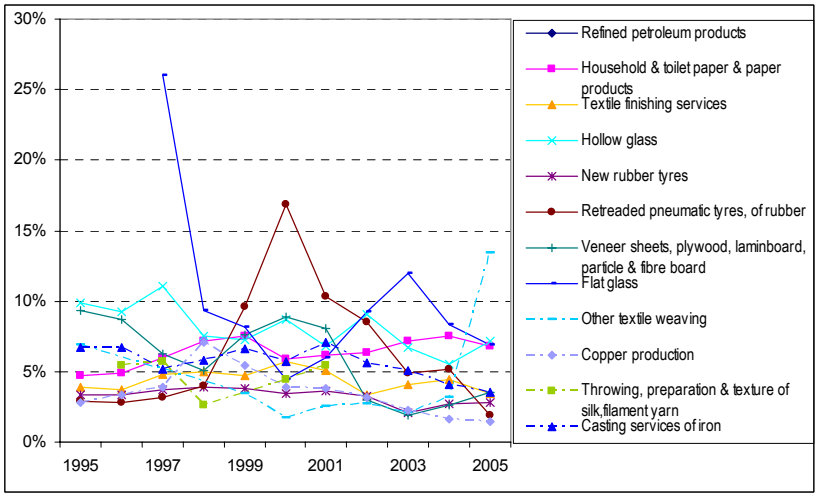


Figure 37 Share of investments in the turnover for German sectors (2)

2.4.4 Denominator choice for value-at-stake indicator

In this report, the sectors' cost increase from carbon pricing is measured relative to their value added. To allow for comparison across sectors, the cost increases had to be compared to some metric so as to create an indicator for the relative cost increase. Why is GVA a preferred metric over other alternatives? This section summarise discussions on metric choice. Figure 38 illustrates the different components of turnover of a sector for which data is typically available at four digit sector level. Their evolution over time is depicted at the example of basic iron and steel in Germany.

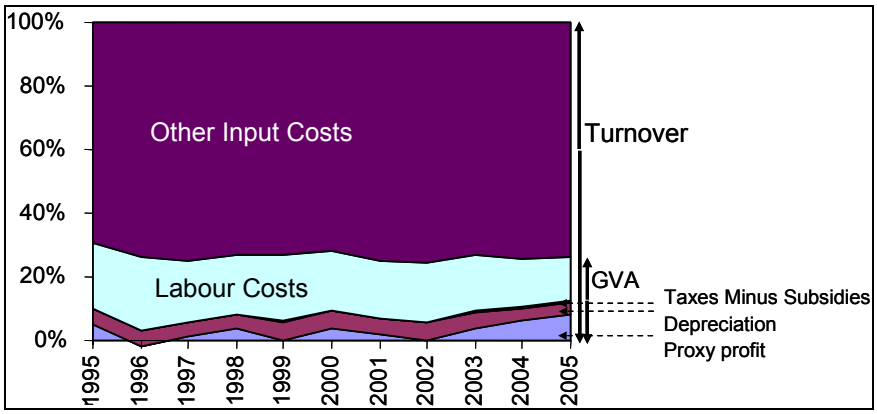


Figure 38 Composition of turnover in the Basic Iron, Steel and Ferro-Alloys (SIC 27.1)

Figure 38 suggests several different metrics that could be used: First, total sales revenue (i.e. turnover) of a sector could be used as comparator for cost increase. This includes, in addition to the value added, the costs for all input factors. Many of the inputs like coal and iron ore are priced in international markets; efficiency improvements in production still would not change the price of inputs, but will change the total expenditure on the input. It is therefore difficult to judge how flexible companies could respond to cost increases measured relative to turnover.

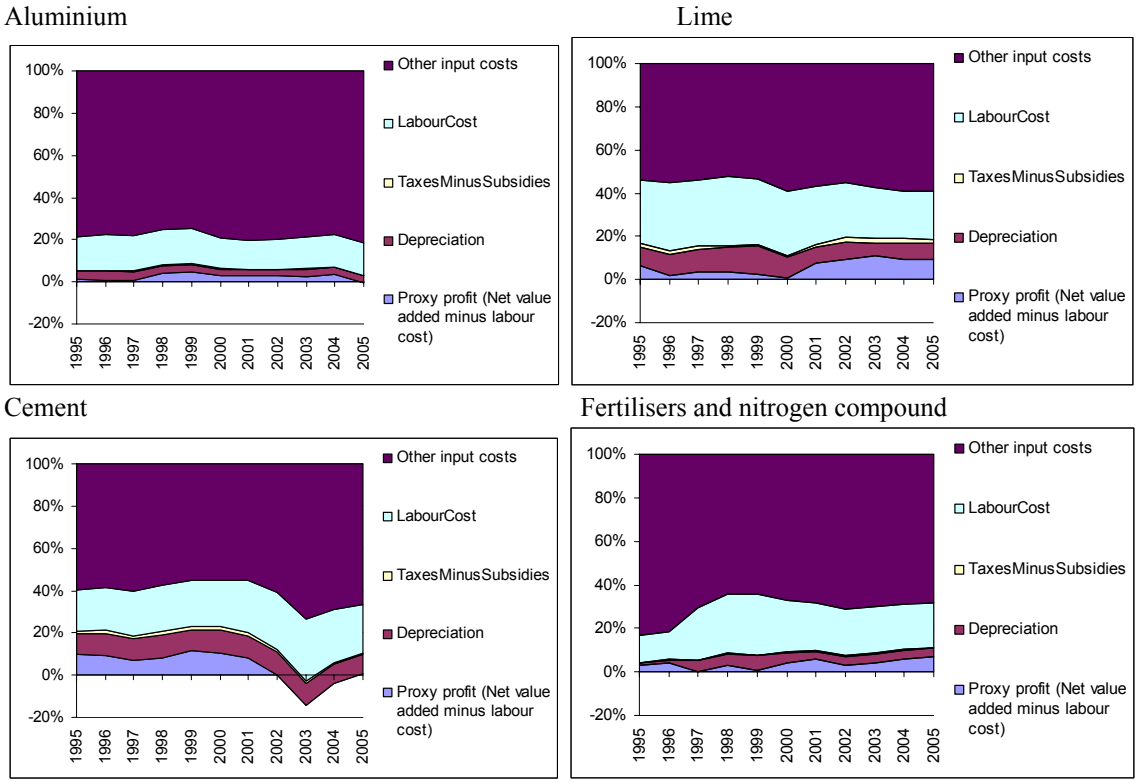


Figure 39 Composition of turnover in Aluminium, Lime, Cement and Fertilisers sectors.

Second, cost increase can be measured relative to profits. This raises several problems as demonstrated in Figure 38 and Figure 39. Profits are very volatile over years, and sometimes negative. Thus data over several years is required, and results are strongly influenced by the time frame. For any one year, the depreciation strategy of firms has a strong influence on the profit levels - depreciation levels allow for smoothing of profits across years. In addition, profit levels can be influenced by tax optimization policies. For example, multinational firms

have the potential to "reduce" profits they accrue in countries with high corporate tax levels, using transfer prices across countries that are biased in their favour. This will understate the profits but obviously varies across sectors and organizations. Finally, if firms incur costs from CO_2 pricing, this reduces profits, however, as profits are the basis for many taxes it also reduces taxes. The reduced tax burden in turn implies that the cost impact on profits is reduced.

Third, earnings before interest, tax and depreciation and amortization (EBITDA) could be used as comparator. From available data, it could be calculated as the sum of taxes, profits and depreciation. Thus cost increases would be measured relative to capital input into production. As labour inputs into production are not considered, the metric 'ignores' one important flexibility that firms can manage and optimise in response to cost increases. It also creates asymmetries across industry sectors - as a comparison across the different sectors illustrates (Figure 39), the relative importance of labour and capital input varies significantly. Finally, it does not address the question of potentially biased transfer prices across countries and segments in the value chain. (Unintended) distortions of transfer pricing are more relevant for this analysis, as leakage concerns relate to specific carbon intensive production steps. In Chapter 3, we use a related metric Earnings before interest and tax (EBIT) for sector-level analysis of the competitiveness implications.

The fourth option – CO_2 price impact on costs relative to sector value added - is the most stable metric over time, that reflects the fraction of costs that are under direct control of the firm and is less subject to strategic optimization (other than via allocation of labour cost as input costs with outsourcing of activities). It is therefore the most robust and suitable denominator. The metric is also helpful to understand the real economic value created by an industrial activity.

Obviously, the choice of metrics affects estimations of carbon pricing's impact on relative cost increases experienced by sectors. At the same time, we stress that these are percentage figures. What matters most is the interpretation of the figure. We argue that measuring cost increase relative to value added provide a good indicator for the cost increases relative to other cost factors that are under control of the management of the firm.

2. 5. Conclusions

In summary, this analysis has shown that the impacts of emission trading on competitiveness are indeed restricted to a far smaller fraction of the overall economic activity than previously assumed. The detailed data also shows that concerns about emission trading results, involving leakage of emissions and relocation of production, are best analysed and addressed by focusing on the small set of subsectors that exhibit strong cost impacts and produce internationally traded commodities.

A cross-country comparison with German data supports the robustness of the metric used in this analysis. From our analysis several aspects emerge that might warrant further work:

- limits to insights gained from analysis using SIC classification in some sectors where distinctions between processes may be more important than the final product[23];

23 For steel and cement, this is addressed in the detailed analysis offered in Chapter 3 of this report. Work on the chemicals sector is currently being conducted as part of Climate Strategies work.

- the limitation of trade intensity as an aggregate indicator of the level of various barriers to trade, and the need for in depth sector cases studies as carried out for steel and cement in Chapter 3.

Chapter 3: Deep-dive study: The EU Cement and Steel sectors

In this chapter, we conduct an in-depth analyses the EU cement and steel sectors[24] which have been identified in the previous chapters as the two subsectors where potential competitiveness impacts and leakage concerns of the EU ETS are most important. This examination is based on expert interviews[25], data analyses, and a review of the economics literature and published studies on these sectors. Section 3.1 provides an overview of the international pressures the sectors face, which influence the two dimensions of competitiveness: market shares and profit margins. We also identify barriers for trade and outsourcing. They tend to segment the international markets. Section 3.2 investigates the impact of the EU ETS on production costs (3.2.1) and on the previously discussed barriers (3.2.2). The ability of EU producers to pass-through opportunity costs of carbon is then discussed, (3.2.3). We complement the qualitative analysis with quantitative analysis of the short-term EU ETS competitiveness impacts for various scenarios, using a simple economic model based on econometric estimates of the trade sensitivity (3.2.4). Long-term impacts are briefly examined (3.2.5) and finally the possible existence of "CO_2 tipping points" (3.2.6) are discussed before concluding.

3.1. GENERAL MARKET TRENDS

3.1.1 General market trends in the EU cement sector

3.1.1.1 EU Cement market: so far low international pressure

In Figure 40, we observe very significant price differences across countries: from over $US110 /t in France and in the UK, to less than $US60/t in Germany and non-EU countries like Algeria or Turkey. Despite these price differences, the trade intensity of the sector is low. Around 16% of the cement consumed in the EU was imported in 2005[26]. However, when focusing on the imports from outside of the EU, which is more relevant as we are assessing the impact of an EU-wide policy, this ratio falls to 8%. About half of cement imports into the EU countries come from non-EU countries.

Around three-quarters of these imports were clinker, the energy and CO_2 intensive intermediary product, which entails lower transportation costs than cement. Clinker is then milled and blended with other materials to make cement. The blending operation is typically located close to consumers, providing a higher flexibility in cement composition. This is a recent evolution as a decade earlier, almost all imports in this sector were cement. Data provided here is given in *cement equivalent*, i.e. we account for the fact that every tonne of clinker imported leads to around 1.2 tonnes of cement consumed in the EU (WBCSD, 2002).

24 Using UK Standard Industrial Classification (92), these corresponds to 26.51 and 27.1 respectively. Using US (72), they then correspond to 3241 and 3312 respectively.

25 Interviews with Ian Rodgers (EEF UK Steel), Ian Goldsmith (Corus), Ian Cooper (Corus), Chris Boyd (ex-Lafarge), Chris Beauman (European Bank for Reconstruction and Development). Within the context of different studies, discussions with Juan Martinez and Vincent Mages from Lafarge. Visit to the Arcelor-Mittal's steel plant in Dunkerque with Pierre Bourrier and Daniel Lao. Visit to the Holcim's cement plant in Rochefort with Bernard Küng, Vincent Bichet, Pascal Paijens (Holcim) and Catherine Alcocer (Syndicat Français de l'Industrie Cimentière). Constructive comments on the interim report from the British Cement Association, the UK Emission Trading Group, The Confederation of British Industry, Neil Walker (University College of Dublin), Patrick Nollet (Entrepriese Pour l'Environnement) and René-François Bizec (Fédération Française de l'Acier).

26 In the cement section, trade data come from Eurostat. We either use the PRODCOM database, which provides production and trade data for the EU countries; or the CN8 database, which provides trade data and allows differentiating across the sources of imports. Occasionally, when these databases are incomplete, we may have resort to some data from CEMBUREAU. This happens for countries whose consumption is marginal. We focus here on the imports of the EU. The analysis would stand qualitatively for the exports. The EU has exported around 5% of its production outside the EU in 2005.

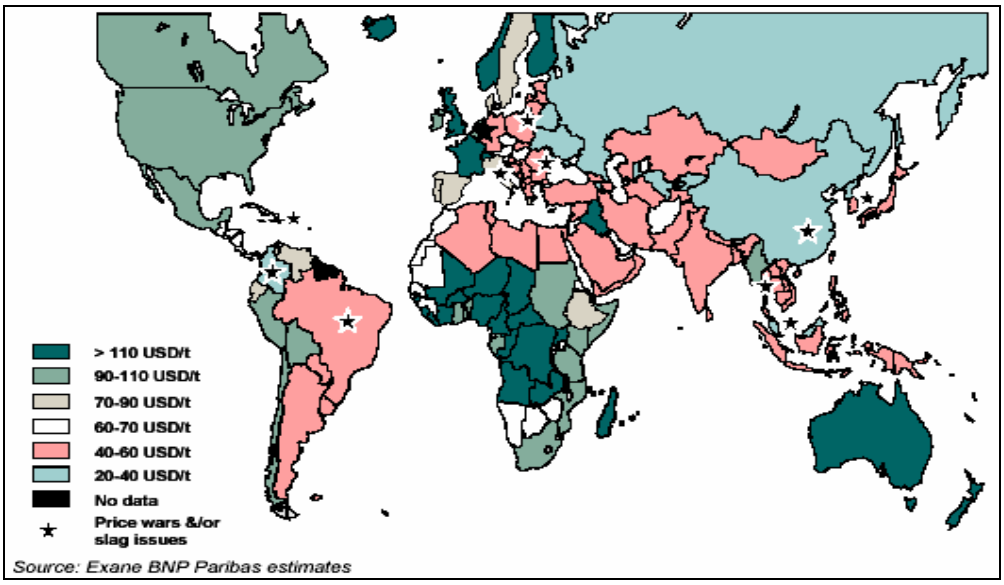


Figure 40 - World Cement Prices (2006)

Some of the imports are intra-firm imports, as several EU firms are trans-national firms which have plants outside the EU. Lafarge and Holcim for example, operate in more than 70 countries (Vieillefosse, 2007). According to IEA (2007), the European cement majors dominate the global cement market. Moreover, all the major cement producers have established trading operations that serve to supply countries where there is a lack of capacity. The ten largest cement firms in the world control about 70% of total cement exports.

The independent imports – not controlled by EU firms – are mostly due to players that do not own clinker production facilities but may own grinding and blending stations in the EU. These "traders" buy clinker or cement where they find the lowest prices.

Not only are imports from outside the EU low, but it also seems that the impact of non-EU countries on EU prices is low. Econometric analysis on the non-metallic minerals sectors estimate that prices in EU countries are not correlated with the prices prevailing outside the EU (Gerald and Scott, 2007). Even the link between the prices in various EU countries is weak. It means that the price and the profitability of the sector in a given country depend mainly on national factors like the number of players or the balance between consumption and production capacity.

Overall, EU cement producers appear to face low international pressure. With high market shares on domestic markets, they are expected to have high ability to pass on opportunity costs of carbon and profit from free-allocation. As we will see below, however, the situation differs from country to country. We also look at recent developments and claims that the picture is changing.

3.1.1.2 Barriers to trade in cement

We first begin by defining the trade barriers for cement which explain relatively low international pressure.

- ***Transportation costs***

Cement is a heavy and bulky relative to its value. It is costly to transport, especially by road. It costs around €10 to transport one tonne of cement over 100km by road, the cost decreasing

with distance[27], whereas one tonne is sold around €65 – excluding transport costs – on average in the EU (Reinaud 2005a). Shipping costs are lower – around €15/tonne to cross the Mediterranean Sea[28], with around €4 added for loading and unloading. Hence, the larger a country and the fewer its ports, the less sensitive it is to trade. Cement does not generally travel over 200km by road from the plant to the consumer (Demailly and Quirion, 2006a).

To these "pure" transportation costs, an exporter has to add the cost of a storage facility in the port of destination. By importing clinker and not cement, transportation costs are reduced, but instead the costs of building a grinding station are incurred.

- ***Import restriction***

In some countries, firms have the ability to restrict imports, for example by taking up available port storage capacities themselves. This is easier in countries with fewer ports, where investment costs for the ports have already been recovered, and local policy makers are worried about employment losses caused by imports. In such cases, the latter may also help local producers by not allowing the building of storage facilities or grinding stations. Such practices are more difficult in countries with more effective antitrust legislation or free trade culture.

Product standards can also restrict imports, although this does not seem to be the case for cement in EU where standards are not particularly difficult to satisfy. Potential for retaliation may also be considered as an import restriction: a foreign producer exporting cement to the EU may fear a price war in response to restrictions, either on the EU market or on its own local market (EU firms are trans-national). This might explain why most exporters are either small independent firms or traders.

- ***Balance between capacity and consumption in the RoW***

The cement industry is a capital intensive sector, with initial investment costs corresponding to the turnover of three years[29]. Capacity constraints play a major role in this sector. As we will see below, capacities are generally sized to satisfy local demand and few capacities are built in order to export.

Excess capacities in a country may result from an imperfect anticipation of local demand. They may also emerge in countries with a rapidly growing consumption as producers oversize their investment to fit future demand (Demailly and Quirion, 2005). In this imbalanced situation, as the local price goes down and as investment costs have to be covered, it may become profitable to export. The balance of consumption and capacity in the Rest of the World (RoW) is an important determinant for the international pressure to which EU cement manufacturers are subjected. Other factors can also play an important role, as the will be illustrated in the subsequent analysis of trade flows (See also Gerald and Scott (2007)).

- ***The cost of instability***

For the export of cement – particularly to serve longer-term demands - it is necessary to build storage facilities in ports. Such an investment is significant and requires some predictability of the trade flows to ensure cost recovery. The same effect applies, but to a greater extent, when an exporter is contemplating the construction of a grinding station near an importing port. However, many elements challenge this stability and constitute a cost for risk-averse investors:

27 Data provided by Lafarge in April 2004.

28 Data provided by Lafarge in April 2004.

29 According to Reinaud (2005), the capital cost is around $US150 for the capacity to produce 1 Tonne/year at an average utilisation ratio of 85%. The average EU price is 65€/t of cement.

1. immaturity of the market considered which might lead to a price collapse;
2. threat of price war in response to this investment, on the market considered or on the local market of the exporters if it has one (retaliation);
3. fluctuation of international transportation costs (see Figure 48), in particular because long-term contracts for freight are less common and failure of loading/unloading facilities;
4. fluctuation of exchange rates (see Figure 41);
5. availability of excess capacities in foreign countries in order to benefit from low cement or clinker prices.

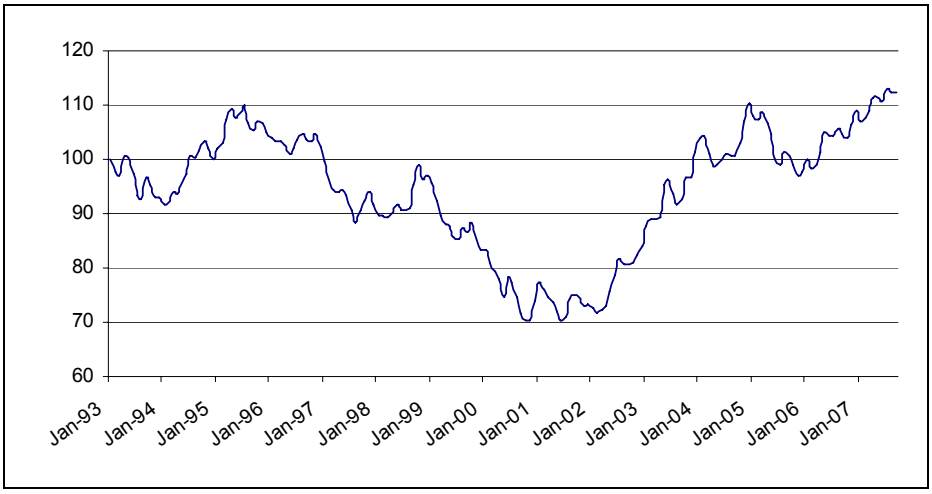


Figure 41: Euro exchange rate vs US Dollars. Jan 93=Base 100[30]

- ***Product differentiation***

Although cement is mostly seen as homogenous, some product differentiation exists. First, European cement firms could push for more stringent standards and thus create some protection from international competition. Currently, the combination of relatively undemanding and basic harmonised standards and production of more sophisticated cements by European cement producers is preferred. Such product differentiation generally reduces competition and results in higher price levels. Second, one of the main quality-aspects from the perspective of a cement consumer is the consistency of the cement over time (e.g. colour, strength and workability). It is difficult for an independent importer to achieve this consistency due to time delays in correcting problems. Differentiation is also an issue of environmental and health (notably Cr 6) standards, which are particularly demanding in the EU. This is contrasted with, for example cement produced in China, 80% of which is classified as low quality cement from small scale plants (Vieillefosse, 2007).

- ***Service differentiation***

While elements other than quality create some product differentiation – the main difference from the perspective of EU consumers relates to the service provided by EU and non-EU cement producers. Service differentiation includes time of delivery, price stability, and certainty in availability. Indeed, non-EU cement differs from EU cement according to these elements because of the fluctuations of international transportation costs, exchange rates and availability of foreign capacities to export (i.e. foreign economic situation). Hence, EU consumers, especially big ones, may have a preference for EU producers which guarantees

30 Source: Pacific Exchange Rate Service, http://fx.sauder.ubc.ca/data.html.

cement availability, even in case of a capacity shortage. Vertical integration is an extreme case of this special link between EU consumers and producers. We stress that large firms are often integrated downstream into concrete manufacturing.

Figure 42 summarises the above trade barriers. The international pressure on the EU market is not simply a function of the operating costs differentials between EU and non-EU producers. Rather, this is given by cost differences minus trade barriers. Barriers vary in magnitude (their relative size has been defined according to expert interviews). A high international pressure means a high pressure on EU margins and market share – even so in some cases there is a trade-off between these two dimensions of competitiveness. In some countries prices (and consequently profit margins) are low, thus limiting imports and preserving market shares. In other countries margins are high and it seems that to maintain market shares, domestic producers make "defensive" investment (import restriction, vertical integration). It is worth noting that independent importers face higher trade barriers than the imports controlled by EU firms (see for example import restriction). Thus, the latter have an advantage in importing cement to the EU.

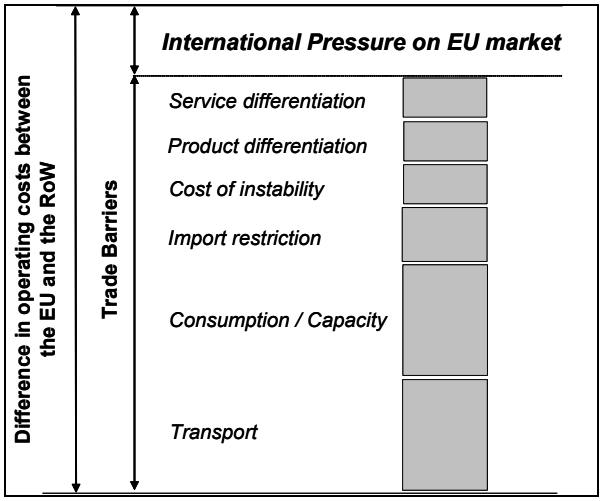


Figure 42: Trade barriers in the cement sector

3.1.1.3 Important country by country variations to cement trade barriers

As we can see in Figure 43, the ratio of imports from non-EU countries varies considerably across EU countries. Six countries have higher import ratio than the EU mean in 2006: Hungary, Bulgaria, Spain, Latvia, Lithuania and Italy. The three Eastern countries mainly import cement from nearby eastern countries (Belarus, Ukraine and ex-Yugoslavia). Their imports represent, in volume, a very small share of total non-EU imports.

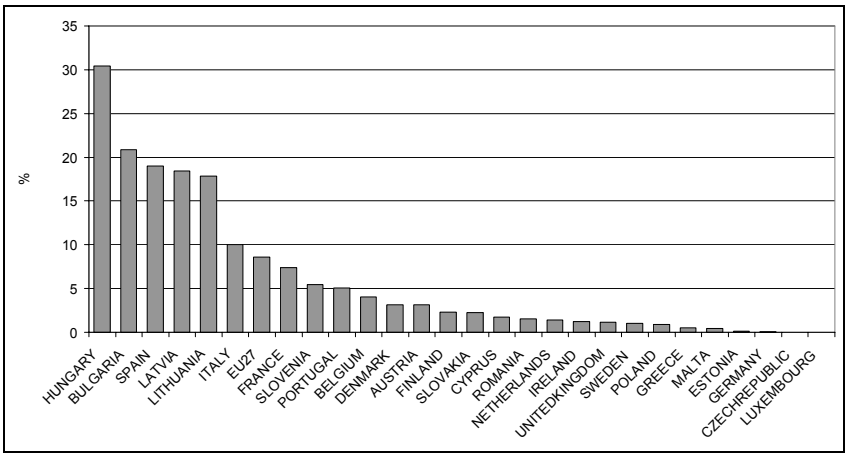


Figure 43: 2006 Non-EU Import ratio – National disaggregation

In 2006, around 95% of imports from outside the EU were focused on six countries: Portugal, Hungary, Bulgaria, France, Italy and Spain. The latter two represent almost ¾ of all imports from outside the EU, and Spain itself more than half. By far the largest consumers in the EU, Spain and Italy have relatively low non-EU import ratios: 20 and 10% respectively.

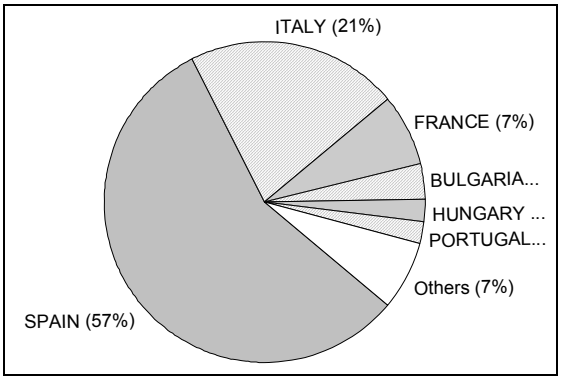


Figure 44: Destination of non-EU imports (2006)

The heterogeneity can be explained by the variations in "heights" of trade barriers. In Spain and Italy, a high share of national consumption is located near coasts. These countries are also close to North African countries where most imports are traditionally sourced.

Finally, and perhaps most importantly, the consumption in Spain has been surging over the past 10 years (+130%) whereas domestic firms have "cautiously" invested (fearing at any time that the current rise is temporary and will be eventually followed by a decline in building activity and cement construction). This imbalance in the Spanish market pushed local producers to reduce their exports and to forgo some market share to independent importers who account for around three-quarters[31] of non-EU imports. The situation is similar in Italy where consumption has increased by 60% in the past 10 years.

3.1.1.4 Is the picture changing?

EU cement manufacturers argue that, even if the international pressure has been limited so far, the picture is changing. For example, cement may be transported over longer distances, notably inland several hundreds of miles by both rail and road. The decrease of the trade barriers may be responsible for the continuous increase in imports to the EU, a greater portion

31 Private Communication with Lafarge, May 2007.

of which is coming from non-EU countries. In particular, imports now come from the Far East and especially from China. At first glance this seems to suggest that the international pressure is increasing, hence reducing further profit margins and/or market shares of EU cement producers. We will test these conclusions based on the most recent data available.

- ***The increase in non-EU imports***

In the last 10 years, total EU imports (including both imports from inside and outside the EU) have continuously increased at an average yearly rate of 4%. This rise is due to the increase of non-EU imports, while intra EU trade has been roughly steady. The share of non-EU imports was around 50% in 2006, whereas it was minor 10 years ago. During the same period, the EU consumption has increased by more than 50%. Although the non-EU import ratio has significantly risen from 3% in 1995, so far it has only reached 8%.

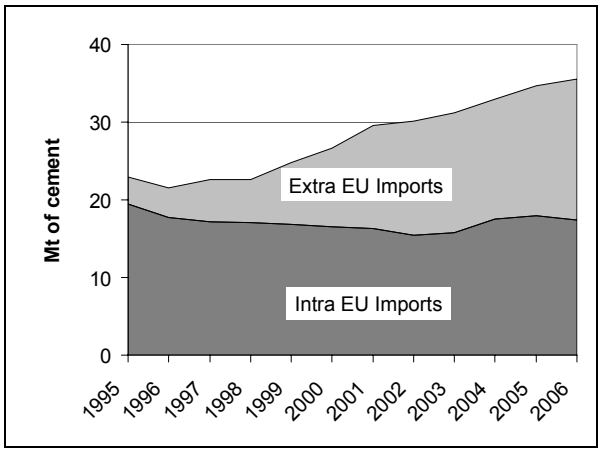


Figure 45: EU imports from inside and outside the EU (1995-2006)

Figure 46 illustrates that the bulk of increase in non-EU imports can be attributed to Italy and Spain. Respectively, they are responsible for more than a quarter and a half of this increase since 1995. Spain is responsible for almost ¾ of the rise in EU imports from outside the EU in the past three years. As noted before, this rise in Spanish and Italian imports is mostly driven by growth of consumption and the lack of new domestic capacities, not by an increase of the pressure from importers. Similarly, ETUC (2007) attributes the increase in cement imports to the recent rise in the consumption of some key countries (Spain, Italy and France). Local producers were unable to satisfy this demand because they had previously closed down some plants to rationalise production.

Therefore it is not possible to deduce from the growth of non-EU imports that international pressure has increased. However, the fact that demand growth in some EU countries is being met by non-EU cement imports despite excess total EU capacity has been interpreted as increasing international pressure. The growth of imports can be mainly attributed to the rise in consumption. Thus imports may stop increasing or even decrease. Moreover, whereas the EU market share declined, this does not necessary equate to a drop in profit margins. However, the fact that total EU capacity is in excess yet growing demand in some EU countries is satisfied by non-EU cement import could be interpreted as increasing international pressure. Assessing to what extent the excess capacity in other European countries was located at costal locations, so as to allow for transport to costal demand regions in Spain and Italy, is beyond the scope of this report.

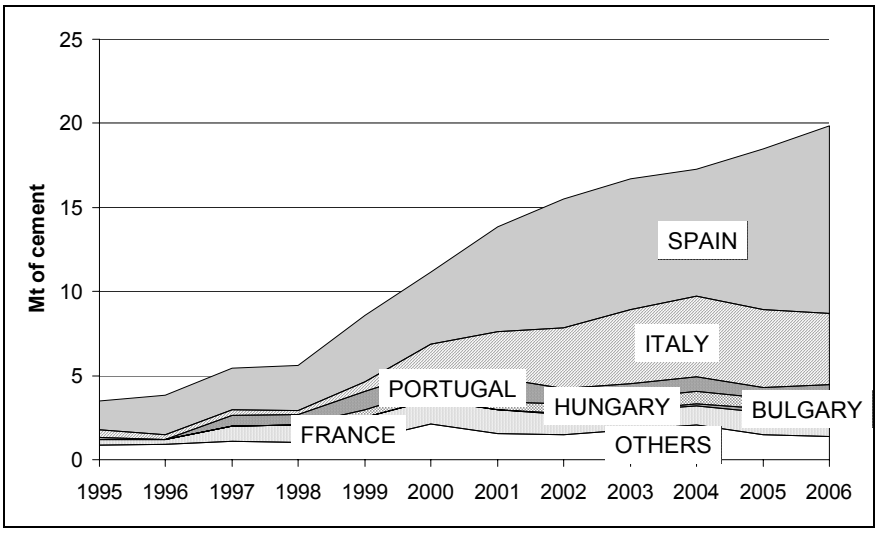


Figure 46: Destination of non-EU imports (1995-2006)

When discussing the evolution of the world cement market, the import of 8Mt of cement from China to the EU in 2006 is often highlighted as evidence for the increase in the international pressure. It is worth noting, however, that the Chinese imports are mainly a substitute for imports from other countries. As Figure 47, shows, the surge in Chinese cement imports substituted the sharp decline in Turkish and Egyptian cement imports. In total, the growth rate of non-EU imports (mainly to satisfy growing demand in Spain and Italy) stayed roughly constant.

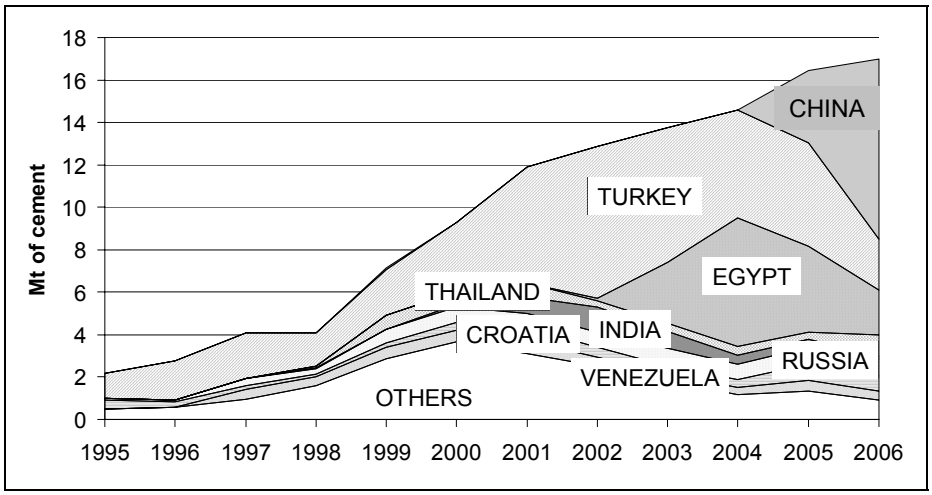


Figure 47: Origins of non-EU imports (1995-2006)

This suggests that import volumes are determined by the imbalance between local capacity and demand rather than a supply-side push. Alternatively the available import capacity (port capacity, capacity of independent retailers to deliver to consumers) may also explain import growth rate. This import demand is then matched with supply from countries with export capacity to satisfy the imbalance. Under this interpretation, EU prices, production cost, and total foreign excess capacity have little impact on EU import volumes.

This interpretation is consistent with the observation that a surge in transport prices from 2004 (both on land and sea)[32] seemed to have little impact on import volumes. Stickiness in arrangements (vessels tend to be hired on yearly contracts) and may also partly explain the lack of responsiveness to high transport costs.

The substitution from Turkish to Egyptian and subsequently Chinese cement imports can be attributed to several developments. First, following years of poor performance and rapid currency depreciation, the Turkish market is recovering: domestic consumption is increasing and producers focus on home markets. Second, in Egypt, the government has implemented a high export tariff (around €8/t cement) to encourage domestic producers to supply their home market and keep domestic prices low (BT, 2007). Finally some excess capacities recently appeared in China because of the continued operation of old shaft kilns despite the announcement of their closure[33] and/or of the austerity control measures imposed in early 2004 and strengthened in 2006.[34] In response to these developments, independent importers have switched their source from Turkey and Egypt to China. Switch to other sources may likely occur in the future: China has announced it will cancel tax rebates for cement exports within three years (IEA, 2007) and the Renminbi has been revalued and the continued economic growth may soak up the surplus capacity.

Although in smaller volumes relative to China, it is also worth noting that other Far East countries (e.g. South Korea, India, Indonesia or Thailand) have in the past 10 years, provided cement to the EU and in some cases continue to do so.

Thus we conclude that Chinese cement imports into the EU are, despite their rapid increase, not necessarily a sign of an increase in the international pressure on EU cement producers. They can be equally, and plausibly, explained by a combination of demand-supply imbalances in Spain and Italy and decreased export capacity in Turkey and Egypt. On the other hand, recent experience illustrates that the developments in the Chinese market may have consequences in the EU. If trade barriers are indeed shrinking, one could anticipate that any demand supply imbalance on the Chinese market - which represents around half of the world market with more than 1000Mt of cement (IEA, 2007) - will have strong impacts on the EU market, roughly one quarter of the size. According to IEA (2007), “China could reach the saturation point of cement production of 1.3 billion tons within 5 years; thereafter, there will be a gradual fallback in cement output”. If the pace of this decline dominates the pace of plant retirement, there would be an significant overcapacity.

3.1.1.5 Potential relocation of cement capacities?

- ***No export capacities***

So far few, if any, new cement production capacities are built for export to the EU. Exports come from domestic excess capacities, this excess – generally transitory – having several origins (Figure 47). Within firms trade is also used to balance supply and demand on a given market, taking advantage of production capacities owned by the firm in other countries. To test this assertion, one may look at stability of trade flows from outside the EU to the EU. Few of these flows are stable over time or at least remain significant over time, suggesting there are very few non-EU production facilities dedicated to exports to the EU.[35]

32 Due to, for example, higher oil prices, more regulation of trucking and sea transportation, the lack of vessels as China has imported more bulk commodities (see Figure 48).

33 The government has decided to replace around 400Mt of capacity using the old and energy intensive shaft technology. An overly ambitious target according to some experts given the massive investment required and the social impacts (IEA, 2007).

34 Chia-Hsin Cement Greater China Holding Corporation, 2006 Annual Results Announcement, March 2007.

35 By adding flows over sets of countries, the aggregate flow volume is more stable, and clever selection of the set of countries can create the impression of a stable flow volume.

- ***Relocation barriers***

What explains the fact that export capacities are not built abroad despite lower operating and investment costs? Several barriers might be responsible - if dedicated export capacities are built, trans-national EU firms (see above) are most likely to "relocate" production first. The following barriers are thus labelled "relocation barriers".

First, barriers to trade correspond to barriers to relocation.

1. Relocation could be frowned on in professions that have close interactions with the public sector, both for permitting of production and sales of products. There may also be pressure from trade unions, although in this sector, their weight is generally small.
2. The political situation is less stable in some low cost countries. This risk increases financing costs for new investment. Similarly, cement flows require convenient ports both in exporting and importing countries. In some cases, ports have to be built or developed.
3. These extra initial overheads add to the investment cost for the cement plant itself. As noted above, cement plants are capital intensive. This is important as outsourcing cement production outside the EU significantly increases the instability hence investment costs for risk-averse investors. Indeed, the production chain becomes sensitive to: A) exchange rate fluctuations (see Figure 41); B) interruption of vessels or loading/unloading facilities, transport cost fluctuations (Figure 48 shows the evolution of cement shipping cost from 2000 and the 2003 surge) and; C) and the implementation of export tariffs in host countries. Such tariffs have been recently implemented in Egypt and to a smaller extent in China.

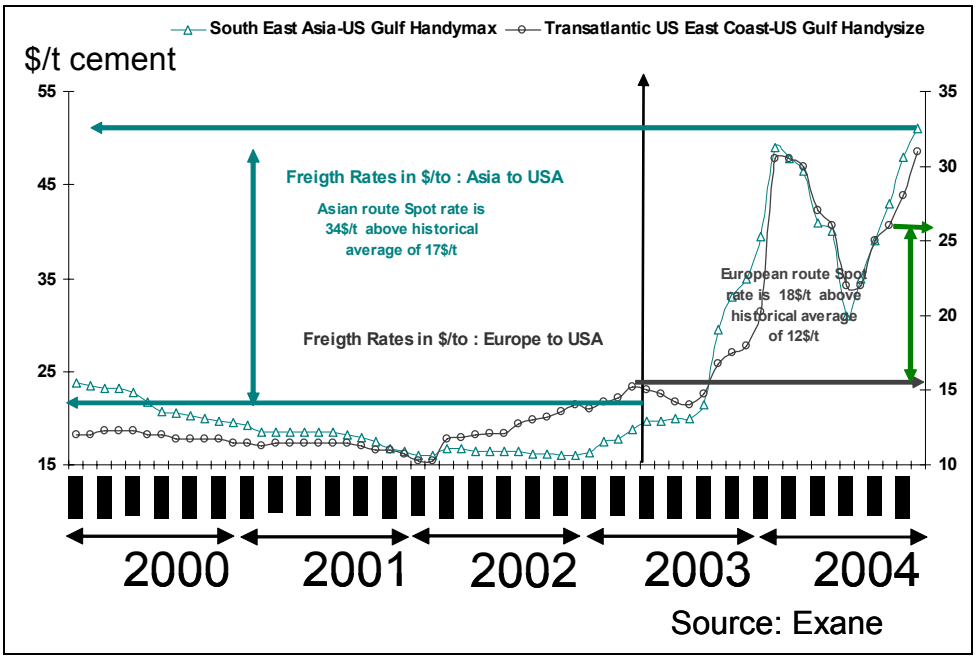


Figure 48: Cement freight costs

One may find more stable and significant flows within the EU, from Germany, Belgium, France or Greece. However, for these flows to show the existence of export capacities, one should also check if the destination remains the same.

- ***Is the picture changing in the cement market?***

Will existing relocation barriers be overcome? Will significant export capacities be built in the future? The process would be driven by trans-national firms that are active in multiple countries including EU Member States. They have already invested in low-cost countries in order to supply local demand. These countries generally exhibit fast growing consumption, reducing the risk of building capacity dedicated to exports; should the opportunity to export disappear, following for example a shock to transport costs, the excess capacity may be rapidly absorbed by the rise in local consumption. Trans-nationals face lower barriers than independent importers – the latter in addition face the potential retaliation barrier. Moreover, as we have seen before, most independent trade is currently managed by traders, sometimes without their own production facilities.

It seems that one may fear a partial relocation of clinker production to the Mediterranean Basin. Indeed, despite the barriers, some EU firms are considering the possibility of relocating part of their production. Until now, however, it seems that there were no clear advantages in relocating globally. Such may exist under particular conditions. Italcementi, for example, has already developed transportation links for cement from South Italy to Northern Italy by ship, in response to the limited availability of raw material in the North. Given that it has become a large producer in Egypt, most of the logistics are already in place to transport cement from Egypt to Italy. Some cement sector experts speculate that Italcementi may be the first mover in relocation. However, the recent implementation of a severe export tax in Egypt, highlighted as one of the risks of relocation, may dampen this process.

Leakage from relocation is therefore a potential concern under limited conditions. Notably, it requires the vicinity of the import market to suitable sea-ports. In addition, given the capital intensive nature of the sector, changes in this sector tend to be gradual - new technologies, consolidation or rationalisation evolved over decades rather than years in the past. Sunk costs tend to slow down the process, while the consumption growth in many countries makes high cost plants still profitable to operate.

3.1.2. General market trends in the EU steel sector

In this section, we discuss the international pressure that EU producers face from the Rest of the World (RoW). High international pressure means that EU producers experience a fall in market share on the EU market and/or profit margins are reduced to maintain market share.

3.1.2.1 What is the current international pressure for EU steel manufacturing?

- ***Market share***

In the steel sector, we can differentiate between two product types: flat products and long products. They differ according to their market and production process. In the EU, according to McKinsey and Ecofys (2006), long products represent around half of steel consumption and are mainly used in the housing sector. About 90% of these products are produced through the minimill route – or Electric Arc Furnace (EAF) route – based on steel scrap. Long products are mostly commodities whereas flat products are more often specialties. Flat products are on average higher value, especially for applications in the automotive industry which represents around 40% of the flat products consumption in the EU[36]. They are produced 70% through the integrated mill route (or Basic Oxygen Furnace – BOF – or Blast Furnace route).

36 Private Communication with Pierre Bourrier and Daniel Lao (Arcelor-Mittal), March 2007.

According to Eurostat (2007b), during 2006 the EU 27 imported around 15% of its long product consumption and 25% of its flat product consumption from non-EU countries, including both semi-finished (semis) and finished products.[37] Five countries are responsible for two thirds of imports. They are, from the highest to the lowest: Italy (almost one third of EU imports), Spain, Belgium, Germany and the UK. Exports from the EU 25 to non-EU in 2006 were around 9% of long and 18% of flat production. Export ratios have been steadier than import ratios in the past years. Around ¾ of trade flows are in finished products.

Compared with 2005, imports from non-EU countries increased significantly in 2006, from 10% to 15% for long products, and from 14% to 25% for flat products (see Figure 54). As we will see below, half of the increase may be attributed to a surge in steel demand in Italy, Spain and Belgium.

Despite the recent increase, the import ratios are strikingly low given the differences in operating costs observed throughout the world. The average BOF western EU plant has 40% higher operating costs than Brazil and Russia. This gap falls to around 20% for India and China (average figures from Watson et al 2005, McKinsey 2007 and data provided by industry). The differences can be mainly attributed to differing labour and raw material costs. They are more striking if one compares operating costs in Brazil and Russia with high cost plants in the EU - typically inland plants with higher transportation costs for raw material imports. Concerning EAF, operating costs vary much less among regions (McKinsey 2007), a fact that might contribute to the lower trade intensity.

- ***Pressure on prices***

The pressure from non-EU producers on profit margins is more difficult to assess as margins are determined both by the international pressure and by local factors (e.g. number of EU players, excess or lack of capacity, marginal cost). We will first discuss the impact of prices abroad on domestic prices, then the impact of local factors.

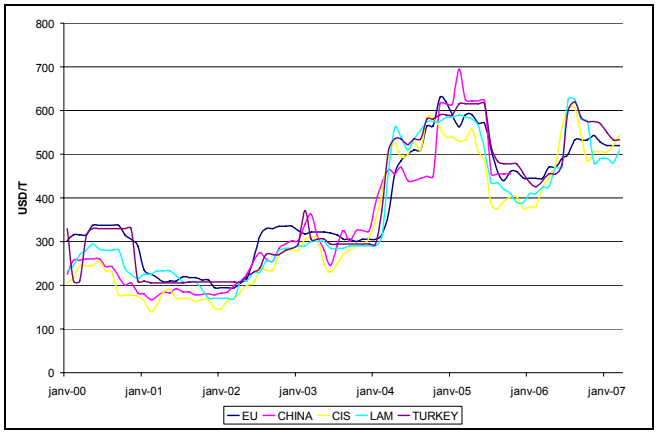


Figure 49: Export prices for HRC (Source: Datastream)

37 We use McKinsey and Ecofys data (2006) for production / consumption and Eurostat (CN8) data for trade (products 72061000 to 72299090), in order to use the most up to data trade data. As Eurostat does not differentiate between semis for flat and long products, we use the ratio from McKinsey and Ecofys (2006): 43% of imports and 50% of export in semis are for flat production.

Unfortunately, long time-series on domestic prices is not readily available. Figure 49 displays f.o.b. export prices[38] from different countries for hot rolled coil (HRC), which can be considered as an index for the price trend of flat products.[39] All prices show similar patterns e.g. they have all increased by around $US200 from 2003 to 2004. One interpretation is that steel prices in a given country are determined by the evolution of prices abroad. An alternative interpretation is that prices are independent, but evolve jointly as steel producers in all regions are exposed to similar changes: consolidation of the market, orientation of consumption/ production toward high value products and before all production costs. Indeed the main inputs like iron ore and coal are globally traded, and scrap to a lower extent. Raw material costs represent around 50% of total production costs (Reinaud 2005a). Hence the rise in raw material prices caused by the surge in Chinese consumption from early 2004 affected steel markets globally.

Obviously, this alternative explanation does not fully explain price increases since 2004. Steel prices dropped between mid-2005 and mid-2006 despite high raw material prices. Does the assumption of a fully integrated global market resulting in a harmonised price then explain steel prices? If the EU price was mainly influenced by prices abroad, then the difference between these prices should show some stability. Figure 50 uses the same data as Figure 49 but displays the evolution of the difference between the EU price and various other foreign prices.

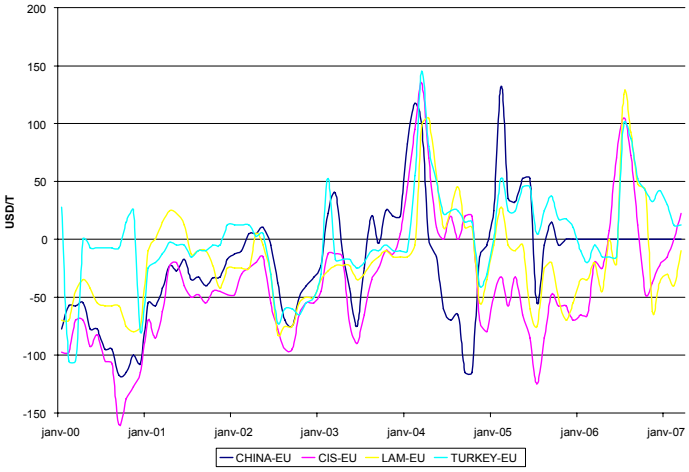


Figure 50: Import prices from RoW minus EU export prices for HRC (Source: Datastream)

As we can see, these differences are not stable, and their range has to be compared to the price of the steel product considered ($US 350 /t in average from 2000 to 2007). The limited influence of foreign prices on EU prices in Figure 50 suggests that other parameters than the foreign price also influence the EU price.

For the Basic Metals sector, Gerald and Scott (2007) have used an econometric approach to test the influence of domestic costs on world price in six EU countries. They conclude that the international price generally has a strong and significant influence on the prices in these EU

38 F.o.b. price (free on board price) of exports and imports of goods is defined by Eurostat as the market value of the goods at the point of uniform valuation, (the customs frontier of the economy from which they are exported); it is equal to the c.i.f. price less the costs of transportation and insurance charges, between the customs frontier of the exporting (importing) country and that of the importing (exporting) country.

39 Private communication by email with Ian Rodgers (EEF) in August 2007.

countries. Except for one country, the influence of the domestic cost on the price formation is similarly strong.

- ***Interlinked regional markets***

Gerald and Scott (2007) also highlight that the average EU price is a more important determinant of the price in individual EU countries. Thus we can depict the world market as fragmented into regional markets which are partially interconnected through prices. This regional feature is in line with the analysis of steel trade volume data from IISI (2007). Figure 51 show trade volumes between and within three regions – Europe, America and Asia – which account for 80% of world exports and 90% of imports. Whereas the trade intensity is globally high – 365Mt of steel traded in 2004, almost 40% of global steel production– most of these were exchanged within regions.

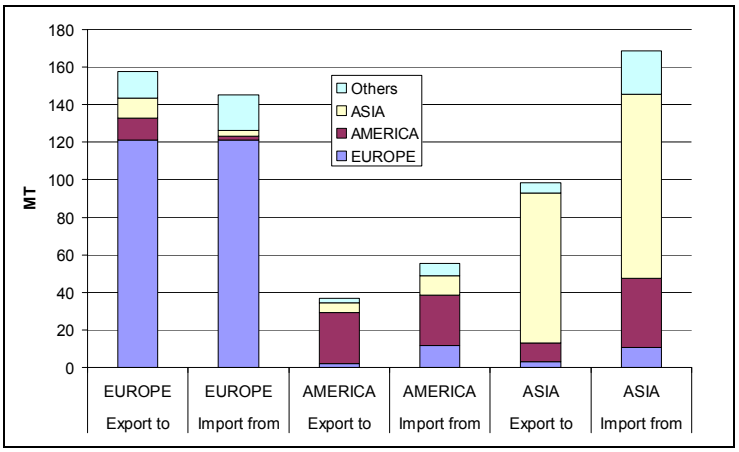


Figure 51: Steel trade across regions by volume

- ***Link between prices and market share***

In order to assess the sensitivity of imports to price differences across regions, Figure 52 displays the monthly evolutions of A) price difference between the EU and RoW (rest of the world), and B) import ration of the market share of the RoW in the EU. Each curve gives an annual average e.g. the value in July equals the average value between January and December.

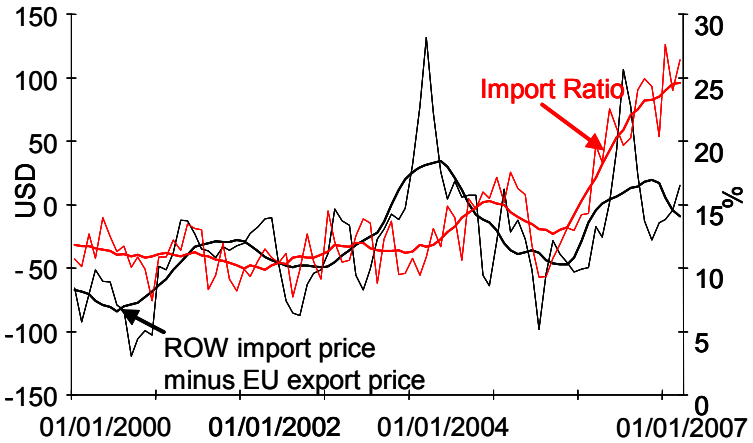


Figure 52: Price difference with the RoW and import ratio *Sources: for imports, Eurostat (2007b); for prices, Datastream (for the RoW price, available regional prices are weighted according to exports to the EU).*

As highlighted before, there are striking differences between the EU and the RoW price change; from $US -100 to +$US 150 between January 2000 and March 2007. These large differences are not explained by the fluctuation of transport costs, given their low relative

importance (see below). Second, price does not appear to be the main explanatory factor for import ratio. By disaggregating at a country-by-country level, a different picture emerges. There is a stronger link between the import volumes and the price difference to Turkey or CIS which are close to the EU market. This is not the case with China or Latin America.

Further econometric work is required to isolate the impact of prices on the level of imports. Such work should account for the consolidation of the regional steel markets and the role of the balance between demand and capacity constraints. The latter may be crucial. As stated previously, EU imports increased in 2006 and at the same time, EU consumption has increased significantly (IISI, 2007). Most of this increase has been supplied by imports, as the EU capacity was unable to satisfy the rise in EU demand. This again suggests that factors other than price might have an important influence on the trade volumes.

3.1.2.2 Barriers to trade in steel

Why do we observe moderate imports despite very important operating cost differences between the EU and other countries? Why are EU producers not pure price takers? In other words, what limits the international pressure faced by EU steel producers?

Import **tariffs** are unlikely to be the core explanation, being limited to a few specific products (McKinsey 2007, IEA 2007). However, one should not only consider import but also export tariffs. For example in early 2007, Egyptian authorities imposed an export duty on selected steel products which amounts to more than €20/t (BT 2007). Similarly, in the same year, the Chinese government increased the export tariffs by 5% on many finished and semi-finished steel products while scrapping or lowering a range of export rebates (IEA 2007).

Transport costs may be an issue, either for large and heavy low-value-added products, or for high quality products which require convenient packaging. In either case, international trade creates price risks.

In some countries, high quality **standards** and certification issues may also disqualify imports, particularly for long products and especially from developing countries.[40] When standards do not apply, **product differentiation** relative to their quality may be a barrier to trade. Many consumers are ready to accept higher prices for higher quality products. High quality flat products are especially sought after by consumers like the automotive industry. Product differentiation is important especially in the EU where most producers have orientated their production toward high value products (ETUC 2007). Obviously, such an advantage may vanish in the medium-term.

There are further aspects surrounding consumer preference for local products, such as the proximity to producers that simplifies discussions about technical specifications. This is particularly important for high value products e.g. in the automotive industry. Many consumers also seek high quality **services** which for which proximity to producers matter e.g. "just in time" delivery for the low-value construction industry and technical assistance in general. In general, proximity of producers gives customers a better sense of control in production.

Figure 53 summarises the previous discussion, using the same representation and typology of trade barriers as used for the cement sector. We do not differentiate between long and flat

40 Japan applies high quality standards to disqualify Chinese imports (McKinsey, 2007). France applies standards, e.g. on concrete reinforcing bars, which disqualify products from some developing countries (private communication).

products. It is worth highlighting, however, that for long products the trade barriers are mainly about certification and service differentiation, whereas for flat products the issue is more to do with close rapport with high customer demands such as in the automotive industry.

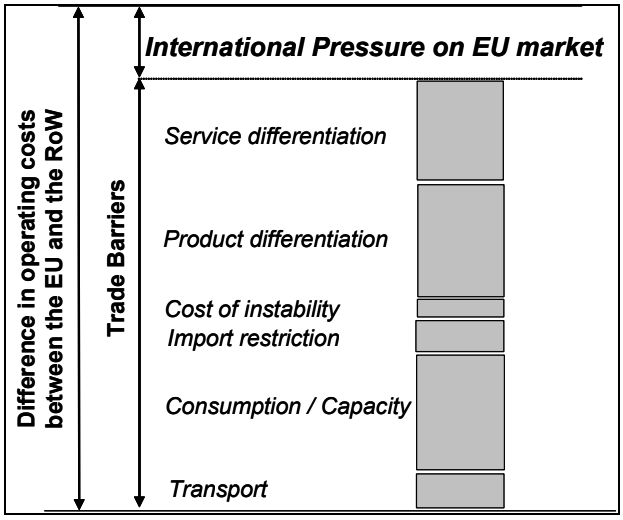


Figure 53: Trade barriers in the steel sector

3.1.2.3 Future challenges for EU steel manufacturing

- ***Shrinking trade barriers?***

As noted earlier and shown in Figure 54, imports into the EU have increased between 2005 and 2006. Does this reflect declining barriers for trade? Excess capacities abroad, notably in China, can also partly explain increase in EU imports and suggest shrinkage is transitory.

According to IISI (2007), the average EU25 consumption has increased by more than 10% between 2005 and 2006, with Spain and Italy showing particularly large increases. If the EU25 steel production capacity did not suffice to satisfy this demand increase, this could also explain the increased import volumes. The observation does not allow a clear conclusion and further analysis would be required to judge whether the increased import volumes reflect a decline of trade barriers.

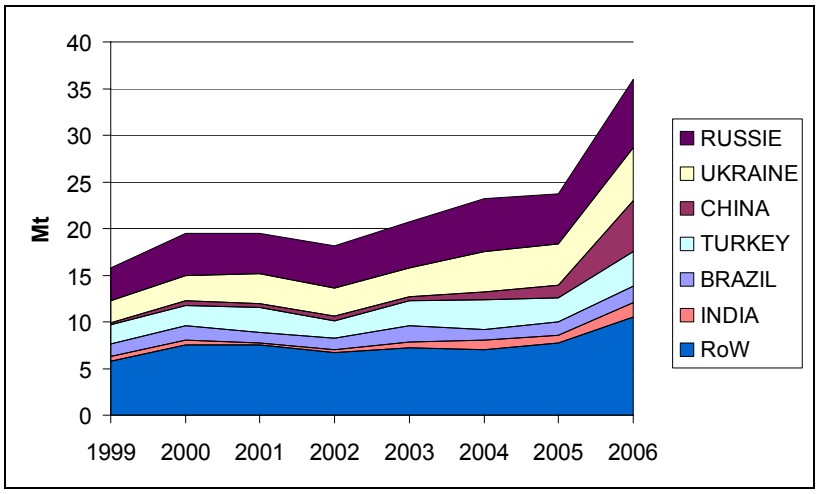


Figure 54: Extra EU steel imports

- ***Overcapacity***

As noted above, one of the main challenges for the EU steel sector is the production capacities built worldwide and the potential excess of capacity that may appear following a demand reduction in some key countries.

Chinese steel production capacity matched demand in 2006, however, steel prices remain high. The increase of world prices for raw materials may explain this. Consolidation - allowing steel majors to flex output to match dimensions of such a downturn and maintain high prices – may also play a role.

- ***Consolidation and internationalisation***

As noted by several studies, the steel industry has undergone considerable consolidation in the past several decades in Europe and in North America. In others countries, such as China, the concentration is much smaller, although some very large firms have emerged in recent years (See Figure 55).

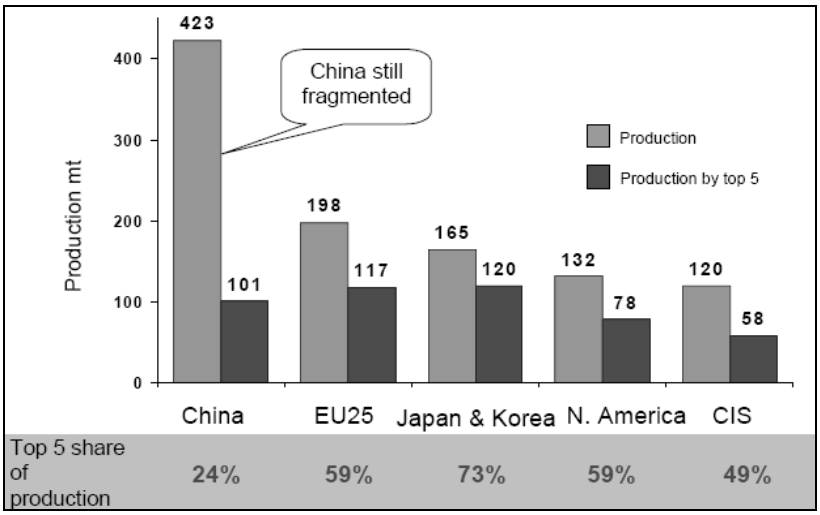


Figure 55: EU industry concentration – 2006. Source: IEA (2007)

Finally, the steel industry remains less concentrated than other industries like cement or Aluminium. While the initial consolidation was mainly due to national or regional mergers, it starts having a more global dimension with cross-regional mergers. The emergence of trans-national firms may significantly modify the picture of the sector. First, it is likely to reduce technological differences across regions, or at least accelerate harmonisation. Second, trans-national firms may benefit by taking advantage of cost differences across countries. They may trade semi-finished products between various plants. However, so far the share of semis in trade has remained constant, for example over last five years (IEA 2007).

3.1.2.4 Potential relocation of steel production capacities?

Concerning locational choices, it is worth highlighting that currently most steel plants are built to supply the local markets. Except in few countries, there are no capacities built in order to export and trade is due to imbalance market.[41] Change to this situation is more likely for BOF than for EAF.

41 The USA are an exception; US firms import some semi-finished products from Latin America to be further processed domestically.

EAF plants in the EU produce mostly long products, for which import ratios are lower compared to flat products. The low import ratios are often explained by the bulky and low-valued-added characteristics of long products. Other reasons cited are product differentiation and the absence of operating and capital costs advantage in developing countries (McKinsey 2007). Finally, raw material for EAF – scrap – is spread globally and costly to transport therefore favouring local 'recycling'. Thus relocation barriers for EAF plants appear high.

BOF plants in the EU mostly produce flat products, for which import penetration is higher than for long products. This may be explained by larger operating cost differentials across countries. Lower operating cost countries tend to benefit from close raw material sources hence lower transport costs for input factors. Vertical integration with iron ore and coal mines can also reduce price uncertainties. While product differentiation may allow the EU flat steel producers to maintain profitability in the short term, it might not suffice in the long-run to facilitate new investment or to re-investment in existing plants. Not only are operating costs significantly lower in developing countries than in the EU; operating plus investment costs in some low cost countries are similar to operating costs in the EU (McKinsey 2007). The main candidates for relocation are based on low-cost are Brazil, Ukraine and India.

However, analysis of cost differentials does not give a complete picture, given the existence of trade barriers discussed above. Most important of these in the case of flat products is quality and service differentiation. Flat semi-finished products - for which differentiation is less of an issue and cross-country production costs differentials are widely varied - may be subjected to relocation. Downstream production activities are likely to remain close to consumers. It is worth highlighting that trade in semis is likely to remain intra-firms trade, or at least maintain strong long-term partnership features. This is because of significant costs of investment in downstream activities, which require security of supply for semi products.[42].

If we suppose that relocation in BOF semis occur in the future, the intensity of this evolution is uncertain. Various experts argue that no new investment will take place in blast furnaces in the EU, which would lead to their closure in the medium term. However, others argue that high cost plants might be relocated. The latter is coherent with the Arcelor-Mittal investment plans, which forecast the closure of EU inland plants by 2020 and relocation to Brazil.[43] Finally, some experts point out that Arcelor-Mittal's plans to bring back iron making to Liege despite Belgian inland costs suggests that the steel making in the EU is still sufficiently profitable.[44] Then what are the underlying barriers to relocation?

First is the reluctance of firms to fire large numbers of workers - labour unions are quite powerful in the EU steel sector. This employment effect is exacerbated by high sunk costs that tend to slow down the relocation process. This inertia is reinforced by the boom in the steel market which ensures sufficient profitability, even for high cost plants. The history of steel production suggests that any changes are gradual, and evolve over decades rather than years. For analysis of competitiveness issues, this implies there is limited value in looking at equilibrium trade situations. It is more insightful to analyse the time delays of such locational decisions.

Secondly, semis tend to be high quality and hence differentiated products. Not all parts of the world have the ability to produce high quality products. More generally, the line which

42 Occasionally one may have firms using the "semis spot market" but only for marginal/temporary imbalances.

43 Private communication , April 2007.

44 Private communication, August 2007.

separates the upstream processes (easier to relocate) and the downstream processes (more difficult to relocate) is unclear and mobile. The position of this line is also a function of quality requirements for final products. Additionally, keeping semis production in the EU for high quality end-products whilst relocating semis for low quality products is a strategy challenged by scale economies - some plants may have a problem to operate on a much lower volume (e.g. Dunkerque[45]).

Thirdly, there are "hidden costs" in investing some low cost countries. One reason is the instability of some countries, with regulatory risks and corruption. Another reason may be the costs of the administrative process for foreign investors. Particularly for development involving an update of old plants (rather than green-field investment), existing pollution levels and energy/labour inefficiencies may put-off managers and investors. Obviously, attitudes towards "hidden costs" depend on firms e.g. Arcelor-Mittal's investment in Eastern countries reflects a different strategy.

Fourthly, some countries, especially China, seem reluctant to host plants dedicated to export, which would increase their dependency on energy or raw material imports. This may lead increasingly to the implementation of export tariffs for energy intensive products. The relocation of a segment of the production chain may also induce export tariff implementation. Examples of these include the temporary implementation of steel import tariffs (principally aimed at though not exclusive to finished steel) in the US in 2002 (McKinsey 2007), and the export tariffs in Egypt (BT 2007) and China (IEA 2007) in 2007. Other risks are the fluctuations in exchange rates or international transportation costs.

The intensity of the international pressure is higher on the EU steel sector than on the cement sector. The latter has a high domestic market share and its evolution over time seems mainly influenced by local factors and the balance between EU consumption and capacity. Its profit margins are weakly influenced by foreign producers. The domestic market share of EU steel producers, though lower compared to cement, remains high. The extent to which it is influenced by local factors, such as the lack of EU capacity, or by external factors, such as the emergence of excess capacities in the rest of the World, is unclear.

In both sectors, one may identify trade and relocation barriers that suggest international pressure is not infinite, and help explain why few exporting capacities are built abroad (notable exceptions are Brazil and Ukraine for semi-finished steel). Although their import intensities have recently increased, further work is required to test whether it can be attributed to a decline of these barriers. Finally, the role of trans-national firms is increasing in both sectors. They are in a better position to take advantage of cost differences across countries and shift parts of production activities outside the EU.

3.2. IMPACT OF CARBON PRICING IN THE EU

Having reviewed the trends in international pressures faced by the EU cement and steel sectors, we now analyse the impact of the carbon pricing e.g. via the EU ETS. For the steel sector we focus on the steels products from BOF. They have been identified as more sensitive

45 Private communication, August 2007. The expert also highlighted that this does not hold for all plants: in 1980, British steel did develop plans to run its two south Wales works on a much lower volume.

to the international pressure than EAF products. The impact of the EU ETS on the EAF products is likely to be smaller given A) dependence on local scrap availability and B) lower CO_2 intensity of production hence lower cost increase from the EU ETS implementation.[46]

We first define the initial impacts of the ETS on costs and on trade barriers. Then, we consider the short term impacts on competitiveness, assuming that production facilities are fixed. Finally, we relax this assumption to briefly investigate the relocation issue.

3.2.1. Impact of carbon pricing on costs

Implementing carbon pricing increases production costs. With the EU ETS, the cost increase depends on the allocation methodology. Under full auctioning (AU), calculating increases in production costs is straightforward. It is the sum of:

- the electricity cost increase due to the rise in electricity prices;
- the abatement cost due to the efforts made to reduce the unitary emissions;
- the emission cost which equals the CO_2 price multiplied by the unitary emission.

When allowances are allocated for free, then allocation methodology matters. In the case of grandfathering based on a fixed historic base line (GF) the amount of free allowances an installation receives is independent of its current decisions in production or emission abatement. To emit one tonne of CO_2 always has a cost – an opportunity cost of not selling the allowance – which is equal to the cost of buying the allowance on the market. Profit maximising firms pass on the opportunity cost of CO_2 to their product prices, which then sends CO_2 signals to consumers and provides an incentive to shift demand away from CO_2 intensive products. Economic models account for the opportunity costs of allowances that are distributed for free. However, the opportunity costs arguably differ from real costs for several reasons.

First, as highlighted by several academic papers, the free-allocation methodology currently applied by the EU ETS differs from the "pure grandfathering". Notably, in the EU ETS, the level of free-allocation is adjusted for each trading period and is therefore not a one-off payment. In contrast to "pure grandfathering", firms may expect an adjustment to future allocation volumes according to their current production or emission level. This reduces the emission cost (see for example Demailly and Quirion 2007b). In addition, closing rules and free allowances for new entrants in the EU ETS also change incentive structures relative to pure grandfathering, and drastically reduce the emission cost for investment and closure decisions (see for example Neuhoff et al 2006).

Second, it is sometimes argued that firms price according to average costs rather than marginal costs. As freely allocated allowances have limited impact on average costs, they would also result in limited price increase. However, the volatile steel price depicted in Figure 49 is more in line with a market price set by the cost of producing the marginal unit of steel.

Third, firms may deliberately refrain from reflecting the full opportunity cost of CO_2 allowance to product prices. Whilst full cost pass-though maximises profits in the short run, firms may fear this would have adverse effect on long-run market shares in the presence of international competition.

46 According to Reinaud (2005): Direct CO2 emissions = 0.15tCO2 per Tonne of steel, Indirect emissions (from electricity consumption) = 0.25tCO2 per Tonne of steel. Then, assuming auctioning of allowances or grandfathering with opportunity cost (see below), the cost increase for a €30/tCO2 price is €12/t of steel. This corresponds roughly to a 4% cost increase, assuming as does Reinaud (2005) that EAF steel price is around 310€/Tonne of steel (before the recent increase in scrap prices).

Lastly, there may be social pressures, notably from labour unions, relating to concerns about loss of market share and hence employment. This may put pressure firms to further reduce price pass-through.

The potential role of these four reasons complicate the prediction of emission costs that firms will add to product prices if they receive allowances for free. In the following analysis, we will simulate the results for three different scenarios that cover the range of possible responses:

- AU - full auctioning with firms passing all allowance costs to product prices;
- Free Eco - full free allowances allocation with full opportunity costs pass-through;
- Free Ind - full free allowances with no opportunity cost pass-through.

It is worth emphasising that these are extreme scenarios. Following the pilot phase, EU ETS has begun the transition away from free-allocation to auctioning and it is unlikely that firms will be allocated allowances at BAU need under any allocation methodology. Figure 56 and Figure 57– based on the modelling work presented below (see also Annex 1) – show the impact of different carbon pricing levels on the cost per tonne of output of the average EU producer. For both sectors, the output considered is the finished product[47] but we include trade in semis in the trade data. For the steel sector, we focus on the steel products from BOF. To account for the abatement in unitary emissions, we rely on Marginal Abatement Cost Curves (MACC) from PRIMES (Blok et al. 2001) which simulate a ten year delay, hence the impact is not long-term.[48] It is assumed that under free allocation the producers receive 90% of their current emissions. As such, a 10% emission reduction target compared with current emissions corresponds roughly to a 15% target compared with 1990 levels at the EU27 level. This is in line with the 8% emission reduction the EU is committed to achieve by 2010 and the 20% target by 2020.[49] The Figures distinguish between the three scenarios on the allocation methodology, the different components of the cost increase and three CO_2 prices: €15, €30 and €45/t. The current CO_2 price on the CO_2 market for Phase 2 of the EU ETS (2008-2012) is just over €20/tonne CO_2 at the point of publishing this report.

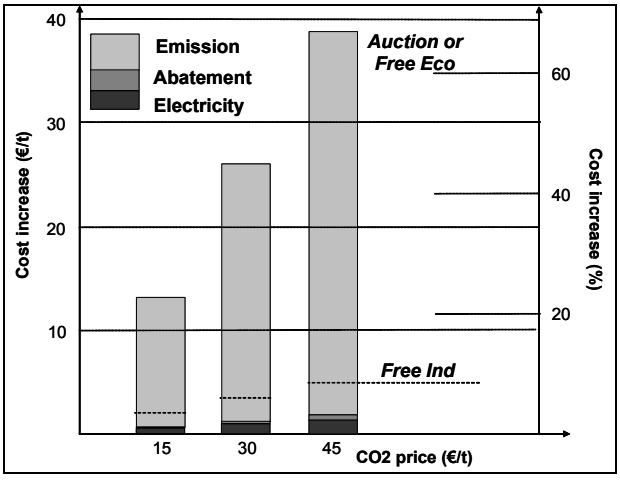


Figure 56: EU ETS impact on average EU cement costs

47 As most trade in steel is in finished products, and as we do not have access to the clinker cost structure, whereas we have access to the cement cost structure.

48 Unfortunately, the MACC for the steel sector merges the two production routes: EAF and BOF. The MACC for the cement sector does not account for the possibility of reducing the clinker content of cement, whereas it is often identified as an important levy to reduce emissions (WBSCD 2002).

49 "The EU has commited to a 20 % reduction of greenhouse gas emissions by 2020 compared to 1990". "The European Council endorses an EU objective of a 30 % reduction in greenhouse gas emissions by 2020 compared to 1990 as its contribution to a global and comprehensive agreement for the period beyond 2012, provided that other developed countries commit themselves to comparable emission reductions and economically more advanced developing countries to contributing adequately according to their responsibilities and respective capabilities". Brussels European Council, 8-9 March 2007.

Given the CO_2 intensity of cement, the impact on the total production cost is very high under AU and Free Eco: for a €30/t CO_2 price, it increases by roughly 40%. In the short run, this is equivalent to the impact of an appreciation of the Euro by around 40% compared with $US.[50] Such an appreciation has occurred since 2001.

The main component of the cost increase is the emission cost. In the scenario Free Ind, the cost increase is much smaller. The emission cost remains positive, however, as cement manufacturers tend to be unable to reduce their unitary emissions by more than 10% according to the MACC used. They are net buyers on the CO_2 market.

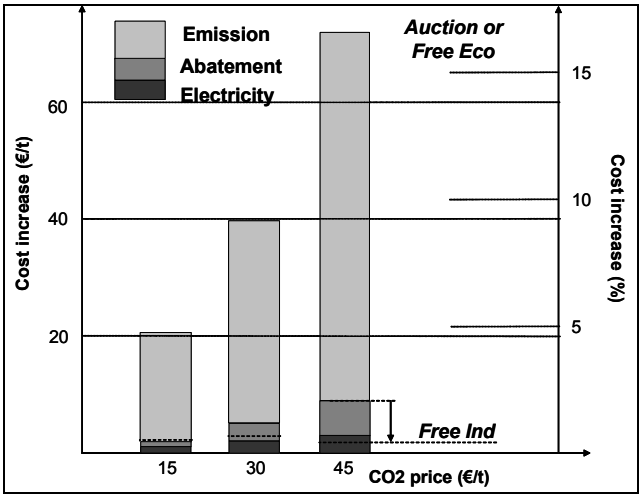


Figure 57: EU ETS impact on BOF steel costs

The impact on the production cost of BOF steel is high under AU or Free Eco: for a €30/t CO_2 price, it increases by roughly 10%. It is difficult to compare this cost increase with an appreciation of the Euro exchange rate, as such an appreciation reduces the costs of raw materials and fossil fuels bought in $US on international markets. In the steel sector, these costs are predominant.

Although the electricity and abatement costs are not negligible, the emission cost is the main component of the cost increase. The cost increase under Free Ind is much smaller. In particular, the emission cost becomes negative for high CO_2 prices as steel manufacturers are able to reduce their unitary emissions by more than 10% according to the MACC used. Thus steel manufactures are net sellers on the CO_2 market.

Obviously, the cost increase under a hybrid allocation methodology that would mix AU and Free Eco would be similar to the increase under full AU or Free Eco. Likewise, a full free allocation methodology with some opportunity cost pass through leads to an intermediate cost increase between Free Ind and Free Eco.

3.2.2 Impact of carbon pricing on trade barriers

Trade barriers will also be impacted by the ETS itself or by climate policies in other sectors.

- The implementation of climate policies on the transport and housing sector could result in changing demand characteristics that might be most readily serviced by local

50 This is more complicated as a share of cement production costs come from the consumption of fossil fuels whose prices in Euro benefit from the appreciation of the EU currency.

producers that have the ability to respond faster, thus increasing the *product differentiation* barrier.

- Climate policies in the transport sector are likely to at least initially increase transport costs and thus increase existing *transport barrier*.
- The ETS by itself may increase the volatility of cement and BOF steel prices, as emissions costs, like other input factors, exhibit volatility. This increases the risk for trading and thus the '*instability cost'* barrier. On the other hand, this volatility may decrease the benefit associated with less volatile local production, characterised in the category *service differentiation*.
- The international discussions on climate change might pursue policy measures to address leakage, and support export tariffs or border tax adjustment and thus undermine the viability of relocation (*import restriction*)

Climate policies might result in demand shifts. For example FONDDRI (2007) anticipates increased cement demand for refurbishment of the building sector and reductions of the steel demand as lighter materials are used in the transport sector to improve fuel efficiency. Where such changes are unexpected, they may influence the demand-supply balance and trade flows.

The Figure 58 summarises the impact of the climate policies on cement trade barriers and cost difference. This picture similarly applied for steel.

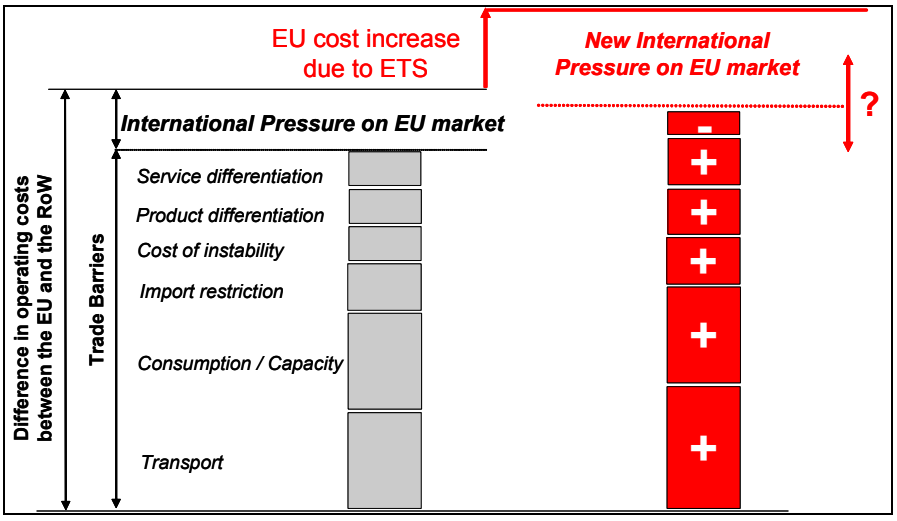


Figure 58 Impact of the EU climate policies on cement trade barriers

Finally, the question as to whether the EU ETS and the various other climate policies lead to an increase or decrease in trade barriers is complicated by many factors. An increase of barriers is likely, at least in the short-run. This is mainly due to the time-lag in the implementation of climate policies and also because the cost increases (e.g. for transport) may be very high. This raises two questions:

- Are EU producers able to maintain profit margins by passing a significant share of their CO_2 costs to consumers?
- To what extent are potential market share losses induced by such a price increase?

These two questions are linked as EU producers may face a trade-off between maintaining profit margins or market shares. The following section provides insights on these two questions, relying on the economics literature and a simple model.

3.2.3 Insights from economics literature on the ability of firms to pass through CO_2 opportunity costs to product prices

In this section, we examine the first question: to what extent are EU cement and steel sectors able to pass-through CO_2 opportunity costs to product prices? We first highlight the various determinants of cost pass-through abilities. This helps underline for each sector the important determinants identified in Section 3.1. We then briefly review the literature on pass-through rates for the two sectors.

- ***Pass through determinants***

In the case of perfect competition, prices will be set at marginal production costs and firms will therefore pass full cost of carbon to product prices. The price increase can result in a demand reduction, both because of demand-side substitution towards lower-carbon products and because of an increase in imports. In the short-term, marginal production costs can fluctuate with the production volume. In competitive markets, the change in product prices will be similar to the carbon cost of the marginal production unit.

We now take account of market power of cement and steel firms, firstly in the EU and secondly outside the EU. Steel and cement are concentrated sectors, characterised by high entry barriers and consolidation in recent years. The five largest EU cement producers represent around 60% of the EU 25 market (McKinsey and Ecofys 2006). The same ratio holds for the EU steel market (from Figure 55). Ten Kate and Niels (2005) show that the amount of cost pass through in the presence of market power depends on the shape of the demand curve. If the demand curve is linear, then pass through rates in an oligopoly situation are lower than in competitive markets. With sufficiently convex demand curves, this result is inverted. So far, there is little evidence on the shape of the demand curve.

Finally, if the number is firms is small, it is not in the interests of exporters to flood the market. Rather, self-imposed export restrictions will allow firms to benefit from higher prices and profit margins. This makes sense provided that the number of exporters is not too high, i.e. that they have some market power. Given the concentration of the cement and steel sectors, one may expect such behaviour from strategic exporters.

- ***Insights from applied models***

There are several applied sector models. Szabo et al (2006) and Hidalgo et al (2005) use a common modelling framework to study the impact of the EU ETS on the cement and steel sectors respectively. They assume that the pass-through is complete but do not provide underlying rationales. Demailly and Qurion (2007b) model both sectors assuming that there is neither market power nor capacity constraint. This also leads to a complete pass through. The analysis for UK sectors by Smale et al (2006) account for market power of both UK and non UK firms. It also assumes a specific demand curve. Under these assumptions, UK firms reduce their cost pass-through levels and the non-UK firms limit exports to the UK so as to benefit from higher prices. Using this approach, they obtain high pass-through rates of around 65% for the UK steel sector and even higher for cement. In a study using a detailed cement model accounting for transportation costs and capacity constraints, Demailly and Quirion (2006a) derive similar pass-through rates but for the EU level.

Except for Demailly and Quirion (2006a), there are no models accounting for capacity constraints. This is problematic because in theory, capacity may drastically reduce or increase the EU pass through ability. In models representing other sectors more open to trade than

cement, capacity constraints are more generally accounted. (E.g. aluminium sector model in Manne and Mathiesen 1994).

For the steel sector, Mathiesen and Maestad (2004) account for the existence of capacity constraints. They assume that the steel products manufactured in the Annex B countries – i.e. the countries which have emission reduction targets in the Kyoto Protocol – and other countries are different. Steel producers are able to pass onto consumers 60% of the BOF cost increase due to a \$US25/ CO_2 tax in the Annex B countries.[51]

McKinsey and Ecofys (2006) make assumptions on the pass through ability of the EU cement and steel sectors: from 0 to 15% for cement, 6% for the flat steel products (and 66% for the long products). However, the underlying rationale is not explicit. With applied models, although they use (endogenously or exogenously) relatively high pass through, there is limited empirical support.

- ***Insights from empirical literature***

Difficulties have been pointed out in gaining empirical evidence on cost pass-through for sectors other than electricity. For example it is difficult to disentangle the role of international pressure on ability to cost pass-through from the dampening effect on opportunity costs due to repeated free-allocation (see Section 3.2.1). In addition, there are time delays implied by infrequent contracting rounds, and the observation period since the start of the EU ETS is still short. Nonetheless, a few econometric studies assessing sectors' pass through abilities are emerging. Walker (2006) assesses the pass through of the opportunity cost for the EU cement sector during the first year of the ETS. Here the opportunity cost equals the CO_2 price multiplied by unitary emissions. This study reports pass-through rates varying between 10-40% depending on countries and econometric assumptions. The low pass-through rate might reflect the limited empirical basis of only one year of carbon pricing. Over time commodity prices that are frequently determined in annual contracting rounds, might adjust..

For the sector Non-Metallic Minerals (including cement), Gerald and Scott (2007) test the influence of domestic costs (including eco-taxation) in various EU countries on both European and world prices. Price change sensitivity is low, particularly on non-European prices. In all countries examined, domestic costs determine a large portion of the output price. This supports the hypothesis of substantial pass through. This study also examines the Basic Metals sector. In this case, the world price has a strong and significant influence on output prices. The influence of domestic costs on price is statistically significant, but outweighed by the influence of prices in other EU countries.

Lessons can also be drawn from the literature on exchange rate pass-through. This literature estimates the ability of EU exporters to pass the impact of an exchange rate variation onto their prices for foreign consumers – unfortunately no such quantifications exist for the domestic market – whereas the foreign producers are not impacted. Hence, this shock is asymmetric and incurred by few producers, as exporters generally have low market shares on foreign markets. One may then expect low pass through, at least lower than the estimates we are looking at in this report, where the cost increase is incurred by more than 90% of the

51 And 80% for EAF steel products. Pass through figures actually come from a study realised by Mathiesen for the OECD (2003). Mathiesen et Maestad (2004) also conclude that market share losses are significant as they are mainly responsible for the 7% drop in production. However, such a result has been obtained setting the Armington elasticity (see below) to 8, far above any econometric estimates we have found in the literature. The authors support this assumption by stating: "this figure is somewhat higher than the Armington elasticity of 5.6 employed for the sector "ferrous metals" in the GTAP model (Hertel 1997). We have chosen a higher elasticity in order to reflect the fact that the sector "ferrous metals", which includes iron ore, scrap, as well as steel, is a more heterogeneous product category than the steel products that are traded in our model." However, the elasticity of substitution between domestic and foreign products for the ferrous metals sector in GTAP – the relevant one – is 2.8, the value 5.6 being the elasticity of substitution between different import sources.

quantity consumed on the market. Exchange rate pass through is generally high but varies widely among industries, products, countries and timescales. For the steel and cement sectors, we found some estimates of the relative pass-through which are equal to the ones used in this report. These estimates are multiplied by the ratio cost over price (i.e. the absolute pass-through is higher than the relative one). These estimates are: for cement, 20% (Gaulier et al (2006), who aggregate cement with other products) and 40% (Knetter (1993) who considers Portland cement exported from Germany to the US); and for steel, 40% (Gaulier et al (2006) for bars and rods of iron or non alloy steel) and 50% (Athukorala and Menon (1994) for metal products from Japan).[52]

- ***Conclusions on pass through***

Thus, the literature gives support to the assumption of significant pass-through in both sectors: high in the cement sector and intermediate pass-through in the steel sector.

For the cement sector, this may be also confirmed by the fact that, according to ETUC (2007), EU cement producers have recently passed to consumers the recent rise in their electricity cost (due to the EU ETS hence EU-wide). In the UK, according to the British Cement Association (BCA)[53], energy costs have increased by 55% between 2003 to 2005 while cement prices increased by 8.5% over the same period. Although it is not clear if this cost increase was mainly UK or EU-wide or was also incurred by non-EU producers, BCA states that this demonstrates that cost pass-through is restricted by competition. However, given the share of energy costs in total costs, this data demonstrates that the pass-through has been around 70% in two years.[54] In the same time period, imports have not increased but have actually slightly declined (Eurostat, 2007b). This is despite the fact that the entire UK market may be considered as coastal.
Some experts point out that this ability may be drastically reduced if huge excess capacities appeared worldwide. This is confirmed by the previous theoretical analysis of pass-through determinants. Section 3.1.2 also supports this point in the EU steel sector: such excess capacities would push world prices down – and consequently also reduce the EU prices – although the magnitude is uncertain given the consolidation of the market. For the EU cement sector, Section 3.1.2 suggests that huge excess capacities worldwide may not automatically increase the international pressure, as EU prices are not significantly influenced by world prices and EU imports seem to be mainly influenced by local factors.

It is worth noting that the cost increase from allowance prices is large relative to most of the cost increases studied other than the exchange rate fluctuations. Thus, the insights from empirical studies must be considered cautiously. Finally, one has to account for the inertia in prices, for example due to annual contracting rounds in the cement sector. Although the pass through ability of this sector is generally seen as high, the delay is of importance.

3.2.4 Insights from a simple modelling framework on impact of carbon pricing on EU cement and steel

In this section, we use a simple modelling framework (Annex 1 provides full description) to quantify the short to medium term impacts of various scenarios on both dimensions of

52 Accounting for the impact of the exchange rate variation on production costs.

53 Communication via industry consultation process in 2007.

54 Following Reinaud (2005), one assumes that energy costs equal around € 15.4/Tonne of cement and UK price is around €68/Tonne of cement. Then, a 55% energy cost increase means a €8.5 increase, and a 8.5% price increase means a €5.8 price increase. Then, using BCA's data, the pass through is 70%, in two years. It would be even higher if the price considered by BCA includes transportation costs (around €12, private communication): 80%.

competitiveness: profit margin and market share. The model gives the result for a static equilibrium and is calibrated for the short to medium term, until around 2015. This reflects the inputs from the marginal abatement cost curves that look at abatement options within a ten year time frame. Likewise, estimates of the price elasticity of trade used in the model do not include long-term effects. The model aggregates the response across the EU countries.

- ***Basics of the model***

To quantify market share losses, we rely on the Armington (1969) representation which assumes that the goods produced in different regions are imperfect substitutes. We distinguish between two regions: the EU and the Rest of the World (RoW). For a given price increase in the EU relative to the RoW, the Armington representation provides a corresponding drop in the demand addressed to EU producers, caused by the drop in consumption and loss of market share. While the drop in consumption depends on the price elasticity of demand, the loss of market shares depends on an elasticity called the "Armington elasticity". This elasticity isolates the role of relative price evolution on market shares.

As Mathiesen and Maestad (1994) suggest, this representation is suitable for the steel sector. In applying the model to the cement sector, the majority of the trade barriers are arguably not associated with consumer choices (between products with different quality and service attributes as intended by the original model specification). We therefore interpret the model in a wider context. As the estimates for the Armington elasticity reflect the historic trade barriers between different regions,[55] so will the simulation results.

Figure 59 and Figure 60 show for the cement and steel sectors, the impact of price differentials between EU and RoW on trade. As expected, the higher the price differentials, the higher the share of EU demand satisfied by foreign producers. The diagrams show the results for three Armington elasticities – the highest and lowest literature value and their average (see in Annex 1). Trade volume in the steel is more sensitive to price differentials.

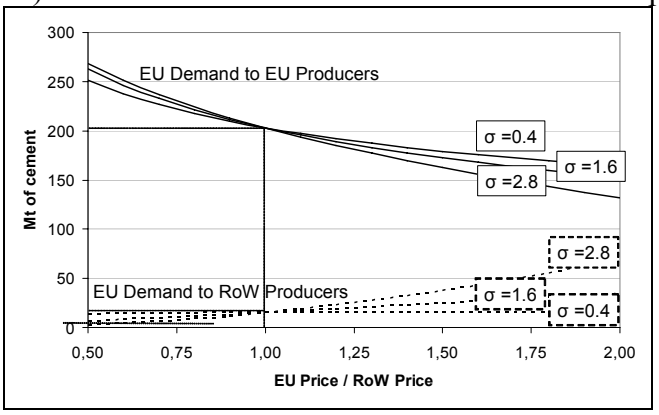


Figure 59: EU cement demand to EU and RoW producers

55 This is not the case for the balance between consumption and capacity barrier which is only accounted for in the pass through assumption.

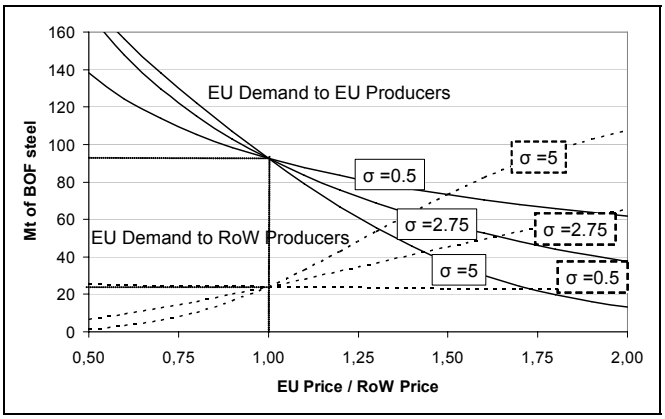


Figure 60: EU steel demand to EU and RoW producers

For the supply side, we do not use a complex model accounting for all the determinants of pass-through previously discussed. Rather, pass-through rates are exogenously set. We also conduct a sensitivity analysis, testing the sensitivity of model results to the assumption on rate of cost pass-through. We assume that the price in the rest of the world stays constant across all scenarios. This ignores two effects that could result in a price increase. With increasing production volume in the rest of the world, marginal costs increase. Increase export volumes from the rest of the world to Europe might also increased the potential for market power, with a similar effect. Both effects would reduce the impact of EU price changes on trade flows.

- ***International pressure scenarios***

We define three scenarios with different assumptions on the pass-through rate and Armington elasticity. The two "extreme" scenarios are intended to span the range of possible outcomes and do not depict scenarios we consider likely. As demonstrated in previous sections, high values of pass through in the cement sector and intermediate values in the steel sector are more likely than low values.

1. In the "zero pass through (PT) scenario" producers do not pass CO_2 allowance costs or production cost increases to product prices. This scenario would have the highest impact on profit margins. As the price charged by EU producers stays constant, demand and trade also stays constant.
2. In the "complete PT scenario" EU firms not only pass the cost increase to consumers but also maintain their EBIT (Earnings before Interest and Taxes) margin.[56] In addition, the highest available literature value for the Armington trade elasticity is selected.[57],[58]
3. In the central scenario, called "half PT scenario", the pass-through is half its complete value. For the Armington elasticity, we take the mean of the range of estimates found in the literature.

To assess the impact of the allowance allocation methodology on the EBIT of all three scenarios, we simulate for three different CO_2 price assumptions of €15, €30 and €45/t CO_2:

1. full auctioning of allowances (labelled AU);
2. full free allowances allocation with opportunity cost pass through (Free Eco);

56 We note that the pass through may theoretically be higher than the complete value. See for example Stennek and Verboven (2001).

57In the Carbon Trust Report "Carbon pricing, industrial competitiveness and emissions leakage: subsector analysis of medium-term impacts" , this value is fixed.

58 There are some claims that the estimates of the Armington elasticity are too low as they do not account for the continuous increase in the international pressure that EU producers have to face. However, as discussed before, this evolution is debatable. Moreover, the main argument in favour of this evolution concerns the apparition of excess capacities throughout the world: this effects the pass through assumption, not the Armington elasticity. It is then possible to use the existing estimates of the literature.

3. full free allowances allocation without opportunity cost pass through (Free Ind). EU producers increase prices to reflect cost increases from efficiency improvements, but do not add opportunity costs of CO_2 to product prices.

- ***Impact on the non-EU import ratio***

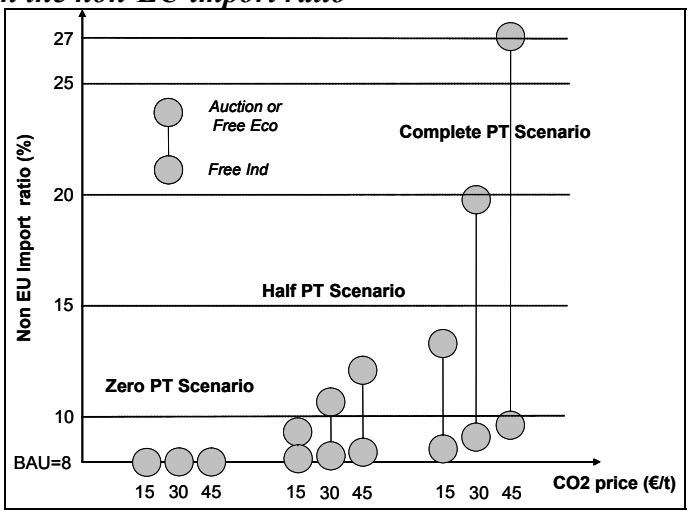


Figure 61: Non-EU cement import ratio for various scenarios

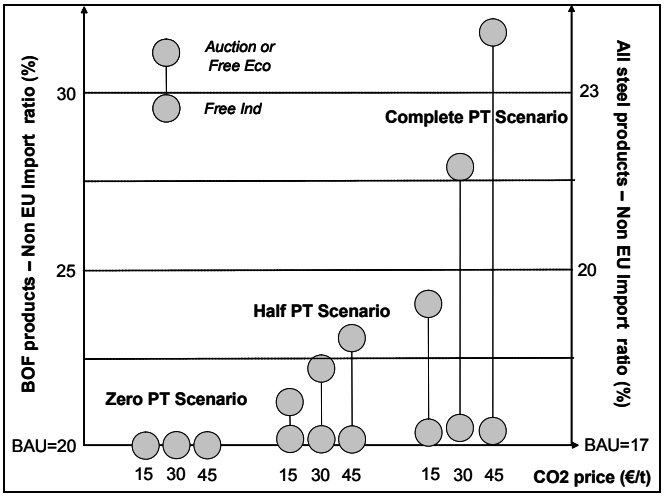


Figure 62: Non-EU BOF steel import ratio for various scenarios

The impact of the EU ETS on the Non-EU import ratio[59] remains modest in the two scenarios with low and intermediate values of pass-through and Armington elasticity. The impact can be significant, however, as illustrated by the scenarios with complete pass through (Complete PT, with Auction or Free Econ). The non-EU import ratios increase from 7% to 18% in the cement sector, and from 20% to 28% in the BOF steel sector (from 17% to 21% if one aggregates EAF and BOF products).

Despite the lower literature values of Armington elasticities applied for the cement sector, the impact on market shares is similar to the BOF steel sector. This is because the price increase of cement relative to cement prices is higher and offsets the lower trade sensitivity.

59 The use of the Armington specification theoretically prevents a quantity of goods from having different origins (meaning they are not equivalent). Import ratio must then be defined using a consumption index aggregating these quantities. We do not use such an index here in order to make the ratio under BaU equivalent to the one observed in 2006. However, these two options are similar in terms of import ratio increase relative to BaU, as long as the consumption drop is not too high (probable given the low trade elasticity of the sector considered).

- ***Impact on profit margins***[60]

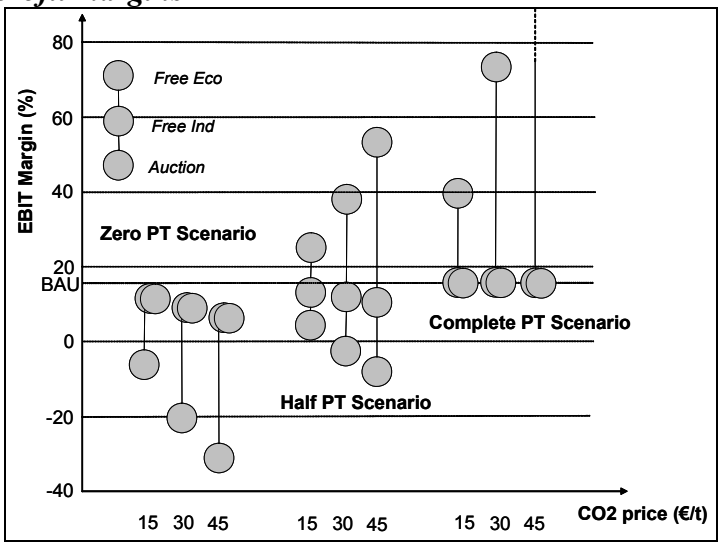


Figure 63: Cement EBIT Margin for various scenarios

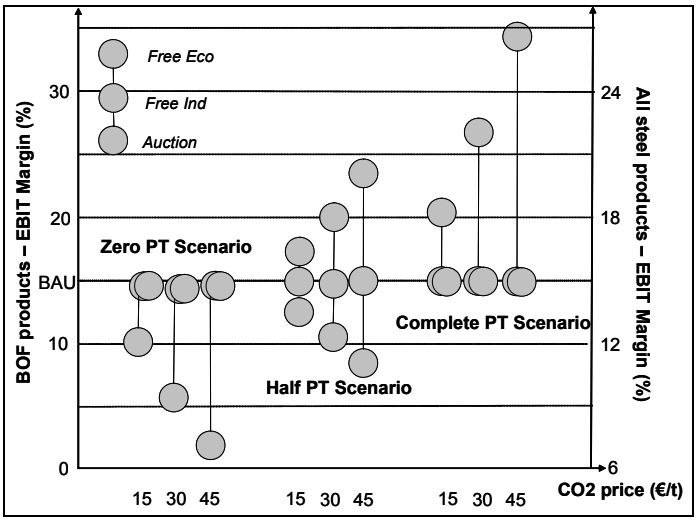


Figure 64: Steel EBIT Margin for various scenarios (EBIT/cost)

In the cement and BOF sectors, the impact on the EBIT margin is potentially large. The Figures above show the change relative to the BAU assumption of 15% (Reinaud 2005a). With free allowance allocation and pass-through, profitability increases. This absolute profit increase depends on the share of opportunity costs passed through to product prices.[61] On the other hand, if allowances are auctioned and producers decide not to pass through CO_2 costs (e.g. to maintain market share), then the effect could be both high and negative. Aggregating BOF and EAF products for the steel sector reduces the impact. The particularly CO_2 intensive nature of cement and BOF steel production means impact on profitability is very sensitive to the level of allowances grandfathered and auctioned. As previously emphasised, these two scenarios depict extreme cases and a likely scenario involves some product price increase even where some market share loss may result.

60 It is fair to stress that most cement plants in the EU are quite old, and their investment cost are already covered. In this case it may be worth investigating the EBITDA (Earnings Before Interest, Taxes, Debt and Amortization), not the EBIT margin. However, given the cost structure of the sector from Reinaud (2005), the qualitative conclusion would hold. Moreover, the profit margin gives insight on the long term impacts as new plants or the "re-building" of retiring plants would require investment.

61 In the full pass through scenario it is assumed that producers keep the profit margins constant. Thus cost increases from carbon result in higher profits per tone of cement/steel sold and compensate for lower sales volumes.

In the half PT scenario, hybrid allocation with 50% auction and 50% Free Eco is enough to maintain the profit margins at low CO_2 prices, for both sectors. At higher carbon prices, less free allowance allocation is required to maintain profit margins. A drop of the EBIT margin below zero does not by itself result in the closure of plants. If a plant continues to operate at zero or negative EBIT margins, it does not recover the full return on capital, but might recover some of the initial investment costs as long as EBIT margins are not too low. However, negative EBIT margins means no new investment will be pursued, as the price does not cover total production and investment costs.

According to the simulation results, negative EBIT margins appear in the cement sector if the pass through is low or intermediate and if allowances are mainly auctioned. In contrast, EBIT margins are positive in the FREE Eco already for low and intermediate past through assumptions. In this case imports are increasing as firms reduce production and sell allowances. This illustrates the point that protecting profitability with free allowance allocation does not by itself ensure continued operation or address leakage concerns. EU producers might reduce production while making large profits.

3.2.5. Long-run impacts from carbon pricing on cement and steel sectors

We now briefly turn to the long-term impacts of unilateral carbon pricing in the EU. Long-run impacts are somewhat more complicated for many reasons. Innovation may drastically reduce the cost of emissions. Carbon mitigation policies in the housing and transport sectors may increase product differentiation between the EU and the RoW, and may generally impact trade barriers. International pressure in the long-run may also increase if excess capacities appear outside of the EU. Moreover, market structures may change through further consolidation and the exit of some players, impacting firms' ability to pass-through costs.

Above all, in the long-run, production facilities are not fixed. Therefore, if the profitability of EU sectors declines over time, local investments may be delayed and/or reduced. In the short-term and medium-term, this could be matched by falling demand for CO_2 intensive products, or increased imports. In the longer-run the question of relocation arises.

As previously stated, for both the cement and steel sectors, dedicated export capacities outside the EU would be first built by EU transnational firms that face lower trade barriers and are in a privileged position to take better advantage of cost differentials between countries. For example, there might be some benefits of relocation clinker production to the Mediterranean Basin or production of semi-finished steel to countries with good coal and iron-ore resources (e.g. Brazil and Ukraine), whilst operation of the downstream transformation continues within the EU to satisfy EU demand.

As discussed in Section 3.1.1.5 and 3.1.2.4, on top of barriers to trade, there are various additional barriers for relocation. For example, these sectors are capital intensive - investment costs represent around three years of turnover for cement, somewhat less for steel[62] and take many years to recover.[63] This needs to be balanced against the various uncertainties associated with relocation including uncertainty about future climate policy at home and abroad. The degree of international asymmetries of CO_2 prices over time depend on the design and coverage future policies e.g. government lead sectoral agreements, system of

62 From Reinaud (2005), investment cost for one Tonne of cement capacity is around $US 150, with an average EU price of € 65per Tonne of cement and incomplete utilisation ratio. Investment cost for one Tonne of BOF steel capacity in Western Europe is $650, with an average steel price – before the 2004 increase – of $310/t and incomplete utilisation ratio.

63 However, investments costs are not recovered during the entire lifetime of the plant. In the cement sector for example, these costs would be recovered in less than 10 years (private communication), whereas a plant may operate for more than 30 years (Szabo et al. 2006).

tradable performance standards such as those promoted by some cement firms and by EUROFER (studied by IISI[64]), export taxes of producing countries or border adjustments between countries with different carbon prices.

Currently free allocation of allowances creates incentives to retain production capacity and volumes within Europe. Installations covered by the ETS lose their allocation allowance with closure, while the New Entrant Reserves grant additional allowances at the time of new investments or capacity boosts. Consequently, the emission costs incurred for new investment in the EU is currently limited to the value of the allowances that are not covered by the New Entrant Reserve. These two features of the EU ETS therefore reduce incentives for relocation – and hence reduce carbon leakage – but they also challenge the economic efficiency of the system (Neuhoff et al, 2006, Demailly and Quirion 2007a).

3.2.6. Tipping points in the competitiveness impacts of the EU ETS

Here, we briefly address the question of whether for a given sector, there is a tipping point? Is there a CO_2 price above which imports or relocates would become massive, the pass through ability would drop to zero, and EU firms would stop producing? In other words, are competitiveness impacts likely to be disruptive or smooth adjustment of CO_2 prices?

First, the impact of the ETS on production costs depends on the plant considered. The figures given previously are average cost impacts. Each plant uses a particular technology, a particular mix of energy sources and produces a particular material. Second, the trade barriers identified before tend to smooth the competitiveness impacts:

- *Product and service differentiation.* Many EU consumers are willing to pay a higher price for quality and service. For a particular consumer and for a particular product, there is a price difference above which the consumer will switch from EU to RoW products. However, the aggregation of personal preferences tends to make this switch smooth. That is why trade elasticities (and also demand elasticities) are not infinite: there is no "bang-bang" effect. This tendency is reinforced if one separates all the products of a sector.
- *The cost of instability.* The cost of instability is not the same for all exporters. It depends on their expectations and their risk aversion vis-à-vis the uncertainty. Various costs have to be considered. For example, in the cement case: storage facility, grinding station, export capacity. The scale of instability – exchange rate and transport cost fluctuations, threat of retaliation, economic conjuncture – is dependent on exporting and importing countries. Hence even if thresholds exist for individual exporters and for a given investment for a given market, they cannot be generalised.
- *Import restriction.* The size of the import restriction barrier depends on the willingness of local or national policy-makers' to restrict imports, as well as the willingness and ability of EU firms to do so. Their ability depends, for example, on their retaliation power. Again, the existence of threshold effect for this barrier cannot be generalised for the EU as a whole.
- *Transportation costs.* Transportation costs are a trade barrier that has different values dependant on the geographical location of the exporters' plant and of the targeted EU consumer. If we consider sea cost as a barrier, then one could assume a tipping point

64 This is the type of Sectoral Agreement industrialists focus on. The agreement is supposed to be worldwide, or at least include the biggest producing countries. One may establish different regional benchmarks, the developed countries being subjected to more ambitious targets. The closer these regional benchmarks, the lower the leakage of production toward inefficient plants.

that would be applicable to several countries with coasts, which is reached if a price difference justifies loading and unloading of a ship.

- *Balance between capacity and consumption in the RoW*. The size of this barrier depends on the exporting country considered, and varies considerably through time: demand evolves and the capacity constraint may be tightened or relaxed according to investment decisions. In China, for example, a lack of capacity has been followed by a large excess.

Local tipping points are more likely for products that are not differentiated, in a given plant, with a given technology, facing a given exporter at a given time. However, even in this case, it is difficult to argue for the idea of a CO_2 price above which no further price pass through is possible. Assume a plant whose cement output does not differ at all from the consumers' point of view. Following a cost increase, it becomes profitable for a cement trader to import cement. However, the trader has interest in benefiting from the high domestic price, hence has no interest to flood the home market. Finally pass-through is not zero, neither is the domestic market share. Market power also tends to smooth the impacts. This effect disappears if one considers EU trans-national firms which may substitute production abroad for EU production: they produce in countries where costs, including export barriers to the EU are the lowest, noting the fact that their capacities abroad are not sized to supply the EU in the short-term.

For these reasons, we argue that tipping points can be identified only by making simplifying assumptions about various factors which are intrinsically uncertain and may evolve over time. These parameters include the future evolution of transport costs, product and service differentiation, stringency of different climate and other policy frameworks, potential trade restrictions, and the demand-supply balance in different countries. This suggests that for analysis of competitiveness impacts, it is useful to take a range of values and complement with sensitivity analysis on the parameters – as we have done in this chapter.

3.3. CONCLUSION

In this chapter, we take a much closer look at the two sectors identified as particularly sensitive to the EU ETS: the cement and steel sectors. This examination is based on expert interviews, data analyses, and a review of the economics literature and published studies on these sectors.

Globally, EU cement firms face a low international pressure: the weight of foreign companies on their prices is low and they retain control of the vast majority of domestic markets. The international pressure faced by EU steel producers is also low and even if one focuses on flat products produced through blast furnaces, the pressure remains moderate. This situation is explained by various trade and outsourcing barriers that we have identified in this chapter. Based on recent trade figures, EU cement and steel manufacturers raise the alert that the picture is changing. By analysing the factors that can explain the changes in trade volumes in Section 3.1, we show that it is difficult to identify a fundamental change.

How may the EU ETS impact on the two dimensions of competitiveness - market share and profitability- for these two sectors? In the steel sector we focus on the more carbon intensive blast furnaces. If one assumes full auctioning of allowances or pure grandfathering, the impact of the EU ETS on production costs is high for blast furnace steel and even higher for cement. However, this is highly dependent on the allocation methodology and the behaviour of manufacturers vis-à-vis the opportunity cost of free allowance allocation.

The literature suggests reasons to expect substantial pass-through of opportunity costs of carbon to product prices for both sectors, possibly with some delay. This is likely to be high for cement and intermediate for steel. We use a simple short term model based on econometric estimates of the trade sensitivity. Short-term market share or profit margin losses may be very high under unlikely sets of assumptions on pass-through ability, trade sensitivity, allocation methodology and CO_2 price. This conclusion would be challenged if international pressures on EU producers are increasing – this hypothesis is highlighted by industry but quantitative evidence gives support to the contrary.

In the long-run, one may fear a significant relocation of semi-finished products of cement and steel blast furnaces if they face the full cost of CO_2 allowances, particularly within trans-national firms. Uncertainty on the permanence of the asymmetry of the carbon prices reduces the incentive to relocate. Free allocation with closure rules and new entrant reserves under the EU ETS also reduces the incentive to relocate, but also affects efficiency of the scheme. Finally, we argue that tipping points can only be identified if we make simplifying assumptions about several factors which are intrinsically uncertain and may evolve over time.

ANNEX 1 The Model for cement and BOF steel sectors

The model's timescale is out to 2015 corresponding to the Phase 3 of the EU ETS. The main rationale for modelling the short to medium term are two fold; the Marginal Abatement Cost Curves assumed have a ten year delay, and the estimates of the price elasticity of trade do not include long term effects. The model estimates impacts for EU countries in aggregate.

Without the ETS i.e. under the Business As Usual (BAU) scenario, we assume that consumption, electricity and CO_2 intensity of production and trade flows remain constant. Prices equal production costs plus the BAU profit margins, which we assume to be 15% following Reinaud (2005a);

$$P^0 = \left(1 + \mu^0\right) \cdot c^0$$

Compared with BAU, the CO_2 price leads to a cost increase for EU producers:
$c = c^0 + \Delta ec + uac + P_{CO_2} ue$

- Δec is the electricity cost increase. It equals the unitary electricity consumption (assumed constant), multiplied by the electricity price increase. Following Sijm et al (2005), we assume80% pass-through in the electricity. The cost increase passed is the average cost increase.[65] The latter is computed as in the previous equation.
- uac is the unitary abatement cost i.e. the cost increase due to the efforts made to reduce unitary emissions from ue^0 to $ue = ue^0 - ua$. ua and uac are derived from the Marginal Abatement Cost Curves (MACC)[66] of PRIMES (Blok et al 2001).
- $PCO_2 \cdot ue$ is the average cost of emissions. Under AU, it is a "real" emission cost. Under a Free Eco, it is an opportunity cost. Under Free Ind, the emission cost is different: it equals the cost of the emissions which have to be bought (may be negative).

We assume that the total emission cap of the EU ETS in 2015 equals 90% of 2005 emissions (E^{2005}). Such a 10% emission reduction target compared with 2005 corresponds more roughly to a 15% target compared with 1990 levels for the EU27. This is in line with the 8% emission reduction the EU is committed to achieve by 2010 and to the 20% by 2020. We assume that the ETS cap is equally shared among the sectors covered.[67] Thus, the amount of free allowances GF may be written:
$GF = 0.9 \cdot E^{2005} \cdot RFA$

where RFA is the rate of free allocation in the sector considered.

65 Not the marginal one, that is equivalent to consider the long run equilibrium under perfect competition.

66 $P_{CO_2} = \alpha \cdot ua_e + \beta \cdot ua_e^2$

$uac_e = \int_0^{ua} \left(\alpha \cdot ua + \beta \cdot ua^2\right) dua$

67 That is far from real world: Electricity producers have received proportionally less allowances than the other sectors in phase 1 (Buchner et al. 2006) and this situation should maintain in the following phases.

EU producers have the ability to pass-through a rate PT of their cost increase Δc to their price, a criticism being that PT does not depend on Δc :

$$P = P^0 + PT \cdot \Delta c$$

We assume that the price of producers from the Rest of the World (RoW) remains at its BAU level. Only the price charged by EU producers changes. For each sector, we distinguish between two markets: the EU market and the RoW market. On a given market, demand is assumed isoelastic and trade is represented using Armington (1969) specification. We label P_{UE} the price of EU producers and P_{RoW} the price of the producers from the RoW. Then, the equilibrium on the market considered is defined by:

$$P = \left(\beta^{\sigma} {P_{UE}}^{1-\sigma} + (1-\beta)^{\sigma} {P_{RoW}}^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$$

$$Q = Q^0 \left(\frac{P}{P^0} \right)^{-\varepsilon}$$

$$Q_{UE} = \left(\beta \frac{P}{P_{UE}} \right)^{\sigma} Q$$

$$Q_{RoW} = \left((1-\beta) \frac{P}{P_{RoW}} \right)^{\sigma} Q$$

where Q_{UE} and Q_{RoW} are the EU and RoW productions sold, P the Armington price index and Q the Armington consumption index. σ is the Armington elasticity , β a parameter calibrated using trade data, and $\varepsilon > 0$ the demand elasticity. By using the Armington specification, we assume that products are separated by their place of origin.

Finally, the profit margin of EU producers on both EU and RoW markets under Free Eco or AU is:

$$\mu_{UE} = \frac{(P_{UE} - c) \cdot (Q_{UE \to UE} + Q_{UE \to RoW}) + P_{CO_2} \cdot GF}{c \cdot (Q_{UE \to UE} + Q_{UE \to RoW}) - P_{CO_2} \cdot GF}$$

Under Free Ind, the equation is similar with GF set at zero as the amount of allowances. Free allowances are already accounted for in the production cost.

DATA

Out of the four parameters - the CO_2 price, the pass through rate, the trade and demand elasticities and the MACC - we draw on the literature for the range of estimates for the pass-through and the Armington elasticity.

The econometrics literature on Armington elasticities is rather limited for EU countries, hence we mainly refer to US literature. Relying on existing literature we get a range of estimates from 0.4 (Shiells and Reinert 1993) to 2.8 (GTAP) for cement, and from 0.5 (Gallaway and Mc Daniel 2003) to 5 (Bishop2004) for steel[68]. For both sectors, the central value is taken as the range's mean: 1.6 and 2.75 respectively.

68 While studying the steel sector, Bishop (2004) refers to a paper by Romalis (2004) in which the Armington elasticity reaches 12. This extreme value was used in the interim report. However, it turns that the Romalis' paper does not investigate the steel sector in particular. Then, the highest value found is 5 from Bishop (2004). We do not use the same assumption as Mathiesen et Maestad (2004): 8. The authors support this assumption by stating: "this figure is somewhat higher than the Armington elasticity of 5.6 employed for the sector "ferrous metals" in the GTAP model. We have chosen a higher elasticity in order to reflect the fact that the sector "ferrous metals", which includes iron ore, scrap, as well as steel, is a more heterogeneous product category than the steel products that are traded in our model." However, the elasticity of substitution between domestic and foreign products for the ferrous metals sector in GTAP – the relevant one – is 2.8, the value 5.6 being the elasticity of substitution between different import sources, what is not relevant here.

Concerning demand elasticity, we use the same values as Smale et al (2006), i.e. 0.3 and 0.6 respectively for the cement and steel sectors. The MACC is taken from PRIMES (Blok et al 2001). Unfortunately, the MACC for the steel sector merges the two production routes: EAF and BOF whereas we only consider the latter. The MACC for the cement sector does not account for the possibility of reducing the clinker content of cement, whereas it is often identified as an important levy to reduce emissions (WBSCD 2002).

The table below displays the data used for EU production, emissions and price EBIT margin. These data aggregate all EU countries thus price or unitary emission data have to be seen as average EU data.

DATA	**SOURCE**
Cement	
EU price: €64/t EBIT margin: 15% Electricity consumption: 0,103 MWh/t	Reinaud (2005a)
EU25 production (Mt) : 212 Mt (of *cement equivalent*[69]) EU25 export to the Rest of the World: 10Mt EU25 import from the Rest of the World: 18Mt EU25 apparent consumption: 220Mt	Eurostat (2007b) in 2005
CO_2 Emissions of the EU cement sector covered by the ETS in 2005: 170 Mt CO_2	Kettner et al (2007)
Induced unitary emissions covered by the EU ETS: 0,80t CO_2/t	
Steel	
Average EU price of steel products[70]: €500/t	Eurostat before the 2004 price increase
EBIT margin: 15% Electricity consumption BOF Plant 1: 0,374 MWh/t Electricity consumption BOF Plant 2: 0,116 MWh/t Avergae induced electricity consumption BOF: 0,245 MWh/t	Reinaud (2005a)
BOF production=114Mt	McKinsey and Ecofys (2006)
BOF imports[71]: 24Mt BOF exports: 19Mt	Own calculation [72] from Eurostat and McKinsey and Ecofys (2006).
CO_2 Emissions of the Steel sector covered by the EU ETS in 2005: 165 Mt	Kettner et al (2007)
CO_2 emissions attributable to BOF: 157Mt	Own calculation based on Reinaud (2005a) and McKinsey & Ecofys (2006) [73]
Induced unitary emissions covered by the EU ETS: 1.40t CO_2/t[74]	
Electricity	
CO_2 unitary emissions of electricity: 0,41t CO_2/MWh.	McKinsey&Ec. (2006)

69 i.e. we account for the fact that one Tonne of clinker leads to around 1.2 Tonne of cement in the EU (WBCSD 2002).

70 As this price increase may be transitory, we consider the average EU price before the important 2004 increase. This price merges all steel products (NACE 27.1, 27.2 and 27.3).

71 More precisely imports competing with EU BOF products

72 As, from McKinsey and Ecofys (2006), 89% of flat products and 32% of long products come from BOF, one may induce BOF trade flows from up-to-date flat and long products trade data from Eurostat, assuming that these ratios hold. As Eurostat does not differentiate between semis for flat and long products, we use the ratio from McKinsey and Ecofys (2006): 43% of imports and 50% of export in semis are for flat production.

73 Using BOF and EAF direct unitary emissions from Reinaud (2005) and BOF and EAF production from McKinsey and Ecofys (2006) we estimate the relative weight of BOF emissions in total EU emissions

74 The gap with the estimate from Reinaud (2005), 1.93tCO2/t steel, stems from the fact that all the emissions from BOF are not covered by the ETS or are not attributed to steel producers

ANNEX 2 The Refined Petroleum Sector

In the refining sector, CO_2 emissions are roughly split between energy consumption during the distillation of crude oil into different components, and subsequent reprocessing of components to increase the yield of products particularly of diesel and jet fuels. Further emissions are associated with desulphurisation and other refinement processes (more details in Reinaud 2005b). We look at general trends associated with all refining, then comment on the difference between hydro-skimming and more complex refineries.

1. CO_2 emissions per barrel of oil produced

3.35% of EU-25 CO_2 emissions in 2002 can be attributed to the refining sector (Reinaud 2005b), corresponding to 140Mt CO_2. According to BP energy statistics the refineries in EU-25 processed 4815 million barrels in this year. Thus the average CO_2 intensity is 0.029t CO_2/barrel. At €20/t CO_2 this suggests on average CO_2 emission costs of €0.58 /barrel.

Refining margins are volatile. While average margins required are in the order of $US4 /barrel, at times of excess capacity margins can fall below $US2 /barrel. At an exchange rate of $US1.2/€, these simplified parameters suggest a value at stake of 17%, similar to the results we present based on industry data for the UK in Chapter 2 Section 2.3.4.

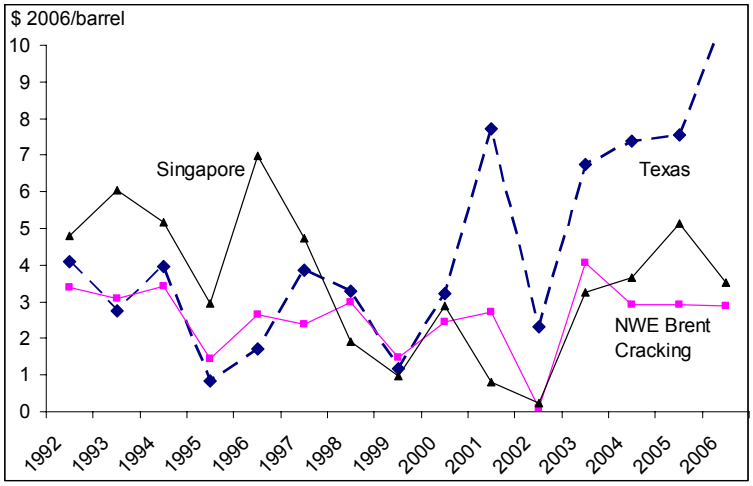


Figure 65 Regional refining margins Source (BP Energy Statistics)

Traditionally, oil refineries are located close to demand.

- Transport costs are higher for refined products than for crude oil. This is because refined products required dedicated tankers/pipelines for each product to ensure product quality, and because the volume of products refined from crude oil is slightly higher thus requiring more transport capacity.
- Dedicated tanker and storage capacity required for different refined products reduces flexibility and increases transport and logistics costs. For example, some of the economies of scale associated with super tankers are lost.
- Investors were reluctant to invest in capital-intensive facilities in many of the countries that are exporting oil due to fears of expropriation or political instability.
- Refineries near markets and at tidewater can optimise their production by mixing various types of crude oil in response to seasonal changes in product demand and

market changes, a benefit that is difficult to achieve where refineries are located close to oil production and dedicated to a particular crude oil steam. Moreover, refineries in producing countries face higher risk in the event of supply disruption from their dedicated crude oil sources.

- When refineries are next to the market, they can respond to market changes immediately. In contrast, refineries with long shipping times lack flexibility and will have a greater proportion of "stress" sales.

Responding to these five factors, we observe a close match between refinery capacity and consumption (see Figure 66). As a result, transport and distribution infrastructure are tailored to the location of refineries. Large-scale changes towards imports of refined products would likely require significant investment and restructuring of the infrastructure.

Two factors induce a limited trade volume of refined products:

- US consumption of gasoline relative to diesel oil is higher than the 'natural' mix in crude oil, while the EU consumption of gasoline relative to diesel is lower than the output of many refineries. As a result, some gasoline is exported from EU to US.
- There is some spare refinery capacity in the former Soviet republics and Russia, allowing for exports of diesel oil to satisfy the excess demand in the EU-25. Environmental specifications, especially the EU low sulphur requirements, require additional treatment of this diesel, hence limit the import volumes.

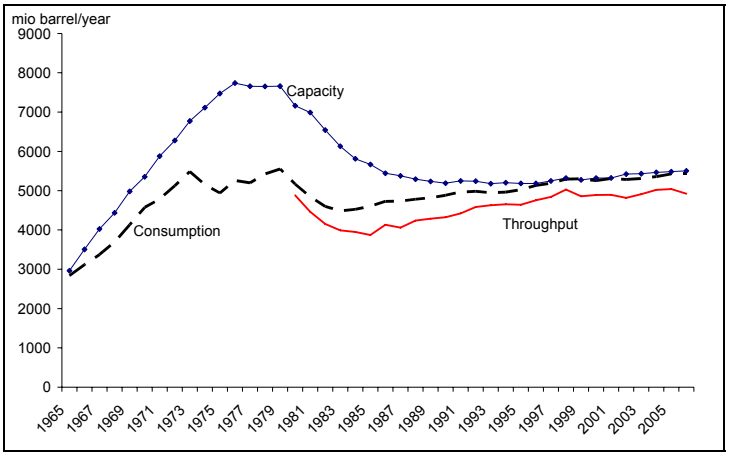


Figure 66 EU 25 refining capacity, throughput and consumption of refined products (Source: Based on BP energy statistics)

2. Relocation outlook

There is no expectation of new greenfield investment or large scale expansion of refining capacity in the EU-25 because of: A) the challenging environmental regulations and B) climate policy, higher prices, and security of supply concerns are likely to prevent further consumption growth while bio-fuels regulations provide for additional supply (Figure 66 shows stable EU consumption over recent years).

The situation of existing refining capacity can be assessed separately for two main categories: hydroskimming and complex refineries. The output of hydroskimming refineries consists of larger share of heavy fuel oils and gasoline. Complex refineries have additional catalytic hydro-cracking, and coking facilities, and can thus shift the product mix towards the more desirable diesel and jet fuels.

There are no obvious reasons for concern about the continued operation of complex refineries. On the other hand, the product mix offered by hydroskimming refineries is becoming increasingly less attractive.

- Diesel and jet fuel demand are increasing relative to gasoline demand, due to environmental regulation (bio-fuels) and increased use of diesel for cars and aviation.
- Fuel oil demand is decreasing with carbon constraints, as it is more carbon intensive than natural gas. This transition is accelerated with high oil prices. Price elasticity of fuel oil is likely to be higher than of gasoline.
- Regulation of SO_2 emissions for maritime transport require desulphurisation, which is typically part of the complex refineries, but not of hydroskimming.
- North Sea oil has a more favourable composition for hydroskimming facilities, but production is declining and increasingly replaced with other oil blends. Thus the value of the product mix of hydro skimming facilities decreases further.

As a result of these impacts – that mainly represent global trends - the refining margins of complex refineries are very high and hydroskimming facilities very low. The difference is bigger than the average margin observed in the market and determines the benefit of upgrading hydroskimming facilities towards complex facilities.

The cost of upgrading a hydroskimming refinery towards a complex refinery is only in the order of one third of the cost of a greenfield facility. Comparing the benefits (higher than the average refining margins) to the costs (a fraction of the costs of new investment) suggests that investments in upgrades are profitable even in regions where higher cost-factors prohibit investment Greenfield refineries. Indeed, investments in upgrading hydroskimming facilities are being pursued.

There is no guarantee that global refinery margins will be preserved, if oil consumption declines. If such a decline is driven by climate policy, a strong climate policy at a global level is implied, hence a level playing field and little concern about leakage. If such a decline were to be caused by a strong economic downturn, or less availability of crude oil, then the question arises in what regions refining capacity were to be closed first. Is there a risk that unilateral high CO_2 costs in Europe could result in an increased closure of refining capacity in Europe and replacement by imports of refined oil products?

In the case of reduced refinery margins associated with an economic downturn, the logistical challenge of developing a transport chain for refined products to and across Europe, and the development of a dedicated tanker fleet would be expensive. Even more so, the European refineries and infrastructure are likely to be kept available as an option to be used once economic activity and demand recovers.

In the case of reduced refinery margins associated with a global oil supply reduction, the geo-political constellations that drive such a change are difficult to anticipate and at this stage it is even more difficult to forecast the impact, let alone interaction with interactions with unilateral CO_2 prices.

Thus we think that the refining sector, despite a high value at stake, is unlikely to exhibit significant leakage in the near-term (or re-location of production) irrespective of the allocation decision.

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